INTERNATIONAL REAL ESTATE REVIEW

2018 Vol. 21 No. 4: pp. 447 – 471

Link between Housing and Stock Markets: Evidence from OECD Using Asymmetry Analysis

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Increases in stock prices are said to affect house prices due to the wealth effect. Researchers have used aggregate indexes of both house and stock prices from different countries and produced mixed and poor results in support of the wealth effect. Like them, we find long-run support for the wealth effect in six out of 18 OECD countries when we use a linear model. However, when we separate the increases in stock prices from declines and estimate a nonlinear model, a long-run wealth effect is observed in 13 out of 18 OECD countries. Not only are the long-run effects asymmetric in all 13 countries, but so are the short-run effects in all of the countries.

Keywords

House Prices, Stock Prices, Nonlinear ARDL Approach, 18 OECD Countries.

1. Introduction

The wealth effect in economics usually refers to the impact of an increase in wealth on consumption. The wealth could originate from different sources including capital gains from engaging in the stock market and consumption could be on different goods including housing. Therefore, it is expected that continuously rising stock prices benefit the housing market by increasing the demand for housing and eventually, house prices, and hence, the wealth effect.

This hypothesis has been tested by different researchers who use data from different countries with mixed results. For example, Liu *et al.* (1990) consider the United States (U.S.) markets but do not find any link between the real estate and stock markets. However, Ambrose *et al.* (1992), Okunev and Wilson (1997), Ling and Naranjo (1999), Tsai *et al.* (2012), and Ding *et al.* (2014) find support for links between these two markets in the U.S. Findings that use data from other countries are also mixed. For example, when Wilson and Okunev (1999) take into consideration the experiences of the United Kingdom (U.K.) and Australia in addition to the U.S., no long-run relationship between the two markets is found. However, when Liow and Yang (2005) use data from Japan, Hong Kong, Singapore and Malaysia, they find evidence that supports the wealth effect in those countries. Similar results that support the wealth effect are also reported for China in Liu and Su (2010), for eight Western European countries (i.e., Belgium, France, Germany, Italy, the Netherlands, Spain, Switzerland and the U.K.) in Su (2011), and for Taiwan, Singapore and Hong Kong in Lin and Fuerst (2014). Finally, Bahmani-Oskooee and Wu (2018) apply a bootstrap panel Granger causality test to examine the causal relationship between the housing and the stock markets across 18 OECD countries. Their approach which accounts for both dependence and heterogeneity across the regions supports the wealth effect in Australia, Canada, France, Greece, Portugal, South Korea, Spain, Sweden and the U.K.

We suspect that failure to find strong evidence of the wealth effect in almost half of the countries through the panel approach in Bahmani-Oskooee and Wu (2018) could be due to either aggregation bias or the assumption that the effects of stock returns on house prices are symmetric. If we believe that the response of house prices to changes in stock prices is different when stock prices rise compared to when they fall, then there is room to engage in asymmetry analyses and apply nonlinear models. Indeed, we plan to show this by using the same data set in Bahmani-Oskooee and Wu (2018). To this end, we introduce the models and methods in Section 2. The empirical results for each of the 18 OECD countries are reported in Section 3, followed by a summary in Section 4. Variable definitions and sources are reported in the Appendix.

2. Model and Methods

In establishing the link between house prices, P, and stock prices, S, two other determinants included in previous research studies to avoid the omitted variable problem are: a measure of the economic activity of a country, and interest rate, R. Since the data are quarterly and the only available measure of economic activity for all of the OECD members is the Index of Industrial Production, we denote this index with I and include the index in our model.[1]

$$LnP_t = a + bLnI_t + cLnR_t + dLnS_t + \varepsilon_t \tag{1}$$

Equation (1) is a long-run model of house price determination and based on the economic theory, while the estimate of b is expected to be positive, and that of c is expected to be negative. Furthermore, the wealth effect will be validated if the estimate of d is significant and positive. However, these significant estimates will only be valid if cointegration among the variables is established. According to Engle and Granger (1987) cointegration is established if each variable in Equation (1) is integrated of the order d, but the residuals are integrated of the order less than d. For example, if all of the variables are integrated of the order one, I(1), the residuals must be I(0). In the event that the residuals are also I(1), Banerjee *et al.* (1998) propose another test embodied in the error-correction representation of Equation (1), which is shown as Equation (2):

$$\begin{aligned}\Delta LnP_t = \alpha + \sum_{i=1}^{n1} \beta_i \Delta LnP_{t-i} + \sum_{i=0}^{n2} \delta_i \Delta LnI_{t-i} + \sum_{i=0}^{n3} \pi_i \Delta LnR_{t-i} \\ + \sum_{i=0}^{n4} \theta_i \Delta LnS_{t-i} + \lambda \varepsilon_{t-1} + \mu_t\end{aligned} \tag{2}$$

They show that if the estimate of λ is negative and significant in an OLS estimate of Equation (2), then the gap between the two sides in Equation (1) will be reduced as the variables adjust and converge to long-run equilibrium values, which indicates cointegration. However, the t-test that is used to determine the significance of λ provides new critical values in their study.

In the event that some of the variables in Equation (1) are I(1) and some are I(0), Pesaran *et al.* (2001) introduce yet another cointegration approach. They solve Equation (1) for ε_t and lag the solution by one period and substitute the lagged solution for ε_{t-1} in Equation (2) to arrive at Equation (3) below:

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[1] The income and interest rate are usually referred to as fundamentals. Some other studies that have emphasized fundamentals other than stock prices as determinants of house prices are: Chen and Patel (1998), Meen (2002), Case and Shiller (2003), Apergis (2003), Chen *et al*. (2007), McQuinn and O'Reilly (2008), Kim and Bhattacharya (2009) and Zhou (2010) who use time-series data from individual countries to estimate their model. However, Malpezzi (1999), Gallin (2006), Mikhed and Zemcik (2009), Holly *et al.* (2010), and Madsen (2012) apply panel models.

$$\Delta LnP_t = \alpha + \sum_{i=1}^{n1} \beta_i \Delta LnP_{t-i} + \sum_{i=0}^{n2} \delta_i \Delta LnI_{t-i} + \sum_{i=0}^{n3} \pi_i \Delta LnR_{t-i}$$
$$+ \sum_{i=0}^{n4} \theta_i \Delta LnS_{t-i} + \lambda LnP_{t-1} + \lambda bLnI_{t-1} + \lambda cLnR_{t-1} \tag{3}$$
$$+ \lambda dLnS_{t-1} + \mu_t$$

Equation (3) is another error-correction model in which the short-run effects of each exogenous variable in house price are reflected in the estimates of the coefficients attached to the first-differenced variable. The long-run effects, i.e., estimates of b, c, and d, are derived from normalizing λb, λc, and λd by λ.[2] However, for these normalized long-run estimates to be valid, Pesaran *et al.* (2001) propose two tests: the standard F test and a t-test. The standard F test is applied to determine whether the linear combination of lagged level variables belongs to the model. A significant F test will support cointegration. The second test is the t-test which is applied to establish a negative sign and the significance of λ in the same spirit as Banerjee *et al.* (1998). However, both tests present the new critical values found in Pesaran *et al.* (2001) and since these critical values account for the integrated properties of the variables, there is no pre-unit-root testing under this approach based on the assumption that the macro variables are either I(1) or I(0). This is one of the main advantages of this method in addition to the fact that the short-run and long-run effects are estimated in one step.

In any of the above equations, it is assumed that the response of house prices to changes in all variables is symmetric. However, Bahmani-Oskooee and Ghodsi (2016) who use state level data from the U.S., argue and demonstrate that changes in the fundamentals, i.e., changes in income and interest rate, could have asymmetric effects on house prices.[3] We now extend their asymmetric approach to include changes in stock prices, S. Following their approach and the nonlinear autoregressive distributed lag (ARDL) approach in Shin *et al.* (2014), Equation (1) is transformed into Equation (4):

$$LnP_t = a + b^+ I_t^+ + b^- I_t^- + c^+ R_t^+ + c^- R_t^- + d^+ S_t^+ + d^- S_t^- + \upsilon_t \tag{4}$$

where I^+ and I^- denote the partial sums of the positive and negative changes in the natural log of the Index of Industrial Production respectively. The same definition is applied to R and S and their positive and negative partial sums.[4] The corresponding error-correction equation takes the following form:

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[2] Once Equation (3) is estimated, the normalized long-run estimates are obtained as $\hat{b} = \hat{\lambda}\hat{b}/-\hat{\lambda}$, $\hat{c} = \hat{\lambda}\hat{c}/-\hat{\lambda}$, $\hat{d} = \hat{\lambda}\hat{d}/-\hat{\lambda}$.

[3] Note that Tsai *et al.* (2012) have also hinted on the asymmetric effects of fundamentals.

[4] For example, S^+ and S^- are constructed as $S_t^+ = \sum_{j=1}^{t} \max\left(\Delta LnS_j, 0\right)$, and $S_t^- = \sum_{j=1}^{t} \min\left(\Delta LnS_j, 0\right)$. Intuitively, the partial sum of positive (negative) changes is the same as the cumulative sum of all changes where negative (positive) changes are

$$\begin{aligned}\Delta LnP_t &= \alpha + \sum_{i=1}^{n1} \beta_i \Delta LnP_{t-i} + \sum_{i=0}^{n2} \delta_i^+ \Delta I_{t-i}^+ + \sum_{i=0}^{n3} \delta_i^- \Delta I_{t-i}^- \\ &+ \sum_{i=0}^{n4} \theta_i^+ \Delta R_{t-i}^+ + \sum_{i=0}^{n5} \theta_i^- \Delta R_{t-i}^- + \sum_{i=0}^{n6} \omega_i^+ \Delta S_{t-i}^+ + \sum_{i=0}^{n7} \omega_i^- \Delta S_{t-i}^- \\ &+ \lambda LnP_{t-1} + \lambda b^+ I_{t-1}^+ + \lambda b^- I_{t-1}^- + \lambda c^+ R_{t-1}^+ + \lambda c^- R_{t-1}^- \\ &+ \lambda d^+ S_{t-1}^+ + \lambda d^- S_{t-1}^- + \zeta_t\end{aligned} \tag{5}$$

Equation (5) is another error-correction model that is applied in Shin *et al.* (2014) who dubbed the model as a nonlinear ARDL model and show that the approach in Pesaran *et al.* (2001) for estimating the linear ARDL model (Equation) (3)) is equally applicable to Equation (5).[5] Again, the t-test is used to determine if the estimate of λ is significantly negative and the F test is used to establish joint significance of all lagged level variables. Shin *et al.* (2014, p. 291) even argue that the critical value of the F test should stay at the same high value when we move from Equations (3) to (5), although Equation (5) has three more exogenous variables. However, this is not the case for the critical value of the t-test.

Once Equation (5) is estimated by using a set lag selection criterion and cointegration is established, a few asymmetry hypotheses could be tested. For example, focusing on the effects of the stock prices on house prices, $n_6 \neq n_7$, which will be an indication of adjustment asymmetry. On the other hand, if the estimate of ω^+ is different than the estimate of ω^- at the same lag i, this will support the short-run asymmetric effects of stock price changes on house prices. However, if $\sum \omega^+ \neq \sum \omega^-$, then short-run cumulative or impact asymmetry is supported. Finally, the long-run asymmetric effects of stock prices on house prices will be established if the normalized estimate of the long-run coefficient assigned to S_{t-1}^+ is different than that assigned to S_{t-1}^-, i.e., if estimate of $d^+ \neq d^-$. To test the last two inequalities, i.e., short-run impact and long-run asymmetries, the common practice is to use the Wald test.

3. Results

In this section, we estimate both the linear ARDL model (Equation (3)) and the nonlinear ARDL model (Equation (5)) for each of the 18 OECD countries by using quarterly data over the period 1993Q1-2015Q4. In order to gain some insights into the link between house and stock prices in each country, we plot them in Figure 1. As can be seen, they move in the same direction for almost all of the countries. However, in order to show that the link is not spurious, both symmetric and asymmetric cointegration are necessary.

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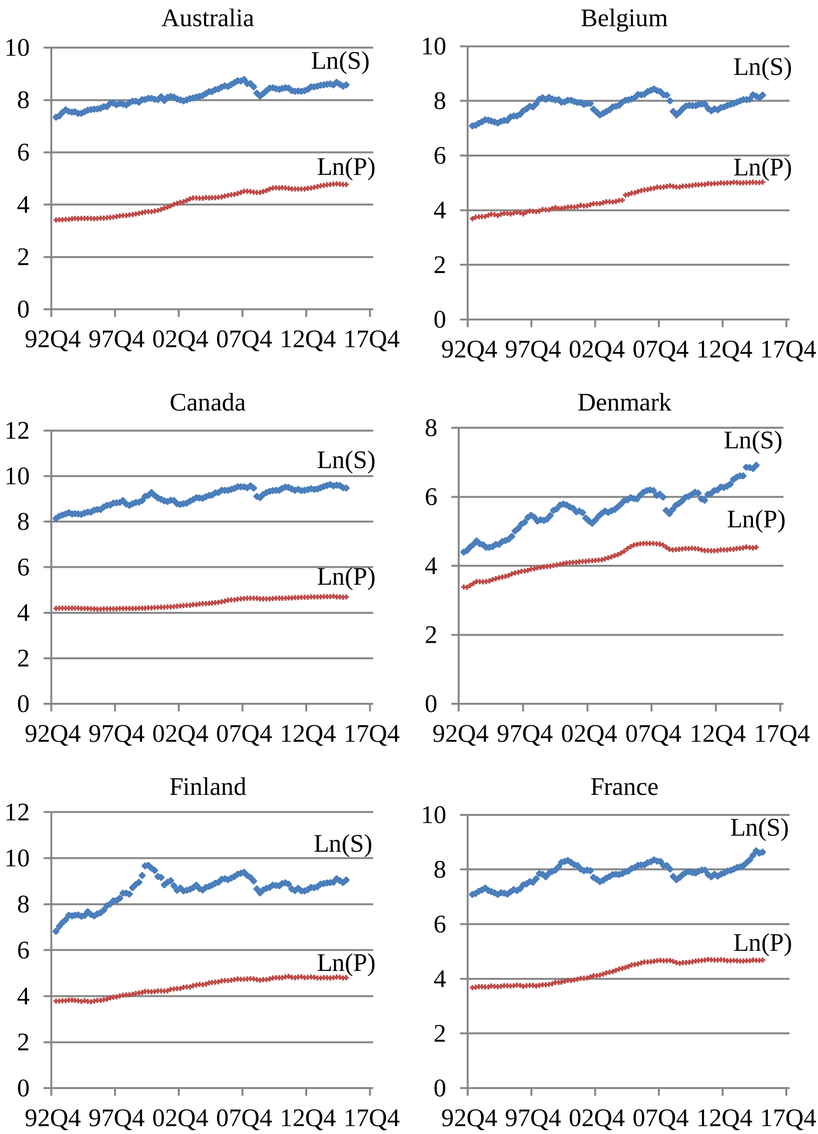
replaced by zeroes.

[5] Note that nonlinearity is introduced due to partial sum variables.

Figure 1 Stock Prices (*LnS*) and House Prices (*LnP*) – by Country



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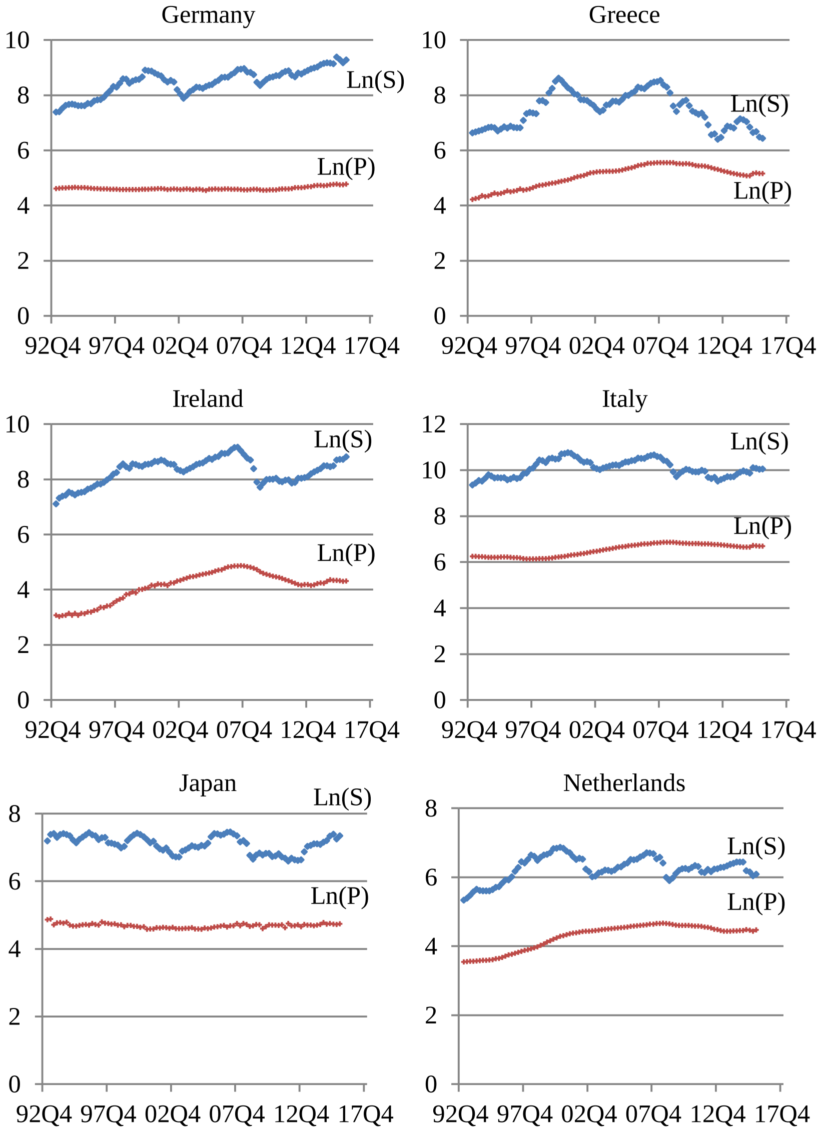
(Figure 1 Continued)



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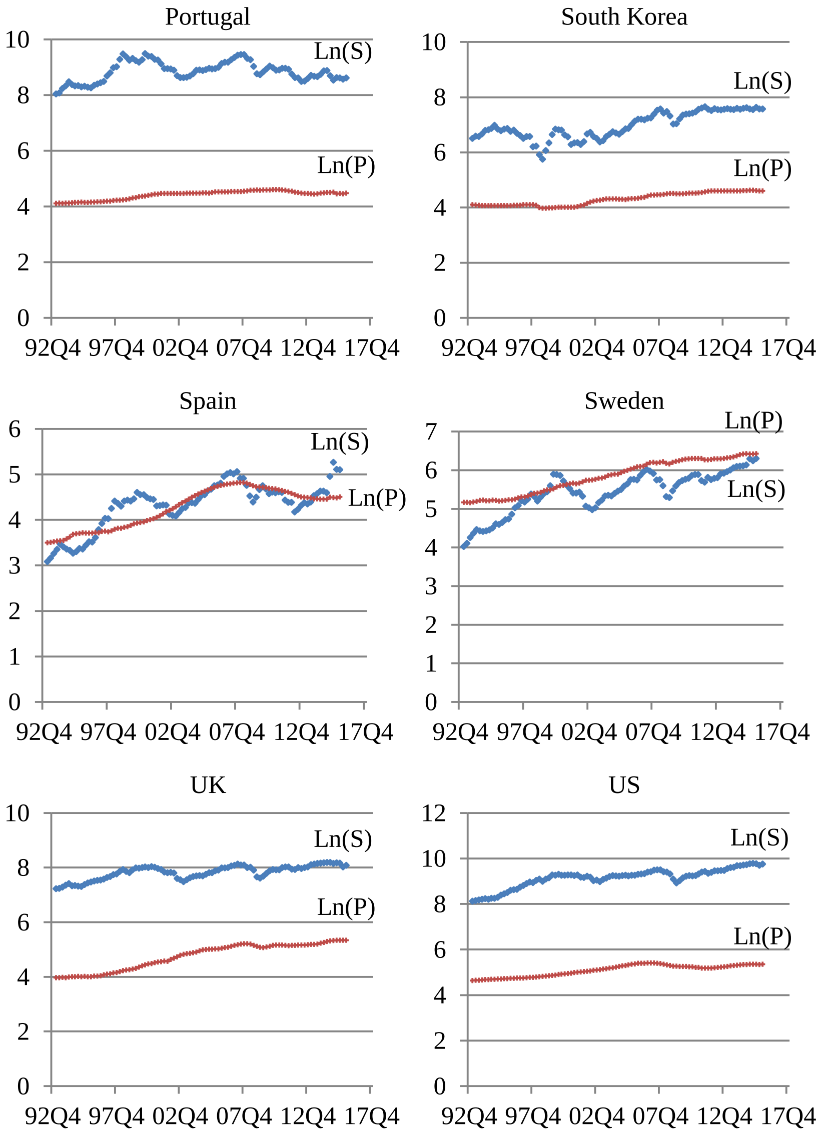

Next we try to estimate each model. It is common practice to use a set lag selection criterion. To this end, we rely on Akaike's information criterion (AIC). We impose a maximum of eight lags (which includes the current value) and use the AIC to select an optimum model. Since different estimates and different diagnostic statistics are subject to different critical values, we collect all of the critical values from the notes to tables and use them to identify significant estimates by using * or **. If an estimate is significant at the 10% level, then * is used. If it is significant at the 5% level, then ** is used. We begin by estimating the optimum linear model for each country as reported in Table 1.

As can be seen from Table 1, the results for each country are reported in Panels A, B, and C. While Panels A and B report the short-run and long-run coefficient estimates respectively, Panel C reports the diagnostic statistics. Focusing on the short-run effects of the stock prices (*S*) on house prices, we suppose that they have significant short-run effects in 11 countries. In those countries, i.e., Australia, Belgium, Canada, Denmark, Finland, Greece, Ireland, Japan, South Korea, Spain, and Sweden, ΔLnS carries at least one significant coefficient. However, the short-run effects last into the long-run significant and meaningful effects only in the cases of Greece, Ireland, Portugal, South Korea, Sweden, and the U.S. Except for the U.S., only in the five other countries does *LnS* carry a significantly positive coefficient in Panel B which is supported by either the F-test or *t*-test for cointegration in Panel C, thus providing support for the wealth effect argument. As for the long-run effects of the two other variables, the Index of Industrial Production, *I*, carries an expected positive, significant, and meaningful coefficient in Finland, Greece, Ireland, the Netherlands, Portugal, Sweden, the U.K. and the U.S., thus implying that economic growth contributes to rising house prices. The interest rate, *R*, also carries an expected negative, significant, and meaningful coefficient in the results for Finland, Germany, Greece, Italy, Portugal, the U.K. and the U.S.

Three additional diagnostics are reported in Panel C. The Lagrange multiplier test statistics are denoted as LM and used to test for autocorrelation. Since we are testing for first-order serial correlation, the Lagrange multiplier test statistics are distributed as χ^2 with one degree of freedom. As can be seen, it is significant only in Denmark, thus supporting autocorrelation free residuals in almost all of the optimum models. We have also applied the well-known cumulative sum (CUSUM) and CUSUM squared (CUSUMSQ) tests to the residuals of each optimum model to establish stability of all short-run and long-run coefficient estimates. The two tests are reported as QS and QS^2, while the stable estimates are indicated by "S" and unstable ones by "U". There are hardly any unstable estimates. Finally, the size of the adjusted R^2 is reported to determine the goodness of fit in each model. How would the results change if we shift to estimates of nonlinear models? These results are reported in Table 2 and discussed below.

Table 1 Coefficient Estimates of Linear ARDL Model
Panel A Short-Run

	Australia	Belgium	Canada	Denmark	Finland	France	Germany	Greece	Ireland
$\boldsymbol{\Delta LnI_t}$	-0.28(2.06)**	0.05(0.37)	0.02(1.33)	-0.04(1.05)	0.13(2.1)**	0.3(3.1)**	-0.09(1.39)	0(0.03)	0.05(0.61)
ΔLnI_{t-1}						0.06(0.42)	0(0.02)	-0.14(1.55)	0.07(0.77)
ΔLnI_{t-2}						0.3(2.28)**	0.07(0.67)		-0.08(0.86)
ΔLnI_{t-3}						0.03(0.25)	-0.16(1.55)		-0.12(1.49)
ΔLnI_{t-4}						-0.2(1.49)	0.29(2.79)**		
ΔLnI_{t-5}						-0.02(0.16)	-0.27(2.57)**		
ΔLnI_{t-6}						-0.28(2.2)**	0.13(2.07)**		
ΔLnI_{t-7}						0.21(2.19)**			
$\boldsymbol{\Delta LnR_t}$	0.01(0.3)	0.001(0.78)	0.001(1.63)	0.001(1.71)*	-0.01(1.9)*	0(0.6)	-0.01(1.45)	0.04(5.32)**	0(0.23)
ΔLnR_{t-1}	0.001(0.12)					0(0.4)	0.02(0.96)	0(0.24)	-0.02(0.57)
ΔLnR_{t-2}	-0.04(1.88)*					-0.04(3.29)**	-0.02(1.1)	-0.01(0.5)	-0.01(0.43)
ΔLnR_{t-3}						0.02(1.73)*	0.02(1.92)*	0(0.11)	0.06(1.79)*
ΔLnR_{t-4}						0.02(1.53)		-0.02(1.18)	-0.1(2.64)**
ΔLnR_{t-5}						-0.03(1.91)*		0.02(1.01)	0.06(1.59)
ΔLnR_{t-6}						0.02(1.67)*		-0.01(0.36)	0.02(0.63)
ΔLnR_{t-7}						-0.02(2.02)**		0.02(1.81)*	-0.06(2.67)**
$\boldsymbol{\Delta LnS_t}$	0.03(2.34)**	0.04(0.97)	0.001(0.1)	0.07(5.34)**	0.05(2.72)**	0(0.51)	0(0.24)	0.02(3.14)**	0.08(4.17)**
ΔLnS_{t-1}		0.07(1.93)*	0.03(2.89)**		0.04(1.44)				
ΔLnS_{t-2}					-0.01(0.4)				
ΔLnS_{t-3}					0.03(1.08)				
ΔLnS_{t-4}					-0.02(0.63)				
ΔLnS_{t-5}					0.03(1.08)				
ΔLnS_{t-6}					-0.04(2.54)**				
ΔLnS_{t-7}									

(Continue…)

(Table 1 Continued)

Panel A Short-Run

	Italy	Japan	Netherlands	Portugal	South Korea	Spain	Sweden	U.K.	U.S.
$\boldsymbol{\Delta LnI_t}$	-0.03(0.47)	-0.01(0.09)	-0.06(1.04)	0.01(0.15)	0.01(0.88)	0.29(3.73)**	0.16(4.78)**	0.7(3.4)**	0.09(1.03)
ΔLnI_{t-1}	-0.11(2.06)**	-0.14(0.69)	0.19(3.25)**	-0.01(0.1)				0.19(0.71)	0.3(1.94)*
ΔLnI_{t-2}		0.32(1.61)	-0.08(1.22)	0.06(0.73)				0.28(1.03)	-0.38(2.3)**
ΔLnI_{t-3}		-0.65(3.31)**	0.15(2.37)**	0.08(0.94)				-0.14(0.54)	0.33(1.98)**
ΔLnI_{t-4}		0.66(3.26)**	-0.17(2.74)**	-0.09(1.04)				-0.43(2.17)**	-0.25(2.87)**
ΔLnI_{t-5}		-0.25(1.97)**	0.1(1.82)*	-0.14(2.12)**					
ΔLnI_{t-6}									
ΔLnI_{t-7}									
$\boldsymbol{\Delta LnR_t}$	0.03(5.11)**	0.01(1.04)	0.01(1.29)	-0.01(1.23)	0(0.17)	0.01(2.89)**	-0.01(1.98)**	0(0.19)	0(0.31)
ΔLnR_{t-1}	-0.03(2.6)**		0(0.65)	-0.02(1.11)	-0.06(3.25)**	-0.02(4.08)**	-0.01(1)	-0.01(0.4)	0(0.5)
ΔLnR_{t-2}	-0.01(1.05)		-0.03(4.01)**	0.02(1.55)	0.03(2.31)**		0(0.07)	-0.01(0.32)	0.02(3.15)**
ΔLnR_{t-3}	0(0.18)		0.04(5.01)**	0.01(0.48)			0(0.23)	0.03(1.63)	-0.01(1.91)*
ΔLnR_{t-4}	0.02(2.17)**		-0.02(3.59)**	-0.01(0.36)			-0.01(0.31)		0(0.22)
ΔLnR_{t-5}				0.01(0.44)			-0.02(0.78)		0(0.46)
ΔLnR_{t-6}				-0.01(1.5)			0.05(2.5)**		0.01(2.07)**
ΔLnR_{t-7}							-0.04(3.2)**		-0.01(2.09)**
$\boldsymbol{\Delta LnS_t}$	0.01(1.45)	0.13(3.17)**	0(0.46)	-0.01(0.97)	0.02(1.76)*	-0.01(0.87)	0.02(3.26)**	0(0.01)	0(0.42)
ΔLnS_{t-1}					-0.03(1.45)	-0.03(2.14)**			
ΔLnS_{t-2}					0.05(3.05)**				
ΔLnS_{t-3}					-0.04(2.84)**				
ΔLnS_{t-4}									
ΔLnS_{t-5}									
ΔLnS_{t-6}									
ΔLnS_{t-7}									

(Continue…)

(Table 1 Continued)

Panel B Long-Run

	Australia	Belgium	Canada	Denmark	Finland	France
Constant	6.57(0.27)	-6.3(5.42)**	-3.06(0.44)	-11.13(1.1)	-3.19(3.02)**	-185.2(74.66)**
LnI_t	-3.56(0.41)	2.49(9.34)**	1.65(0.75)	4.21(1.34)	1.69(4.49)**	421.29(0.05)
LnR_t	-0.94(0.66)	0.03(0.69)	-0.19(1.59)	-0.33(1.05)	-0.09(3.28)**	-6.37(0.05)
LnS_t	1.88(0.89)	-0.02(0.17)	0(0.01)	-0.67(0.74)	0.02(0.22)	-12.39(0.05)
	Germany	Greece	Ireland	Italy	Japan	Netherlands
Constant	5.43(16.31)**	-5.14(4.84)**	-3.55(6.8)**	-1.8(0.33)	4.19(2.23)**	-51.78(1.83)*
LnI_t	-0.18(2.16)**	2(7.46)**	0.98(9.41)**	0.99(0.62)	0.08(0.22)	15.11(1.81)*
LnR_t	-0.07(5.57)**	-0.14(5.53)**	0.2(9.43)**	-0.2(2.57)**	0.03(1.32)	-0.2(0.84)
LnS_t	0.01(0.23)	0.16(3.36)**	0.41(4.12)**	0.4(1.12)	0.02(0.29)	-2(1.27)
	Portugal	South Korea	Spain	Sweden	United Kingdom	United States
Constant	-0.12(0.13)	2.26(3.09)**	-6.73(0.64)	-9.42(3.89)**	-94.95(2.42)**	-3.61(3.18)**
LnI_t	0.59(3.1)**	0.19(0.94)	2.18(0.78)	2.96(6.26)**	21.87(2.41)**	3.07(6.47)**
LnR_t	-0.04(2.46)**	-0.11(1.05)	-0.31(1.67)*	-0.11(1.02)	-1.08(2.75)**	-0.08(5.32)**
LnS_t	0.21(3.4)**	0.21(2.64)**	0.28(0.49)	0.4(2.79)**	0(0.01)	-0.57(4.14)**

(Continue…)

(Table 1 Continued)

Panel C Diagnostic

	Australia	Belgium	Canada	Denmark	Finland	France	Germany	Greece	Ireland
F	1.13	2.32	2.28	3.4	4.27*	2.55	4.59**	7.14**	9.78**
t-test (λ)	-0.01(0.95)	-0.1(2.39)	-0.02(1.29)	-0.01(1.42)	-0.08(3.17)	0(0.05)	-0.19(3.55)*	-0.1(5.45)**	-0.19(5.25)**
LM	1.1	0.18	0.43	3.14	0.32	0.81	0.06	0.19	0.06
QS (QS^2)	U(S)	S(S)	S(S)	S(S)	S(S)	S(S)	S(S)	S(S)	S(S)
Adjusted R^2	0.65	0.34	0.6	0.8	0.61	0.88	0.55	0.79	0.75
	Italy	Japan	Netherlands	Portugal	South Korea	Spain	Sweden	United Kingdom	United States
F	4.41**	1.47	6.04**	8.29**	3.35	2.41	7.78**	5.2**	8.7**
t-test (λ)	-0.02(2.97)	-0.22(2.35)	0.01(1.2)	-0.09(4.6)**	-0.07(3.58)*	-0.01(2.68)	-0.05(4.72)**	-0.02(2.87)	-0.05(4.92)**
LM	1.01	1.54	1.73	0.19	1.19	1.69	1.01	0.11	0.78
QS (QS^2)	S(S)	S(S)	S(S)	S(S)	S(S)	S(S)	S(S)	S(S)	S(S)
Adjusted R^2	0.79	0.42	0.88	0.63	0.63	0.84	0.67	0.67	0.9

Notes:

a. Numbers inside parentheses are absolute values of the t-ratios and * (**) indicates significance at the 10% (5%) confidence level.
b. At the 10% (5%) significance level when there are three exogenous variables (k=3), the critical value of the F test is 3.77 (4.35). This is derived from Pesaran et al. (2001; Table CI-Case III, page 300).
c. At the 10% (5%) significance level when there are three exogenous variables (k=3), the critical value of the t-test for significance of λ is -3.46 (-3.78). This is derived from Pesaran et al. (2001; Table CII-Case III, page 303).
d. LM denotes Lagrange multiplier test of residual serial correlation. The Lagrange multiplier test statistics are distributed as $\chi2$ with one degree of freedom since we are testing for 1st order serial correlation. Its critical value at the 10% (5%) level is 2.71 (3.84).

Table 2 Full Information Estimates of Nonlinear ARDL Model
Panel A Short-Run

	Australia	Belgium	Canada	Denmark	Finland
ΔI^{+}_{t}	-0.46(2.53)**	0.03(0.12)	-0.14(1.46)	-0.12(2.03)**	0.02(0.15)
ΔI^{+}_{t-1}			-0.09(0.69)		0.96(4.54)**
ΔI^{+}_{t-2}			0.14(1.03)		-0.56(4.07)**
ΔI^{+}_{t-3}			-0.11(0.8)		
ΔI^{+}_{t-4}			0.3(2.15)**		
ΔI^{+}_{t-5}			-0.23(2.58)**		
ΔI^{+}_{t-6}					
ΔI^{+}_{t-7}					
ΔI^{-}_{t}	-0.03(0.11)	0.17(1.05)	0.09(1.19)	0.04(1.34)	-0.02(0.2)
ΔI^{-}_{t-1}					-0.29(1.72)*
ΔI^{-}_{t-2}					0.38(3.56)**
ΔI^{-}_{t-3}					
ΔI^{-}_{t-4}					
ΔI^{-}_{t-5}					
ΔI^{-}_{t-6}					
ΔI^{-}_{t-7}					
ΔR^{+}_{t}	0.001(0.08)	-0.04(2.01)**	0.001(1.55)	-0.04(3.63)**	-0.04(1.41)
ΔR^{+}_{t-1}					
ΔR^{+}_{t-2}					
ΔR^{+}_{t-3}					
ΔR^{+}_{t-4}					
ΔR^{+}_{t-5}					
ΔR^{+}_{t-6}					
ΔR^{+}_{t-7}					
ΔR^{-}_{t}	-0.03(1.65)*	0(0.18)	0.01(1.64)	0.01(2.17)**	0.04(3.56)**
ΔR^{-}_{t-1}					-0.04(1.86)*
ΔR^{-}_{t-2}					0.03(1.36)
ΔR^{-}_{t-3}					-0.02(0.87)
ΔR^{-}_{t-4}					0.01(0.36)
ΔR^{-}_{t-5}					-0.05(2.21)**
ΔR^{-}_{t-6}					0.06(4.35)**
ΔR^{-}_{t-7}					
ΔS^{+}_{t}	0.02(0.95)	0.01(0.21)	0.01(0.24)	0.04(1.7)*	0.04(4.79)**
ΔS^{+}_{t-1}		0.14(2)**		-0.11(3.52)**	
ΔS^{+}_{t-2}				0(0.11)	
ΔS^{+}_{t-3}				0.05(1.69)*	
ΔS^{+}_{t-4}				-0.04(1.13)	
ΔS^{+}_{t-5}				0.07(1.82)*	
ΔS^{+}_{t-6}				-0.07(2.72)**	
ΔS^{+}_{t-7}					
ΔS^{-}_{t}	0.1(2.65)**	0.01(0.19)	0.001(0.07)	0.13(5.97)**	0.06(2.91)**
ΔS^{-}_{t-1}	0.07(1.3)		0.05(3.36)**		0.07(2.85)**
ΔS^{-}_{t-2}	0.04(0.76)				
ΔS^{-}_{t-3}	-0.04(0.67)				
ΔS^{-}_{t-4}	0.03(0.58)				
ΔS^{-}_{t-5}	-0.1(2.5)**				
ΔS^{-}_{t-6}					
ΔS^{-}_{t-7}					

(Continue…)

(Table 2 Continued)

Panel A Short-Run

	France	Germany	Greece	Ireland	Italy
$\boldsymbol{\Delta I^{+}_{t}}$	-0.28(0.81)	-0.57(3.45)**	0.35(1.85)*	-0.07(0.6)	-0.36(2.18)**
ΔI^{+}_{t-1}	-0.08(0.22)	-0.18(0.89)	-0.14(0.55)	-0.02(0.13)	-0.3(2)**
ΔI^{+}_{t-2}	0.33(0.96)	0.55(2.71)**	-0.49(1.98)**	-0.01(0.05)	
ΔI^{+}_{t-3}	0.08(0.28)	-0.22(1.04)	0.12(0.55)	-0.41(2.32)**	
ΔI^{+}_{t-4}	0.32(0.9)	-0.36(1.57)	0.01(0.04)	-0.09(0.59)	
ΔI^{+}_{t-5}	-0.18(0.65)	-0.28(1.45)	-0.57(3.04)**	0.25(1.59)	
ΔI^{+}_{t-6}	-0.22(0.83)	0.33(2.38)**	0.27(1.53)	-0.16(1.17)	
ΔI^{+}_{t-7}	0.37(1.57)		-0.29(1.58)		
$\boldsymbol{\Delta I^{-}_{t}}$	0.39(2.78)**	-0.07(0.73)	-0.54(2.3)**	0.24(0.97)	-0.04(0.44)
ΔI^{-}_{t-1}	0.03(0.12)	-0.23(1.77)*	0.02(0.06)	0.21(0.76)	-0.13(1.2)
ΔI^{-}_{t-2}	0.21(1.01)	0.13(1.07)	0.36(1.61)	-0.32(1.29)	0.12(1.15)
ΔI^{-}_{t-3}	0.25(1.14)	-0.31(2.45)**	-0.62(3.08)**	0.44(2.38)**	-0.09(0.81)
ΔI^{-}_{t-4}	-0.29(1.32)	0.35(3.32)**			0.22(1.88)*
ΔI^{-}_{t-5}	0.31(1.44)				-0.08(0.66)
ΔI^{-}_{t-6}	-0.21(1.14)				0.15(1.19)
ΔI^{-}_{t-7}	0.14(0.79)				-0.26(3.36)**
$\boldsymbol{\Delta R^{+}_{t}}$	-0.02(0.9)	-0.05(1.87)*	0.01(0.7)	0.02(0.37)	0.03(2.1)**
ΔR^{+}_{t-1}	0.07(2.33)**	0.01(0.37)	0.03(1.37)	0.05(0.76)	-0.06(2.58)**
ΔR^{+}_{t-2}	0(0.13)	0.03(0.97)	-0.02(0.84)	-0.01(0.07)	0.03(1.17)
ΔR^{+}_{t-3}	-0.03(0.95)	0.03(0.84)	-0.03(0.83)	0.18(2.19)**	-0.04(1.59)
ΔR^{+}_{t-4}	0.04(1.43)	-0.06(1.49)	-0.02(0.45)	-0.13(1.38)	0.02(0.64)
ΔR^{+}_{t-5}	0.03(0.85)	0.04(1.05)	0.1(2.14)**	0.12(1.22)	-0.03(1.33)
ΔR^{+}_{t-6}	0.03(1.11)	0.02(0.46)	-0.09(1.96)**	-0.06(0.64)	0.04(1.71)*
ΔR^{+}_{t-7}		-0.06(1.74)*	0.08(2.73)**	-0.09(1.12)	-0.06(2.94)**
$\boldsymbol{\Delta R^{-}_{t}}$	0(0.35)	0.03(2.46)**	0.06(3.13)**	0.05(1.65)*	0.02(1.99)**
ΔR^{-}_{t-1}	0.01(0.57)	-0.02(1.28)	-0.07(1.82)*	-0.07(1.58)	0(0.22)
ΔR^{-}_{t-2}	-0.02(0.94)	0(0.1)	0.06(1.74)*	0(0.08)	-0.04(2.93)**
ΔR^{-}_{t-3}	-0.01(0.44)	0.02(1.11)	-0.03(1.01)	0.03(0.58)	0.02(1.8)*
ΔR^{-}_{t-4}	0.02(1.37)	0(0.14)	-0.06(1.99)**	-0.06(1.18)	
ΔR^{-}_{t-5}	-0.04(2.18)**	-0.03(1.15)	0.04(1.8)*	0(0.06)	
ΔR^{-}_{t-6}	0.03(1.9)*	-0.03(1.3)		0.07(2.1)**	
ΔR^{-}_{t-7}		0.08(4.38)**			
$\boldsymbol{\Delta S^{+}_{t}}$	-0.03(1.01)	-0.09(3.36)**	-0.01(0.35)	-0.06(0.8)	0.05(2.24)**
ΔS^{+}_{t-1}	-0.03(0.59)	0.05(1.59)	-0.03(0.96)	-0.13(1.53)	-0.09(3.65)**
ΔS^{+}_{t-2}	0.03(0.66)	-0.06(1.8)*	-0.07(2.33)**		0.05(1.85)*
ΔS^{+}_{t-3}	-0.02(0.59)	0.04(1.14)	0.01(0.42)		-0.05(2.01)**
ΔS^{+}_{t-4}	0(0.02)	-0.06(1.73)*	-0.03(0.83)		
ΔS^{+}_{t-5}	-0.09(1.91)*	-0.02(0.86)	0.09(2.83)**		
ΔS^{+}_{t-6}	0.03(0.6)				
ΔS^{+}_{t-7}	-0.11(2.8)**				
$\boldsymbol{\Delta S^{-}_{t}}$	0(0.03)	0.06(2.06)**	0.04(1.26)	0.07(1.06)	0(0.13)
ΔS^{-}_{t-1}	0.02(0.5)	0.02(0.46)	-0.07(1.72)*	-0.02(0.16)	0.03(0.99)
ΔS^{-}_{t-2}	-0.02(0.55)	0.02(0.54)	0.07(1.65)*	0.02(0.14)	-0.01(0.33)
ΔS^{-}_{t-3}	0.03(0.64)	0.06(1.59)	0.02(0.47)	-0.02(0.21)	0.08(2.72)**
ΔS^{-}_{t-4}	0.02(0.41)	-0.08(2.21)**	-0.06(1.37)	-0.01(0.07)	-0.03(1.16)
ΔS^{-}_{t-5}	0.08(1.83)*	0.09(2.57)**	-0.04(0.83)	-0.02(0.21)	-0.02(1.05)
ΔS^{-}_{t-6}	-0.04(0.95)	-0.06(2.55)**	-0.06(1.28)	0.1(0.98)	
ΔS^{-}_{t-7}	0.06(1.64)		0.06(1.59)	-0.19(2.9)**	

(Continue…)

(Table 2 Continued)

Panel A Short-Run

	Japan	Netherlands	Portugal	South Korea
$\boldsymbol{\Delta I^{+}_{t}}$	1.05(2.84)**	0.07(0.74)	0.11(0.77)	0.2(1.34)
ΔI^{+}_{t-1}	0.02(0.04)	0.22(2.31)**	0.12(0.68)	0.01(0.03)
ΔI^{+}_{t-2}	0.49(0.93)		-0.32(1.7)*	0.5(2.86)**
ΔI^{+}_{t-3}	-0.3(0.59)		0.02(0.09)	-0.28(2.07)**
ΔI^{+}_{t-4}	-0.73(1.51)		-0.01(0.06)	0.07(0.57)
ΔI^{+}_{t-5}	-0.53(1.1)		-0.06(0.38)	-0.23(1.95)*
ΔI^{+}_{t-6}	0.82(2.56)**		-0.3(1.74)*	-0.07(0.67)
ΔI^{+}_{t-7}			0.35(2.47)**	0.12(1.26)
$\boldsymbol{\Delta I^{-}_{t}}$	-0.45(2.42)**	-0.21(1.98)**	-0.12(1.14)	0.12(0.84)
ΔI^{-}_{t-1}	-0.26(1.04)	-0.04(0.29)	-0.07(0.54)	0.19(0.76)
ΔI^{-}_{t-2}	0.2(0.81)	-0.16(1.53)	0.22(1.64)	-0.47(1.75)*
ΔI^{-}_{t-3}	-0.5(1.87)*	0.36(3.35)**	0.2(1.45)	1.01(2.91)**
ΔI^{-}_{t-4}	0.66(2.3)**		-0.18(1.16)	-0.26(0.9)
ΔI^{-}_{t-5}	-0.34(1.16)		-0.19(1.33)	0.85(3.4)**
ΔI^{-}_{t-6}	0.12(0.41)		0.07(0.47)	-0.59(2.94)**
ΔI^{-}_{t-7}	-0.46(1.91)*		-0.3(2.24)**	0.25(1.78)*
$\boldsymbol{\Delta R^{+}_{t}}$	-0.02(0.8)	0(0.04)	0(0.01)	0.05(1.65)
ΔR^{+}_{t-1}	0.03(0.97)	0(0.05)	-0.02(0.59)	-0.12(3.15)**
ΔR^{+}_{t-2}	-0.06(2.07)**	-0.08(7.33)**	-0.03(1.08)	0.12(3.31)**
ΔR^{+}_{t-3}	0.03(0.9)	0.05(2.62)**	0.09(2.58)**	0.02(0.43)
ΔR^{+}_{t-4}	-0.03(1.71)*	0(0.03)	-0.01(0.33)	0(0.04)
ΔR^{+}_{t-5}		-0.02(0.8)	-0.03(1.4)	0.03(0.77)
ΔR^{+}_{t-6}		0.06(2.18)**		-0.08(2.59)**
ΔR^{+}_{t-7}		-0.02(1.09)		
$\boldsymbol{\Delta R^{-}_{t}}$	0.03(1.28)	0.02(1.56)	-0.01(1.15)	-0.02(0.7)
ΔR^{-}_{t-1}	-0.04(1.78)*	0(0.02)	-0.05(3.24)**	0.02(0.4)
ΔR^{-}_{t-2}		0.03(1.46)	0.03(1.64)	-0.16(2.65)**
ΔR^{-}_{t-3}		-0.02(2.44)**	-0.01(0.69)	0.15(2.91)**
ΔR^{-}_{t-4}			0.02(1.22)	-0.22(4.78)**
ΔR^{-}_{t-5}			0.02(1.07)	
ΔR^{-}_{t-6}			-0.05(3.67)**	
ΔR^{-}_{t-7}				
$\boldsymbol{\Delta S^{+}_{t}}$	0.03(0.37)	0.01(0.28)	-0.05(1.6)	-0.06(1.23)
ΔS^{+}_{t-1}	-0.09(1.04)	0.04(1.25)	0.08(2.41)**	0.06(1.01)
ΔS^{+}_{t-2}		0.01(0.41)	-0.06(1.72)*	-0.07(1.3)
ΔS^{+}_{t-3}		0.04(1.4)	-0.04(1.1)	-0.01(0.19)
ΔS^{+}_{t-4}		-0.02(0.67)	0(0.07)	-0.1(2.28)**
ΔS^{+}_{t-5}		-0.05(2.17)**	-0.05(1.61)	0.09(2.11)**
ΔS^{+}_{t-6}			0(0.01)	-0.04(1.37)
ΔS^{+}_{t-7}			0.03(1.13)	
$\boldsymbol{\Delta S^{-}_{t}}$	0.15(1.73)*	-0.01(0.85)	-0.01(0.17)	0.02(0.79)
ΔS^{-}_{t-1}	0.1(0.81)	0(0.05)	-0.02(0.63)	0.01(0.4)
ΔS^{-}_{t-2}	0.02(0.16)	0(0.2)	0.06(1.67)*	0.04(1.1)
ΔS^{-}_{t-3}	-0.21(1.79)*	-0.03(1.38)	-0.02(0.52)	0.03(0.63)
ΔS^{-}_{t-4}	0.12(1)		0.03(0.73)	-0.09(2)**
ΔS^{-}_{t-5}	0.08(0.71)		0.03(1.01)	-0.05(1.38)
ΔS^{-}_{t-6}	-0.23(2.72)**			0.14(3.38)**
ΔS^{-}_{t-7}				

(Continue…)

(Table 2 Continued)

Panel A Short-Run

	Spain	Sweden	United Kingdom	United States
$\boldsymbol{\Delta I^{+}_{t}}$	0.1(0.4)	-0.39(1.87)*	1.15(2.38)**	0.24(1.56)
ΔI^{+}_{t-1}	0.43(1.62)	-0.34(1.65)	0.56(0.99)	0.16(0.68)
ΔI^{+}_{t-2}	0.12(0.44)	0.21(1.13)	-0.09(0.17)	-0.15(0.65)
ΔI^{+}_{t-3}	-0.66(2.63)**	0.19(1.15)	-0.09(0.17)	0.05(0.22)
ΔI^{+}_{t-4}	0.27(0.97)	-0.2(1.25)	-0.57(1.15)	-0.08(0.41)
ΔI^{+}_{t-5}	0.54(1.89)*	0.36(2.4)**	0.68(1.38)	0.23(1.18)
ΔI^{+}_{t-6}	-0.05(0.18)	-0.19(1.25)	0.05(0.1)	-0.47(3.78)**
ΔI^{+}_{t-7}	-0.31(1.63)	-0.18(1.34)	-0.7(2.03)**	
$\boldsymbol{\Delta I^{-}_{t}}$	0.35(2.9)**	0.4(2.72)**	0.62(1.97)**	-0.05(0.35)
ΔI^{-}_{t-1}	-0.18(0.99)	-0.03(0.08)	0.26(0.65)	0.72(2.12)**
ΔI^{-}_{t-2}	0.22(1.72)*	-0.23(0.68)	0.99(2.52)**	-0.53(1.37)
ΔI^{-}_{t-3}		0.62(1.63)	-0.63(1.77)*	0.07(0.16)
ΔI^{-}_{t-4}		-0.16(0.44)	-0.6(2.08)**	-0.02(0.05)
ΔI^{-}_{t-5}		-0.54(1.98)**		0.12(0.27)
ΔI^{-}_{t-6}				-0.48(1.67)*
ΔI^{-}_{t-7}				
$\boldsymbol{\Delta R^{+}_{t}}$	0.02(1.99)**	0.02(1.57)	0.17(3.48)**	0.01(0.91)
ΔR^{+}_{t-1}	-0.02(1.11)	-0.01(0.62)		-0.03(2.3)**
ΔR^{+}_{t-2}	-0.04(2.88)**	0.02(1.17)		0.02(1.86)*
ΔR^{+}_{t-3}				-0.02(1.39)
ΔR^{+}_{t-4}				0.01(0.8)
ΔR^{+}_{t-5}				0.01(1.38)
ΔR^{+}_{t-6}				
ΔR^{+}_{t-7}				
$\boldsymbol{\Delta R^{-}_{t}}$	0.02(2.58)**	-0.03(1.97)**	-0.04(1.62)	0(0.43)
ΔR^{-}_{t-1}		0(0.04)	-0.02(0.49)	0.02(1.35)
ΔR^{-}_{t-2}		-0.02(0.6)	-0.06(1.6)	-0.01(0.82)
ΔR^{-}_{t-3}		-0.01(0.52)	0.1(3.94)**	0(0.13)
ΔR^{-}_{t-4}		0.04(1.61)		-0.01(0.74)
ΔR^{-}_{t-5}		0.01(0.29)		0(0.38)
ΔR^{-}_{t-6}		0.04(1.69)*		0.02(2.3)**
ΔR^{-}_{t-7}		-0.02(1.18)		
$\boldsymbol{\Delta S^{+}_{t}}$	0.01(0.5)	0.01(0.38)	0.02(0.48)	0.04(1.6)
ΔS^{+}_{t-1}		-0.04(1.09)		0.06(2.28)**
ΔS^{+}_{t-2}		0.1(2.17)**		0.06(2.34)**
ΔS^{+}_{t-3}		-0.08(1.52)		0(0.15)
ΔS^{+}_{t-4}		0(0.08)		0.03(1.01)
ΔS^{+}_{t-5}		0.04(0.98)		0.03(1.18)
ΔS^{+}_{t-6}		-0.11(2.55)**		
ΔS^{+}_{t-7}		0.08(2.67)**		
$\boldsymbol{\Delta S^{-}_{t}}$	-0.03(1.16)	0.02(0.61)	-0.02(0.52)	-0.03(1.48)
ΔS^{-}_{t-1}	-0.01(0.36)	0.01(0.27)		-0.02(0.6)
ΔS^{-}_{t-2}	0.01(0.34)	-0.05(1.04)		-0.06(1.79)*
ΔS^{-}_{t-3}	-0.07(3.13)**	-0.02(0.36)		0.02(0.73)
ΔS^{-}_{t-4}		0.1(1.88)*		0.01(0.23)
ΔS^{-}_{t-5}		-0.03(0.56)		0.03(1.21)
ΔS^{-}_{t-6}		0.13(2.59)**		0.03(1.03)
ΔS^{-}_{t-7}		-0.12(3.18)**		0.04(1.41)

(Continue…)

(Table 2 Continued)
Panel B Long-Run

	Australia	Belgium	Canada	Denmark
Constant	2.93(5.1)**	3.66(52.8)**	4.26(126.71)**	4.46(10.83)**
I^+	1.2(0.27)	2.59(2.78)**	-2.21(5.4)**	-0.55(0.63)
I^-	-1.29(0.11)	1.23(1.1)	0.79(0.99)	1.02(1.27)
R^+	0.14(0.09)	-0.27(1.57)	0.04(1.76)*	-1.01(2)**
R^-	-1.33(0.86)	0.01(0.18)	0.07(2.21)**	0.3(3.93)**
S^+	0.9(1.03)	0.08(0.49)	0.59(6.69)**	1.52(2.65)**
S^-	3.35(0.98)	0.04(0.19)	-0.43(3.05)**	-0.33(1.51)
	Finland	France	Germany	Greece
Constant	3.58(124.88)**	3.87(38.25)**	4.68(412.05)**	4.41(108.49)**
I^+	0.91(5.96)**	-4.43(2.97)**	0.13(0.44)	4.2(6.36)**
I^-	-0.24(1.47)	1.94(1.78)*	-0.27(1.32)	-0.44(0.53)
R^+	-0.2(4.19)**	-0.71(2.81)**	0.06(1.09)	-0.13(1.17)
R^-	0(0.14)	-0.04(0.54)	-0.02(1.34)	0.1(2.21)**
S^+	0.11(4.47)**	0.92(6.67)**	-0.06(2.91)**	-0.03(0.33)
S^-	-0.09(5.38)**	-1.02(8.76)**	0.06(3.38)**	0.22(1.41)
	Ireland	Italy	Japan	Netherlands
Constant	3.1(47.08)**	6.56(31.39)**	4.73(219.31)**	3.01(6.98)**
I^+	0.94(8.1)**	-5.83(1.79)*	0.56(3.07)**	6.75(1.45)
I^-	0.45(1.41)	-0.98(0.51)	0.22(2.08)**	9.83(1.98)**
R^+	-0.1(0.86)	0.97(1.57)	0(0.78)	0.87(1.28)
R^-	0.03(0.66)	0.24(2.39)**	0.03(5.7)**	0.18(0.87)
S^+	0.42(5.2)**	1.05(1.94)*	0.11(2.33)**	-1.17(1.18)
S^-	0.52(6.9)**	0.53(0.53)	0.14(2.54)**	-1.67(2.16)**
	Portugal	South Korea	Spain	Sweden
Constant	4.1(117.88)**	4.11(64.17)**	3.04(4.52)**	6.79(1.96)**
I^+	0.45(0.92)	0.35(0.75)	0.99(0.23)	-9.2(0.53)
I^-	0.56(2.71)**	-1.18(2.01)**	-1.25(0.27)	10.59(0.61)
R^+	0.03(0.97)	0(0.02)	0.31(0.97)	-0.06(0.13)
R^-	0.05(2.68)**	0.83(2.39)**	-0.13(0.38)	-1.1(0.52)
S^+	0.12(1.77)*	0.22(1.9)*	0.35(0.58)	1.27(0.65)
S^-	-0.09(1.26)	-0.55(1.69)*	0.99(0.55)	-0.61(0.76)
	U.K.	U.S.		
Constant	3.18(6.53)**	4.54(105.22)**		
I^+	1.74(0.21)	5.05(5.44)**		
I^-	-8.28(0.84)	3.59(3.35)**		
R^+	0.7(0.92)	-0.11(3.53)**		
R^-	0.98(1.46)	-0.05(0.92)		
S^+	-0.43(0.46)	-1.02(4.68)**		
S^-	-1.69(2.18)**	-0.97(7.51)**		

(Continue…)

(Table 2 Continued)
Panel C Diagnostic

	Australia	Belgium	Canada	Denmark
F	3.64	2.2	4.18*	4.22*
t-test (λ)	-0.02(1.12)	-0.14(2.9)	-0.12(3.59)	-0.04(2.22)
LM	1.98	0.41	0.27	1.72
QS (QS^2)	U(S)	U(S)	S(S)	S(S)
Adjusted R^2	0.73	0.39	0.7	0.87
Wald-Short	5.95**	0.29	1.42	23.18**
Wald-Long	21.37**	13.45**	132.51**	63.04**
	Finland	France	Germany	Greece
F	10.12**	5.99**	10.31**	4.92**
t-test (λ)	-0.38(6.9)**	-0.19(2.8)	-0.62(4.84)**	-0.3(3.35)
LM	0.07	17.46	5	4.29
QS (QS^2)	U(S)	S(S)	S(S)	U(S)
Adjusted R^2	0.82	0.97	0.87	0.94
Wald-Short	3.38*	43.34**	22.30**	9.28**
Wald-Long	13.31**	80.75**	38.44**	36.80**
	Ireland	Italy	Japan	Netherlands
F	6.17**	5.66**	5.53**	5.30**
t-test (λ)	-0.48(4.27)*	-0.05(1.31)	-1.54(3.62)	0.03(1.55)
LM				
QS (QS^2)	10.41	2.48	6.63	0.76
Adjusted R^2	S(S)	S(S)	S(S)	S(S)
Wald-Short	0.91	0.93	0.8	0.95
Wald-Long	14.08**	1.3	0.84	0.03
F	4.71**	145.92**	3.48*	267.18**
	Portugal	South Korea	Spain	Sweden
F	8.3**	4.86**	5.04**	4.09*
t-test (λ)	-0.43(4.27)**	-0.23(3.62)	-0.03(1.78)	-0.04(0.55)
LM	0.2	3.6	0.58	0.1
QS (QS^2)	S(S)	U(S)	S(S)	S(S)
Adjusted R^2	0.93	0.92	0.92	4.09
Wald-Short	20.29**	20.24**	10.29**	1.64
Wald-Long	62.18**	11.74**	59.27**	27.15**
	U.K.	U.S.		
F	4.59**	7.25**		
t-test (λ)	0.04(1.1)	-0.15(4.04)**		
LM	2.69	0.26		
QS (QS^2)	S(S)	U(S)		
Adjusted R^2	0.78	0.97		
Wald-Short	0.01	0.16		
Wald-Long	110.66**	28.37**		

Notes:

a. Numbers inside parentheses are absolute values of the t-ratios and * (**) indicates significance at the 10% (5%) confidence level.

b. At the 10% (5%) significance level when there are three exogenous variables (k=3), the critical value of the F test is 3.77 (4.35). This is derived from Pesaran et al. (2001; Table CI-Case III, page 300).
c. At the 10% (5%) significance level when there are three exogenous variables (k=3), the critical value of the t-test for significance of λ is -3.46 (-3.78). This is derived from Pesaran et al. (2001; Table CII-Case III, page 303).
d. LM denotes Lagrange multiplier test of residual serial correlation. The Lagrange multiplier test statistics are distributed as $\chi 2$ with one degree of freedom since we are testing for 1st order serial correlation. Its critical value at the 10% (5%) level is 2.71 (3.84).
e. All Wald tests are distributed as $\chi 2$ with one degree of freedom and its critical value at 10% (5%) level is 2.71 (3.84).

Focusing on the short-run effects of stock price changes, we find from Panel A that either ΔS^+ or ΔS^- carry at least one significant coefficient in all of the models except for the one that belongs to the U.K. Compared to the number of countries in the linear model, the increase from 11 to 17 cases must be attributed to the introduction of the nonlinear adjustment of stock prices. Furthermore, the size of the coefficient attached to ΔS^+ at the same lag is different than the one attached to ΔS^- , thus supporting the short-run asymmetric effects of stock price changes on house prices. However, their CUSUM is significantly different among one another in the cases of Australia, Denmark, Finland, France, Germany, Greece, Ireland, Portugal, South Korea, and Spain. The Wald test, which is reported as Wald-Short in Panel C, is significant in those countries. Therefore, while we find evidence of short-run asymmetric effects in 17 out of 18 countries, short-run impact asymmetry is found in only 10 countries. So do short-run asymmetric effects last into the long run?

From the long-run results in Panel B, it is clear that either S^+ or S^- carry a significant estimate that is supported by one of the tests for cointegration in 13 out of 18 countries. The list includes Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, the Netherlands, Portugal, South Korea, the U.K. and the U.S. The increase from six countries in the linear model to 13 in the nonlinear model must, again, be attributed to the nonlinear adjustment of stock prices. Furthermore, the long-run effects of increases compared to decreases in stock prices seem to be asymmetric since the Wald test, which is reported as Wald-Long, is significant in all of the countries. In almost all of the countries, the long-run normalized coefficient attached to S^+ is positive, thus supporting the wealth effect. However, the normalized coefficient attached to S^- is negative in the cases of Canada, Finland, France, the Netherlands, South Korea, the U.K. and the U.S., thus implying that declines in stock prices contribute to increases in house prices in those countries. This could be due to changes in the expectations of the market participants. As the stock prices drop, demand for housing may not be affected if there are expectations that the market will increase.

Clearly, our findings are country specific. For example, we find no long-run effects of stock prices on house prices in the linear model for Australia and Belgium. The same is true in their nonlinear models, but not so in the results for Canada. While there are no long-run effects nor cointegration in the linear model for Canada, both increases and decreases in stock prices in the nonlinear model have significant effects on house prices which is supported by asymmetry cointegration. Other diagnostic statistics are similar to those of the linear models in that almost all of the estimates are stable and most optimum models are autocorrelation-free. However, the fact that in most cases, the value of the adjusted R^2 is larger in the nonlinear models compared to the linear models suggests that future research must focus on nonlinear models due to their relatively better predictive power.

4. Summary and Conclusion

Although economic fundamentals such as income and interest rate are said to be the main determinants of house prices in every country, other factors have also been identified that affect house prices. One such factor that has received some attention in the literature is the link between the housing and stock markets. A rising stock market generates wealth to shareholders, stimulating their demand for housing and eventually, increasing house prices. This is known as the wealth effect and tested by different authors who have applied data from different countries with mixed results.

In this paper, we consider a reduced form model of house price determination which included stock prices as a determinant in addition to a measure of income or economic activity and interest rate. Using quarterly data from each of the 18 OECD countries, we show that when we use a linear ARDL model, which has also been done in previous research, the results that support the wealth effect are poor. However, they become more robust and more relevant when we apply a nonlinear ARDL model. More precisely, the linear equations support a short-run wealth effect in 11 out of 18 countries but a long-run wealth effect in only six countries. The number of countries increase to 17 and 13 respectively when we estimate the nonlinear models. Since the increases in stock prices are separated from the declines in the nonlinear models, the results also show the short-run asymmetric effects of stock price changes on house prices in all of the countries, but short-run cumulative or impact asymmetry in only 10 countries. The long-run effects in 13 countries are also found to be asymmetric and include: Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, the Netherlands, Portugal, South Korea, the U.K. and the U.S. In sum, our nonlinear ARDL approach which separates increases in stock prices from declines lends more support to the wealth effect not just compared to the linear ARDL approach in this model but also the panel approach in Bahmani-Oskooee and Wu (2018).

Our findings point to two highly important issues. First, panel models suffer from aggregation bias in that the strong relationship between the house and the stock prices in some countries is eliminated by a weak relationship between the same variables in some of the other country members of the panel. We have shown this by estimating a model for each of the OECD countries. Second, we have also shown that our findings are country specific. While there are significant long-run asymmetric effects of stock prices on house prices in most OECD countries, this is not true in some of the countries, which could be due to the different expectations of investors in different countries and the different degrees of substitution among different assets.

Acknowledgement

The valuable comments of two anonymous referees and the editor are greatly appreciated. The remaining errors, however, are our own.

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Appendix

Data Definition and Sources

Quarterly data over the period 1993Q1-2015Q4 are used to carry out empirical work. The following sources are used to collect the data:

a. Bahmani-Oskooee and Wu (2018, Datastream)
b. OECD website

Variables:

P = House Price Index (Source a).
R = Short term interest rate (Source a)
S = Stock price index (Source a)
I = Industrial Production Index (Source b)