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Modelling stock price-exchange rate nexus in OECD countries: A new perspective

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Abstract

This paper subjects the Portfolio Balance Theory to empirical scrutiny using panel data of OECD countries. Thus, it examines the response of exchange rate to stock price changes contrary to the prominent practice in the literature where the former is hypothesized as the predictor. It also tests for the role of asymmetries in the nexus in response to the increasing evidence in the literature suggesting that most financial series tend to exhibit leverage effects. Given the significance of Euro currency in the OECD, we further partition the full data into Euro and Non-Euro areas. In addition, separate regressions are conducted for the pre- and post-Global Financial Crises (GFC) in order to account for the role of financial crisis in the nexus. For robustness, we consider both nominal and real variables and multiple data frequencies. In all, our findings validate the Portfolio Balance Theory for the full OECD, the Euro area, and the non-Euro area, albeit with lesser evidence for the latter. Also, the validity of the theory became more evident after the global financial crises while both long-run and short-run asymmetries are present in the nexus regardless of the data sample. Interestingly, our findings that give rise to this conclusion are robust to different data frequencies and variable measurements.

JEL Classification: C53; F31; G11

Key Words: OECD; stock price; exchange rate; portfolio balance theory; asymmetry; global financial crisis

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1. Introduction

The widespread adoption of floating exchange rates regimes by many countries and increased integration of the global financial system have encouraged capital flows among countries, and these have evoked researchers' interests to study the link between financial and foreign exchange markets (Phylaktis and Ravazzolo, 2005; Tsai, 2012; Liang et al., 2013; Ndako, 2013; Andrieș et al., 2014; Stillwagon, 2016). Evidence of strong relationship between the two markets is instructive for domestic policy making and portfolio reallocation because shocks to either market may be transmitted quickly to another or to the domestic economy through various contagious channels (Chkili and Nguyen, 2014; Sensoy and Sobaci, 2014; Dahir, et al. 2017; Leung et al., 2017). More specifically, arguments from scholars connect equity prices and exchange rates, suggesting that both stock and exchange rate markets are governed by the same set of factors through fund managers' portfolio rebalances (Hau and Rey, 2006; Pavlova and Roberto 2007; Dunne, et al. 2010; Ding and Ma, 2013; Wong, 2017). These arguments provide research direction for the present study.

Earlier, the stock price - exchange rate nexus has been majorly studied treating exchange rate as the predictor for stock market fundamentals (see for example the works of Phylaktis and Ravazzolo, 2005; Kasman and Tunç, 2011; Dellas and Tavlas, 2013; Zubair, 2013; Al-Shboul and Anwar, 2014; Sui and Sun, 2015; Raza et al., 2016; Zivkov et al., 2016).[2] The theoretical proposition informing such research interest is linked to Dornbusch and Fischer (1980). The theory establishes the direction of relationship from exchange rate movements to stock returns at the aggregate level given that changes in exchange rates affect international competitiveness of an economy. For instance, at the aggregate level, domestic currency appreciation (depreciation) decreases (increases) the demand for a nation's exports and worsens (boosts) its trade balance and thereby depresses (improves) stock prices (see Lin, 2012; Mitra, 2017). The resulting impacts on firms; their profitability and stock prices depend on whether the they are export or import-based.

[2] See Dahir, et al. (2017) for an extensive review of the literature that consider exchange rate as the predictor of stock market fundamentals.

When the domestic currency appreciates for instance, we expect decrease in foreign demand of exporting firms' products; consequently, the firms' profits will decline along with their stock prices, and vice versa for importing firms (see Pan, et al. 2007 for more).

On the other hand, a study of this nature is rooted in the portfolio balance approach of Branson (1983); Frankel (1983) and Branson and Henderson (1985) to explain exchange rates on the basis of stock prices. Here, exchange rates are driven by the changes in stock prices through changes in supply and demand of foreign and domestic assets in internationally diversified portfolios (see Chkili and Nguyen, 2014; Moore and Wang, 2014). The Portfolio Balance Theory (PBT) leans on risk averse behaviour of investors who allocate their resources between domestic and foreign financial assets in which they seek to diversify their investment portfolios from countries with lower stock returns to countries with higher stock returns. Such increase in demand for domestic stocks of high-return yield economy causes higher needs for the currency, which eventually leads to its appreciation (Kutty, 2010; Walid, et al. 2011; Ulku and Demirci, 2012; Salisu and Oloko, 2015; Zivkov, et al 2016). In other words,[3] the model predicts negative relationship where increase in domestic stock prices indicates rise in wealth and the demand for money resulting to increase in domestic interest rates and consequently, rise in capital inflows, domestic currency appreciation and a fall in the real exchange rate (Diamandis and Drakos, 2011; Dahir, et al. 2017).[4]

Interestingly, considering the role of financial crises in the foregoing analysis appears to corroborate the position of the portfolio balance theory. The underlying intuition is such that in periods of crisis, asset returns are lower and their volatilities increase and these have implications for correlating with other asset markets like the foreign exchange since money is also an asset (see Climent and Meneu, 2003; Guo, et al. 2011; Lin, 2012). More elaborately, it follows that during financial bubbles in stock markets; profit-opportunity-seeking investors cause substantial

[3] A more elegant presentation of this theory can be found in the works of Ding and Ma, (2013). The authors link exchange rate dynamics with financial assets' portfolio reallocation between domestic and foreign assets given that financial customers are always profit seekers and attempt to maximize the return of their portfolios. Using a two-economy case study, one with higher assets return designated as high-return-currency (HRC) and the other with lower asset returns. The ensuing arguments is such that financial customers tend to hold more HRC assets when they become more risk-loving or the relative return of the assets is expected to increase. Such a portfolio reallocation generates buy order toward the HRC and the currency appreciates leading to fall in exchange rate.

[4] See Kodongo and Ojah (2012) for empirical evidence as well as extensive review of literature on the nexus between portfolio flows and exchange rate determination.

quantities of foreign capital to leave the stock markets and this eventually lead to currency depreciation (see Tsai, 2012).[5] Thus, for example, the GFC which led to disruptions in capital flows to most developing and emerging economies, and which culminated in the heavy sales of liquidated of financial assets and currencies (in order to reduce the realized losses that investors had already suffered) led to dramatic capital outflow from these countries and precipitated currency depreciation (see Diamandis and Drakos, 2011).

The objective of this paper is to test the Portfolio Balance Theory (PBT) for the OECD countries. The work of Liang et al. (2013) also involves "stock-oriented" hypothesis of exchange rates proposed by Branson (1983) and Frankel (1983) similar to the underlying intuition behind the PBT, however, we differ in terms of methodology, data scope and research hypotheses. In other words, we differ markedly from related studies including Liang et al. (2013) as follows. First, we conduct the analyses for regional sub-samples such as Euro and Non-Euro areas. This consideration is inevitable since a good number of the OECD members also belong to the Euro area with attendant implications on the valuation of stocks in the affected region. Nonetheless, any inherent heterogeneity in the Euro area owing to variations in their stock prices is captured in the estimation process (this is explained shortly). The demarcation is also extended to include financial crisis covering both the pre-GFC and post-GFC periods. The idea here is to establish whether the stock-exchange rate nexus is susceptible to exogenous shocks such as those associated with the global financial crisis. If it does, then we do not expect the response of exchange rate to stock price to be identical between the pre- and post-GFC periods. Second, we also account for asymmetry in the stock price-exchange rate nexus in order to test whether exchange rate responds asymmetrically to changes in stock price. There is a growing body of literature particularly in finance suggesting that most financial series tend to exhibit leverage effects including exchange rate and stock price (see for example, Bahmani-Oskooee and Saha, 2016 a&b for asymmetric relationship between stock price and exchange rate although the latter variable is considered as a predictor in these papers unlike in our study where it is hypothesized as the predicted). Thirdly, given the nature of panel data utilized [i.e. large N and large *T*], we employ both the symmetric and asymmetric variants of the non-stationary heterogeneous panel

[5] This theoretical construct corroborates the portfolio balance theory to show that the relationship between stock prices and exchange rates is negative.

data model where the underlying regression model follows the Autoregressive Distributed Lag (ARDL) framework. Thus, this approach allows us to deal with any inherent heterogeneity as well as non-sationarity in the data. The symmetric panel ARDL model is the panel representation of Pesaran et al. (2001) while the nonlinear panel ARDL is the panel representation of Shin et al. (2014). In the case of the latter, asymmetries are measured in terms of the partial sum decomposition of stock prices into positive and negative components. Fourth, irrespective of the variant of Panel ARDL used, we are able to produce both the long-run and short-run estimates for the stock price-exchange rate nexus. This distinction in the estimates is particularly important when dealing with the PBT as the theory assumes that the relationship is more likely to be evident in the short run. Thus, we offer various long-run and short-run empirical analyses using both the nominal and real variables and different data frequencies [monthly and quarterly]. All these analyses are conducted using three data samples: full data, pre-GFC data and post-GFC data. With all these consideration, we are able to render some robust estimates that may further strengthen our understanding of the dynamics between stock price and exchange rate and whether asymmetries and financial crisis may alter such dynamics.

Overall, our findings validate the Portfolio Balance Theory for the full OECD, the Euro area, and the non-Euro area, albeit with lesser evidence for the latter. Consequently, we argue for portfolio reallocation in favour of more Euro area stocks for smart investment decisions involving the OECD. Also, our evidence lends support to the consideration of long-run and short- run asymmetries in stock-exchange rate nexus. Interestingly, findings that give rise to this conclusion are consistent to data frequency and nature of variables.

Following this section, we structure the rest of the paper as follows. The next section provides motivation for the inclusion of asymmetries and the role of financial crises in the stock price–exchange rate nexus. Thereafter, the discussion of the predictive model and the underlying estimation and forecasting procedures is rendered in Section 3. In Section 4, we offer some preliminary analyses while Section 5 presents and discusses the results. Section 6 concludes the paper.

2.0 Asymmetry and the role of financial crises in the stock price-exchange rate nexus

The theoretical basis for the present study, the Portfolio Balance Theory suggests a negative relationship, with co-movement emanating from stock price to exchange rate. Empirical evidences abound on the interactions between stock and foreign exchange markets[6] Recently, and in support of our theoretical construct, Kubo (2012) reports negative relationship between the domestic stock and foreign exchange markets where the exchange rates of the countries examined show relative vulnerability to fluctuations in international portfolio investments. Corroborating evidence can also be obtained in Lin, (2012) who investigates the co-movement between exchange rates and stock prices in the Asian emerging markets. Like the present study, the study adopts the autoregressive distributed lag (ARDL) model proposed by Pesaran et al. (2001). Results show that the co-movement between exchange rates and stock prices becomes stronger during crisis periods and most of the spill-overs during crisis periods can be attributed to the channel running from stock price shocks to the exchange rate. Elsewhere, Chkili and Nguyen, (2014) using a regime-switching model show that stock markets have more influence on exchange rates during both calm and turbulent periods for the BRICS countries.

An interesting result by Tsai, (2012) also in a way supports the portfolio balance theory by showing the negative relationship between stock and foreign exchange markets, but findings show that this nexus is more obvious when exchange rates are extremely high or low. However, a different strand of the literature also establishes contrasting evidence. For instance, findings from Diamandis and Drakos, (2011) suggest that the stock and foreign exchange markets are positively related and that the U.S. stock market acts as a channel for these links in the countries studied. Furthermore, for BRICS countries, Sui and Sun, (2015) find significant spill over effects from foreign exchange rates to stock returns in the short-run, but not vice versa and these spill over effects are stronger during the 2007-2009 financial crisis.

Consequently, there are a number of additional empirical evidence to support the notion that accounting for financial crisis matters in the nexus between stock price and exchange rate with argument that volatilities in these markets grow in periods of crises and with the linkage between the markets, financial crisis which affect financial markets could spill over to impact the foreign

[6] See Chkili and Nguyen (2014) for a review of relevant literature in this regard.

exchange market (for example Coudert, et al. 2011; Diamandis and Drakos, 2011; Lin, 2012; Tsai, 2012; Chortareas, et al. 2012; Dahir, et al. 2017). Such financial crises that have been accounted for in these previous studies include the Mexican currency crisis of 1994–1995, the Asian crisis of 1997, the 2007-2009 global financial crisis (GFC), and the European debt crisis of 2010. Specifically, and in line with the present study, Diamandis and Drakos (2011) associate the GFC with distortions in capital flows among countries leading to adverse effects on the stock markets and the economies of the recipient countries. Further, Wong, (2017) adopting the DCC-MGARCH model sampling Malaysia, the Philippines, Singapore, Korea, Japan, the United Kingdom (UK) and Germany show that the exchange rate market and the stock market are significantly correlated and the dynamic conditional correlations are found to be high in the periods of financial crises. However, in contrast with this view, Pan, et al. (2007) find evidence of no significant causality from stock prices to exchange rates during the Asian crisis for any of the seven East Asian countries (Hong Kong, Japan, Korea, Malaysia, Singapore, Taiwan, and Thailand) studied.

The theoretical foundation for asymmetry in the stock price-exchange rate nexus is traceable to the theoretical model of Dieci and Westerhoff (2013). The model situates the nexus between the stock and foreign exchange markets in a nonlinear framework. The authors argue that the stock and foreign exchange markets are, by construction, nonlinearly interwoven. Thus, accounting for stock price asymmetries in the predictive model for exchange rate provides valuable information relevant currency and stock hedging strategies for portfolios diversification. Empirically, Walid, et al. (2011) employ a Markov-Switching EGARCH model to investigate the dynamic linkage between stock price volatility and exchange rate changes for four emerging countries over the period 1994–2009. The study establish that stock price volatility responds asymmetrically to events in the foreign exchange market. Standing upon this evidence therefore, the task ahead of the present study is to verify whether exchange rates respond asymmetrically to (positive and negative) stock price changes.

3.0 The Model and Estimation Procedure

As previously noted, our empirical model hinges on the stock-based Portfolio Balance Theory (PBT) which captures the role of stock prices in the determination of exchange rates. In the PBT, short-run exchange rate adjustments are linked to the dynamics in the asset markets where increases in stock prices encourage the demand for such stocks both from local and foreign investors. In this case, the demand for domestic currency relative to foreign currency in the domestic economy increases which consequently leads to the appreciation of the domestic currency. Conversely, however, decreases in stock prices will lead to depreciation in the domestic currency as investors seek investments elsewhere with higher returns. In this case, the increased outflow of capital fuels higher demand for foreign currency relative to the domestic currency thus, culminating into depreciation of the latter. A typical representation of a bivariate model for the PBT is given below:[7]

$$e_t = \alpha + \beta p_{t-1} + \varepsilon_t, \tag{1}$$

where e is the log of nominal exchange rate in which case US dollar is the reference currency; p is the log of stock price while ε is assumed to be identically and independently distributed with zero mean and constant variance. A negative relationship is hypothesized between stock price and exchange rate at least in the short- run. Since we are using panel data of OECD countries, we can re-specify equation (1) in a linear Panel ARDL (1,1) form as follows:

$$\Delta e_{it} = \alpha_i + \rho_i e_{i,t-1} + \beta_i p_{i,t-1} + \gamma_i \Delta p_{it} + \upsilon_{it},\ i = 1,2,\ldots,N;\ t = 1,2,\ldots,T. \tag{2}$$

where Δ is the first difference operator while γ measures the short-run relationship between the two variables. The long-run relationship, which is evaluated at $\Delta e_{it} = 0,\ \Delta p_{it} = 0;$ is computed as $-\beta_i / \rho_i$. There are a number of attractions to the choice of Panel ARDL. First, the model allows for slope heterogeneity which is a prominent feature of large T panels. Second, it facilitates the computation of both long-run and short-run relationships between asset prices and exchange rate. Therefore, we are able to compare the long-run relationship with the short-run and a test of equality of the two coefficients can easily be implemented. Thirdly, the model as in equation (2)

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[7]A number of papers have also modeled exchange rate dynamics (see Moosa, 2013; Moosa and Burns, 2012, 2014a,b&c; for a review); however, all these papers do not account for the role of stock price and therefore their models and consequently their analyses are not viewed from the perspective of the Stock-based Portfolio Balance theory.

is considered appropriate when non-stationarity is a concern in panel data analyses as in the case in this study. Fourth, it can be used to establish the existence or otherwise of a stable long-run relationship whether the underlying regressors are $I(0)$, $I(1)$ or mutually cointegrated.

An error correction model for equation (2) which accounts for the deviations of the short-run dynamics from the long-run equilibrium can be expressed as:

$$\Delta e_{it} = \rho_i \varepsilon_{i,t-1} + \gamma_i \Delta p_{it} + \upsilon_{it},\ i = 1, 2, \ldots, N;\ t = 1, 2, \ldots, T. \tag{3}$$

where $\varepsilon_{i,t-1} = e_{i,t-1} - \phi_{0i} - \phi_{1i} p_{i,t-1}$ in which $\phi_{0i} = -\alpha_i / \rho_i$ and $\phi_{1i} = -\beta_i / \rho_i$. The parameter ρ_i is the error-correcting speed of adjustment term. There is evidence of long-run relationship if this parameter is significantly negative and satisfies the stationarity condition; otherwise, there is no long-run.

In order to estimate equations (2) and (3), we employ both the Mean Group (MG) estimator of Pesaran and Smith (1995) and the Pooled Mean Group (PMG) estimator of Pesaran, Shin, and Smith (1997, 1999). The MG estimator allows for variations in all the relevant parameters across the groups both in the long-run and short-run. In other words, the MG parameters are simply the unweighted means of the individual coefficients. The MG estimates of the error correction coefficient, ρ , and the short-run coefficient, γ are respectively computed as $\hat{\rho} = N^{-1}\sum_{i=1}^{N} \hat{\rho}_i$ and $\hat{\gamma} = N^{-1}\sum_{i=1}^{N} \hat{\gamma}_i$. However, the PMG estimator only allows the intercept and short-run coefficients to differ across the groups but constrains the long-run coefficients to be equal. Since equation (2) is nonlinear in the parameters, a maximum likelihood method is proposed by Pesaran, Shin, and Smith (1999) to estimate the parameters. The corresponding maximum likelihood function for equation (3), which involves taking the log of the product of each cross-section's likelihood, is expressed below:

$$l_T\left(\phi, \rho, \sigma^2\right) = -\frac{T}{2}\sum_{i=1}^{N} \ln\left(2\pi\sigma_i^2\right) - \frac{1}{2}\sum_{i=1}^{N} \frac{1}{\sigma_i^2}\left\{\Delta e_i - \rho_i \varepsilon_i\left(\phi_i\right)\right\}' H_i \left\{\Delta e_i - \rho_i \varepsilon_i\left(\phi_i\right)\right\} \tag{4}$$

where $\varepsilon_i(\phi) = e_{i,t-1} - \phi_{0i} - \phi_{1i} p_{i,t-1}$; $H_i = I_T - W_i'(W_i'W_i)W_i$; I_T is an identity matrix of dimension T and $W_i = (\Delta e_{i,t-1}, \ldots, \Delta e_{i,t-p+1}, \Delta p_{it}, \Delta p_{i,t-1}, \ldots, \Delta p_{i,t-q+1})$. The maximum likelihood (PMG) estimator involves the following steps:

(1) Begin with an initial estimate of the long-run coefficient vector, $\hat{\phi}$;

(2) Regress Δe_i on $\hat{\varepsilon}_i$ and W_i in order to obtain the short-run coefficients and the group-specific speed of adjustment terms;

(3) Use the conditional estimates in (ii) to update the estimate of ϕ;

(4) Iterate the steps (i) to (iii) until convergence is achieved. (see Baltagi, 2008)

3.1 Testing for asymmetries

We also test for possible nonlinearities in the nexus by allowing for asymmetries in stock price. Financial markets like stock and foreign exchange markets are traditionally preoccupied with news which can be classified as either good or bad. Theoretically, these two news announcements may have dissimilar impacts on the foreign exchange market. For example, if there is bad news, it may discourage investment in the stock market including inflow of foreign portfolio investment, *ceteris paribus*. This may consequently lead to depreciation in the domestic currency relative to foreign currency as investors may have to seek investments in another country with possibly higher rates of stock returns. The reverse is hypothesized to be the case if there is good news. In essence, positive and negative changes in stock price may have differing effects on the foreign exchange market. This consideration also portends that an assumption of a simple unambiguous link between movements in stock price and exchange rate reaction may not be ideal particularly for foreign exchange markets in most OECD countries that allow for some flexibility in exchange rate. To the best of our knowledge, there is no study that accounts for such nonlinearities in the response of exchange rate to stock price changes particularly for a panel of countries whose consideration may offer some generalization about the nexus. Evidently, the literature is replete with papers on exchange rate modelling and forecasting including asymmetric response (see for example, Moosa and Burns, 2012, 2014 a,b & c; Moosa, 2013; for a review*)*, however none of these papers captures asymmetries in the exchange rate model.[8]

We follow the Shin et al. (2014) approach to capture nonlinearities by decomposing stock price into positive and negative changes.[9] Thus, the nonlinear relationship between stock price and exchange rate nexus is viewed from the 'asymmetry' perspective as shown in the works of Shin et al., 2014 and Salisu and Isah, 2017, respectively. In other words, the stock price variable - p_{it}, as in equation (2) is now decomposed into positive and negative changes, respectively as follows:

$$p_{it}^{+} = \sum_{j=1}^{t} \Delta p_{ij}^{+} = \sum_{j=1}^{t} \max(\Delta p_{ij}, 0) \tag{5a}$$

$$p_{it}^{-} = \sum_{j=1}^{t} \Delta p_{ij}^{-} = \sum_{j=1}^{t} \min(\Delta p_{ij}, 0) \tag{5b}$$

where equations (5a) and (5b) denote positive and negative partial sum decompositions of stock price changes, respectively. Thereafter, we formulate a nonlinear Panel ARDL model which is a panel data representation of the Nonlinear ARDL model developed by Shin et al. (2014) Shin et al (2014) highlight a number of attractions to the nonlinear ARDL. Firstly, it captures the dynamic error correction representation associated with the asymmetric long-run cointegrating regression, resulting in the nonlinear autoregressive distributed lag model. Secondly, like the symmetric case, it can also be used to establish the existence or otherwise of a stable asymmetric long-run relationship whether the underlying regressors are *I*(0), I(1) or mutually cointegrated. Thirdly, it can also be used to estimate asymmetric cumulative dynamic multipliers that allow us to trace out the asymmetric adjustment patterns following positive and negative shocks to the explanatory variables. In addition, since we are using a nonlinear Panel ARDL, we also able to capture some level of heterogeneity in the asymmetric slope coefficient(s) across groups. The nonlinear variant of equation (2) is specified as:

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[8] There is also another variant of the literature which considers asymmetric response of stock price to changes in exchange rate (see Bahmani-Oskooee and Saha, Sujata, 2015, 2016a,b; for a review) which is the converse of the model adopted in this paper. Such considerations usually rely on the asset pricing models like the Arbitrage Pricing Theory which allows for macroeconomic factors in the asset pricing model. Thus, in this case, exchange rate is the predictor and not the predicted as hypothesized in our study.

[9] Some of the studies that have used this approach include, but not limited to, Apergis (2015), Bahmani-Oskooee et al. (2017), Bahmani-Oskooee and Aftab (2017a,b), Bahmani-Oskooee and Kanitpong (2017), Bahmani-Oskooee *and* Saha (2016a,b,2017) and Salisu and Isah (2017).

$$\Delta e_{it} = \alpha_i + \rho_i e_{i,t-1} + \beta_i^+ p_{i,t-1}^+ + \beta_i^- p_{i,t-1}^- + +\gamma_i^+ \Delta p_{it}^+ + \gamma_i^- \Delta p_{it}^- + \upsilon_{it}, \tag{6}$$

where $i = 1, 2, \ldots, N$; $t = 1, 2, \ldots, T$; p_{it}^+ and p_{it}^- denote the positive and negative stock price changes, respectively. There is evidence of asymmetry, if the coefficients of s_t^+ and s_t^- are statistically different from each other; otherwise their effect on exchange rate is considered identical. We verify this hypothesis by conduct a Wald test where the null hypotheses are stated as $H_0^a: \beta_i^+ = \beta_i^-$ and $H_0^b: \gamma_i^+ = \gamma_i^-$ for long-run asymmetry and short-run asymmetry, respectively. There is no asymmetry in either case if the null hypothesis is rejected. For instance, if H_0^a is true (implying that there is no long-run asymmetry) but H_0^b is rejected, then, equation (6) reduces to:

$$\Delta e_{it} = \alpha_i + \rho_i e_{i,t-1} + \beta_i p_{i,t-1} + \gamma_i^+ \Delta p_{it}^+ + \gamma_i^- \Delta p_{it}^- + \upsilon_{it}, \tag{7}$$

In equation (7), it is assumed that $\beta_i^+ = \beta_i^- = \beta_i$ suggesting that exchange rate does not respond asymmetrically to changes in stock price in the long-run although it does in the short-run. However, if H_0^b is true (implying that there is no short run asymmetry) but there is in the long run, then, equation (6) becomes:

$$\Delta e_{it} = \alpha_i + \rho_i e_{i,t-1} + \beta_i^+ p_{i,t-1}^+ + \beta_i^- p_{i,t-1}^- + \gamma_i \Delta p_{it} + \upsilon_{it}, \tag{8}$$

In equation (8), the effects of positive and negative stock price changes on exchange rate are identical in the short run; $\gamma_i^+ = \gamma_i^- = \gamma_i$ although such 'symmetry' fizzles out with time (i.e., in the long-run). In a situation where both null hypotheses are not rejected, then, equation (6) reduces to equation (2) where exchange rate is assumed to respond symmetrically to changes in stock price.

4.0 Data and Preliminary Analyses

The data set utilized are monthly stock prices and exchange rates of 32 OECD countries, the exchange rates are in comparison with USD, with USD as the denominator, hence United States is not included in the sample. The data scope spans from 31st May 2004 to 30th June 2017, yielding exactly 158 observations for each cross section unit. The selected countries are sub divided into Euro Area and Non-Euro Area. The Euro Area includes Austria, Belgium, Czech, Estonia, Finland, France, Germany, Greece, Italy, Ireland, Latvia, Luxemburg, Netherland, Portugal, Slovenia and Spain, while the non-Euro area includes Australia, Canada, Chile, Denmark, Hungary, Iceland, Israel, Japan, Korea, Mexico, New Zealand, Poland, Slovak, Sweden, Switzerland, Turkey and United Kingdom. The data sets are obtained from same source (Bloomberg Terminal) for easy comparability.

Table 1: Data Scope

	Periods				
Variables	**Start Date**	**End Date**	**No.**	**No. of Cross Sections**	**Observations**
Full Sample					
Stock Prices	5/31/2004	6/30/2017	158	32	5056
Exchange Rates	5/31/2004	6/30/2017	158	32	5056
Sub Samples					
Euro Area	5/31/2004	6/30/2017	158	16	2528
Non-Euro Area	5/31/2004	6/30/2017	158	16	2528

As orthodoxy, we consider the statistical features of the series for each sub sample and full sample, starting with the descriptive statistics in Tables 2 and 3, respectively. The mean statistic for example, reveals that average stock price is larger in the OECD region after the global financial (GFC) crisis of 2007 than before but at a cost of higher volatility as depicted in the standard deviation, skewness and kurtosis. The inverse is experienced in the case of exchange rate; better average exchange rate with lesser volatility is obtained before the financial global crisis than after. To further break down this revelation, we consider sub samples of Euro area and non-Euro area. For stock price, the non-Euro area performed better on the average than the Euro area, even when the comparison is further broken down into pre- and post-global financial crisis. However, exchange rate portrays the Euro area better, as on the average their exchange rate performs better with lesser volatility than that of the non-Euro area before and after the global financial crisis.

Furthermore, adjusting for inflation in the series by calculating the real stock price and real exchange rate, same comparison as in the case of nominal values is obtained. The stock price full sample performs better after GFC than before, with higher volatility while the inverse is established for real exchange rate. Average stock price for the non-Euro area outshines that of the Euro area on the average, considering pre-GFC and post-GFC. In addition, exchange rate for the

Euro area seems better, as on the average, it performs better pre and post GFC, with lesser volatility than that of the non-Euro area.

Table 2 Descriptive Statistics: Nominal Stock Prices and Exchange Rate

Country/Stock Price	Obs	Mean	Std Dev.	Skewness	Kurtosis	Min	Max
Nominal Stock Price							
Full Sample	5056	8615.523	14114.64	2.8392	11.8174	179.9	100440
Pre GFC	1280	7893.548	11004.7	2.2761	8.1968	192.76	66077.7
Post GFC	3744	8842.813	15014.82	2.8385	11.4717	179.9	100440
Euro Area	2528	4972.57	6315.175	2.9022	13.7469	208.869	43755
Pre GFC	640	6138.181	8376.836	2.8125	10.9034	323.12	43755
Post GFC	1872	4550.709	5333.835	2.3144	10.0683	208.869	40512
Non-Euro Area	2528	12258.48	18223.36	1.9906	6.5435	179.9	100440
Pre GFC	640	9648.915	12886.14	1.8298	6.0503	192.76	66077.7
Post GFC	1872	13134.92	19639.15	1.8841	5.8687	179.9	187.49
Nominal Exchange Rate							
Full Sample	5056	67.3398	213.1215	4.0150	19.0637	0.4808	1534.35
Pre GFC	1280	63.0709	197.9798	3.8926	17.8096	0.4923	1170.1
Post GFC	3744	68.8812	218.3135	4.0305	19.1678	0.4808	1534.35
Euro Area	2528	0.78157	0.0761	0.4592	2.5236	0.6334	0.9506
Pre GFC	640	0.7878	0.0352	0.0210	1.7197	0.7308	0.8484
Post GFC	1872	0.7801	0.0856	0.4805	2.1352	0.6334	0.9506
Non-Euro Area	2528	133.8982	286.3495	2.6141	8.9428	0.4808	1534.35
Pre GFC	640	125.354	125.354	2.5153	8.2755	0.4923	1170.1
Post GFC	1872	136.9824	293.3711	2.6266	8.9933	0.4808	1534.35

Intuitively, in order to visually inspect any possible co-movement between stock price and exchange rate, we plot the exchange rate against each of the selected stock price indexes for each country as shown in figures 1 and 2, respectively. It is evidenced that exchange rate and stock price co-move for all the countries, although the rate of co-movement seems different in each country. More of note however, is the case of Global Financial Crisis of 2007; all countries' series responded to this period, directions or rates of co-movement between exchange rate and stock prices virtually changed for all. Apart from the warning about responses in pre- and post-GFC, the standard deviations of the full samples for each subsample further signal of possible asymmetry in the stock price-exchange rate nexus.

As traditional for macro panels with large *T*, the relevant variables are subjected to panel unit root test (see Table 4). Usually, the dynamic heterogeneous panel data model (the preferred model in this study) is preferred where unit root is in existence. We, therefore, estimate three different panel unit root tests. Panel unit root tests with the null hypothesis of unit root with common process is the first (Harris and Tzavalis, 1999; Breitung, 2000; Levin et al., 2002 tests). The second type assumes unit root with individual unit root process (Im et al., 2003; Maddala and Wu, 1999 tests) while the third also assumes unit root in the null hypothesis but in the presence of cross-section dependence (Pesaran, 2007).

The fourth category, however, tests the null hypothesis of no unit root with common unit root process (Hadri, 2000 Lagrange Multiplier test). Given the structure of their hypotheses and test regressions, they have been regarded as stationary (the fourth type) and non-stationary (first, second and third) tests in the literature. More important is the Pesaran (2007) unit root test in this study as it can also be used to test whether the various cross-sections in each group are homogenous or heterogenous, its null hypothesis assumes homogeneous non-stationary as against the alternative of possible heterogeneous. After running the tests, we discovered that all the series (Nominal stock price and exchange rate as well as real stock price and exchange rate) are $I(1)$ given the Im, Pesaran and Shin W statistic. Although considering the different unit root tests, there seems to be some variations as some variables are $I(0)$, but this only further motivates our choice of panel-ARDL model as the preferred estimation framework in the context of this study.

Table 3 Descriptive Statistics: Real Stock Prices and Exchange Rate

Country/Stock Price	Obs	Mean	Std Dev.	Skewness	Kurtosis	Min	Max
Real Stock Price							
Full Sample	5056	89.8374	154.6626	3.1735	15.0658	1.7725	1312.45
Pre GFC	1280	79.5680	113.0953	2.2574	7.8946	2.5121	647.701
Post GFC	3744	93.1968	166.4063	3.1526	14.3657	1.7725	1312.45
Euro Area	2528	49.6187	62.2701	2.8176	13.0697	1.8478	426.442
Pre GFC	640	60.3733	81.4319	2.8168	10.9427	3.0766	426.442
Post GFC	1872	45.724	53.3129	2.2317	9.3240	1.8478	393.512
Non-Euro Area	2528	130.0561	201.833	2.2330	8.2966	1.7725	1312.45
Pre GFC	640	98.7626	135.0257	1.7666	5.5154	2.5121	647.701
Post GFC	1872	140.6696	219.1914	2.1164	7.4078	1.7725	1312.45
Real Exchange Rate							
Full Sample	5056	72.8264	25.2219	3.6447	14.3683	0.5378	119.935
Pre GFC	1280	67.4916	193.2049	3.6015	15.6777	0.4031	1235.72
Post GFC	3744	74.7902	225.6487	4.0791	20.5229	0.3895	2001.09
Euro Area	2528	7.3257	217.5191	4.0244	20.1463	0.3895	2001.09
Pre GFC	640	7.6488	26.2701	3.6184	14.104	0.7109	115.114
Post GFC	1872	7.2172	24.8642	3.6498	14.4254	0.5378	119.935
Non-Euro Area	2528	138.3272	292.2801	2.6488	9.6825	0.3895	2001.09
Pre GFC	640	127.3345	258.5556	2.3174	7.3152	0.4031	1235.72
Post GFC	1872	142.3633	303.4906	2.6889	9.8514	0.3895	2001.09

Table 4: Panel unit root test results

Panel A: Full Sample

Test Method	**Stock Prices**				**Exchange Rate**			
	Nominal		**Real**		**Nominal**		**Real**	
	Level	**1st Diff.**	**Level**	**1st Diff.**	**Level**	**1st Diff.**	**Level**	**1st Diff.**
Null Hypothesis: Unit root with common process								
Levin, Li and Chu t*	-0.3808	-37.8866***	-0.1082	-38.5586***	-0.5997	-43.0962***	-1.4363*	-39.4272***
Breitung lambda	1.6467	-39.8405***	1.8666	-40.8349***	-4.9365***	-48.5012***	-4.1664***	-41.0726***
Harris Tzavalis rho	0.9823	0.1605***	0.9833	0.1311***	-2.4061***	0.0042***	0.9772	0.2080***
Null Hypothesis: Unit root with individual unit root process								
Im, Pesaran & Shin W Stat	0.2063	-44.8507***	0.8953	-45.9680***	-0.9243	-49.8745***	0.9377	-43.4997***
ADF Fisher Chi-Square	2.7110***	45.1407***	1.9026**	45.3609***	1.3849*	46.7040***	1.0180	44.0389***
Pesaran Cd test[2]	2.867	-18.923***	2.967	-19.061***	-0.822	-20.038***	-1.156	-18.749***
Null Hypothesis: no unit root with individual unit root process								
Hadri Z-Stat	304.1983***	1.5478*	312.5469***	0.5595	292.5035***	-1.1314	214.5969***	2.6708***

Note: ***, **, * indicate statistical significance at 1%, 5% and 10% respectively. All the variables here are expressed in natural logs.

Panel B: Euro Area

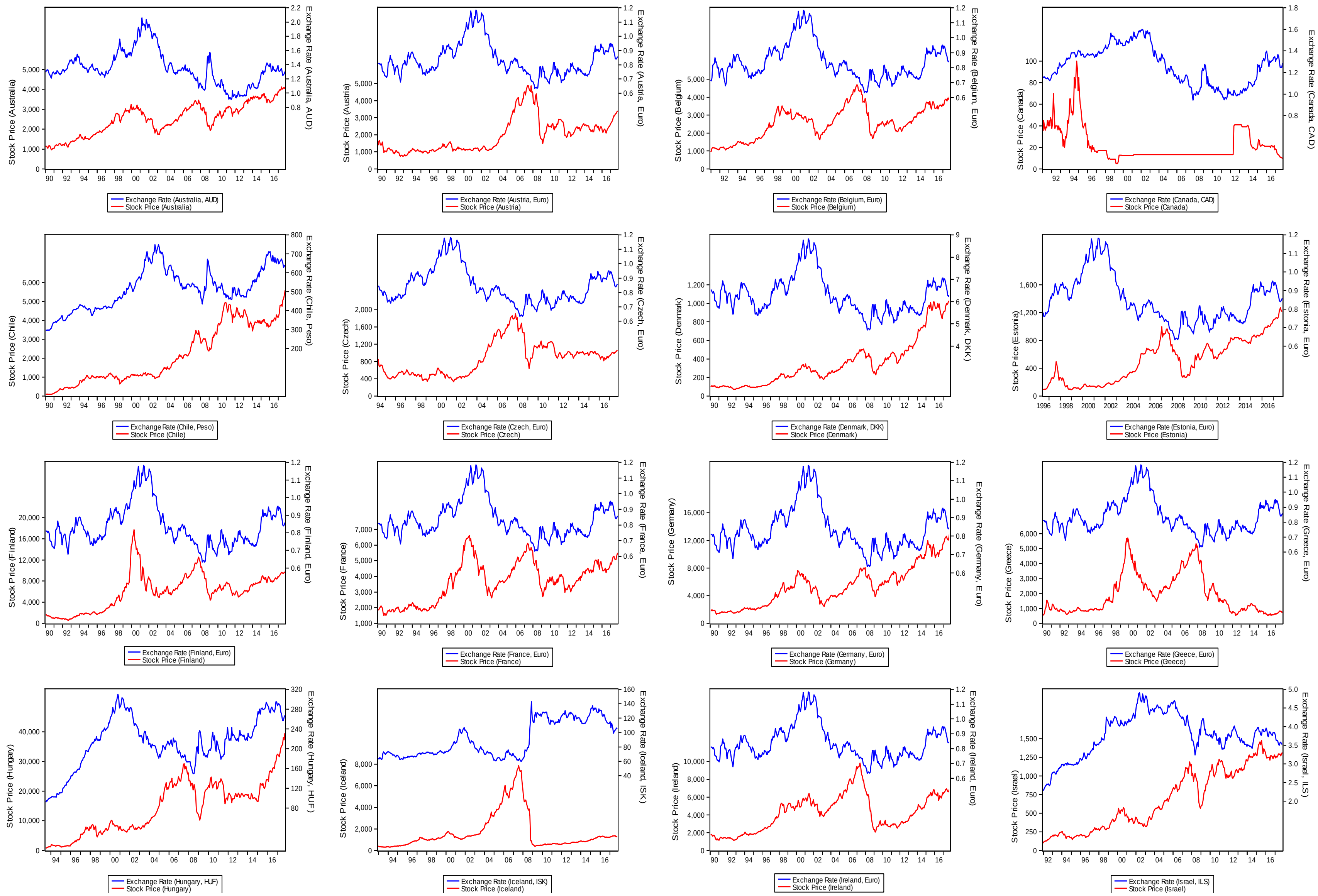
Test Method	**Stock Prices**				**Exchange Rate**			
	Nominal		**Real**		**Nominal**		**Real**	
	Level	**1st Diff.**	**Level**	**1st Diff.**	**Level**	**1st Diff.**	**Level**	**1st Diff.**
Null Hypothesis: Unit root with common process								
Levin, Li and Chu t*	1.1831	-27.2732***	1.3000	-27.2230***	-1.0180	-31.2361***	-1.0725	-28.2770***
Breitung lambda	-1.0477	-28.1617***	-1.1773	-28.6985***	-6.5146***	-35.7127***	-4.0146***	-30.9414***
Harris Tzavalis rho	0.9835	0.1827***	0.4071	0.1765***	0.9562***	-0.0322***	0.9722**	0.1482***
Null Hypothesis: Unit root with individual unit root process								
Im, Pesaran & Shin W Stat	0.9844	-30.8722***	1.0053	-31.0621***	-1.2755	-35.8963***	0.5126	-31.6152***
ADF Fisher Chi-Square	2.0011**	30.0506***	1.9269**	29.1956***	1.1904	29.7960***	0.5893	27.8275***
Pesaran Cd test[2]	2.839	2.839***	3.002	-13.344***	19.556	19.556	0.740	-11.140***
Null Hypothesis: no unit root with individual unit root process								
Hadri Z-Stat	202.3282***	0.6623	192.7406***	0.5092	131.0255***	-1.4926	108.8669***	1.6952**

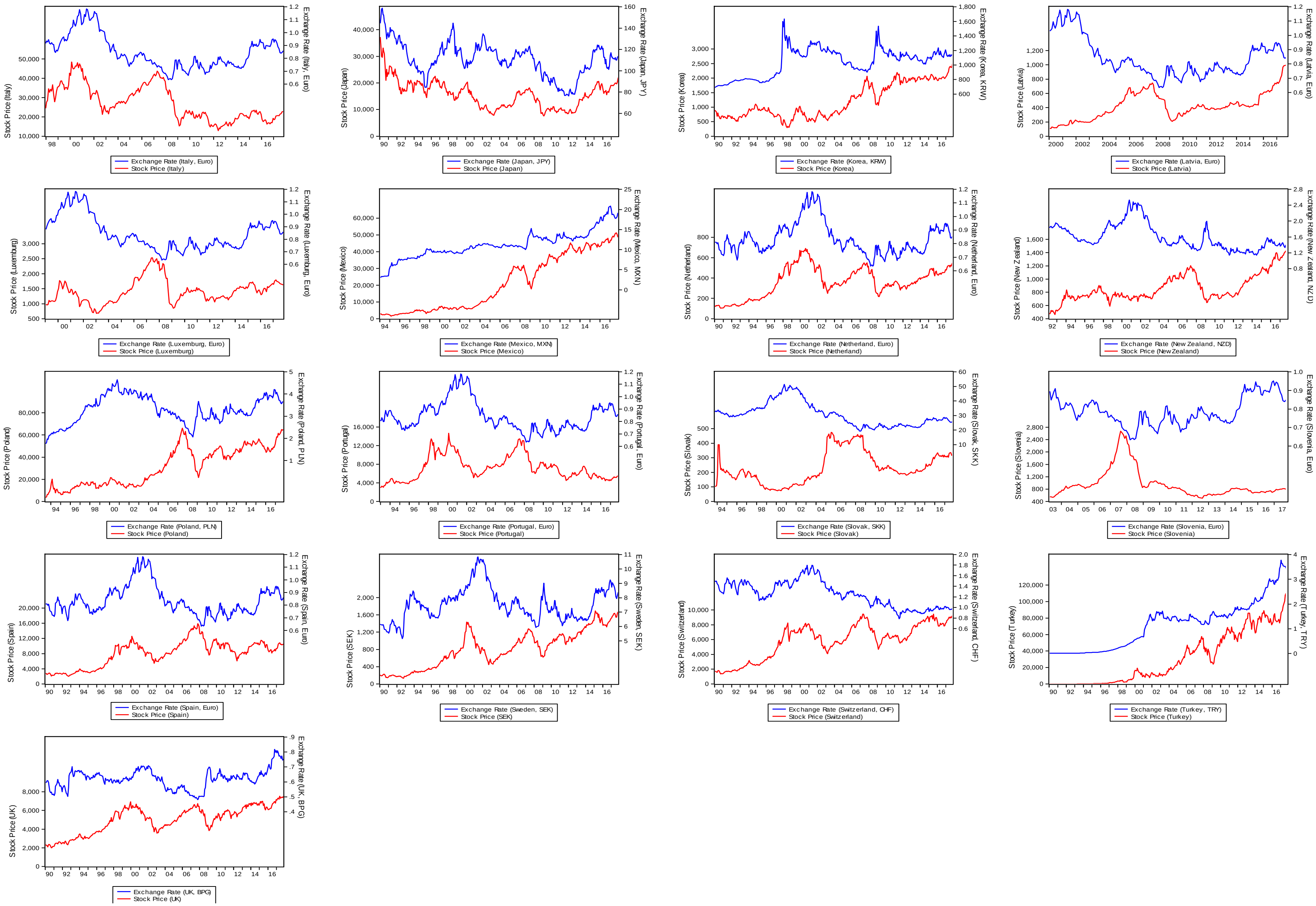
Note: ***, **, * indicate statistical significance at 1%, 5% and 10% respectively. All the variables here are expressed in natural logs.

Panel C: Non-Euro Area								
Test Method	**Stock Prices**				**Exchange Rate**			
	Nominal		**Real**		**Nominal**		**Real**	
	Level	**1st Diff.**	**Level**	**1st Diff.**	**Level**	**1st Diff.**	**Level**	**1st Diff.**
Null Hypothesis: Unit root with common process								
Levin, Li and Chu t*	-1.5680*	-26.2987***	-1.2501	-27.3677***	-0.0031	-29.7678***	-0.9720	-27.5355***
Breitung lambda	2.4863	-28.1813***	2.7969	-29.0537***	-1.9374**	-33.0329***	-2.1000**	-27.4539***
Harris Tzavalis rho	0.9814	0.1360***	0.9834	0.0791***	0.9786	0.0303***	0.9792	0.2410***
Null Hypothesis: Unit root with individual unit root process								
Im, Pesaran & Shin W Stat	0.2443	-32.5562***	0.2609	-33.9464***	-0.0317	-34.6370***	0.8136	-29.9027***
ADF Fisher Chi-Square	1.8328**	33.7880***	0.7638	34.9544***	0.7681	36.2535***	0.8504	34.4529***
Pesaran Cd test[2]	1.106	-13.063***	1.539	-13.458***	1.573	-13.844***	0.772	-13.312***
Null Hypothesis: no unit root with individual unit root process								
Hadri Z-Stat	225.6967***	1.5692*	245.0273***	0.2654	234.6134***	-0.3051	169.5419***	1.9952**

Note: ***, **, * indicate statistical significance at 1%, 5% and 10% respectively. All the variables here are expressed in natural logs.

Fig. 1: Trends in exchange rate and stock prices of OECD countries




Exchange Rate (Italy, Euro)
Stock Price (Italy)
Exchange Rate (Japan, JPY)
Stock Price (Japan)
Exchange Rate (Korea, KRW)
Stock Price (Korea)
Exchange Rate (Latvia, Euro)
Stock Price (Latvia)
Exchange Rate (Luxemburg, Euro)
Stock Price (Luxemburg)
Exchange Rate (Mexico, MXN)
Stock Price (Mexico)
Exchange Rate (Netherland, Euro)
Stock Price (Netherland)
Exchange Rate (New Zealand, NZD)
Stock Price (NewZealand)
Exchange Rate (Poland, PLN)
Stock Price (Poland)
Exchange Rate (Portugal, Euro)
Stock Price (Portugal)
Exchange Rate (Slovak, SKK)
Stock Price (Slovak)
Exchange Rate (Slovenia, Euro)
Stock Price (Slovenia)
Exchange Rate (Spain, Euro)
Stock Price (Spain)
Exchange Rate (Sweden, SEK)
Stock Price (SEK)
Exchange Rate (Switzerland, CHF)
Stock Price (Switzerland)
Exchange Rate (Turkey, TRY)
Stock Price (Turkey)
Exchange Rate (UK, BPG)
Stock Price (UK)

5.0 Discussion of results

Essentially, this study rests on the Portfolio Balance Theory (in line with theoretical constructs of Branson, 1983; Frankel, 1983; Branson and Henderson, 1985; Ding and Ma, 2013 among others) to validate or refute the negative impact of stock prices on exchange rates of OECD countries' currencies denominated in the USD. This is done with the view to comment, on the basis of panel Autoregressive Distributed Lag (ARDL) models, on how stock price affect exchange rate behaviour in both short and long run. For extensive analyses, one, we estimate both the symmetric and asymmetric panel ARDL models to differentiate the linear and nonlinear responses of exchange rates from stock price changes; two, we conduct analyses for nominal and real stock price and exchange rate variables; three, we consider four data samples and estimate three different panels within the OECD, that is, the full OECD sample, the Euro area, and the non-Euro area; four, we explore the role of financial crisis in the nexus by dividing the time frame for each of the four previously mentioned panels into three data samples, full-period sample, pre GFC and post GFC. Lastly, for robustness, we investigate the consistency of the preceding results based on monthly data for quarterly data. We turn to the discussion presently.

5.1 The Linear (Symmetric) ARDL Model

5.1.1 Nominal Variables

Beginning with the symmetric panel ARDL model, we discuss the result of the linear stock – exchange rate nexus based on nominal series as contained in Tables 5 to 7. In the face of the two alternative estimators, the Hausman test comes in handy as the point of reference in selecting between the MG and PMG results. Except otherwise where the Hausman test result is indicated with "^", generally, the estimation is conducted with PMG as the null and the MG as the alternative. In the latter case, statistical significance of the Hausman test indicates preference for the MG estimator, otherwise, the PMG is favoured. In the former case (indicated with ^ symbol) where the MG is the null, the non-significance of the Hausman statistic signifies preference for the MG results over the PMG. In essence, our discussion of results depends on the estimator backed by the Hausman test.

For the full OECD panel data, we prefer the PMG for the full sample and pre GFC while the MG is chosen for the post GFC data sample. While the short-run and long-run coefficients of stock price are both negative and significant in the full sample analysis, this is only true in the long-run in the pre GFC and in the short-run in the post GFC. In the Euro area, the coefficients exhibit short and long-run negative significance in full and post GFC data samples while a positive relationship is observed in the short run in pre GFC. Convincing evidence based on the level of significance show negative and significant short-run stock price-exchange rate nexus in the non-Euro area for full sample and post-GFC but in the long run for the pre-GFC.

In all, on the average, while negative and significant impact of stock price on exchange rate is established for the full sample and post-GFC in the short-run, the pre-GFC consistently turn up negative nexus in the long run. These evidences appear to validate the Portfolio Balance theory (for the nominal variables) especially for the full sample and the period after the global financial crisis. This indicates that the global financial crisis might have a role to play in the nexus given that the negative impact is delayed to the long run in the pre-GFC sample period, which also covers the GFC period. Further, aside validating the PBT for OECD countries, our results also corroborate findings from Walid, et al. (2011); Kubo, (2012); Lin, (2012); Ulku and Demirci, (2012); Zivkov, et al (2016); and Dahir, et al. (2017) but appear to negate Chkili and Nguyen, (2014) who show high influence of the stock markets on exchange rates during in turbulent periods and Diamandis and Drakos, (2011) who find that the stock and foreign exchange markets are positively related. We can therefore infer from the foregoing the viability of the stock markets of these economies especially in the post-GFC era. We offer more insights on this with real variables in the succeeding section before highlighting policy implications of the findings.

Table 5: Linear ARDL Model for Full OECD Panel

	Full Sample		Pre-GFC		Post-GFC	
VARIABLES	mg	pmg	mg	pmg	mg	pmg
ec	-0.0360***	-0.0290***	-0.129***	-0.106***	-0.0493***	-0.0386***
	(0.00383)	(0.00340)	(0.0132)	(0.0109)	(0.00709)	(0.00625)
d.lstock	-0.158***	-0.157***	0.0257	0.0274	-0.183***	-0.181***
	(0.0263)	(0.0265)	(0.0253)	(0.0257)	(0.0281)	(0.0288)
Lstock	-21.43	-0.240***	-0.199***	-0.202***	0.0757	-0.176***
	(21.54)	(0.0410)	(0.0234)	(0.0233)	(0.0995)	(0.0306)
Constant	0.0772***	0.0802***	0.366***	0.295***	0.128**	0.107***
	(0.0183)	(0.0137)	(0.0666)	(0.0644)	(0.0515)	(0.0363)
Hausman test		0.97		2.43		7.08***
		[0.3252]		[0.1190]		[0.0078]
No. of countries	32	32	32	32	32	32
Observations	5,024	5,024	1,280	1,280	3,744	3,744

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Values in [ ] are the chi-square prob. values of Hausman test. Also, ec denotes the error correction term, lstock is the log of stock and d.lstock is the first difference of lstock. The lstock is for the long-run and d.lstock for the short-run.

Table 6: Linear ARDL Model for the Euro Area

	Full Sample		Pre-GFC		Post-GFC	
VARIABLES	mg	pmg	mg	pmg	mg	pmg
ec	-0.0400***	-0.0325***	-0.0975***	-0.0942***	-0.0486***	-0.0321***
	(0.00299)	(0.00404)	(0.0126)	(0.0112)	(0.00639)	(0.00691)
d.lstock	-0.116***	-0.117***	0.0629***	0.0633***	-0.134***	-0.136***
	(0.0113)	(0.0112)	(0.0179)	(0.0179)	(0.0125)	(0.0121)
Lstock	-0.204***	-0.279***	-0.227***	-0.222***	-0.155**	-0.376***
	(0.0470)	(0.0643)	(0.0195)	(0.0417)	(0.0717)	(0.0722)
Constant	0.0558***	0.0648***	0.157***	0.145***	0.0590*	0.0894***
	(0.0177)	(0.00914)	(0.0226)	(0.0195)	(0.0347)	(0.0209)
Hausman test		3.00*		0.02		576.06***
		[0.0833]^		[0.8909]^		[0.0000]^
No. of countries	16	16	16	16	16	16
Observations	2,512	2,512	640	640	1,872	1,872

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Values in [ ] are the chi-square prob. values of Hausman test. Also, ec denotes the error correction term, lstock is the log of stock and d.lstock is the first difference of lstock. The lstock is for the long-run and d.lstock for the short-run.

Table 7: Linear ARDL Model for the Non Euro Area

	Full Sample		Pre-GFC		Post-GFC	
VARIABLES	mg	pmg	mg	pmg	mg	pmg
ec	-0.0319***	-0.0231***	-0.160***	-0.114***	-0.0499***	-0.0409***
	(0.00704)	(0.00611)	(0.0207)	(0.0182)	(0.0129)	(0.0112)
d.lstock	-0.200***	-0.202***	-0.0115	-0.00959	-0.232***	-0.229***
	(0.0499)	(0.0507)	(0.0463)	(0.0474)	(0.0529)	(0.0548)
Lstock	-42.66	0.117*	-0.170***	-0.189***	0.306*	-0.123**
	(43.09)	(0.0675)	(0.0421)	(0.0304)	(0.169)	(0.0494)
Constant	0.0986***	0.0391*	0.574***	0.445***	0.198**	0.149**
	(0.0318)	(0.0205)	(0.110)	(0.112)	(0.0956)	(0.0597)
Hausman test		0.99		0.41		7.02***
		[0.3209]		[0.5196]		[0.0080]
No. of countries	16	16	16	16	16	16
Observations	2,512	2,512	640	640	1,872	1,872

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Values in [ ] are the chi-square prob. values of Hausman test. Also, ec denotes the error correction term, lstock is the log of stock and d.lstock is the first difference of lstock. The lstock is for the long-run and d.lstock for the short-run.

5.1.2 Real Variables

We attempt to corroborate evidence obtained from the stock price and exchange rate nexus hitherto expressed in nominal terms (as shown in Tables 5 to 7) now as real variables. The resulting findings are contained in Tables 8 to 10. After controlling for inflation, the results from the full OECD and the Euro area support the previous evidence where the full sample and post GFC reveal negative and significant estimates in the short and long-run while this relationship is only established for the long-run in the pre GFC. In contrast however, the non-Euro area in most data samples either show evidence of positive or no significant nexus between stock and exchange rate. These results show that for the real variables, the PBT is only established for the full OECD and the euro area. Harmonising the findings for the two data forms, therefore, one could safely confirm the PBT for the Euro area as well as the viability of its stock markets over the non-Euro sub-panel. One could also further argue that risk averse investors especially in the OECD interested in portfolio reallocation/diversification could take advantage of better opportunities offered by firms in the stock markets of Euro area.

Table 8: Linear ARDL Model for Full OECD Panel

	Full Sample		Pre-GFC		Post-GFC	
VARIABLES	mg	pmg	mg	pmg	mg	pmg
ec	-0.0264***	-0.0141***	-0.103***	-0.0714***	-0.0312***	-0.0143***
	(0.00311)	(0.00237)	(0.0141)	(0.00993)	(0.00547)	(0.00398)
d.lstock	-0.0793**	-0.0758**	0.200***	0.202***	-0.121***	-0.112***
	(0.0320)	(0.0334)	(0.0408)	(0.0419)	(0.0330)	(0.0340)
Lstock	-0.243	-0.756***	-0.310***	-0.352***	-0.516	-1.285***
	(0.231)	(0.172)	(0.0673)	(0.0536)	(0.368)	(0.275)
Constant	0.0459***	0.0450***	0.275***	0.177***	0.0957**	0.0913**
	(0.0158)	(0.00864)	(0.0669)	(0.0455)	(0.0398)	(0.0362)
Hausman test		11.01***		1.07		9.83***
		[0.0009]		[0.3019]		[0.0017]
No. of countries	32	32	32	32	32	32
Observations	5,024	5,024	1,280	1,280	3,744	3,744

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Values in [ ] are the chi-square prob. values of Hausman test. Also, ec denotes the error correction term, lstock is the log of stock and d.lstock is the first difference of lstock. The lstock is for the long-run and d.lstock for the short-run.

Table 9: Linear ARDL Model for the Euro Area

	Full Sample		Pre-GFC		Post-GFC	
VARIABLES	mg	pmg	mg	pmg	mg	pmg
ec	-0.0229***	-0.0168***	-0.0800***	-0.0636***	-0.0273***	-0.0158***
	(0.00240)	(0.00270)	(0.0188)	(0.0108)	(0.00393)	(0.00416)
d.lstock	-0.115***	-0.116***	0.166***	0.163***	-0.142***	-0.143***
	(0.0185)	(0.0183)	(0.0259)	(0.0263)	(0.0207)	(0.0203)
Lstock	-0.559***	-0.791***	-0.297***	-0.346***	-1.013*	-1.064***
	(0.131)	(0.235)	(0.0506)	(0.0839)	(0.593)	(0.275)
Constant	0.0378***	0.0451***	0.164*	0.0754***	0.0390*	0.0584***
	(0.0130)	(0.00913)	(0.0920)	(0.0159)	(0.0222)	(0.0162)
Hausman test		1.41		0.55		0.01
		[0.2343]^		[0.4568]^		[0.9231]
No. of countries	16	16	16	16	16	16
Observations	2,512	2,512	640	640	1,872	1,872

Table 10: Linear ARDL Model for the Non Euro Area

	Full Sample		Pre-GFC		Post-GFC	
VARIABLES	mg	pmg	mg	pmg	mg	pmg
ec	-0.0298***	-0.0197***	-0.126***	-0.0793***	-0.0351***	-0.0131**
	(0.00572)	(0.00600)	(0.0199)	(0.0169)	(0.0103)	(0.00644)
d.lstock	-0.0435	-0.0518	0.234***	0.242***	-0.0998	-0.0789
	(0.0609)	(0.0620)	(0.0779)	(0.0797)	(0.0634)	(0.0649)
Lstock	0.0738	0.721***	-0.323**	-0.356***	-0.0193	-1.590***
	(0.437)	(0.0852)	(0.127)	(0.0689)	(0.420)	(0.516)
Constant	0.0541*	0.00298	0.387***	0.279***	0.152**	0.123*
	(0.0293)	(0.0169)	(0.0917)	(0.0837)	(0.0751)	(0.0697)
Hausman test		2.28		0.10		27.46***
		[0.1312]		[0.7576]		[0.0000]^
No. of countries	16	16	16	16	16	16
Observations	2,512	2,512	640	640	1,872	1,872

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Values in [ ] are the chi-square prob. values of Hausman test. Also, ec denotes the error correction term, lstock is the log of stock and d.lstock is the first difference of lstock. The lstock is for the long-run and d.lstock for the short-run.

5.2 The Non-Linear (Asymmetric) ARDL Model

5.2.1 Nominal Variables

We build on the results obtained from the linear model which validate the PBT across the panels for the full sample and the post GFC using the nominal variables and in two of the panels (full OECD and euro area) using the real variables. We provide additional evidence on the relationship to show whether the nexus shown to be linear could actually be nonlinear; that is, whether asymmetry matters in the relationship. Results stemming from Tables 11 to 13 reveal that both short- run and long-run asymmetry could matter in virtually all the panels and data samples except for the evidence of no long-run asymmetry in pre GFC in Euro area. The conclusion is based on the chi-square distributed Wald test with the null hypothesis of identical impact of the positive and negative stock prices changes on exchange rate. In essence, our results provide enough evidence to validate the theoretical construct of Dieci and Westerhoff (2013) for OECD as previously espoused in this paper. We can safely conclude that asymmetry does matter in the nexus given that the consistent non-rejection of the null hypothesis for the Wald test. Nonetheless, virtually all the estimates for the positive and negative stock price changes, whether in the short-run and long-run, consistently produce negative impacts on exchange rate like the symmetric case. Thus, even when the asymmetry is found to be significant, the PBT is still largely upheld.

Table 11: Non-Linear ARDL Model for Full OECD Panel

	Full Sample		Pre-GFC		Post-GFC	
VARIABLES	mg	pmg	mg	pmg	mg	pmg
ec	-0.0564***	-0.0336***	-0.188***	-0.00451	-0.129***	-0.085***
	(0.00546)	(0.00374)	(0.0188)	(0.00439)	(0.00802)	(0.00917)
d.lstock_p	-0.0711**	-0.0801***	0.623	2.077	-0.0762**	-0.0929**
	(0.0282)	(0.0281)	(4.334)	(3.946)	(0.0337)	(0.0380)
d.lstock_n	-0.225***	-0.225***	-2.382	-5.640	-0.270***	-0.286***
	(0.0294)	(0.0304)	(6.906)	(7.129)	(0.0310)	(0.0313)
lstock_p	-0.107	-0.0432	-1.841	-291.7	-0.0678	0.102***
	(0.0780)	(0.0341)	(9.046)	(228.8)	(0.0584)	(0.0216)
lstock_n	-0.271**	-0.168***	6.879	-890.3	-0.271***	-0.073***
	(0.114)	(0.0318)	(18.29)	(703.1)	(0.0828)	(0.0229)
Constant	0.0875**	0.0403*	15.51*	3.666	0.139*	0.0117
	(0.0393)	(0.0209)	(8.981)	(2.892)	(0.0758)	(0.0278)
Short run asymm.	35.25***	42.76***	9.45***	6.67***	25.98***	27.97***
	[0.0000]	[0.0000]	[0.0021]	[0.0098]	[0.0000]	[0.0000]
Long run asymm.	11.72***	70.63***	5.57**	59.63***	39.50***	351.5***
	[0.0006]	[0.0000]	[0.0182]	[0.0000]	[0.0000]	[0.0000]
Hausman test	-	0.88	-	1.63	-	13.64***
	-	[0.6433]	-	[0.4416]	-	[0.0011]
No. of countries	32	32	32	32	32	32
Observations	4,832	4,832	1,184	1,184	3,552	3,552

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Values in [ ] are the chi-square prob. values of Hausman test. Also, ec denotes the error correction term, lstock_p and lstock_n represent the logs of positive and negative changes in stock respectively while d.lstock_p and d.lstock_n are the first differences of lstock_p and lstock_n respectively. The lstock_p and lstock_n capture the long-run asymmetry while d.lstock_p and d.lstock_n are for the short-run.

Table 12: Non-Linear ARDL Model for the Euro Area

	Full Sample		Pre-GFC		Post-GFC	
VARIABLES	mg	pmg	mg	pmg	mg	pmg
ec	-0.0475***	-0.0417***	-0.161***	-0.0859***	-0.131***	-0.119***
	(0.00251)	(0.00189)	(0.0310)	(0.0164)	(0.00424)	(0.00702)
d.lstock_p	-0.0426**	-0.0466***	0.118**	0.159***	-0.0408**	-0.0468**
	(0.0168)	(0.0156)	(0.0512)	(0.0447)	(0.0201)	(0.0201)
d.lstock_n	-0.171***	-0.171***	-0.0357	-0.0208	-0.240***	-0.240***
	(0.0147)	(0.0147)	(0.0403)	(0.0390)	(0.0185)	(0.0174)
lstock_p	0.00824	0.0812	-0.0893	-0.283***	0.0589**	0.0982***
	(0.0540)	(0.0555)	(0.0897)	(0.0708)	(0.0272)	(0.0261)
lstock_n	-0.0772*	-0.0270	0.0992	-0.522**	-0.102***	-0.0738***
	(0.0445)	(0.0523)	(0.291)	(0.230)	(0.0197)	(0.0270)
Constant	-0.0208***	-0.0217***	-0.0429***	-0.0197***	-0.0864***	-0.0833***
	(0.00233)	(0.000928)	(0.00864)	(0.00331)	(0.00393)	(0.00447)
Short run asymm.	33.69***	38.99***	4.03**	5.60**	39.66***	39.98***
	[0.0000]	[0.0000]	[0.0446]	[0.0180]	[0.0000]	[0.0000]
Long run asymm.	52.29***	35.66***	0.86	1.96	193.49***	281.62***
	[0.0000]	[0.0000]	[0.3536]	[0.1617]	[0.0000]	[0.0000]
Hausman test	-	180.76***	-	11.43***	-	3.18
	-	[0.0000]	-	[0.0033]	-	[0.2029]
No. of countries	16	16	16	16	16	16
Observations	2,416	2,416	592	592	1,776	1,776

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Values in [ ] are the chi-square prob. values of Hausman test. Also, ec denotes the error correction term, lstock_p and lstock_n represent the logs of positive and negative changes in stock respectively while d.lstock_p and d.lstock_n are the first differences of lstock_p and lstock_n respectively. The lstock_p and lstock_n capture the long-run asymmetry while d.lstock_p and d.lstock_n are for the short-run.

Table 13: Non-Linear ARDL Model for the Non Euro Area

	Full Sample		Pre-GFC		Post-GFC	
VARIABLES	mg	pmg	mg	pmg	mg	pmg
ec	-0.0653***	-0.0359***	-0.208***	-0.140***	-0.126***	-0.046***
	(0.0103)	(0.00835)	(0.0219)	(0.0192)	(0.0157)	(0.0152)
d.lstock_p	-0.0996*	-0.109**	0.0612	0.0328	-0.112*	-0.143**
	(0.0539)	(0.0537)	(0.0662)	(0.0635)	(0.0643)	(0.0696)
d.lstock_n	-0.279***	-0.281***	-0.152**	-0.176**	-0.299***	-0.299***
	(0.0545)	(0.0564)	(0.0740)	(0.0786)	(0.0594)	(0.0580)
lstock_p	-0.223	-0.0698**	0.0415	0.190***	-0.194*	-0.451***
	(0.143)	(0.0348)	(0.0969)	(0.0455)	(0.106)	(0.0747)
lstock_n	-0.464**	-0.195***	0.432*	0.828***	-0.440***	-0.780***
	(0.215)	(0.0273)	(0.226)	(0.152)	(0.155)	(0.0918)
Constant	0.196***	0.107**	0.562***	0.349***	0.364***	0.0768*
	(0.0693)	(0.0426)	(0.156)	(0.0995)	(0.130)	(0.0440)
Short run asymm.	14.64***	19.52***	5.20**	4.62**	7.09***	5.72**
	[0.0001]	[0.0000]	[0.0226]	[0.0315]	[0.0078]	[0.0168]
Long run asymm.	6.87***	50.36***	7.81***	32.73***	15.29***	165.2***
	[0.0088]	[0.0000]	[0.0052]	[0.0000]	[0.0001]	[0.0000]
Hausman test	-	1.71	-	15.87	-	15.73
	-	[0.4251]	-	[0.0004]	-	[0.0004]
No. of countries	16	16	16	16	16	16
Observations	2,416	2,416	592	592	1,808	1,808

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Values in [ ] are the chi-square prob. values of Hausman test. Also, ec denotes the error correction term, lstock_p and lstock_n represent the logs of positive and negative changes in stock respectively while d.lstock_p and d.lstock_n are the first differences of lstock_p and lstock_n respectively. The lstock_p and lstock_n capture the long-run asymmetry while d.lstock_p and d.lstock_n are for the short-run.

5.2.2 Real Variables

We further assess the asymmetric nature of the stock–exchange rate nexus for the variables in real terms to either verify or disprove the results obtained from preceding analysis based on nominal variables. The ensuing results on the real variables are contained in Tables 14 to 16. Like the nominal variables, the results also support the significance of asymmetry in the nexus both in the long-run and short-run again judging by the Wald test. Thus, notwithstanding the variations in the magnitude and direction of relationship between the nominal and real variables, the conclusion about the role of asymmetry remains the same regardless of the nature of variables.

In terms of the direction of relationship, in contrast with the behaviour of the nominal variables where both the positive and negative shocks to stock prices exert negative effects on exchange rate in most cases, the estimates in real terms from full OECD, Euro area and non-Euro area for full sample and post GFC show consistently that positive and negative shocks to stock prices exert positive and negative impacts, respectively on exchange rates both in the short-run and long run. Yet again, the results are largely inconclusive for the pre-GFC sub-sample.

Table 14: Non-Linear ARDL Model for Full OECD Panel

	Full Sample		Pre-GFC		Post-GFC	
VARIABLES	mg	pmg	mg	pmg	mg	pmg
ec	-0.0357***	-0.0257***	-0.176***	-0.127***	-0.0821***	-0.0616***
	(0.00386)	(0.00198)	(0.0182)	(0.0155)	(0.00462)	(0.00555)
d.lstock_p	0.147***	0.141***	0.259***	0.249***	0.141**	0.140**
	(0.0492)	(0.0506)	(0.0640)	(0.0625)	(0.0552)	(0.0582)
d.lstock_n	-0.256***	-0.254***	-0.0107	-0.0137	-0.312***	-0.333***
	(0.0426)	(0.0413)	(0.0616)	(0.0660)	(0.0474)	(0.0446)
lstock_p	0.695	0.144*	0.0866	0.249***	-0.346	0.152***
	(0.972)	(0.0865)	(0.104)	(0.0449)	(0.262)	(0.0415)
lstock_n	0.636	-0.157*	0.688**	1.199***	-0.807*	-0.137***
	(1.351)	(0.0841)	(0.277)	(0.124)	(0.412)	(0.0475)
Constant	0.0483*	0.0194	0.333***	0.187**	0.0711	0.00102
	(0.0254)	(0.0142)	(0.110)	(0.0727)	(0.0440)	(0.0200)
Short run asymm.	41.18***	42.60***	8.99***	8.50***	35.37***	40.75***
	[0.0000]	[0.0000]	[0.0027]	[0.0036]	[0.0000]	[0.0000]
Long run asymm.	0.02	62.56***	11.23***	122.25***	5.09**	206.69***
	[0.8776]	[0.0000]	[0.0008]	[0.0000]	[0.0241]	[0.0000]
Hausman test	-	0.50	-	5.66*	-	7.66**
	-	[0.7770]	-	[0.0592]	-	[0.0217]
No. of countries	16	16	16	16	16	16
Observations	4,832	4,832	1,184	1,184	3,744	3,744

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Values in [ ] are the chi-square prob. values of Hausman test. Also, ec denotes the error correction term, lstock_p and lstock_n represent the logs of positive and negative changes in stock respectively while d.lstock_p and d.lstock_n are the first differences of lstock_p and lstock_n respectively. The lstock_p and lstock_n capture the long-run asymmetry while d.lstock_p and d.lstock_n are for the short-run.

Table 15: Non-Linear ARDL Model for the Euro Area

	Full Sample		Pre-GFC		Post-GFC	
VARIABLES	mg	pmg	mg	pmg	mg	pmg
ec	-0.0287***	-0.0251***	-0.118***	-0.0827***	-0.0873***	-0.0794***
	(0.00259)	(0.00181)	(0.0152)	(0.0139)	(0.00418)	(0.00614)
d.lstock_p	0.0616**	0.0561**	0.221***	0.198***	0.0698**	0.0637**
	(0.0278)	(0.0262)	(0.0731)	(0.0696)	(0.0319)	(0.0313)
d.lstock_n	-0.246***	-0.244***	-0.0265	-0.0493	-0.334***	-0.334***
	(0.0296)	(0.0291)	(0.0559)	(0.0579)	(0.0354)	(0.0335)
lstock_p	-0.172	-0.0344	-0.0642	0.264***	0.0637	0.140***
	(0.130)	(0.126)	(0.134)	(0.0940)	(0.0516)	(0.0498)
lstock_n	-0.332***	-0.235*	0.505	1.520***	-0.195***	-0.149***
	(0.116)	(0.139)	(0.412)	(0.334)	(0.0439)	(0.0553)
Constant	-0.0165***	-0.0166***	0.0602	-0.0243*	-0.0679***	-0.0732***
	(0.00389)	(0.00378)	(0.0752)	(0.0124)	(0.0171)	(0.0125)
Short run asymm.	49.73***	54.03***	4.95**	5.05**	49.85***	50.66***
	[0.0000]	[0.0000]	[0.0260]	[0.0247]	[0.0000]	[0.0000]
Long run asymm.	0.45	18.01***	2.83*	37.48***	238.03***	157.18***
	[0.5030]	[0.0000]	[0.0924]	[0.0000]	[0.0000]	[0.0000]
Hausman test	-	6.61**	-	10.77***	-	8.66**
	-	[0.0366]	-	[0.0046]	-	[0.0132]
No. of countries	16	16	16	16	16	16
Observations	2,512	2,512	640	640	1,872	1,872

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Values in [ ] are the chi-square prob. values of Hausman test. Also, ec denotes the error correction term, lstock_p and lstock_n represent the logs of positive and negative changes in stock respectively while d.lstock_p and d.lstock_n are the first differences of lstock_p and lstock_n respectively. The lstock_p and lstock_n capture the long-run asymmetry while d.lstock_p and d.lstock_n are for the short-run.

Table 16: Non-Linear ARDL Model for the Non Euro Area

	Full Sample		Pre-GFC		Post-GFC	
VARIABLES	mg	pmg	mg	pmg	mg	pmg
ec	-0.0456***	-0.0209***	-0.214***	-0.161***	-0.0768***	-0.0258***
	(0.00636)	(0.00413)	(0.0242)	(0.0199)	(0.00819)	(0.00798)
d.lstock_p	0.238***	0.228**	0.283***	0.267***	0.213**	0.203*
	(0.0904)	(0.0909)	(0.106)	(0.101)	(0.104)	(0.106)
d.lstock_n	-0.262***	-0.243***	-0.00691	-0.00149	-0.289***	-0.285***
	(0.0814)	(0.0793)	(0.109)	(0.115)	(0.0893)	(0.0870)
lstock_p	-0.537	-0.729**	0.0507	0.233***	-0.755	-1.384***
	(0.364)	(0.292)	(0.221)	(0.0611)	(0.509)	(0.336)
lstock_n	-1.145**	-1.299***	0.503	0.975***	-1.419*	-2.281***
	(0.527)	(0.399)	(0.453)	(0.155)	(0.806)	(0.452)
Constant	0.118***	0.0519*	0.572***	0.430***	0.210***	0.0513**
	(0.0447)	(0.0296)	(0.169)	(0.136)	(0.0716)	(0.0249)
Short run asymm.	19.00***	18.99***	4.01**	3.80*	12.15***	12.43***
	[0.0000]	[0.0000]	[0.0453]	[0.0514]	[0.0005]	[0.0004]
Long run asymm.	8.88***	20.44***	10.96***	33.16***	2.88*	0.30
	[0.0029]	[0.0000]	[0.0009]	[0.0000]	[0.0897]	[0.5845]
Hausman test	-	1.92	-	1.83	-	27.28***
	-	[0.3822]	-	[0.3996]	-	[0.0000]
No. of countries	16	16	16	16	16	16
Observations	2,416	2,416	544	544	1,872	1,872

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Values in [ ] are the chi-square prob. values of Hausman test. Also, ec denotes the error correction term, lstock_p and lstock_n represent the logs of positive and negative changes in stock respectively while d.lstock_p and d.lstock_n are the first differences of lstock_p and lstock_n respectively. The lstock_p and lstock_n capture the long-run asymmetry while d.lstock_p and d.lstock_n are for the short-run.

5.3 Robustness Checks with Quarterly Data

The previous analyses with nominal and real data are conducted with monthly data of OECD stock prices and USD denominated exchange rates. In the event of differing outcomes from the nominal and real series, it becomes necessary to test the consistency of our findings to data frequency. We therefore, examine the robustness of our results for nominal and real variables based on the findings from quarterly data analysis of linear and nonlinear nexus between the variables of interest. However, due to data constraint, we are only able to estimate the full data sample for this data frequency (see Tables 17 to 20). Starting with the linear panel ARDL model for the nominal variables, the full OECD and the Euro area turn up negative and significant estimates for both short-run and long-run while the non-Euro area only reveals negative and significant figures in the short run which is still consistent with the PBT. Remarkably, these foregoing results for nominal variables (for quarterly data) are consistent when the variables are expressed in real terms. Thus, we are confident that the PBT is actually valid but more pronounced in the Euro area than in the non-Euro area. Our previous assertion that investors in the non-Euro area could profit by keying-into Euro area asset portfolios is applicable.

Also, like the monthly frequency, the nonlinear panel ARDL estimation from quarterly data provides overwhelming supports evidence of asymmetric response of exchange rate to changes in stock price regardless of the nature of variables whether nominal or real. However, in terms of direction of relationship, the results for the non-linear variant using the quarterly frequency seems to validate the PBT like the results for the nominal variables involving the monthly frequency.

Table 17: Linear ARDL Model for the Four Panels (Nominal Variables)

	Full OECD		Euro Area		Non Euro	
VARIABLES	mg	pmg	mg	pmg	mg	pmg
ec	-0.128***	-0.107***	-0.132***	-0.0985***	-0.125***	-0.107***
	(0.0196)	(0.0160)	(0.0203)	(0.0196)	(0.0344)	(0.0294)
d.lstock	-0.161***	-0.153***	-0.0844***	-0.0874***	-0.238***	-0.223***
	(0.0324)	(0.0332)	(0.00858)	(0.00886)	(0.0591)	(0.0626)
Lstock	1.714	-0.163***	3.089	-0.391***	0.339*	-0.0677
	(1.661)	(0.0285)	(3.335)	(0.0695)	(0.182)	(0.0505)
Constant	0.273***	0.219***	0.239**	0.286***	0.307**	0.239***
	(0.0778)	(0.0583)	(0.0927)	(0.0620)	(0.128)	(0.0843)
Hausman test		1.28		1.09		5.44**
		[0.2584]		[0.2967]		[0.0197]
No. of countries	32	32	16	16	16	16
Observations	1,280	1,280	640	640	640	640

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Values in [ ] are the chi-square prob. values of Hausman test. Also, ec denotes the error correction term, lstock is the log of stock and d.lstock is the first difference of lstock. The lstock is for the long-run and d.lstock for the short-run.

Table 18: Linear ARDL Model for the Three Panels (Real Variables)

	Full OECD		Euro Area		Non Euro	
VARIABLES	mg	pmg	mg	pmg	mg	pmg
ec	-0.138***	-0.0894***	-0.119***	-0.102***	-0.156***	-0.0655**
	(0.0200)	(0.0140)	(0.0162)	(0.0173)	(0.0367)	(0.0328)
d.lstock	-0.132***	-0.120***	-0.0625***	-0.0630***	-0.202***	-0.240***
	(0.0297)	(0.0314)	(0.00929)	(0.00945)	(0.0538)	(0.0546)
Lstock	-0.0952	-0.378***	-0.373***	-0.393***	0.183	0.504***
	(0.213)	(0.0583)	(0.107)	(0.0684)	(0.406)	(0.0481)
Constant	0.249***	0.173***	0.0893**	0.108***	0.408***	0.0322
	(0.0760)	(0.0651)	(0.0352)	(0.0242)	(0.139)	(0.0777)
Hausman test		1.91		0.06		0.64
		[0.1670]		[0.8068]		[0.4250]
No. of countries	32	32	16	16	16	16
Observations	1,280	1,280	640	640	640	640

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Values in [ ] are the chi-square prob. values of Hausman test. Also, ec denotes the error correction term, lstock is the log of stock and d.lstock is the first difference of lstock. The lstock is for the long-run and d.lstock for the short-run.

Table 19: Non-Linear ARDL Model for the Four Panels (Nominal Variables)

	Full OECD		Euro Area		Non Euro	
VARIABLES	mg	pmg	mg	pmg	mg	pmg
ec	-0.318***	-0.249***	-0.358***	-0.329***	-0.277***	-0.122***
	(0.0199)	(0.0213)	(0.0153)	(0.0176)	(0.0345)	(0.0343)
d.lstock_p	-0.0965***	-0.119***	-0.0515*	-0.0614**	-0.142**	-0.181**
	(0.0366)	(0.0428)	(0.0273)	(0.0274)	(0.0673)	(0.0779)
d.lstock_n	-0.313***	-0.314***	-0.231***	-0.226***	-0.394***	-0.364***
	(0.0495)	(0.0453)	(0.0258)	(0.0196)	(0.0927)	(0.0766)
lstock_p	0.132	0.156***	0.153***	0.165***	0.110	-0.131**
	(0.1000)	(0.0213)	(0.0330)	(0.0257)	(0.200)	(0.0639)
lstock_n	-0.0523	-0.0174	-0.0186	-0.0185	-0.0860	-0.534***
	(0.173)	(0.0254)	(0.0351)	(0.0289)	(0.349)	(0.106)
Constant	0.201*	0.0414	-0.206***	-0.196***	0.607***	0.113
	(0.116)	(0.0643)	(0.0113)	(0.00910)	(0.183)	(0.0977)
Short run asymm.	20.84***	27.60***	14.92***	14.60***	9.21***	9.21***
	[0.0000]	[0.0000]	[0.0001]	[0.0001]	[0.0024]	[0.0024]
Long run asymm.	4.94**	151.99***	112.84***	154.29***	1.37	46.90***
	[0.0262]	[0.0000]	[0.0000]	[0.0000]	[0.2419]	[0.0000]
Hausman test	-	0.08	-	3.15	-	1.83
	-	[0.9631]	-	[0.2070]	-	[0.4006]
No. of countries	32	32	16	16	16	16
Observations	1,184	1,184	592	592	592	592

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Values in [ ] are the chi-square prob. values of Hausman test. Also, ec denotes the error correction term, lstock_p and lstock_n represent the logs of positive and negative changes in stock respectively while d.lstock_p and d.lstock_n are the first differences of lstock_p and lstock_n respectively. The lstock_p and lstock_n capture the long-run asymmetry while d.lstock_p and d.lstock_n are for the short-run.

Table 20: Non-Linear ARDL Model for the Four Panels (Real Variables)

	Full OECD		Euro Area		Non Euro	
VARIABLES	mg	pmg	mg	pmg	mg	pmg
ec	-0.325***	-0.250***	-0.354***	-0.327***	-0.296***	-0.135***
	(0.0205)	(0.0214)	(0.0190)	(0.0218)	(0.0356)	(0.0309)
d.lstock_p	-0.0805**	-0.0970**	-0.0427	-0.0437	-0.118*	-0.171**
	(0.0364)	(0.0411)	(0.0281)	(0.0275)	(0.0670)	(0.0749)
d.lstock_n	-0.303***	-0.302***	-0.226***	-0.219***	-0.380***	-0.294***
	(0.0513)	(0.0477)	(0.0306)	(0.0233)	(0.0956)	(0.0817)
lstock_p	0.225**	0.200***	0.224***	0.208***	0.225	-0.237***
	(0.109)	(0.0226)	(0.0326)	(0.0265)	(0.219)	(0.0668)
lstock_n	0.0709	-0.00728	0.0302	-0.00422	0.112	-0.551***
	(0.135)	(0.0249)	(0.0305)	(0.0278)	(0.273)	(0.0837)
Constant	0.240*	0.0254	-0.213***	-0.204***	0.693***	0.144
	(0.133)	(0.0611)	(0.0159)	(0.0124)	(0.213)	(0.0881)
Short run asymm.	18.86***	21.92***	12.53***	14.36***	8.62***	3.16*
	[0.0000]	[0.0000]	[0.0004]	[0.0002]	[0.0033]	[0.0754]
Long run asymm.	14.42***	237.69***	114.13***	218.66	2.08	66.64***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.1491]	[0.0000]
Hausman test	-	2.62	-	14.46***	-	8.59**
	-	[0.2584]	-	[0.0007]	-	[0.0136]
No. of countries	32	32	16	16	16	16
Observations	1,184	1,184	592	592	592	592

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Values in [ ] are the chi-square prob. values of Hausman test. Also, ec denotes the error correction term, lstock_p and lstock_n represent the logs of positive and negative changes in stock respectively while d.lstock_p and d.lstock_n are the first differences of lstock_p and lstock_n respectively. The lstock_p and lstock_n capture the long-run asymmetry while d.lstock_p and d.lstock_n are for the short-run

6.0 Conclusion

This paper provides a new insight into the stock – exchange rate nexus. The study departs from the vast majority of the extant literature which predict stock prices on the basis of exchange rates of the concerned economies. Conversely, the present study seeks to unravel the extent to which exchange rates of OECD countries respond to stock price shocks with a view to validating the Portfolio Balance theory for the OECD. We adopt the panel Autoregressive Distributed Lag (ARDL) models to examine the short and long run impacts of stock price on exchange rate behaviour. We conduct extensive analyses where we estimate both the symmetric and asymmetric panel ARDL models to differentiate the linear and nonlinear responses of exchange rates to changes in stock price for the full OECD sample, the Euro area, and the non-Euro area. Our analyses also involve both the nominal and real stock price and exchange rate variables for the various data samples and we test for robustness using both monthly and quarterly frequencies. We validate the PBT for the OECD and show that it is more pronounced in the Euro area than the non-Euro area regardless of the data frequency. We therefore argue that investors in the non-Euro area could take advantage of better opportunities through portfolio reallocation/diversification towards stock markets of

Euro area. In addition, our results further validate the theoretical construct of Dieci and Westerhoff (2013) for asymmetry in the nexus in OECD countries.

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