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Asymmetric Impact of Exchange Rate Changes on Stock Prices: Empirical Evidence from Germany

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Abstract: This study examines whether shifts in exchange rate has symmetric or asymmetric impact on stock prices in Germany. Linear and nonlinear autoregressive distribution lag models are applied by using monthly data from the period January 1993 till April 2017. Findings suggest that only currency devaluation affects stock prices which implies asymmetric impact of changes in exchange rate on stock prices. The empirical results from this study would be useful for policymaking as well as for forecasting the impact of exchange rate changes on stock prices.

Keywords: Asymmetry; NARDL; Germany; stock market.

JEL Classification: G15; F31.

1. Introduction

Stock markets are usually considered as one of the important performance indicator for any economy. One possible reason could be that they impounds shocks or policy changes (Shiskin and Moore, 1968). To examine the relationship between exchange rates and stock prices a portfolio approach to exchange rate determination is considered as a starting point. This approach implies that increasing stock prices would increase public wealth which then increases the demand for money that result to increase interest rates. Increasing interest rates open avenues for foreign investment for any economy which normally leads to appreciation of domestic currency (Ajaz *et al.*, 2017). Alternatively, depreciation in domestic currency may improve export and has favorable impact for export-oriented firms. As these firms report high profit margin which further increases the share prices. The domestic currency depreciation adversely affect those firms that are not export-oriented i.e., import-input oriented firms as their cost of production increases. Higher production cost results in lower in profits or expectation of lower of lower profit, hence, stock prices would be affected (Ajaz *et al.*, 2017). Due to this mechanism stock prices would move in either direction.

As existing literature provides different theoretical frameworks for example, Fama (1970) proposed efficient market hypothesis (EMH) and Ross (1976) proposed arbitrage pricing theory that have used in numerous studies to examine the impact of macroeconomic fundamentals on stock markets returns. Applying these theoretical frameworks and various econometrics methods researchers have examined the link between macroeconomic fundaments and stock market response. The basic idea of the models used in these studies is the asymmetric effect, which need not be the case. It is necessary to examine asymmetries in the stock prices adjustment process, for instant stock prices impounds bad news (overpricing) faster than good news (underpricing) (Koutmos, 1998;1999). We examine whether is there any relationship exist between stock prices and exchange rate and thus the nature of the relationship.

The reminder of this paper is organize as follows, section two review the literature. Section three presents data and methodology. Section four provides the results. Section five concludes the current study.

2. Literature Review

To bring into line with the aim of current study, we briefly review the literature on the relationship between stock prices and exchange rate. Aggarwal (2003) who find positive relation between two variables using monthly data from 1974-1978 of US. On the other hand, Soenen and Hennigar (1988) conducted study on stock prices response of seven industrial sector in US to change in exchange rate. They found negative relationship between stock prices and exchange rate. Moreover, these two studied have not taken into account the integrating property of the

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variable which results in spurious regression. Bahmani-Oskooee and Sohrabian (1992) Using monthly data from the period 1978-1988 and concluded that the dollar stock prices and real effective exchange rate are non-stationary variables. Employing Engle and Granger cointegration analysis provided no evidence of long-run relationship exist between two variables. Nevertheless, Granger causality test revealed that in the short-run these two variable Granger cause each other. Granger *et al.* (2000) Conducted study on the relationship between stock prices and exchange rate on the nine East-Asian countries using daily data during the period 1986-1997. They argued that the exchange rate affected stock prices in eight of the nine countries. Nieh and Lee (2002) Examined the dynamic relationship between stock prices and exchange rate in G-7 countries using daily data from the period 1993-1996. Their results are mainly consistent with the study of Bahmani-Oskooee and Sohrabian (1992) and reported that no long-run relationship exist between stock prices and exchange in all G-7 countries. On the other hand, certain G- 7 countries show significant short-run relationship for very short span of time usually for one day only. Smyth and Nandha (2003) Explored the relationship between stock prices and exchange rate using daily data during the period 1995-2001 for four Asian countries namely Bangladesh, India, Pakistan and Sri Lanka. Their study revealed that no long-run relationship found between the two variables in any of the four countries. Employing Granger causality test, they argued that in two of the four countries i.e., India and Sri Lanka the exchange rate Granger cause stock prices, whereas such no evidence exist in Bangladesh and Pakistan in either direction. Phylaktis and Ravazzolo (2005) examined the relationship between stock prices and exchange rate in Hong Kong, Indonesia, Malaysia, Philippines, Singapore and Thailand. In this study they used monthly data from the period 1980-1998 and applied cointegration and Granger causality tests. Their revealed positive relationship between stock prices and exchange rates. Rahman and Uddin (2009). Conducted study on Bangladesh, India, Pakistan using monthly data from the period 2003-2008.Applying Johansen cointegration and Granger causality tests, their empirical results find neither causality relationship nor long-run relationship in either direction between the two variables. Their study suggests using information in one market cannot assist participant to forecast another market. Yang *et al.* (2014) using daily data from the period 1997-2010 and applied Granger causality tests in quantiles on Taiwan, Singapore, Philippines, Malaysia, Korea, Thailand, Japan, Indonesia, and India during the Asian financial crises. They concluded that the feedback relation exist among all sample countries except Thailand in two variables (i.e., stock market returns and exchange rate). In Thailand stock returns leads exchange rates. The heterogeneous causal effects are found in among different quantiles and in different time periods. They also found negative correlation between stock prices and foreign exchange rates. All above cited studies assumed that the effects of exchange rate on stock prices is symmetric which may not be the case. Ismail and Bin Isa (2009) applying Markov-switching VAR model and assumed that the relationship between exchange rate and stock prices is regime dependent. They then conducted study on Malaysia using monthly data from 1990 to 2005 to examine the non-linear relation between exchange rates and stock prices. They applied Johansen cointegration test and found no evidence of cointegration between the exchange rates and stock prices. Their study concluded that non-linear model is more appropriate to model the series then the linear model. Recently, Bahmani-Oskooee and Saha (2015) applied multivariate model and nonlinear ARDL approach developed by (Shin *et al.* (2014)) to examine the changes in the nominal effective exchange rate of U.S. dollar have asymmetric effects on S & P 500 index. They recommend that a similar analysis should be conducted using data from other countries to whether similar conclusion would be drawn or not. Hence, our objective in this study is to examine whether similar inference could be drawn from Germany too.

3. Data and Methodology

3.1. Data

To determine the asymmetric effect of exchange rate on stock prices of Germany. We use monthly data from the period January 1993 till April 2017. The data for all variables are collected from the database of international financial statistics of the (IMF) except for the stock index data which is retrieved from Bloomberg. Germany stock index (DAX) is dependent variable, the important exogenous variable is real effective exchange rate defines as the price of domestic currency relative to basket of foreign currencies. The Industrial Production Index IPI (i.e., a proxy for measuring economic activity) and Consumer Price Index (CPI) are considered as the control variables for this study. All variables are transformed into logarithmic forms.

3.2. Methodology

The current study investigates the asymmetric impact of exogenous variable on the dependent variable both in short and long-run based on the nonlinear (NARDL) cointegration approach suggested (Shin *et al.*, 2014). This approach relies on positive and negative partial sum of decompositions of the variables of interest. The NARDL model is easy to implement, it allows jointly to analyze the non-stationarity and non-linearity, and importantly the detection of asymmetries both in the short and long-run. This model is the advanced version of ARDL model proposed by Pesaran *et al.* (2001).

The general econometric specification of ARDL is expressed as follow:

$$\Delta y_t = \alpha_0 + \sum_{i=1}^{p-1} b_i \Delta y_{t-1} + \sum_{i=0}^{q-1} c_i \Delta x_{t-i} + \rho y_{t-1} + \theta x_{t-1} + \varepsilon_t \qquad (1)$$

Where y_t indicates dependent variable; x_t shows vector of k x 1 dimension for all k set of variables; α_o represents intercept; Δ indicates the difference operator; b_i and c_i represent coefficient to capture short-run effect; ρ and θ indicate coefficient to capture long-run effect; the $\sum$ sign with limit of p and q indicate the lag orders for the dependent and independent variables respectively; while $\boldsymbol{\varepsilon_t}$ is the disturbance term with constant mean and constant variance (i.e., with an iid stochastic process) in the above model.

To test the null hypothesis in Equation (1) of no cointegration of coefficient of two lagged level variables jointly zero ($\boldsymbol{\rho = \theta = 0}$) against the alternative hypothesis of cointegration in long run ($\boldsymbol{\rho \neq \theta \neq 0}$). Bound testing approach to ARDL framework applied to test null hypothesis Pesaran *et al.* (2001) argued that null hypothesis (no cointegration) would be tested by the Wald coefficient restriction or more precisely F-statistics. We compare computed value of F-statistics with the tabulated value of Pesaran *et al.* (2001) This procedure is usually relied on two critical bounds: the upper tabulated bound value and lower tabulated bound value. If the computed value of F-statistics is greater than the upper bound value implies the rejection of null hypothesis for no cointegration meaning that the long-run relationship exist. If F-statistics value is lower than upper bound value implies non-rejection for cointegration meaning that no relationship in the long-run exist between variables. Result is inconclusive if the F-statistics value falls between upper and lower bound values.

The combination of stochastic regressors in standard ARDL approach is linear implies the symmetric adjustment both in the short-run and long-run. The expression for linear ARDL model is given as:

$$\Delta LnSP_t = \alpha_o + \sum_{i=0}^{p-1} b_i \, \Delta LnSP_{t-i} + \sum_{i=0}^{q2} c_{1,i} \, \Delta LnREER_{t-i} + \sum_{i=0}^{q2} c_{2,i} \, \Delta LnCPI_{t-i} + \sum_{i=0}^{q3} C_{3,i} \, \Delta LnIPI_{t-i} + \rho LnSP_{t-1} + \theta_1 LnREER_{t-1} + \theta_2 LnCPI_{t-1} + \theta_3 LnIPI_{t-1} + \varepsilon_t \quad (2)$$

Where $\boldsymbol{Ln}$ before variables indicate the natural logarithm; $\boldsymbol{SP}$ represents the stock market index; $\boldsymbol{REER}$ shows real effective exchange rate; $\boldsymbol{CPI}$ represents consumer price index; $\boldsymbol{IPI}$ shows industrial production index; $\boldsymbol{\varepsilon_t}$ represents error term to account for all variation not explained by included variables.

To account for asymmetries in the short-run and long-run Shin *et al.* (2014) proposed NARDL model in which $\boldsymbol{x_t}$ decomposed as positive and negative partial sums (Shin *et al.*, 2014).

$$\boldsymbol{x_t = x_o + x_t^+ + x_t^-} \quad (3)$$

Where $\boldsymbol{x_t^+}$ and $\boldsymbol{x_t^-}$ represent positive and negative partial sums process of changes in $\boldsymbol{x_t}$, can be expressed as follows:

$$\mathbf{x_t^+ = \sum_{i=1}^{t} \Delta x_i^+ = \sum_{i=1}^{t} max(\Delta x_i, 0)} \quad (4)$$

$$\mathbf{x_t^- = \sum_{i=1}^{t} \Delta x_i^- = \sum_{i=1}^{t} min(\Delta x_i, 0)} \quad (5)$$

Therefore, asymmetric long-run relationship can be expressed as follows:

$$\mathbf{y_t = \beta^+ x_t^+ + \beta^- x_t^- + \varepsilon_t} \quad (6)$$

Where $\boldsymbol{\beta^+}$ and $\boldsymbol{\beta^-}$ indicate the coefficients that capture the asymmetric effects in the long-run associated with the positive and negative changes in $\boldsymbol{x_t}$; $\boldsymbol{\varepsilon_t}$ indicates disturbance term that normally reports deviation in the long-run equilibrium.

Shin *et al.* (2014) argued that by combining Equation (6) with the ARDL (p,q) Equation (1) we obtain NARDL (p , q) model as given:

$$\boldsymbol{\Delta y_t = \alpha_o + \sum_{i=1}^{p-1} b_i \, \Delta y_{t-i} + \sum_{i=0}^{q-1} (c_i^+ \, \Delta x_{t-i}^+ + c_i^- \Delta x_{t-i}^-) + \rho y_{t-1} + \theta^+ x_{t-1}^+ + \theta^- x_{t-1}^- + \varepsilon_t} \quad (7)$$

Where $\boldsymbol{\theta^+ = +\rho\beta^+}$ and $\boldsymbol{\theta^- = -\rho\beta^-}$ and short-run adjustments in both positive and negative shocks can be explained by the $\boldsymbol{c_i^+}$ and $\boldsymbol{c_i^-}$ respectively.

The implementation of nonlinear ARDL model requires the following steps. Firstly of all we estimate the error correction model (ECM) employing OLS technique presented in equation 7. Then with bound testing approach we determine asymmetric long-run relationship, to null hypothesis ($\boldsymbol{\rho = \theta^+ = \theta^- = 0}$) of no cointegration. The rejection of null hypothesis is based on computed F- statistics value. If the f-statistics value is greater than tabulated upper bound value of Pesaran *et al.* (2001), we reject the null hypothesis of no cointegration implies that the long-run relationship exist whereas the lower value of F-statistics than tabulated lower bound value implies cointegration meaning that no long-run relation exist between variables of interest. Finally, we estimate whether the effect of independent variable is symmetric or asymmetric on the dependent variable in the long-run ($\boldsymbol{\theta^+ = \theta^-}$) and in the short-run($\boldsymbol{\sum_{i=o}^{q-1} c_{k,i}^+ = \sum_{i=0}^{q-1} c_{k,i}^-}$) . The standard Wald test is employ to test nonlinearity (asymmetries) in the short and long-run.

The econometric specification of NARDL model employed in this current study given as:

$$\boldsymbol{\Delta LnSP_t = \alpha_o + \sum_{i=1}^{p-1} b_i \, \Delta LnSP_{t-i} + \sum_{i=0}^{q1} c_{1,i}^+ \, \Delta LnREER_{t-i}^+ + \sum_{i=0}^{q2} c_{1,i}^- \, \Delta LnREER_{t-i}^- + \sum_{i=0}^{q3} c_{2,i} \, \Delta LnCPI_{t-i} + \sum_{i=0}^{q4} c_{3,i} \, \Delta LnIPI_{t-i} + \rho LnSP_{t-1} + \theta_1^+ LnREER_{t-1}^+ + \theta_1^- LnREER_{t-1}^- + \theta_2 LnCPI_{t-1} + \theta_3 LnIPI_{t-1} + \varepsilon_t} \quad (8)$$

Where $REER^+$ and $REER^-$ are the partial sum of positive and negative shocks for the REER respectively.

4. Result Discussion

One of the preliminary assumption that ARDL and nonlinear ARDL models required the integration order of the variables that could be I(1) or I(0) or any combination of these but none of the variable should be I(2). Therefore, to examine stationarity of the data we use Augmented Dickey-Fuller (ADF) test. Table 1 summarized the results of ADF test and suggests that all variables are non-stationary in level, they become stationary after taking first difference. This test ensures that none of the variable understudy is integrated of order two I (2) so we proceed to next to estimate the models.

Table 2 reports the results for linear ARDL model in three distinct panel. Panel A reports short-run estimates, panel B reports long-run estimates and panel C presents diagnostic statistics. To consider linear model first, panel A reports short-run effects of variables, the REER has significant and positive affect on stock prices of Germany. The CPI is significant and negative in the short-run implies that the prices of goods produced by firms decreases and hence profits of these firms which resultantly decreases stock prices whereas panel B indicates that the CPI is positive and significant in the long-run implies that CPI affects stock prices positively. Moreover, panel C reports diagnostic statistics, the F test result for the joint lagged variables for linear model (2) rejects the null hypothesis which indicates the long-run association between the variables. The coefficient of ECM suggests that any short-term deviation from equilibrium would be corrected with speed of 23% month. Finally we analyze econometric problem of this model by employing the Lagrange Multiplier (LM) test statistics, to examine autocorrelation the value of coefficient indicates the model lacks autocorrelation. The Ramsey's RESET test, is used to examine the misspecification of the model, the coefficient result indicates the model is correctly specified. However, to check the validity of the model in the short and long-run we apply CUSUM, and CUSUMQ test, as shown in panel C all estimates are stable this is represented by (S).

Table 3 presents the results for nonlinear ARDL model by estimating Equation (8) to determine whether exchange rate shifts impact symmetrically or asymmetrically on stock prices. The short-run estimates are presented in Panel A, whereas Panel B indicates long-run estimates and panel C reveals diagnostic statistics. Discussing short-run estimates from Panel A, all estimates are insignificant for both positive changes($\Delta \boldsymbol{REER^{+}}$) and negative changes ($\Delta \boldsymbol{REER^{-}}$) in exchange rate employing that in the short-run, exchanges rate changes have symmetric effect on stock prices. Moreover, ($\Delta \boldsymbol{REER^{-}}$) changes in exchange rate is negative and significant in the long-run from panel B whereas changes in ($\Delta \boldsymbol{REER^{+}}$) is positive and significant meaning that these positive and negative shocks have asymmetric effect on stock prices in Germany. Diagnostic statistics reported in panel C, the Wald coefficient restrictions result indicates the rejection of null hypothesis in the long-run whereas null hypothesis is non-rejected in the short-run, meaning that changes in exchange rates have symmetric effect on stock prices whereas in the long-run these have asymmetric impact on stock prices. We can also examine the other econometrics problems such as either the model lacks serial correlation, model misspecification and the model validity. The Lagrange Multiplier (LM) test result shows that the model lacks serial correlation. The Ramsey's RESET test, estimates the model has correct functional form. To check for stability we use CUSUM and CUSUMQ test statistics, this show that all estimates are stable by indicating (S) in parentheses. Here the purpose of the model is forecast, therefore we are interested in Adjusted R-squared test statistics and the value indicates the model enjoy goodness of fit.

5. Conclusion

Does change in exchange rate has symmetric or asymmetric impact on stock price? This study extends previous literature by answering this question. Based on the evidence from the linear ARDL model in this study we find that exchange rate has significant and positive affect on the stock prices in the short-run on stock prices. On the contrary, nonlinear ARDL model suggests that exchange rate has symmetric effect on the stock prices in the short-run, whereas for the long-run asymmetric effects has observed.

This study infers that the relationship between stock prices and exchange rate is asymmetric in the long-run, that is, currency appreciation or depreciation does not affects stock prices in the same way. Stock prices are more affected by currency depreciation than currency appreciation. Policy makers and other stake holders are therefore advised to consider these asymmetries before considering taking any decision.

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Table-1. ADF Test Results at Level and at First Difference

Variable	P value at level	P value at first difference
LnSP	0.56	0.00*
LnREER	0.51	0.00*
LnCPI	0.89	0.012*
LnIPI	0.56	0.00*

Notes: (*) shows significance level at 5 percent critical value.
All variables are in logarithmic form.

Table-2. Linear ARDL model

<table>
<tr><td colspan="7">Panel A: Short-run</td></tr>
<tr><td rowspan="2">Variables</td><td colspan="6">Lags</td></tr>
<tr><td>0</td><td>1</td><td>2</td><td>3</td><td colspan="2">4</td></tr>
<tr><td>ΔLnSP</td><td></td><td>0.046(0.75)</td><td>-0.024(-0.39)</td><td>-0.42(-2.67***)</td><td colspan="2">-0.51(-4.21***)</td></tr>
<tr><td>ΔLnREER</td><td></td><td>0.12(2.89***)</td><td></td><td>037(2.99***)</td><td colspan="2"></td></tr>
<tr><td>ΔLnCPI</td><td></td><td>-0.12(-2.88***)</td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>ΔLnIPI</td><td></td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td colspan="7">Panel B: Long-run</td></tr>
<tr><td>LnSP</td><td colspan="2">LnREER</td><td>LnIPI</td><td>LnCPI</td><td></td><td></td></tr>
<tr><td>-0.33(-7.21***)</td><td colspan="2">-0.25(-0.94)</td><td>-0.19(-0.16)</td><td>0.12(1.81*)</td><td></td><td></td></tr>
<tr><td colspan="7">Panel C: Diagnostics</td></tr>
<tr><td>ECMt-1</td><td colspan="2">CUSUM(CUSUMQ)</td><td>Wald (joint significance)</td><td>Adj. R squared</td><td>RESET</td><td>LM</td></tr>
<tr><td>-0.23***</td><td colspan="2">S(S)</td><td>0.0063</td><td>0.024</td><td>0.92</td><td>0.93</td></tr>
</table>

Notes:
a. Δ indicates first difference operator.
b. * indicates at 10% level.
c. *** indicates at 1% level.
d. The numbers in parentheses indicate t-statistics.

Table-3. Nonlinear ARDL model

Panel A: Short-run				
Variables	Lags			
	0	1	2	
Δ ln SP		0.26(2.36**)	0.01(0.05)	
Δ ln CPI	-0.13(-0.49)	-0.36(-1.68*)	-0.22(-1.00)	
Δ ln IPI	-0.51(-1.76*)	0.42(1.69*)	-0.15(-0.55)	
Δ ln $REER^-$	-0.33(-0.27)	0.07(0.43)	0.07(0.06)	
Δ ln $REER^+$	-1.13(-1.27)	0.46(0.52)	0.46(0.53)	
Panel B: Long-run				
Ln SP	Ln CPI	Ln IPI	Ln $REER^-$	Ln $REER^+$
-0.34(-3.19***)	-0.02(-0.25)	-0.10(-1.13)	-0.28(-3.26***)	-0.25(-1.42)

Panel C: Diagnostics					
F	ECMt-1	LM	Adj. R squared	RESET	CUSUM(CUSUMQ)
1.59*	-0.13***	2.5	0.69	9.66***	S(S)
Joint significance	Ln $REER_{LR}$	Ln $REER_{SR}$			
10.87***	-.08[0.00***]	0.38[0.16]			

Notes:
a. Δ Indicates first difference operator.
b. * indicates at 10% level.
c. *** indicates at 1% level.
d. The numbers in parentheses indicate t-statistics.