Project Report

Econometric Analysis II

Title: Econometric Analysis of the Determinants of Real Effective Exchange Rate in the OECD Countries

Under the Guidance of Professor Pulak Mishra, HSS Department

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Abstract

This research aims to investigate the determinants of real effective exchange rate in OECD countries, including Australia, France, Germany, United Kingdom, and United States. The research was conducted by using yearly time series data set from 1980 to 2019. We have not considered the observations of 2020 and 2021 because of the pandemic (to take care of outliers). Cointegration and the error correction model (ECM) methods were applied to test the long run and short run relationship of the real effective exchange rate and its determinants. The results indicate that the ratio of foreign direct investment to GDP and government spending had a significant impact on real effective exchange rate in the OECD countries. The impact of FDI is positive in the case of Australia and the UK and negative for Germany. Similarly, the impact of GOV is negative in case of Australia, France and USA and positive for Germany. The trade opening had influenced the real effective exchange rate in most of the abovementioned countries, except France and Germany. In addition, the international reserve (INR) had a significant long-run impact on the real effective exchange rate in France, USA and UK. In the short run equilibrium, the error collection term suggests that France has the fastest speed adjustment to equilibrium followed by USA and Australia. In addition, Trade Openness influences the real effective exchange rate in France, Germany and the USA but it is not in Australia and the UK. However, the Terms of Trade is a major factor of the real effective exchange rate in Germany, but not for other countries.

1. Introduction

Analyzing the determinants of the real exchange rate is an important matter for any government and international agencies. The real exchange rate can be modeled as a method to understand the economic demographics of a country, which is helpful in deciding public policy and economic growth trajectory. Any changes to the real exchange rate-related policies can have a direct impact on the economic activities of the country; hence this should be treated very carefully. Multiple prior researchers have tried to analyze the exchange rate fluctuation using a plethora of models to identify causes and predict future rate movement and allied topics, such as portfolio balance models and monetary exchange rate models. We have attempted to employ **co-integration and a Vector Error Correction Model (VECM)** to analyze the determinants of the real effective exchange rate in 5 OECD countries namely Australia, France, Germany, UK and USA.

This report is organized as follows: *Section I* provides the introduction & literature reviews related to this analysis. *Section II* presents a research methodology. *Section III* outlines the empirical results and discussion of the analysis, and *Section IV* presents a conclusion of the analysis..

2. Literature Review

One of the most common topics in international economic studies is the topic of exchange rates and the variables that influence them, and this topic has been examined by a number of scholars. Dornbusch (1976) and Rogoff (1983) created the first analyses of exchange rate dynamics. The model looked at rational expectations, sticky prices, and exchange rate adjustments. The research clearly indicated that the sticky prices and the rational expectations remains a significant concept since several pieces of evidence in recent years appeared to be more remarkable for deviations from than observance.

After that, Lane (1999) conducted a thorough investigation into the study of exchange rates and the factors influencing nominal exchange rates. He examined long-run exchange rate equilibrium using theoretical and empirical research, and he created a model for nominal and real exchange rates using data from 107 nations between 1974 and 1992. The findings indicate that, over the long run, the nominal exchange rate is most significantly impacted by the inflation rate. While the size of the country had no substantial impact on the exchange rate, other factors including economic development and international commerce were found to be significant. The nominal exchange rate was significantly influenced by the openness of the nation, its size, and its level of public debt. But in the OECD countries,

In order to examine the relationship between the actual effective exchange rate and its factors, AbuDalu et al. (2014) employed quarterly time series data between 1991 and 2006. The factors include the ASEAN-5 countries' terms of trade, money supply, domestic interest rate, foreign interest rate, and net foreign assets.

The vector error correction model was used by Lee and Brahmasrene (2019) to calculate long-term and short-term causality of exchange rate in Korea. Culiuc (2020) examined the cause and impact of the overshooting exchange rate. He discovered that quick balance sheet shrinkage and increased spending determine how the economy is affected by significant depreciations. The impact of foreign direct investment and financial innovation on the volatility of exchange rates in the South OECD was studied by Qamruzzaman et al. (2021) using data from 1980–2017. He contends that FDI inflow and financial innovation have a long-term, favorable, and considerable impact on exchange rate volatility.

3. Research Methodology

3.1 Data Set

This analysis focuses on the long-run and short-run relationship between the real effective exchange rate and its determinants in the OECD countries, including Australia, France, Germany, the United Kingdom, and the United States. The paper was conducted by using time series secondary data from 1980 to 2019. All data sets were extracted from the International Financial Statistics (IFS), which was published by the International Monetary Fund (IMF) and the World Development Indicators (WDI) by the World Bank. All the data were transformed to the natural logarithm before using in the estimated model.

3.2 Research Model

In this analysis, the determinant of the real effective exchange rate in five countries in the OECD countries, including Australia, France, Germany, United Kingdom, and United States were examined by the following equation:

$$REXC = \alpha_1 + \beta_1 FDI + \beta_2 TOT + \beta_3 GOV + \beta_4 TOE + \beta_5 INR$$

REXC refers to the real effective exchange rate in each country. The REXC is defined as the relative price of tradable products to non-tradable products in domestic countries compared to foreign countries. Each real effective exchange rate is based on 2010 (2010 = 100) of each country.

FDI refers to the ratio of foreign direct investment to the GDP of each country. The FDI is calculated as follows:

$$FDI = Net\ foreign\ investment\ /\ Nominal\ GDP$$

TOT refers to a term of trade, which is calculated from the relative price of the exports index compared to its imports index.

$$TOT = Export\ Index\ /\ Import\ Index$$

where

$$Export\ Index = Export\ Value\ /\ Export\ Price\ Index$$

$$Import\ Index = Import\ Value\ /\ Import\ Price\ Index$$

GOV (Government Expenditure) refers to the government spending that includes all expenditure for employment, buying goods and services, paying for fixed capital, interest, grants, subsidies, and other expenses by the government.

$$GOV = Government\ Spending\ /\ Nominal\ GDP$$

The TOE is calculated by the value of export plus import divided by the nominal GDP in each country.

$$TOE = Export\ Import\ /\ Nominal\ GDP$$

$$INR = International\ Reserves\ /\ Nominal\ GDP$$

3.3 Research Methods

The first step in this work was to use the Augmented Dickey-Fuller test (ADF test) to determine whether each variable in the model was stationary. The real effective exchange rate function was then put to the test for a long-run relationship using Johansen's (1991) cointegration approach. Then, using the Vector Error Correction Model (ECM), we have studied the short-run determinants of the real effective exchange rate and its determinants.

3.3.1. Testing for Stationary and Unit Root Test

There are two ways to identify nonstationary variables in time series data. The first is to plot each variable to look for any clear trends. Another technique is the unit root test, a formal technique for identifying non-stationarity. Dickey and Fuller (1979) developed the Dickey-Fuller test (DF test), the industry-standard technique for identifying the unit-roots . When the error term (ε_t) appeared to be white noise, the DF test is valid. The DF test makes the assumption that the error terms (ε_t) are uncorrelated and will become auto-correlated if the dependent variable in the regression model exhibits autocorrelations. When the error term is less likely to be white noise, Dickey and Fuller (1981) created an alternative technique for finding the unit root. The Augmented Dickey-Fuller test (ADF test) is the popular name for this technique. The developed version of the DF test is called the Augmented Dickey-Fuller test (ADF test). In order to remove the autocorrelation, the dependent variable ΔY_t has an additional ρ-lag value in the ADF test. In order to find the nonstationary or unit root of each variable included in the research model, this project employed the ADF approach.

The equation that has been used for the unit root testing are following:

$$\Delta y_t = \delta y_{t-1} + \sum_{i=1}^{\rho} \phi_i \Delta y_{t-i} + \varepsilon_t$$

$$\Delta y_t = \alpha + \delta y_{t-1} + \sum_{i=1}^{\rho} \phi_i \Delta y_{t-i} + \varepsilon_t$$

$$\Delta y_t = \alpha + \beta_t + \delta y_{t-1} + \sum_{i=1}^{\rho} \phi_i \Delta y_{t-i} + \varepsilon_t$$

Where Y_t indicates time series variables at time t,
Y_{t-1} refers to the lag of each time series variable,
ρ presents the lag of the time series a coefficient,
t is time, t = 1, 2, 3, …, and
ε_t refers to the disturbance term. It is identically and independently distributed with 0 mean and variance.

The hypothesis of the ADF test is similar to the original DF test. Therefore, the null hypothesis of the unit root can be written as H_0: $\delta = 0$, and the alternative hypothesis is that H_1: $\delta < 0$. By contrasting the absolute value of the ADF statistic (t-statistic) with a MacKinnon critical value, it is possible to practically detect the ADF approach. The null hypothesis of a unit root might be rejected if the absolute value of the ADF statistic appeared to be higher than the absolute critical value. The series is regarded as stationary. The series is non-stationary if the ADF statistic is lower than the absolute critical value. In case the time series contains a unit root or it is non-stationary at level, it can be first differenced or second differenced, or so on. The differencing method on the unit root can be continued until the null hypothesis is rejected.

3.3.2. Cointegration Test

In this study, a cointegration test using Johansen's (1991) methodology was tested after the unit root test. The trace statistic and the maximal eigenvalue statistic are two likelihood ratio statistics that can be used to evaluate the cointegration hypothesis. The following are the two equations:

$$\lambda_{trace}(r) =- T \sum_{i=r+1}^{n} ln(1 - \hat{\lambda}_i)$$

$$\lambda_{max}(r, r + 1) =- T\, ln(1 - \hat{\lambda}_{r+1})$$

where $\hat{\lambda}_i$ is an estimated value of the characteristic roots, which is obtained from the estimated metric. π refers to the number of usable observations. The null hypothesis of trace statistics is that the number of cointegrating vectors is smaller or equal to r, against the alternative hypothesis $r > r_0$. The hypothesis of maximal eigenvalue statistics is that at least r cointegrating against the alternative $r = r_0 + r_1$.

3.3.3 The Vector Error Correction Model

The long-run equilibrium is given more consideration in the cointegration technique, but the short-run relationship between two variables is not taken into account. Engle and Granger (1987) and Granger (1988) created the Error Correction Model (ECM) as an alternate approach to explain the short-run relationship between variables in order to capture the short-run dynamic connection between the two variables. Using the first difference term, which can take trend out of the equation, is one advantage of the ECM technique. The ECM can also represent the links between the variables' long-run and short-run equilibrium states.

According to Engle and Granger (1987), a linear combination of the two time series x_t and y_t should be the same if they cointegrate in the same order (series x_t and y_t are $I(d)$). Additionally, $I(d)$ should be the value of the residual that results from the regression of y_t on x_t. Therefore, determining whether y_t and x_t are linear functions of the latent integrated progress is the simplest way to derive the Error Correction Model, or ECM. It should be stationary for the residual of the y_t regression on x_t.

To test an equilibrium between the two variables in the short-run, Engle and Granger present the simple dynamic of short-run adjustment equilibrium as following Equation:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \beta_0 x_t + \beta_1 x_{t-1} + \varepsilon_t$$

Rearrange Equation above by taking first difference

$$\Delta y_t = \alpha_0 + \gamma(y_{t-1} - x_{t-1}) + \lambda_1 \Delta x_t + \lambda_2 \Delta x_{t-1} + \varepsilon_t$$

Where: $\gamma = (\alpha_1 - 1)$, $\lambda_1 = \beta_0$ and $\lambda_2 = \beta_0 + \beta_0 + \alpha_1 - 1$

The γ or $(\alpha_1 - 1)$ indicates a speed that y_t is adjusted to any discrepancy between y_t and x_t in the previous period, while $(y_{t-1} - x_{t-1})$. It is equal to zero when y_t and x_t are in equilibrium. It indicates the extent to which the long-run relationship is not satisfied. The λ_1 indicates the short-run relationship between the two variables. However, instead of explaining the error correction term in $(y_{t-1} - x_{t-1})$ form, De Boef and Keele (2004) explain the convenient method to estimate the error correction model as following:

$$\Delta y_t = \alpha_0 + \gamma\, y_{t-1} + \eta_1 \Delta x_t + \eta_2 \Delta x_{t-1} + \varepsilon_t$$

where $\gamma = (\alpha_1 - 1)$, $\eta_1 = \lambda_1 = \beta_0$, and $\eta_2 = \beta_0 + \beta_1$.

Therefore it can be re-written in the form of an Error Correction Model as following:

$$\Delta y_t = \alpha_0 + \gamma\,(y_{t-1} + \eta_2 x_{t-1}) + \eta_1 \Delta x_{t-1} + \varepsilon_t$$

3.3.4 Testing for Validity of Assumptions

(i) Test for presence of autocorrelation

- **Used the Lagrange Multiplier Test**:
  It is a test for autocorrelation in a regression model's errors. A test statistic is obtained from the residuals from the model being considered in a regression analysis. The null hypothesis H_0 is that there is no serial correlation of any order up to ρ.

(ii) Testing for normality

- **Used the Jarque-Bera statistic for skewness and kurtosis:**
  The test determines whether sample data have skewness and kurtosis that are consistent with a normal distribution.

  The test statistic JB is defined as:

$$JB = \frac{n}{6}(S^2 + \frac{1}{4}(K - 3)^2)$$

  n is the number of observations (or degrees of freedom in general);
  S is the sample skewness,
  K is the sample kurtosis

(iii) Testing for Stability of the VEC model

- **Used the Eigenvalue stability condition:**
  Checks the eigenvalue stability condition in a vector error-correction model (VECM). For a model with K variables and r cointegrating vectors, there will be K − r unit eigenvalues. Stability requires absolute value of the remaining eigenvalues to be less than unity

4. Empirical Results and Discussion

4.1. Unit Root Test

Since to use stationary data, it is necessary to analyze the time series data, we started by detecting the stationarity of each variable that was included in the model. The Augmented Dickey-Fuller (ADF) test was adopted in this section for testing the stationarity of each variable. Table 1 presents the results of the unit root test by using the ADF test, both the ADF test at the level and at the first difference. The numbers in the table indicate the ADF statistic (t-statistic) and their p-values. The number in the bracket indicates the optimum lag length of the ADF. The results of ADF statistic in Table 1 suggest that at level:

(i) All variables in the model, except term of trade (TOT) in Australia, contain unit root at level.

(ii) All variables in the model, except Government Expenditure (GOV) in France, contain unit root at level.

(iii) All variables in the model, except Foreign Direct Investment (FDI) in Germany, contain unit root at level.

(iv) All variables in the model, except FDI and TOT in the UK, contain unit root at level.

(v) All variables in the model, except TOT in the USA , contain unit root at level.

The null hypothesis of unit root cannot be rejected. Therefore, it can be said that most variables in this analysis appeared to be non-stationary at level. However, the tests of unit root at the first difference of time series shows that all variables do not contain unit root after their first differentiation, the null hypothesis of unit roots can be rejected at a 1% significant level. This can be concluded that all variables in this analysis are integrated in order one, or (I (1)). Therefore, all variables in this analysis appeared to be stationary and can be used in time series analysis.

Table 1

Variables	Australia		France		Germany		UK		USA	
ADF Unit Root Test in level form										
	Test Statistic	p-value	Test Statistic	p-value	Test Statistic	p-value	Test Statistic	p-value	Test Statistic	p-value
REXC	-1.711(1)	0.4257	-1.32(1)	0.62	-1.476 (3)	0.5452	-1.546(1)	0.5105	-2.647(2)	0.0836
FDI	-2.198(3)	0.2068	-2.78(0)	0.06	-3.494 (2)	0.0081	-4.907(2)	0	-1.841(3)	0.3604
TOT	-2.845(1)	0.0521	-1.575(1)	0.4961	-1.942 (1)	0.3127	-4.152(2)	0.0008	-3.102(2)	0.0264
GOV	-0.922 (1)	0.7805	-3.314 (1)	0.0142	-2.197 (1)	0.2074	-2.242(2)	0.1914	-2.081(3)	0.2524
TOE	-2.418(2)	0.1368	-0.865(1)	0.7992	-2.046(3)	0.2666	-0.601(1)	0.8708	-1.006(1)	0.751
INR	-1.119 (1)	0.7073	-1.343(0)	0.6092	-1.250 (1)	0.6518	-1.03(1)	0.7423	-2.037(1)	0.2705
ADF Unit Root Test for first difference										
REXC	-3.875(0)	0.0022	-5.323(0)	0	-4.556 (0)	0.0002	-3.519(0)	0.0075	-4.065(0)	0.0011
FDI	-7.576 (0)	0	-6.121(0)	0	-4.154 (0)	0.0008	-3.267(0)	0.0164	-8.554(0)	0
TOT	-4.566 (0)	0.0001	-3.942 (0)	0.0017	-4.604 (0)	0.0001	-4.051(0)	0.0012	-3.149(0)	0.0231
GOV	-4.446(0)	0.0002	-4.259 (0)	0.0005	-4.896 (0)	0.0005	-2.781(1)	0.061	-3.501(0)	0.008
TOE	-6.834(0)	0	-5.582(0)	0	-4.746(0)	0.0001	-5.108(0)	0	-6.222(0)	0
INR	-5.116 (0)	0	-5.873(0)	0	-5.724 (0)	0	-4.593(0)	0.0001	-6.235(0)	0

4.2. Co-Integration

When the variables are integrated, they might or might not be cointegrated. Therefore, we have applied Johansen cointegration for analyzing the cointegration among variables included in the model. Table 2 presents the Johansen cointegration estimation for the real effective exchange rate function in the OECD countries. According to the table, the result of Australia states that the rank is 1, i.e. there exists 1 cointegrating relation as the null hypothesis is rejected for 0. The estimation of Johansen cointegration for real effective exchange rate function in France indicates that the trace (λtrac) statistic of at most 2 is 57.862, which is greater than the 5% critical value (47.21). This can be concluded that there are three integrating vectors in the real effective exchange rate function. Similar to the estimation of Johansen cointegration for real effective exchange rate function in Germany, the trace statistic suggests that the null hypothesis of 0 is rejected at a 5% significance level, as a trace statistic (108.144) is greater than 5% critical value (94.15). This means that at least 1 stationary linear combinations of variables are cointegrated in a real effective exchange rate function in Germany in the long run.

The result of Johansen cointegration for real effective exchange rate function in the UK indicates that the null hypothesis of 2 is rejected at a 5% significance level since their trace statistic (54.463) is greater than the 95% critical value (47.21). This can be concluded that there exists 3 cointegrating equations in the real effective exchange rate function in the UK. However, the Johansen cointegration for real effective exchange rate function in the USA indicates that there are 2 cointegrating vectors. The statistic suggests that the null hypothesis of 1 is rejected at a 5% significance level since their trace statistic is 76.1319, which is greater than the 95% critical value (68.52). The results of normalized cointegration vectors of the real effective exchange rate function in the analysis countries are presented in table 3. The number in the table shows the coefficient of the long-run relationship among the variables, their standard errors and p-values. The results were performed by setting the estimated coefficient on the real effectiveness exchange equal to −1.

Table 2

No. of CEs	***Australia***		***France***		***Germany***		***UK***		***USA***	
	Trace Statistic	*Critical Value*	*Trace Statistic*	*Critical Value*	*Trace Statistic*	*Critical Value*	*Trace Statistic*	*Critical Value*	*Trace Statistic*	*Critical Value*
0	107.7794	94.15	156.604	94.15	108.1448	94.15	158.1385	94.15	123.3317	94.15
1	65.4205*	68.52	103.8029	68.52	60.8345*	68.52	91.2423	68.52	76.1319	68.52
2	31.8733	47.21	57.8626	47.21	35.7411	47.21	54.4639	47.21	45.9051*	47.21
3	17.5977	29.68	29.4564*	29.68	19.5251	29.68	26.1896*	29.68	22.3357	29.68
4	8.2559	15.41	12.9594	15.41	7.4039	15.41	11.581	15.41	7.9151	15.41
5	1.7959	3.76	4.002	3.76	0.0007	3.76	3.0105	3.76	2.78	3.76

Table 3

Variables		Australia	France	Germany	USA	UK
	Coeff.	0.6948665	-6.94E-18	-1.074705		0.0779407
FDI	*Std. Error*	0.0604495	-	0.3993137		0.0260467
	p-value	0	-	0.007		0.003
	Coeff.	1.745294	4.16E-17	6.218704	-1.183542	-
TOT	*Std. Error*	0.3021414	-	1.163906	0.1046767	-
	p-value	0	-	0	0	-
	Coeff.	-1.351978	-1.32E+00	4.912344	-1.270479	-
GOV	*Std. Error*	0.5469626	0.2691804	0.8276868	0.161955	-
	p-value	0.013	0	0	0	-
	Coeff.	-2.71428	-0.0424034	1.625622	-0.7647904	-0.8138202
TOE	*Std. Error*	0.2538633	0.0861448	0.9082809	0.0555973	0.1830516
	p-value	0	0.623	0.073	0	0
	Coeff.	-0.0205044	0.0173188	-0.0713961	0.1152041	-0.029842
INR	*Std. Error*	0.0124312	0.0063593	0.0646702	0.0219442	0.0086706
	p-value	0.099	0.006	0.27	0	0.001

Australia

As can be seen from table 3, the long-run movement in all variables in the Australian real effective exchange rate model, except INR, had significant impact on the Real Effective Exchange Rate at 5% significance level. Trade Openness (TOE) had the highest impact on Australia's real effective exchange rate. The coefficient of TOE is -2.714, which means that 1% increase in trade openness leads to 2.714 percent reduction in Australia's real effective exchange rate. Similarly, the ratio of Government expenditure to the Nominal GDP (GOV) had a negative impact on the Real Effective Exchange Rate. On the other hand, Foreign Direct Investment (FDI) and Terms of Trade (TOT) had a positive effect on the Real Effective Exchange Rate in the long-run.

France

In the case of France, only Government Expenditure (GOV) and International Reserves (INR) had an impact on the Real Effective Exchange Rate in the long-run. The ratio of Government Expenditure to the Nominal GDP (GOV) is the most important factor of those significant impacts on France's Real Effective Exchange Rate with coefficient equal -1.32. This suggests that 1% increase in GOV will lead to 1.32 percent fall in the Real Effective Exchange Rate. On the other hand the ratio of International Reserves to Nominal GDP had a positive impact on the Real Effective Exchange Rate.

Germany

The estimated long-run coefficients of the Real Effective Exchange Rate of Germany in Table 3 indicate that Foreign Direct Investment, Terms of Trade and the ratio of Government Expenditure to Nominal GDP had a significant impact (significance level 5%) on the Real Effective Exchange Rate in the long-run. Table 3 indicates that Terms of Trade (TOT) and Government Expenditure (GOV) had a positive impact on the Real Effective Exchange Rate while on the other hand Foreign Direct Investment (FDI) had a negative impact. Terms of Trade had the largest impact governed by its coefficient (6.219) followed by Government Expenditure (4.912). It implied that 1% increase in TOT will lead to a 6.22 percent rise in the Real Effective Exchange Rate while a 1 percent rise in GOV will cause the REXC to rise by ~ 5%.

United Kingdom (UK)

The statistical results of the long-run coefficients of real effective exchange in the UK in Table 3 presents that ratio of Foreign Direct Investment (FDI), Trade Openness (TOE) and International Reserves (INR) had significant long-run impacts on UK's real effective exchange rate, while it is not influenced by the Terms of Trade (TOT) and Government Expenditure (GOV). Trade Openness (TOE) appeared to be the most important factor affecting the UK's real effective exchange rate with coefficient equal to -0.814. This can be said that 1 percent increase in Trade Openness; 0.814 percent decreased in the UK's real effective exchange rate. The ratio of Foreign Direct Investment to Nominal GDP had a positive impact on the UK's real effective exchange rate while the ratio of International Reserves to the Nominal GDP had a negative impact.

United States of America (USA)

The statistical results in Table 3 point out that the ratio of Terms of Trade (TOT), Government Expenditure (GOV), Trade Openness (TOE) and International Reserves (INR) had a significant long-run impact on the USA's real effective exchange rate. Government Expenditure (GOV) had the highest negative impact governed by its coefficient (-1.27) implying that a 1% increase in the Government expenditure will lead to a 1.27 percent fall in the real effective exchange rate in the long-run. Similarly, Terms of Trade and Trade Openness had a negative impact on the real effective exchange rate. On the other hand, International Reserves had a significant positive impact on the real effective exchange rate in the USA.

4.3. The Short Run

While the previous section presents the long of real effective exchange rate determinant in 5 OECD countries by using the co-integration approach, next we investigate a short run dynamic relationship of variables included in real effective exchange rate determinant by using Vector Error Correction Model.

The results of short run real effective exchange rate determinants of 5 OECD countries, Australia, France, Germany, UK and USA are presented in an equation form below. The equations were written by eliminating the insignificant lagged variables from the model based on t-statistic.

Australia

$$\Delta REXC_{t-1} = -0.19ECT_{t-1}$$

R-square= 0.1528 Number of observations = 30 (1989-2019)

RMSE = 0.056 Log likelihood = 241.6073

Chi Square = 5.049 p value = 0.081

No. of lags = 1

$$ECT_{t-1} = REXC_{t-1} - 0.695FDI_{t-1} - 1.745TOT_{t-1} + 1.352GOV_{t-1} + 2.714TOE_{t-1}$$

In this case, the optimal lag length is 1, therefore there is only the error correction term in the model. The coefficient of the error correction term (ECTt-1) of the long run real effective exchange rate equation is -0.19. As error correction terms present the speed of adjustment to the long-run equilibrium, it can be concluded that the disequilibrium of the real effective exchange rate in Australia is able to correct approximately 19% in a year.

France

$$\Delta REXC_{t-1} = -1.164ECT^{1}_{t-1} + 0.08ECT^{2}_{t-1} - 0.398ECT^{3}_{t-1} + 0.065\Delta FDI_{t-1} + 0.093\Delta FDI_{t-2} + 0.379\Delta TOE_{t-1}$$

R-square= 0.8532 Number of observations = 28 (1989-2019)

RMSE = 0.015 Log likelihood = 394.6188

Chi Square = 63.9435 p value = 0

No. of lags = 3

$$ECT^1t-1 = REXC_{t-1} + 1.322GOV_{t-1} - 0.017INR_{t-1}$$

$$ECT^2t-1 = FDI_{t-1} - 0.458INR_{t-1}$$

$$ECT^3t-1 = TOT_{t-1} - 1.905GOV_{t-1} + 0.855TOE_{t-1} + 0.032INR_{t-1}$$

In the case of France, there are 3 long-run cointegration relations and the coefficients for all of them are significant at 10%. The coefficient for the first error correction term including REXC is -1.164, which signifies that the disequilibrium in the real effective exchange rate in France will be corrected by 116.4% within a year. The other two speeds of convergence are 8% and 39.8%. In this case, the coefficients of 1st and 2nd lag difference terms of FDI and 1st lag difference terms of Terms of Trade are also significant. All of them have a positive impact on the real effective exchange rate in the short-run.

Germany

$$\Delta REXC_{t-1} = 0.679TOT_{t-1} + 0.986TOE_{t-1}$$

R-square= 0.8738 Number of observations = 25 (1991-2019)

RMSE = 0.026 Log likelihood = 867.0311

Chi Square = 34.626 p value = 0.02

No. of lags = 4

Error Correction Term :

$$ECTt-1 = REXC_{t-1} + 1.075FDI_{t-1} - 6.219TOT_{t-1} - 4.912GOV_{t-1}$$

In the case of Germany, the coefficient of the Error Correction Term in the VECM model turns out to be not significant. In the short-run, the real effective exchange rate is determined only by the 1st lag difference terms of Terms of Trade and Trade Openness. Both have a significant positive impact, which is higher for Trade Openness. The long-run cointegration equation for Germany has already been defined in the cointegration section.

USA

$$\Delta REXC_{t-1} = -0.604ECT^{2}_{t-1} - 0.612\Delta REXC_{t-3} + 0.533\Delta FDI_{t-1} + 0.481\Delta FDI_{t-2} + 0.341\Delta FDI_{t-3} + 2.151\Delta GOV_{t-1} + 3.267\Delta GOV_{t-2} - 0.389\Delta TOE_{t-1} - 0.35\Delta TOE_{t-3} - 0.09\Delta INR_{t-1} - 0.142\Delta INR_{t-2} - 0.086\Delta INR_{t-3}$$

R-square= 0.8842 Number of observations = 36 (1980-2019)

RMSE = 0.028 Log likelihood = 504.0501

Chi Square = 106.8916 p-value = 0

No. of lags = 4

Error Correction Terms :

$$ECT^{1}t - 1 = REXC_{t-1} + 1.184TOT_{t-1} + 1.27GOV_{t-1} + 0.765TOE_{t-1} - 0.1152INR_{t-1}$$

$$ECT^{2}t - 1 = FDI_{t-1} - 0.814TOT_{t-1} + 2.043GOV_{t-1} - 2.642TOE_{t-1} - 0.16INR_{t-1}$$

In the case of the USA, the coefficient of the first Error Correction Term turns out to be not significant whereas for the second ECT, it is significant. Whereas, the short-run real effective exchange rate is determined by many other variables. The number of lags considered are 4. The 2nd lag difference term had the highest impact on the short-run REXC governed by its high coefficient 3.267. Government Expenditure and Foreign Direct Investment had a positive impact as shown by their positive coefficients for all the lag values. Whereas, Trade Openness and International Reserves had a negative impact as the coefficients obtained are negative for the different lag values.

UK

In the case of the UK, the number of cointegrating relations are coming out to be 3 according to the Johansen Cointegration test and the optimal lag length is 3 according to AIC. But the number of observations available are 21, therefore if these parameters were used, n was exceeded by the degrees of freedom, therefore the model could not be estimated by taking 3 rank and 3 lags. We have tried estimating the models for different values of lag and rank, but the VECM model with REXC as the dependent variable is not coming out to be significant. The significant long-run relation (Error Correction Term) is defined below:

$$ECT^1t-1 = REXC_{t-1} + 0.814TOE_{t-1} - 0.078FDI_{t-1} + 0.03INR_{t-1}$$

$$ECT^2t-1 = GOV_{t-1} - 0.318FDI_{t-1}$$

4.4. Validity of Assumptions

Autocorrelation

We have applied the Lagrange multiplier test to check for the presence of serial autocorrelation.

For all the countries except France, no autocorrelation was found at 10% significance level.

France: We found autocorrelation at 10% significance level for one and two lags.

Lagrange-multiplier test			
lag	chi2	df	Prob>chi2
1	63.8173	36	0.0029
2	73.5776	36	0.00022

Normality

We have used the Jarque Bera statistic to test for normality.

For all the countries except France, normality assumption holds.

France: Normality is violated for the first differenced term of Government Expenditure (GOV).

Jarque-Bera test			
Equation	chi2	df	Prob>chi2
D_lnrexc	0.482	2	0.78589
D_lnfdi	2.226	2	0.3286
D_lntot	1.929	2	0.38117
D_lngov	12.124	2	0.00233
D_lntoe	0.345	2	0.84173
D_lninr	0.305	2	0.85851
ALL	17.411	12	0.13478

Stability test

We have used the Eigenvalue stability condition. For all countries the Eigenvalues obtained have modulus less than 1, therefore, the Vector Error Correction Models are stable for all countries.

5. Conclusions

Real exchange rate analysis is an efficient benchmarking technique for any government and/or economic institution since the movement impacts investment portfolio values and has a profound impact on the import and export to and from a particular nation. This also impacts a country's ability to pay interests and other debts, hence becoming a matter of significant economic importance. Changes in the exchange rate can lead to an imbalance in international trade due to nations that have trade surpluses will expect an appreciation in their currency. However, the currencies of countries with trade deficits will depreciate and keep on falling in a spiral.

This analysis aims to analyze factors affecting real effective exchange rate in the OECD countries, including Australia, France, Germany, United Kingdom, and United States. The results indicate that the ratio of government spending to GDP has a significant impact on the real effective exchange rate in all countries except the UK. The trade opening had an influence on the real effective exchange rate in Australia, USA and UK . In addition, the international reserve (INR) had a significant long-run impact on the real effective exchange rate in France, the USA and the UK. Similarly FDI had an impact on the real effective exchange rate in Australia, Germany and the UK. Government Expenditure had a significant negative impact on all countries except Germany where it had a positive impact. The results differ a lot for every country, because most of the countries considered are developed. And developed economies have quite different economical structures. Since the effect of the real effective exchange rate on other economic activity and monetary policy should be considered for the future research as the real effective exchange rate also plays an important role in the monetary policy.

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