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THE EXCHANGE RATE DISCONNECT PUZZLE: A Panel Analysis for Developing Countries

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Abstract

This study tests the validity of the exchange rate disconnect puzzle in developing countries by using the flexible price monetary model and the sticky price monetary model of the exchange rate by employing the static and the panel data estimation techniques. The sample of the study consists of 84 developing countries and covers the time period from 1991 to 2016. The findings of the flexible price monetary model of the exchange rate by using the static and dynamic panel data estimation techniques reveal that the exchange rate disconnect puzzle does not hold in developing countries as all the variables appear statistically significant contributors of the exchange rate. In contrast, the static and dynamic panel data estimations of the sticky price monetary model of the exchange rate suggest that the exchange rate disconnect puzzle partially holds in developing countries. The robustness of the results is also checked by dividing the whole sample into three categories: low-income countries, middle-income countries and upper-middle-income countries. The robustness check also supported our previous findings that the flexible price monetary model of exchange can better explain the exchange rate movements as compared to the sticky price monetary model of the exchange rate in the context of low, middle and upper-middle-income countries.

Keywords: Exchange Rate, Monetary Policy, Interest Rate.
JEL Classification: E30, E52, E4.

I. Introduction

The mercantilists used the exchange rate as an instrument to manage the inflows and outflows of currencies. At that time, authorities mostly generated fiscal revenues by changing the official values of the precious commodities. Anecdotal evidence showed that the external forces working at the foreign exchange market altered the expected results and ended up generating different exchange rates in the domestic market. Bordazar (1736) best explains the working of the foreign exchange markets by comparing it with the musical recital because each nation is required to follow the ex-

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change rate of other countries without losing its own. In other words, we can compare the value of a currency with the melody, where the synchronization made by a few players reminds other players to match their tunes as well and leads to the up-and-down movements in the exchange rate.[1] It is also a well-known fact that the market forces such as foreign exchange traders, bankers and commercial traders cannot be ignored while analyzing the behaviour of the exchange rate.

Montesquieu stated that in this theoretical debate, 'such violent operations (attempts on the part of national governments to influence the value of precious metals or currencies) could not occur nowadays; Since the Prince who carried them out would be deceiving himself but would deceive nobody else. Currency exchange has taught the banker to compare all World currencies and to assign to them their fair value. Currency exchange has done away with outrageous abuses of authority or, at least, with their possibilities of success.'[2]

The exchange rate at that time emerged from the uncontrollable desire on the government's side to impact the relative price of precious metals or currencies relative to the currencies of other nations. Originally, the Purchasing Power Parity (PPP) model formed in the 16th century was used to test the hypothesis that two nations adjust the value of their currencies to ensure the equality of prices in both countries. However, there exists weak empirical support in favour of the PPP.[3] There are a number of economic considerations behind the failure of the PPP hypothesis, such as the existence of trade barriers, transportation costs, foreign exchange speculation, government intervention and the inclusion of non-tradable goods in the price indices construction. Some other empirical reasons for the failure of the PPP are the use of short time series data that is unable to capture statistical properties of deviations from PPP, various exchange regimes and the management of exchange rates for different regimes.

Therefore, it can say that the exchange rate determination remains an open question, but at the same time, it is quite difficult to measure empirically. Different researchers have analyzed the nexus between the fundamental economic variables and the exchange rate using different models. However, most results do not support the ability of these fundamental variables to determine the dynamic exchange rate determination for different countries.[4] Meese and Rogoff (1983) argued that the economic fundamental variables are not capable of determining the exchange rate, which has created a challenge for international economists to solve this puzzle. Obsfeldt and Rogoff (2000) observe that the seeming lack of a link between the exchange rates and other fundamental variables is one of the main open questions in international macroeconomics. It is known as the exchange rate disconnect puzzle. This study investigates the validity of the exchange rate disconnect puzzle (ERDP) for developing countries.

[1] For more details see Bordazar (1736).
[2] For details see Hirschman (1949).
[3] Rogoff (1995) and Froot and Rogoff (1995).
[4] Guerra (2003).

Major countries of the world replaced fixed exchange rate regimes with flexible exchange rate regimes from 1971 to 1973. It is also evident from the existing literature that the exchange rate has become a crucial variable in judging the economic performance of developing countries. However, one of the most important challenges faced by these countries includes how the exchange rate is determined, as their data shows that exchange rate fluctuations over time. In this regard, this study is an attempt to test the validity of the exchange rate disconnect puzzle by examining whether macroeconomic fundamental variables, including money supply differential, output differential, interest rate differential, and inflation differential, play a significant role in determining the exchange rate in the context of developing countries or not.

The rest of the paper is organized as follows: Section II presents the empirical evidence of exchange rate discount puzzles, Section III presents the theoretical framework, and Section IV presents the result and discussion. Finally, the paper is concluded with policy recommendations.

II. Exchange Rate Disconnect Puzzle: Empirical Evidence

Various researchers examined major anomalies, such as the exchange rate disconnect puzzle in the field of international economics. Meese and Rogoff (1983) analyze the US exchange rate behaviour by using three different models, i.e. the sticky price monetary, the flexible monetary and the sticky price asset model, by using monthly data from March 1973 to June 1981. The study investigates the performance of the US dollar against three major currencies, including the Japanese Yen, the British Pond and the German Deutschmark. Results indicate that all models poorly explain the movements in the exchange rate. Only the random walk without drift model performs well in explaining the exchange rate behaviour of the US economy. The study also repeats the univariate and the multivariate time series analysis after adjusting various econometrics issues such as the choice of estimation technique, sampling error, simultaneous bias, and model misspecification. However, the performance of the model does not show any improvement, which implies there exists a disconnect between the exchange rate and fundamental macroeconomic variables.

As we discussed earlier, major countries of the world replaced fixed exchange rate regimes with flexible exchange rate regimes from 1971 to 1973. In this regard, Baxter and Stockman (1989) analyze the fluctuations in various macroeconomic variables, for instance, output, government consumption, consumption and trade volatility in different exchange rate regimes for 23 OECD and 21 non-OECD countries. The study reveals that the exchange rate regime does not influence the movement of these variables. This study also highlights the possibility that countries faced the 1971 to 1973 series of global shocks, which makes it difficult to separate the exchange rate regime effect on these variables. After incorporating different episodes of exchange rate regime changes, the study reinforces its earlier findings. Moreover, the study in-

dicates that output fluctuations among countries decrease over time. From 1971 to 1973, the post data also confirm that the national output and consumption correlation increased, and the correlation in public purchases in different countries increased.

Obstfeld and Rogoff (2001) incorporate the role of trade costs in the existing macroeconomic models of the exchange rate to resolve six major puzzles of exchange rates for all OECD countries from 1975 to 1998. They argue that by including tradeable costs in the empirical analysis to resolve the home business in trade puzzle, the low consumption correlation puzzle, the home bias equities puzzle, and most importantly, the Feldstein and Horioka savings investment puzzle. However, the study suggests that a more comprehensive framework incorporating price rigidities and imperfect market characteristics, such as imperfect competition, is required to resolve the Purchasing Power Parity (PPP) puzzle and the exchange rate disconnect puzzle. Devereux and Engle (2002) extend the work of Obstfeld and Rogoff (2001) by investigating the influence of the exchange rate volatility on the macroeconomic variables with the help of the exchange rate pass-through hypothesis by using quarterly data, 1973:1- 2003:1, of G7 countries. The study highlights three major factors responsible for the exchange rate volatility; firstly, the exchange rate variations do not pass through to commodity price in the short-run, which is also termed as the lack of presence of local currency price; secondly, the existence of heterogeneity in the international goods market regarding the determination of good prices and the ways products are sold. The study assumes that some firm can sell products directly to the international market and avoids the exchange rate risk.

In contrast, others sell their products through foreign distributors, which creates the wealth effect as distributors take advantage of the exchange rate risk.[5] If these two effects are equal in magnitude, then the exchange rate will remain unaffected. However, the study assumes that exporters prefer to sell their products through their own offices to distribute their products which minimizes the wealth effect and hence the exchange rate volatility. Finally, the presence of arbitrage in the international market also restricts the exchange rate volatility. The study confirms that in the presence of the above three factors, the exchange rate shows high volatility, which causes the exchange rate to disconnect from the real economy. It also implies that the fluctuations of exchange rates have a small impact on the economy.

Engel and West (2005) examined the long-run link between the ER and fundamental macroeconomic variables by applying the standard Johansen and Juselius cointegration estimation technique. The study covers the quarterly data from 1974-I to 2001-VI for six industrialized countries of the G7 group.[6] The results of the granger causality test reject the null hypothesis of no Granger causality from the exchange rate to its fundaments for Italy, France, Japan and Germany. The hypothesis has not been rejected for Canada and the United Kingdom, which shows that the exchange

[5] "Buying goods priced in the exporter's currency and selling in the consumers' currency".
[6] The Italy,United Kingdom, Canada, Germany, Japan, France and against the U.S.

rate is not a strong predictor of interest, inflation, money supply and output differentials. However, the study indicates weak evidence in support of the hypothesis that the fundamental macroeconomic variables of the study granger cause exchange rates in five out of six countries. The findings of the study do not change drastically when the authors divide the sample into two sub-samples. The bivariate and multivariate VAR results show that the study accepts the null hypothesis of no causality in 108 tests performed to check the causality from fundamentals to the exchange rate.

In contrast, 35 out of 180 tests reject the hypothesis of no causality from the exchange rate to all fundamental macroeconomic variables. Overall, the study supports the present value models, which state that exchange rates can be utilized for the forecast of the future values of the variables such as money supply, inflation, interest and output. One possible explanation for the exchange rates disconnect theory is given by Jindrova (2007). The author opines that a micro-founded approach based on the expectations of heterogeneous economic agents can be useful in resolving the problem of the exchange rate disconnect. The author introduces the non-linearity in the micro-founded model via the transaction costs and the non-linear goods market, proving that the presence of non-linearity is the main source of the missing link between the fundamental macroeconomic variables and the exchange rate.

Kutlu (2013) investigates the long-run relationship between exchange rates and fundamental macroeconomic variables by using the Taylor rule model and the monetary model. The study covers the quarterly data over the period 1980:I to 2007:IV for 13 industrialized countries. The Panel cointegration test results favour the existence of the long-run empirical connection between the exchange rate and fundamental macroeconomic variables in both cases, i.e. the Taylor rule model and the monetary model of the exchange rate. This study also applies the panel ordinary least square estimation (DOLS) technique to measure the cointegration estimates for the Taylor rule and monetary models. The results of the Monetary Model Test specify that the money supply coefficient is significant statistically, and the sign is theoretically correct, but its value is less than unity.

Similarly, the coefficient of income is also significant statistically, but it carries an incorrect sign. In the case of the Taylor rule model, results show that the price coefficient is statistically significant, having the correct size and sign. The interest rate coefficient also appears statistically significant but with a theoretically incorrect sign. Overall, the DOLS technique does not validate the monetary model in explaining the behaviour of the exchange rate. At the same time, it provides little support for the Taylor rule model.

Evans (2010) solved the apparent exchange rate disconnect puzzle by using a micro-founded theoretical exchange rate model. He introduced the order flows rather than the fundamental real macroeconomic variables to resolve the exchange rate disconnect. The study reveals that the availability to disseminate microeconomic information to the individual economic agents outside the foreign exchange markets and

transmit to the dealers through the order flows (transaction flows) establishes a link between the macroeconomic fundamental variables and the exchange rate, which resolves the exchange rate disconnect puzzle. Moreover, Wang (2010) explains that home bias in trade reduces the influence of exchange rate fluctuations on the macroeconomic fundamental variables. In other words, if the proportion of domestic goods in the consumption bundle of the consumer is higher as compared to the foreign goods then it will disconnect the exchange rate from the macroeconomic variables of the economy. The author suggests that in such a situation, there should be minimum policy interference in the exchange rate determination because real economic variables do not influence the exchange rate.

Hosny (2013) extends Engel and West (2005) work to validate the ER disconnect puzzle for six countries[7] over the time period 1971Q1 to 2001Q2. The author assumes that all fundamental variables, including money supply differential, output differential, interest and inflation differentials play a crucial role in the ER determination. The study estimates six multivariate and twenty-four bivariate equations by applying the ARDL estimation technique.[8] The findings of the multivariate model show the existence of a long-run relationship between the ER and all its fundamental determinants. However, money supply differential, interest and inflation differentials are significant only in France, and output differential appears significant only in Canada. In the case of bivariate models, ten out of twenty-four equations indicate there exists a long-run relationship between ER and all variables of the study. The signs of all coefficients except the output differential in Germany and inflation differential in Canada carry theoretically correct signs.

Similarly, Towadros (2017) tests the exchange rate disconnect puzzle for the Australian exchange rate by utilizing the quarterly data from 1984: I to 2015: IV. The findings of the study after applying the ARDL bound testing cointegration approach confirm the existence of the long-run relationship between the exchange rate and the fundamental macroeconomic variables. Moreover, the granger causality test also resolves the ERDP, which implies that the fundamental macroeconomic variables granger causes the Australian exchange rate both in the short-run and the run.

Itskhoki and Mukhin (2017) proposed a dynamic general equilibrium model to analyze major animalities in international macroeconomics, including the exchange rate disconnect puzzle, the terms of trade puzzle, the PPP puzzle, the UIP puzzle and the Bachus-Smith puzzle, collectively referred them as the disconnect puzzle. The model building is based on two main factors: exogenous shocks (monetary shocks) and the transmission mechanism, which consists of weak substitution between foreign goods and domestic goods, home bias in consumption, and the strategic price setting complementarities. The study considers that a small but persistent shock to the international asset demand is the key driver of the exchange rate disconnect. The nominal

[7] The United Kingdom, Italy, Canada, Germany, Japan, France and against the U.S.
[8] 24 bivariate equations are consisting of 6 countries and 4 fundamentals.

rigidities, which improve the performance of the model but do not rely on the monetary shock, are not proved as a source of exchange rate disconnect.

Similarly, Wardhono, et al., (2017) also explore the validity of the ERDP for ASEAN-6 countries covering the sample period from 2001 to 2015. Unlike the previous literature on the exchange rate disconnect theory, the authors use all the variables at a level rather than taking them in differential form. The findings of the Panel Generalized Method of Moments (GMM) estimation technique reveals that interest rate and money supply are significantly and positively linked with the exchange rate, which implies that an upsurge in money supply and interest rate will depreciate the exchange rate in ASEAN-6 countries. The inflation rate and the exchange rate also have a significant but negative relationship, meaning higher inflation causes exchange rate appreciation. Contrary to other variables, the output variable does not affect the exchange rate statistically significantly. Their study concludes that the exchange rate disconnect theory does not hold for ASEAN-6, which verifies that a long-run relationship exists between the exchange rate and the macroeconomic fundamentals.

Recently, Salim, et al., (2018) investigated the ERDP for Indonesian Rupiah and the US dollar over the quarterly data from 1990: II to 2017: I. The study tests the Dornbusch-Frankel sticky price model and the Frenkel-Bilson flexible price model by using the ARDL bound testing approach. The findings of the sticky price model reveal that the model resolves the ERDP only in the short-run, implying that the macroeconomic fundamental variables are correlated with the Indonesian exchange rate. In contrast, the flexible price model fails to provide any support that there exists of correlation between the fundamental macroeconomic variables and the exchange rate in the context of Indonesia. The findings of the study suggest that the GDP growth should be considered as a primary tool to understand the exchange rate movements within Indonesia as in both models, the income differential remains significant for both the short and long-run.

The above discussion clarifies that different researchers have tried to revisit ERDP for different countries. We could not find a single study in the context of developing countries focusing on the ERDP and the influence of the fundamental macroeconomic variables shocks towards exchange rate. Wardhono et al., (2017) tested the puzzle for a sample of six ASEAN countries. However, the analysis is quite simple and incomplete because the authors do not test the validity of the ERDP by using the flexible price monetary model and the sticky price monetary model of the exchange rate, which is the heart of the analysis.

Economists subscribing to various schools of thought have attempted to solve the exchange rate disconnect puzzle. A market micro-structure-based explanation has been tried, from structural equation modelling to DSGE models. Several modifications have been tested within the DSGE approach to establish the disconnect between the exchange rate and macroeconomic fundamentals, more important of them being the incorporation of sticky prices, home bias, habit persistence, incomplete pass-

through, trade costs, etc. While they do explain disconnect to some extent, some of them remain to be empirically validated. The market microstructure models may be better predictors of exchange rate movements. However, they lack explanatory power in connecting the exchange rate movements to other macroeconomic fundamentals and may have limited use in policy formation. Therefore, we attempt to fill the gap in prior literature on the exchange rate determination and its response towards different shocks. This study analyzes the relevance of the ERDP for developing economies.

III. Theoretical Framework

1. Monetary Approaches of the Exchange Rate

Two different monetary approaches of the exchange rate are used to check the validity of the exchange rate disconnect. Frenkel (1976) and Bilson (1978) developed the first approach, the monetary model of flexible price, also called the Chicago model. Whereas the sticky price model to determine exchange rate was introduced by Dornbusch in 1976 and modified by Frankel (1979) and named the interest differential model, the flexible and sticky price models of exchange rate determination are derived from Hosny (2013).

a) The Flexible-Price Monetary Model

The two major assumptions of the flexible price model include the condition of purchasing power parity and the function of money demand. The quantity theory of money states that prices play an important role in determining the equilibrium in the money market. By using the first assumption, we can derive the money demand functions for the domestic and foreign countries in Equations (1) and (2):

$$m_t - p_t = \alpha y_t - \beta i_t \tag{1}$$

$$m_t^* - p_t^* = \alpha y_t^* - \beta i_t^* \tag{2}$$

Equations (1) and (2) represent the demand functions of money for both domestic and foreign countries, respectively.

where m_t, y_t and i_t are the logs of the domestic money stock, output level and price level in the domestic country at the time *t*. Similarly, m_t^*, y_t^* and i_t^* are the logs of all the variables of the foreign countries at the time *t*. Finally, α and β represents the income-elasticity with respect to money demand and semi-elasticity with respect to money demand, respectively.

Now the application of the PPP condition provides the price of foreign currency defined in terms of the spot nominal exchange rate (s_t), which can be obtained by taking the difference between the domestic price (p_t) and foreign price (p_t^*) levels as follows in Equation (3).

$$s_t = p_t - p_t^* \quad (3)$$

The flexible price model of exchange rate can be derived by solving the values of (p_t) and (p_t^*) from Equations (1) and (2) and then putting these values in Equation (3) and adding up the error terms. Equation (4) is formed as follows:

$$s_t = (m_t - m_t^*) - \alpha\,(y_t - y_t^*) + \beta\,(i_t - i_t^*) + \varepsilon_t \quad (4)$$

The econometric form for the monetary model of flexible price is presented in Equation (4) which assumes the same coefficients for the domestic and foreign countries. In other words, the flexible price model portrays that the money supply differential, output differential and relative interest rate are important in determining the exchange rate in an economy. The domestic currency will depreciate if the money supply growth exceeds domestically compared to a foreign country. Similarly, the domestic currency appreciates if the output growth remains higher in the domestic and foreign countries. The domestic currency also depreciates when the domestic interest rate is high compared to the foreign interest rate.

Now, rather than assuming the simple demand function, we will use the Cagan-demand function used by Frenkel (1976), who used the expected inflation rate in the money demand function despite using the interest rate:

$$m_t - p_t = \alpha y_t - \beta i\,[E\,(\pi_t)] \quad (5)$$

$$m_t^* - p_t^* = \alpha y_t^* - \beta\,[E\,(\pi_t^*)] \quad (6)$$

Equations (5) and (6) are quite like Equations (1) and (2) based on the derivation of Bilson (1978). However, the difference arises due to the Cagan-demand function, which replaces the interest rate with the anticipated inflation rate. It provides a flexible price model of exchange rate determination developed by Frenkel in 1976, and it can be written for time series and panel data as follow in Equation 7 and 8, respectively

$$s_t = (m_t - m_t^*) - \alpha(y_t - y_t^*) + \beta\,(E_t\,(\pi_t) - E_t\,(\pi_t^*)) + \nu_t \quad (7)$$

$$s_{it} = (m_{it} - m_{it}^*) - \alpha(y_{it} - y_{it}^*) + \beta\,(E_{it}\,(\pi_{it}) - E_t\,(\pi_{it}^*)) + \nu_{it} \quad (8)$$

b) <u>The Sticky-Price Monetary Model</u>

Dornbush developed the sticky price model in 1976 and later, as modified by Frankel in 1976, assumes that prices are sticky/rigid. This price stickiness slows the adjustment process once the exchange rate faces a short-run deviation from its long-run equilibrium path. The sticky price monetary theory states that the short-run nominal exchange rate overshoots its long-run level coupled with the condition of the PPP. The model uses the uncovered interest parity (UIP) condition that is written as follows in Equation (9):

$$E\,(s_{t-1} - s_t) = i_t - i_t^* \quad (9)$$

Using the UIP given through Equation (9), Frankel (1976) defines $E_t\,(s_{t-1} - s_t)$ it as a function to deviate the spot exchange rate from its equilibrium value during the long-run and inflation differential of the domestic and foreign county.

$$E\,(s_{t-1} - s_t) = -\phi\,(s_t - \bar{s}) + (\pi_t - \pi_t^*) \tag{10}$$

where ϕ shows the exchange rate's speed of adjustment when it deviates from its equilibrium level during the long-run $\bar{s}$. Now substituting Equation (9) into (10) and solving it $(s_t - \bar{s})$, we get Equation (11)

$$s_t - \bar{s} = -\frac{1}{\phi}[(i_t - \pi_t) - (\,i_t^* - \pi_t^*)] \tag{11}$$

Equation (11) provides the real interest rate differentials. Moreover, the PPP equation is as follows:

$$\bar{s} = \bar{p} - \bar{p}^* = (\bar{m} - \bar{m}^*) - \alpha\,(\bar{y} - \bar{y}^*) + \beta\,(\bar{i} - \bar{i}^*) \tag{12}$$

Equation (12) holds when $s_t = \bar{s}$ and $(i_t - \bar{i}^*) = (\pi_t - \bar{\pi}^*)$. When we combine these two conditions by assuming that the money supply and income at their equilibrium level are approximated by their current values, we get the subsequent relationship:

$$\bar{s} = p_t - p_t^* = (m_t - m_t^*) - \alpha\,(y_t - y_t^*) + \beta\,(i_t - i_t^*) \tag{13}$$

Now by putting Equation (13) into Equation (11) and solving it s_t we get Equation (14):

$$s_t = (m_t - m_t^*) - \alpha\,(y_t - y_t^*) + \frac{1}{\phi}\,(i_t - i_t^*) + (\frac{1}{\phi} + \beta)(\pi_t - \pi_t^*) \tag{14}$$

We can also write Equation (14) as follow:

$$s_t = (m_t - m_t^*) - \alpha\,(y_t - y_t^*) + \gamma\,(i_t - i_t^*) + \delta\,(\pi_t - \pi_t^*) + \omega_t \tag{15}$$

$$s_{it} = (m_{it} - m_{it}^*) - \alpha\,(y_{it} - y_{it}^*) + \gamma\,(i_{it} - i_{it}^*) + \delta\,(\pi_{it} - \pi_{it}^*) + \omega_{it} \tag{16}$$

where $\gamma\frac{1}{\phi}$ and $\delta\,(\frac{1}{\phi} + \beta)$ and ω_t is the error term.

The only difference between the Dornbusch (1976) model and the Frenkel (1976) model is that the Dornbusch model assumed that the inflation differential of Equation (15) is zero.

Based on both the flexible price model and the sticky price model of exchange rate determination, our focus would be on the estimation of Equations (8) and (15). The major difference in these two equations exists due to the anticipated inflation rate and the nominal interest differentials. In Chicago or the flexible price, model prices are flexible. A relative upsurge in the domestic interest rate as compared to the foreign interest rate would cause domestic inflation to increase relative to the foreign inflation rate and vice versa. The higher foreign interest rate also decreases the domestic currency demand compared to the foreign currency, which results in domestic

currency depreciation. Therefore, exchange and interest rate differentials are positively associated with each other.

On the other hand, the Keynesian or sticky price theory assumes fixed prices; a relative upsurge in the domestic interest rate compared to the foreign interest rate would cause the money supply to drop. Due to the stickiness of prices, prices will not adjust automatically but will fall over time. The domestic currency will be appreciated when there is an increase in the domestic interest rate relative to the foreign interest rate. Hence, the interest and exchange rates are inversely related to each other differential under the sticky price model.

2. Data Sources

The study uses the Panel data of 84 developing countries covering the period from 1991 to 2016. All the required data is sourced from the World Development Indicators (WDI) by The World Bank and the International Financial Statistics (IFS) by the IMF. The nominal exchange rate (s_t) is taken as a dependent variable, the domestic currency of the developing countries per US dollar. Following the methodology of Engle and West (2005) and Hosny (2013) we use money supply differential $(m - m^*)_{it}$, output differential $(Y - Y^*)_{it}$, consumer prices are used as a proxy of interest rate differential $(i - i^*)_{it}$ and anticipated inflation differential $(\pi - \pi^*)_{it}$ US is taken as reference country and the differentials of all variables are calculated by taking the difference of the domestic variables from that of US (which is the reference countries).

3. Estimation Technique and Methodology

The hypothesis of the ERDP will be tested by using the system GMM estimation technique.

a) <u>The System GMM Approach</u>

System GMM is the most appropriate econometric technique in a dynamic panel model to test the validity of the ERDP in the context of developing countries. According to Dollar and Kraay (2004) and Chang, et al., (2009), dynamic panel modelling addresses the problem of endogeniety along with controlling the unobserved country-specific factors in the data. Though, it is important to find out whether to apply the system GMM presented by Blundell and Bond (2000) and Arrelano and Bover (1995) or the difference GMM presented by Arrelano and Bond (1991). Generally, system GMM yields more efficient and consistent results as compared to the different GMM techniques [Baltagi (2008)]. Following the studies of Bond (2002) and Roodman (2009), we have employed the system GMM in the presence of macroeconomic variables with random walk characteristics such as output, interest rate, exchange rate and inflation; the system GMM avoids orthogonal deviations.

However, one issue with the use of the system GMM is the presence of larger instruments relative to the explanatory variables of the study, as the presence of larger instruments relative to explanatory variables results in biased estimators [Windmeijer (2005) and Roodman (2009)]. Roodman (2009) suggests that the problem of larger instruments can be resolved if instruments are divided into smaller sets and restrict ourselves to using a few lags of the endogenous variables. The system GMM estimation consists of two steps; the first step reports the Sargan test statistics, which is considered a non-robust estimation; in the second step, the Hansen J statistic, which is robust to both autocorrelation and heteroskedasticity is reported. Overall, the two-step system GMM is considered more efficient and robust as compared to the one-step estimation procedure [Windmeijer (2000)].

IV. Results and Discussion

1. Some basic Tests

a) Panel Unit Root Test

The first step to estimate panel SVAR is to test the stationarity property of the series. We apply the panel unit root test, which assumes a common unit root process to check the stationarity property of the series under consideration. The findings of the Panel unit root test are reported in Table 1. Results indicate that all variables are stationary at the level except output (*LY*). However, *LY* it becomes stationary at its first difference.

b) Descriptive Statistics

The descriptive statistics of the data are presented in Table 2, which consists of the mean, median, maximum, minimum, standard deviation and number of observations of all the variables of the study. The output level (*ly*) measured by the nominal GDP of 84 developing countries is summarized for 2119 observations. The mean and median levels of output of the developing countries are 23.562 and 23.66, respectively. The maximum output level observed in china is 30.046, and the minimum value observed in Guinea-Bissau is 19.145. Similarly, the mean and median level of the money supply is 26.11 and 26.23, respectively. The maximum level of the money supply is observed in Vietnam (36.456), and the minimum level of the money supply comes from the Congo, Dem. Rep.

The mean level of inflation in developing countries is 4.062, and the maximum and minimum level of inflation is in Sudan and Congo, Dem. Rep. respectively. Moreover, the maximum level of nominal interest rate (4820.635) was observed in Brazil in 1994, and the minimum nominal interest rate (-0.440) in Denmark in 2016. Finally, the mean value of the nominal effective ER is 3.656, and the minimum and maximum values are 9.996 and -16.773, respectively.

TABLE 1

Panel Unit Root Test (Common Unit Root Process-Levin, Lin & Chu)

Variables	Level	First Difference	Result	Order of Integration
LY	-0.537 (0.286)	-27.670 (0.000)	Stationary at first difference	*I(1)*
LM	-17.832 (0.000)	–	Stationary at Level	*I(0)*
LEINF	-25.236 (0.000)	–	Stationary at Level	*I(0)*
IR	-7.654 (0.000)	–	Stationary at Level	*I(0)*
LOER	-21.569 (0.000)	–	Stationary at Level	*I(0)*

Source: Authors' estimation.

TABLE 2

Descriptive Statistics: Developing Countries

Variable/Sample	*ly*	*lms*	*linf*	*ir*	*loer*
Mean	23.562	26.116	4.062	20.731	3.656
Median	23.266	26.231	4.350	5.880	3.450
Maximum	30.046	36.456	5.857	4820.635	9.996
Minimum	19.145	4.274	-18.492	-0.440	-16.773
Std. Dev.	2.0415	3.473	1.271	206.238	2.919
Observations	2119	2064	1971	1871	2036

Source: Authors' estimation.

2. Exchange Rate Disconnect Puzzle

We will test the validity of the ERDP by using the sticky price monetary model and the flexible price monetary model of the exchange rate. This analysis is performed by using both the static panel data approach and the dynamic panel data approach.

a) The Flexible Price Monetary Model: The Static Panel Data Estimation Analysis

In static panel modelling, we test the validity of the flexible price monetary model of the exchange rate by applying the fixed effect and random effect estimation techniques. The intercept can change within the cross-section units in the fixed effect

model, and random variations are considered independent across cross-sections. Ordinarily, autocorrelation and heteroscedasticity within each time series of each cross-sectional unit are allowed, and these can be relatively more easily tackled in estimation. In contrast, the Random effect model postulates that the cross-sectional variations are the result of overlapping but do not come from the same population.

Table 3 presents the results of the fixed effect model. The Hausman test is applied to make a choice between the random effect and the fixed effect results. Based on the Hausman test, we reject the null hypothesis, which implies that the fixed effect model is preferable over the random effect model for empirical analysis (Table 3). When we estimate the flexible price monetary model of the exchange rate by using the FE model results, the coefficient of money supply differential (0.001) carries a theoretically correct positive sign but appears statistically insignificant. On the other hand, the output/income differential statistically significantly and negatively affects the exchange rate in the case of developing countries. It indicates that an upsurge in output in developing countries will accelerate the money demand domestically, which will decrease (appreciate) the exchange rate, which will leash to the appreciation of domestic currency against the US dollar. Whereas the coefficient of the expected inflation differential (0.896) is positive and significantly statistically related to the exchange rate, which implies that an increase in expected inflation in developing countries is a major cause of the depreciation of domestic currencies towards the US dollar. Hence, according to the static panel data estimation results, the ERDP does not hold in developing countries. In other words, there exists a statistically significant relationship between the exchange rate and its macroeconomic fundamental variables except in the case of the money supply differential.

b) The Flexible Price Monetary Model: The Dynamic Panel Data Estimation Analysis

A dynamic model such as system GMM is preferable over static models such as the random effect model and fixed effect model as it resolves the issues of endogeneity, heteroskedasticity and serial correlation present in the panel data [Leitao (2010)]. This study applies the methodology of Blundell and Bond (1998) to estimate the dynamic panel model. The findings of the dynamic panel estimates are reported in Table 3. Results specify that the money supply differential coefficient (0.583) is statistically significantly associated with the exchange rate with the theoretically correct positive sign, which implies that an upsurge in money supply leashes to exchange rate depreciation in developing countries. This result is steady with the results of Mankiw (2012), Oskooee, et al., (2014), Wardhono, et al., (2017) and Salim, et al., (2018); these authors opine that an easy monetary policy of the central bank would affect the domestic interest rate and level of income which further causes outflows of capital and hence, depreciate the exchange rate. Moreover, Krugman et al., (2012) and Pozzi and Sadaba (2018) consider money supply as a significant driver of the exchange rate in emerging economies.

On the other hand, the coefficient of relative income differential is -0.614, and it is significant statistically and negatively affects the exchange rate. Similarly, the coefficient of the expected inflation differential (-0.118) is negative and significantly statistically linked with the exchange rate in the context of developing countries. In other words, an upsurge in anticipated inflation causes an appreciation of the exchange rate in developing countries. Finally, the exchange rate's own lag value (*l.ner*) is positively and statistically significantly related to the exchange rate movements. Overall, the findings of the flexible price monetary model by using the dynamic panel model (system GMM) suggest that the exchange rate disconnect puzzle does not hold in developing countries. In other words, macroeconomic fundamental macroeconomic variables, for instance, money supply differential, output differential and expected inflation differential have the ability to predict exchange rate movements. Table 3 also reports results

TABLE 3

The Flexible Price Monetary Model (1991-2016)

Variables	Fixed Effect Model	(Dynamic Panel Estimation) System GMM
C	4.0680***	0.0396
	(0.0680)	(0.2030)
l.ner	–	0.4280**
		(0.2040)
$l(m_{it} - m^*_{it})$	0.0010	0.5830***
	(0.00886)	(0.2120)
$l(Y_{it} - Y^*_{it})$	-0.0198**	-0.6140**
	(0.0097)	(0.2310)
$l(E_{it}(\pi_{it}) - E_{it}((\pi^*_{it}))$	0.8960***	-0.1180*
	(0.0135)	(0.0600)
Hauman Test	0.03	
No. of observation	1755	762
Hansen test	–	0.6230
Sargen Test		0.2460
AR(1) Arellano-Bond test	–	0.1210
AR(2) Arellano-Bond test		0.3370

Source: Author's Estimation.

Notes: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. P values are reported for the Hausman test, Hansen test, and the tests of the AR (1) and AR(2), respectively. Hausman tests:(RE model is preferred), Arellano-Bond test for AR(2): (Ho = No autocorrelation), Hansen test: (Ho=all instruments are valid). Instruments include lag values of money supply, output and inflation.

regarding the validity and exogeneity of additional instruments and other exogenous regressors through the Sargan and Hansen tests. In both cases, we accept the null hypothesis that instruments are valid. Moreover, AR (2) in the first difference of the Arellano and Bond test suggests no autocorrelation problem in the data.

3. The Sticky Price Monetary Model

a) The Sticky Price Monetary Model: The Static Panel Data Estimation Analysis

The static panel data estimation of the exchange rate sticky price monetary model is performed using the random and fixed effect estimation techniques. The Hausman test is used to make a choice between these two models. Based on the Hausman test, we prefer the fixed effect over the random effect model (Table 3).[9] The results are specified in Table 3. The results of the fixed effect model indicate that the coefficients of the relative income differential, money supply differential, and the expected inflation differential statistically significantly affect the movements of the exchange rate in developing countries and their signs are steady with the flexible price monetary model of the exchange rate reported earlier. However, the interest rate differential is the additional variable which differentiates between the flexible price monetary model and the sticky price monetary model. The coefficient of the interest rate differential carries a negative sign that is correct theoretically, but the value of its coefficient is quite small (-0.0000516) which makes its impact almost negligible on the exchange rate.

Such a small magnitude can be attributed to a possible endogeneity problem in the model which may exist between the interest rate and money supply variables. Campos and Kinoshita (2008) argue that the fixed effect model yields biased estimates when regressors are correlated with the error term. Whereas Arellano (2003) argues that the random effect model, which assumes a common intercept gives more robust results by addressing the issue of the degree of freedom within the model. Though, the random effect model is considered time-invariant. Thereby, the error term in any period can be found uncorrelated with past, present, and future.

Contrary to the static models, such as the random effect and the fixed effect models, the dynamic panel models, such as system GMM, addresses the issue of endogeneity by using the internally generated set of instruments. Another benefit of dynamic panel modelling is that the error term is not correlated with all the variables included in the model. Thus, the difference and lags of the variables can be used as a valid instrument. Hence, the dynamic Panel models are considered as more diverse estimation techniques such as the dynamic panel model (system GMM) which tackles the issue of endogeneity.

[9] Null hypothesis is rejected; random effect model is preferable over the fixed effect model.

b. The Sticky Price Monetary Model: The Dynamic Panel Data Estimation Analysis

The findings of the dynamic panel data estimates by using the system GMM technique reveal that the inclusion of the interest rate differential in the flexible price monetary model has not improved the results of the study. This is obvious from Table 4 that only the money supply differential and the relative income differential appear significant statistically at a one per cent significance level, carrying correct signs theoretically. In contrast, both inflation differential and interest rate differential are not proven significant contributors of the exchange rate movements in developing countries. The results also confirm the finding of the Dornbusch-Frankel sticky price monetary model

TABLE 4

The Sticky Price Monetary Model (1991-2016)

Variables	Fixed Effect Model	(Dynamic Panel Estimation) System GMM
C	1.1920***	
	(0.0832)	
l.ner		0.3900***
		(0.0810)
$l(m_{it} - m^*_{it})$	0.3620***	0.6240***
	(0.0162)	(0.0828)
$l(Y_{it} - Y^*_{it})$	-0.5830***	-0.6580***
	(0.0181)	(0.0968)
$l(E_{it}(\pi_{it}) - E_{it}((\pi^*_{it}))$	0.6070***	-0.1530
	(0.0165)	(0.0940)
$(i_{it} - i^*_{it})$	-0.0000516**	0.000256
	(0.0000208)	(0.000211)
Hauman Test	0.04	
No. of observation	786	763
Hansen test	-	0.6750
Sargen Test		0.1180
AR(1) Arellano-Bond test	-	0.1260
AR(2) Arellano-Bond test		0.1180

Source: Authors' estimation.

Notes: Notes: *** p<0.01, ** p<0.05, * p<0.1ii)Standard errors in parentheses. Hansen test, the tests of the AR(1) and AR(2), p values are reported for the Hausman test, respectively. Hansen test: (Ho=all instruments are valid), Hausman tests:(RE model is preferred), Arellano-Bond test for AR(2): (Ho = No autocorrelation), instruments include lag values of money supply, output and inflation.

that the coefficient of the own lag of exchange rate (*l.ner*) variable with a positive sign statistically significantly affects the exchange rate movements. Overall, results indicate that the exchange rate disconnect puzzle partially holds in developing countries when we estimate the sticky price monetary model of the exchange rate. Table 4 also reports the results of the Sargan and the Hansen tests to check the validity of the instruments used in the model estimation process. We accept the null hypothesis in both cases that instruments are valid. Moreover, AR (2) in the first difference for Arellano and Bond test suggests that there is no problem of autocorrelation in the data.

On the basis of the above discussion, we can draw two important conclusions: firstly, dynamic Panel data estimation technique like system GMM is preferable over the static panel data estimation technique; secondly, the comparison of the sticky and flexible price monetary models shows that the flexible price monetary model can better explain the exchange rate movements in developing countries. In other words, macro-economic fundamental variables completely explain the exchange rate behaviour when we utilize the flexible price monetary model.

TABLE 5

The Flexible Price Monetary Model (1991-2016)
(Dynamic Panel Estimation) System GMM

Variables	Low-Income Countries	Middle-Income Countries	Upper Middle-Income Countries
C	0.870	0.341	0.661
	(0.842)	(0.202)	(0.231)
l.ner	0.383*	0.556**	0.241**
	(0.166)	(0.207)	(0.855)
$l(m_{it} - m^{*}_{it})$	0.453**	0.427*	0.748***
	(0.156)	(0.207)	(0.093)
$l(Y_{it} - Y^{*}_{it})$	-0.545**	-0.405*	-0.677***
	(0.201)	(0.209)	(0.065)
$l(E_{it}(\pi_{it}) - E_{it}((\pi^{*}_{it}))$	0.128	-0.109*	-0.069
	(0.143)	(0.061)	(0.0803)
Hansen test	0.324	0.731	0.542
Sargen Test	0.764	0.117	0.321
AR(1) of Arellano-Bond test	0.383	0.971	0.121
AR(2) of Arellano-Bond test	0.221	0.165	0.312

Source: Authors' estimation.

Notes: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. Instruments include lag values of money supply, output and inflation.

4. Robustness Check

In the previous section, we checked the validity of the ERDP by using two different monetary models of the exchange rate. The findings indicate that the flexible price monetary model of exchange rates can better explain the exchange rate movements in developing countries. In other words, macroeconomic fundamental variables completely explain the exchange rate behaviour when we use the flexible price monetary model. Now the question arises whether our findings are robust as we use the whole sample of the developing countries directly. Thus, we checked the robustness of our results by dividing the whole sample into three groups comprised of low-income countries, middle-income countries and upper-middle-income countries. The exchange rate's flexible price monetary model is assessed using the system GMM and the results are shown in Table 5. Results indicate that the ERDP does not hold in the case of low,

TABLE 6

The Sticky Price Monetary Model (1991-2016)
(Dynamic Panel Estimation) System GMM

Variables	Low-Income Countries	Middle-Income Countries	Upper Middle-Income Countries
C	0.895	0.418	0.232
	(0.697)	(0.344)	(0.245)
l.ner	0.445*	0.296**	0.540***
	(0.210)	(0.107)	(0.149)
$l(m_{it} - m^{*}_{it})$	0.387**	0.679***	0.465***
	(0.153)	(0.999)	(0.152)
$l(Y_{it} - Y^{*}_{it})$	-0.455**	-0.655***	-0.456***
	(0.178)	(0.120)	(0.145)
$l(E_{it}(\pi_{it}) - E_{it}((\pi^{*}_{it}))$	-0.460	-0.135	-0.152
	(0.418)	(0.087)	(0.115)
$(i_{it} - i^{*}_{it})$	0.0089	0.0087	0.00027
	(0.0083)	(0.0001)	(0.00019)
Hansen test	0.432	0.812	0.198
Sargen Test	0.652	0.612	0.512
AR(1) of Arellano-Bond test	0.135	0.871	0.432
AR(2) of Arellano-Bond test	0.542	0.563	0.241

Source: Authors' estimation.

Notes: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. Instruments include lag values of money supply, output and inflation.

middle and upper-middle-income countries. In other words, macroeconomic fundamental variables successfully explain the exchange rate behaviour in low-income, middle-income, and upper-middle-income countries.

Similarly, the sticky price monetary model is examined by using the system GMM and findings reported in Table 6 findings indicate that the inclusion of the interest rate in the flexible price monetary model has not improved the results of the study as in all cases as the interest rate coefficient remains statistically insignificant.

Overall, the robustness check also shows that the flexible price monetary model of exchange rate performs relatively better than the sticky price monetary model in the case of low, middle and upper middle-income countries, which re-confirm the earlier findings of the study when the whole sample of the developing countries is used directly.

V. Conclusions and Policy Recommendations

This study aims to analyze the behaviour of exchange rates in the context of developing countries. It is an eminent fact that the exchange rate significantly influences trade balance, allocation of resources, return to assets, the balance of payment, debt burden and overall economic performance of a country. Exchange rate instability reduces economic efficiency, and capital flight misallocates recourses and creates instability. Therefore, sudden and unexpected changes in the exchange rates have received significant attention in discussions of macroeconomic policy as a vital source of macroeconomic disequilibrium. Consequently, the exchange rate can be broadly used as a policy instrument that responds to the movements of macroeconomic variables and policy-induced shocks.

The significance of the exchange rate in the macroeconomic stability of developing countries, we have analyzed the behaviour of the exchange rate by using two different approaches. In the first approach, we explored the validity of ERDP by using two different monetary models of the exchange rate: the flexible price monetary model and the stick-price monetary model. This analysis is performed by using both the static and dynamic panel data approaches. The results of the static panel data estimation analysis for the flexible price monetary model of exchange rate indicate that the ERDP does not hold in developing countries, which indicates a statistically significant association among the exchange rate and its fundamental macroeconomic variables except in the case of money supply differential. The findings of the static panel data estimation analysis for the sticky price monetary model also support the stance that the ERDP does not hold in developing countries. However, the magnitude of the interest rate variable, which differentiates between the flexible price model and the sticky price model, is quite small, which makes its impact quite negligible on the exchange rate. Such a small magnitude can be attributed to a possible endogeneity problem in the model, which exists between the interest rate and the money supply

variables. It creates uncertainties about the robustness of the results obtained from the static panel data estimation method. Therefore, we move to dynamic panel modelling, which addresses the issues of endogeneity.

The findings of the flexible price monetary model by applying the dynamic panel model (system GMM) suggest that macroeconomic fundamental variables like money supply differential, output differential and expected inflation differential have the ability to predict the exchange rate movements. In other words, the exchange rate disconnect puzzle does not hold in developing countries. In contrast, the sticky price monetary model using the system GMM indicates that only the money supply differential and the relative income differential appear statistically significant. Whereas both inflation differential and interest rate differential are not proven significant contributors in movements of the exchange rate in developing countries which specify that the ERDP partially holds in developing countries. Overall, the comparison of the flexible and sticky price monetary models depicts that the flexible price monetary model can better explain the movements of the exchange rate in developing countries. In other words, macroeconomic fundamental variables completely explain the exchange rate behaviour when we use the flexible price monetary model.

The policy implication of the study is straightforward: the finding that the exchange rate disconnect puzzle doesn't hold in developing countries suggests that developing countries need to formulate economic policies with regard to attaining desired variations in the exchange rate fundamntals, so these fluctuations in the exchange rate can be minimized or avoided.

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