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Analysis of the asymmetric response of exchange rate to interest rate differentials: Evidence from the MINT countries

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Abstract

The asymmetric response of exchange rate to interest rate differential is empirically examined for the MINT countries. Consequently, we formulate a nonlinear autoregressive distributed lag model that accounts for asymmetries and structural breaks. We find that exchange rate responds asymmetrically to interest rate differential both in the long run and short run. Our results lend support to the sticky price hypothesis to justify the use of conventional policy tools for short run stabilisation. The same is established for the long run to drive in foreign investment flows. We argue contrarily for unconventional policies in Nigeria to correct short run fluctuations and to encourage long run investment flows given the positive relationship obtained in both time horizons.

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1.0 Motivation

The relationship between interest rates and exchange rates has been studied extensively in the literature (see Moosa and Burns, 2014 a,b,c; Ozmen and Yilmaz, 2017, for a review). The nexus is relevant given that central banks usually use interest rate and exchange rate policies to control inflation. In addition to such considerations, the economics behind the study of the nexus lies in validating either the sticky-price thesis (short run negative relationship) or flexible-price thesis (short run positive relationship) (see Frankel, 1979). By implication, if sticky-prices hold, demand and supply does not react instantaneously to fix disequilibrium in the economy, hence, monetary policy has prominent role to play in stabilizing the economy. This is unlike the flexible prices where market forces respond promptly to macroeconomic shocks to leave little role for conventional policy tools.

This paper focuses on MINT countries (Mexico, Indonesia, Nigeria and Turkey) to reassess the relationship between interest rate differentials and exchange rates given the roles of asymmetry and structural breaks in the predictive models. Virtually all the known studies in the related literature analyze the nexus from the symmetric perspective (see for example, Bautista, 2006; Tafa, 2015; Ndako and Mobolaji, 2015). Nonetheless, studies such as Engel (2016) and Golit et al. (2019) have argued that the relation may change depending on time horizon. The study of asymmetric effects allow us to understand how exchange rate react to positive and negative differentials in interest rate where positive (long run) relationship indicates that investors prefer the foreign country for investment, leading to exchange rate appreciation and vice versa (see Auten, 1963). This knowledge is important to central banks particularly when confronted with the choice of raising interest rate to attract foreign portfolio investors.

The paper is structured into four sections. Sequel to this section, Section two provides the methodology and data. The analysis of empirical results is presented in section three and Section four concludes.

2.0 Model and data issues

We adopt the models synthesis of Frankel (1979) where the fundamentals of exchange rate determination consist of the growth of money supply, output growth, prices and the short-term interest rate for both the domestic and foreign countries of the bilateral exchange rate. For the purpose of empirical analyses, the Autoregressive Distributed Lag (ARDL) model depicting the relationship is specified in equation (1)[1].

$$\begin{aligned}\Delta s_t &= c + \phi_1 s_{t-1} + \beta_1\left(m_{t-1} - m^*_{t-1}\right) + \delta_1\left(\pi_{t-1} - \pi^*_{t-1}\right) + \lambda_1\left(i_{t-1} - i^*_{t-1}\right) + \gamma_1\left(y_{t-1} - y^*_{t-1}\right) \\ &+ \sum_{j=1}^{p}\phi_{2j}\Delta s_{t-j} + \sum_{i=0}^{q_1}\beta_{2i}\Delta\left(m_{t-i} - m^*_{t-i}\right) + \sum_{i=0}^{q_2}\delta_{2i}\Delta\left(\pi_{t-i} - \pi^*_{t-i}\right) + \sum_{i=0}^{q_3}\lambda_{2i}\Delta\left(i_{t-i} - i^*_{t-i}\right) \\ &+ \sum_{i=0}^{q_4}\gamma_{2i}\Delta\left(y_{t-i} - y^*_{t-i}\right) + \varepsilon_t\end{aligned} \tag{1}$$

[1] The choice of this model is underscored by the mixed order of integration evident in the unit root analyses for the relevant series (see Table 2).

where s_t is the logarithm (log) of the bilateral exchange rate (domestic currency/US$); m_t is the log of the domestic nominal money supply, π_t is the inflation rate, i_t is the interest rate, y_t is output growth while the corresponding foreign variables (using US data) are denoted with an asterisk, c is an arbitrary constant, and ε_t is a disturbance term. Other variables are included to avoid omitted variable bias. The "differential" variable is obtained by subtracting the domestic variable from its foreign counterpart.

We follow the Shin et al. (2014) approach to decompose interest rate differential into positive and negative changes to account for asymmetries between interest rate differential and exchange rate in equation (2).

$$\begin{aligned}\Delta s_t &= c + \phi_1 s_{t-1} + \beta_1\left(m_{t-1} - m^*_{t-1}\right) + \delta_1\left(\pi_{t-1} - \pi^*_{t-1}\right) + \lambda_1^+\left(i_{t-1} - i^*_{t-1}\right)^+ + \lambda_1^-\left(i_{t-1} - i^*_{t-1}\right)^- \\ &+ \gamma_1\left(y_{t-1} - y^*_{t-1}\right) + \sum_{j=1}^{p}\phi_{2j}\Delta s_{t-j} + \sum_{i=0}^{q_1}\beta_{2i}\Delta\left(m_{t-i} - m^*_{t-i}\right) + \sum_{i=0}^{q_2}\delta_{2i}\Delta\left(\pi_{t-i} - \pi^*_{t-i}\right) \\ &+ \sum_{i=0}^{q_3}\lambda_{2i}^+\Delta\left(i_{t-i} - i^*_{t-i}\right)^+ + \sum_{i=0}^{q_4}\lambda_{2i}^-\Delta\left(i_{t-i} - i^*_{t-i}\right)^- + \sum_{i=0}^{q_5}\gamma_{2i}\Delta\left(y_{t-i} - y^*_{t-i}\right) + \varepsilon_t\end{aligned} \tag{2}$$

The computation of the asymmetric effect follows the Shin et al. (2014) approach where $\left(i_{t-1} - i^*_{t-1}\right)^+$ and $\left(i_{t-1} - i^*_{t-1}\right)^-$ are computed as positive and negative partial sum decompositions of interest differential respectively as follows:[2]

$$\left(i_{t-1} - i^*_{t-1}\right)^+ = \sum_{k=1}^{t}\Delta\left(i_{t-1} - i^*_{t-1}\right)^+ = \sum_{k=1}^{t}\max\left(\Delta\left(i_{t-1} - i^*_{t-1}\right), 0\right) \tag{3}$$

$$\left(i_{t-1} - i^*_{t-1}\right)^- = \sum_{k=1}^{t}\Delta\left(i_{t-1} - i^*_{t-1}\right)^- = \sum_{k=1}^{t}\min\left(\Delta\left(i_{t-1} - i^*_{t-1}\right), 0\right) \tag{4}$$

The study uses monthly time series data from 2000Q1 to 2018Q4 for the MINT countries (Mexico, Indonesia, Nigeria and Turkey). The data were sourced from the International Monetary Fund (IMF) International Financial Statistics (IFS) and the Federal Reserve (FRED) online database. The variables used as indicated in the estimable equations are the bilateral exchange rate, interest rates, industrial production index, inflation rate, and money growth.

3.0 Discussion of results

3.1 Preliminary Analysis

We render some preliminary analyses to highlight the salient properties of the series of interest (see Table 1 and Figure 1). A striking observation from the mean figures show that Indonesia has the lowest average exchange rate value over the period while Nigeria has the highest. The country with the lowest has the highest industrial productivity index with relatively high domestic interest rate which if it exceeds foreign interest rate may attract investment flows and be responsible for domestic currency appreciation in the short run and higher productivity in the long run. In the same vein, the graphs in Figure 1 indicate that the relationship between exchange rate and interest is predominantly negative as the graphs are diverging in most cases. The economic implication of this is that a higher domestic interest rate (above the foreign) may attract foreign portfolios/capital

[2] Several studies have also adopted this approach in the analyses of asymmetric response of exchange rate (see Salisu and Ndako, 2018).

inflows thereby increasing the supply of forex which consequently strengthens the domestic currency. If the positive interest rate differential is sustained over considerable length of time, the impacts on long run domestic capital formation on productivity will be huge. We also conduct unit root test (with structural breaks) for the relevant variables and the results are presented in Table 2. The results indicate that the variables are predominantly of mixed order of integration [i.e. both $I(0)$ and $I(1)$]. Thus, the consideration of ARDL framework that accommodates such features is justified.

Table 1: Summary Statistics

Variable	Mexico		Indonesia		Nigeria		Turkey	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
s_t	107.03	23.76	98.48	18.65	110.28	33.55	106.09	59.20
i_t	7.32	3.41	14.04	2.57	18.22	2.57	4.83	1.91
π_t	0.36	0.34	0.54	0.74	2.99	2.27	1.10	1.36
m_t	59.33	34.25	58.64	37.73	52.89	38.89	224.90	170.77
y_t	102.44	6.51	118.01	13.37	107.35	10.81	106.00	34.80

Figure 1: Relationship between exchange rate and interest rate differentials in MINT

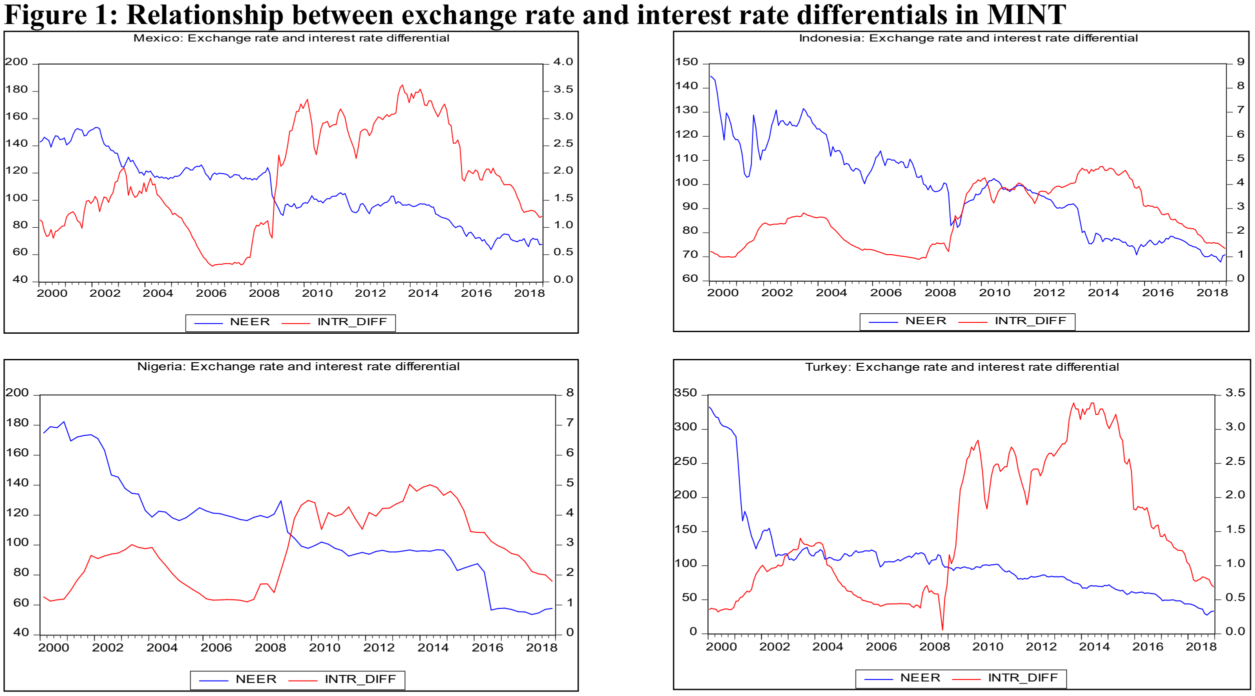

Table 2: Unit Root Test

Variable	Mexico		Indonesia		Nigeria		Turkey	
	ADF-SB	I(d)	ADF-SB	I(d)	ADF-SB	I(d)	ADF-SB	I(d)
s_t	-13.391*$^{\lambda}$	I (1)	-13.521*$^{\lambda}$	I (1)	-12.625*$^{\#}$	I(1)	-11.387*$^{\#}$	I(1)
i_t	-15.439*$^{\#}$	I (1)	-7.623*$^{\lambda}$	I (1)	-4.919*$^{\lambda}$	I(0)	-7.407*$^{\lambda}$	I(1)
i_t^*	-11.260*$^{\#}$	I (1)	-11.260*$^{\#}$	I (1)	-11.260*$^{\#}$	I(1)	-11.260*$^{\#}$	I(1)
π_t	-19.101*$^{\lambda}$	I (1)	-17.567*$^{\#}$	I (0)	-13.539*$^{\lambda}$	I(1)	-11.315*$^{\#}$	I(0)
π_t^*	-16.118*$^{\#}$	I (1)	-16.118*$^{\#}$	I (1)	-16.118*$^{\#}$	I(1)	-16.118*$^{\#}$	I(1)
m_t	-21.720*$^{\lambda}$	I (1)	-16.473*$^{\#}$	I (1)	-8.416*$^{\lambda}$	I(1)	-8.215*$^{\#}$	I(1)
m_t^*	-13.302*$^{\lambda}$	I (1)	-13.302*$^{\lambda}$	I (1)	-13.302*$^{\lambda}$	I(1)	-13.302*$^{\lambda}$	I(1)
y_t	-4.638*$^{\lambda}$	I (0)	-5.550*$^{\#}$	I (0)	-4.822*$^{\#}$	I(0)	-8.773*$^{\#}$	I(0)
y_t^*	-4.568*$^{\lambda}$	I (0)	-4.568*$^{\lambda}$	I (0)	-4.568*$^{\lambda}$	I(0)	-4.568*$^{\lambda}$	I(0)

Note: (*) denotes statistical significance at 5% level; λ and # denote test equations 'with constant only', and 'with constant and trend' respectively. ADF-SB denotes Augmented Dickey Fuller test with structural breaks and I(d) represents order of integration.

3.2 The main results

The results of the asymmetric ARDL model for the four countries examined are presented in Table 3. There are statistical and economic facts of the results and are addressed presently. Statistically, we find evidence of cointegration between exchange rate and interest rate differentials for the MINT countries although the choice of test equation appears to matter particularly for Indonesia and Nigeria. Two, our results lend support to the asymmetric response of exchange rate to interest rate differentials in the countries except for short run asymmetry in Nigeria. Three, we show the need to account for structural breaks in the NARDL model given significant improvements in the asymmetric response of exchange rate to interest rate differential when we accounted for structural breaks (note that these findings support the studies of Engel, 2016 and Ozmen and Yilmaz, 2017 that the relationship depend on time horizon). Four, the serial correlation and heteroscedasticity diagnostics tests indicate that the estimated models are correctly specified and permit meaningful economic discussions to be teased out from the results.

Speaking in economic sense, we report both the unstandardized (***B***) and standardized (***Beta***) coefficients.[3] The latter is useful for comparison to tease out the economic impact of a one-standard deviation change in interest rate differential on exchange rate. The standard coefficients in a way confirm the asymmetry in the nexus as the stronger of the positive or negative asymmetries consistently turn up with higher standardized coefficients. In the short run, one standard deviation decrease in interest rate differential causes exchange rate appreciation in Indonesia to increase by 0.84 standard deviation, in Mexico by 0.23 standard deviation and in Turkey by 0.07 standard deviation. The exception is Nigeria where one standard deviation increase in interest rate differential still increase exchange rate by 0.19 standard deviation in the short run. Hence, we

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[3] The standardized coefficients are calculated as: $Beta = B * s_{x_i} / s_y$ **;** B is the unstandardized coefficient, s_{x_i} is the standard deviation of the regressors and s_y is the standard deviation of the dependent variable.

validate the sticky-price hypothesis for the MINT countries since the negative effects overwhelms the positive effects in three out of the four countries.

In the long run, one standard deviation decrease in interest rate differential raises exchange rate by 1.27 and 1.22 standard deviations in Mexico and Turkey respectively. The reverse is noticed in Indonesia although the relationship is also negative. In Indonesia in the long run, we notice that a one standard deviation increase in the differential reduces exchange rate by 0.95 standard deviation. Positive long run relationship is obtained for Nigeria. The exceptional case of Nigeria may be connected to high inflation rate in Nigeria (in addition to other factors beyond the scope of this study) which may discourage capital inflows even in the face of high domestic interest rate.

Two policy implications are discernible from the foregoing results. One, the short run results in support of the sticky-price thesis and the predominant negative relationship found in the long run give strong backing for the monetary institutions in Mexico, Indonesia and Turkey to continue to employ monetary policy rate that influence the interest rate and prices for stabilizing the macroeconomic shocks. Two, the positive relationships observed for Nigeria call for measures to complement the conventional monetary policy to attract foreign portfolio investors given that positive interest rate differentials are causing exchange rate appreciation as against the reverse. There may be need to explore unconventional means for the case of Nigeria.

Table 3: the Nonlinear ARDL results

Variable	**Mexico**		**Indonesia**		**Nigeria**		**Turkey**	
	B	**Beta**	**B**	**Beta**	**B**	**Beta**	**B**	**Beta**
$\left(i_t - i_t^*\right)^+$	0.0324	0.5220	-0.0574*	-0.9556	0.0949*	0.9131	0.02882	0.1898
	(0.0240)		(0.0235)		(0.0424)		(0.0447)	
$\left(i_{t-1} - i_{t-1}^*\right)^-$	0.0967*	1.2750	0.0244	0.4248	0.0253	0.1895	0.2277*	1.2240
	(0.0208)		(0.0174)		(0.0681)		(0.0928)	
$\left(i_t - i_t^*\right)^+ = \left(i_{t-1} - i_{t-1}^*\right)^-$	-0.0623*		-0.0815*		0.0696*		-0.1988*	
	(0.0060)		(0.0046)		(0.0157)		(0.0071)	
$\Delta\left(i_t - i_t^*\right)^+$	0.0058	0.0906	-0.1700*	-3.0759	0.0206*	0.1982	0.00174	0.0115
	(0.0040)		(0.0276)		(0.0104)		(0.0028)	
$\Delta\left(i_t - i_t^*\right)^-$	0.0174*	0.2312	0.0634*	0.83850	0.0055	0.0411	0.0138*	0.0742
	(0.0043)		(0.0211)		(0.0148)		(0.0042)	
$\Delta\left(i_t - i_t^*\right)^+ = \Delta\left(i_t - i_t^*\right)^-$	-0.0115*		-0.2267*		0.0151		-0.0120*	
	(0.0058)		(0.0395)		(0.0178)		(0.0029)	
ECT_{t-1}	-0.1799*		-0.1491*		-0.2170*		-0.0606*	
	(0.0313)		(0.0187)		(0.0592)		(0.0121)	
Bounds (F)	5.3840*		10.2571*		3.6452*		4.0861*	
R^2	0.9911		0.9875		0.9773		0.9952	
F-Stat	2694.25*		1177.30*		242.93*		4541.63*	
SIC	-4.6164		-4.5529		-2.5925		-3.8373	
Q-stat (5)	4.0427		1.5364		4.4177		5.9759	
Q^2-Stat (5)	4.2449		2.9615		0.3380		15.124*	
ARCH-LM(5)	0.7794		0.5439		0.0578		2.7851	

Note: The results of the control variables have been suppressed for brevity. **(*)** denotes statistical significance at 5% level; values in ( ) denotes standard errors; SIC is Schwartz Information Criterion; Q-Stat and Q^2 Stat are serial correlation tests with the null hypotheses of no serial correlation and ARCH-LM is heteroscedasticity test with the null hypothesis of no heteroscedasticity. The nulls: $\Delta\left(i_t - i_t^*\right)^+ = \Delta\left(i_t - i_t^*\right)^-$ and $\left(i_t - i_t^*\right)^+ = \left(i_{t-1} - i_{t-1}^*\right)^-$ test the short and long run asymmetric effects respectively.

4.0 Conclusion

This study examines the relationship between interest rate differential and exchange rate in the MINT countries. Consequently, it offers two innovations to the extant literature on the subject. It allows for asymmetries in the predictive model and accounts for the role of structural breaks. We validate the sticky-price hypothesis for three of the four countries, therefore establishing role for conventional monetary policy to correct short run macroeconomic shocks in the countries. The exception in Nigeria appears to defy conventional monetary policy in the short run. This is also established in the long run for Nigeria where despite high domestic interest rate, positive interest rate differential leads to domestic currency depreciation. The rest of the three countries are encouraged to continue with their conventional monetary policies to continue to attract foreign capital/investment.

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