Exchange Rate Behavior in the BRICS

Comportamento da Taxa de Câmbio nos BRICS

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RESUMO: O artigo tem por objetivo investigar o comportamento da taxa de câmbio nos países do BRICS com ênfase no repasse da taxa de câmbio e em modelos empíricos de determinação da taxa de câmbio. O artigo aplica metodologia ARDL Bounds Testing de Janeiro de 2005 a Dezembro de 2019. Os principais resultados indicam que: i) existe uma relação cointegrante de longo prazo entre as variáveis analisadas para todos os modelos estimados; ii) a velocidade de ajustamento em direção ao equilíbrio de longo prazo é lenta: iii) existe evidência de repasse cambial para a inflação, principalmente no longo prazo, mas o repasse não é tão expressivo como antes; iv) não existe evidência de ultrapassagem da taxa de câmbio; v) a acumulação de reservas pode ser considerada como uma explicação parcial para a evidência de não ultrapassagem da taxa de câmbio.
PALAVRAS-CHAVE: Taxa de câmbio; inflação; ultrapassagem; repasse cambial; ARDL; cointegração.

ABSTRACT: This article aims to investigate the behavior of exchange rate in the BRICS countries, with an emphasis on exchange rate passthrough and exchange rate determination empirical models. By applying the ARDL Bounds Testing Approach Methodology, from January 2005 to December 2019. Our main results show that: i) there is a long run cointegration among the variables analyzed for all estimated models; ii) there is a very slow speed of adjustment towards the long run equilibrium; iii) there is evidence of exchange rate passthrough to inflation mainly in the long run, but not as strong as before; iv) there is no evidence of exchange rate overshooting; v) international reserve accumulation can be considered a partial explanation for the evidence of no exchange rate overshooting.
KEYWORDS: Exchange rate; inflation; overshooting; passthrough; ARDL; cointegration.
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1. INTRODUCTION

Topics related to exchange rate movements have always been subject to analysis by economists and researchers in general, as they impact everyone's lives in many ways, such as in business and trade. In economics, specifically, there are some important phenomena that are worth mentioning. One of them is the so-called exchange rate passthrough, which is based on the argument that, in a more globalized world environment, exchange rate movements are more likely to have an impact on domestic prices and, consequently, on inflation. Another one is how exchange rates are determined and how these dynamics differ amongst countries. In fact, exchange rate determination models enable us to analyze the consequences of excessive fluctuation and volatility of exchange rate, which can lead to an overshooting phenomenon. These models can also help to understand the role of international reserves in preventing exchange rate volatility and in helping to cushion external shocks to the balance of payments.

Issues related to exchange rate dynamics are also relevant the New Developmentalism Approach (Bresser-Pereira and Gala, 2010; Bresser-Pereira, 2012; Bresser-Pereira et al., 2014), which emphasizes the long-run currency appreciation problems brought by an economic expansion based on a foreign saving strategy and/or by the so-called Dutch Disease. This line of research highlights, among other aspects, the importance of keeping an industrial equilibrium exchange rate, so that a high technology industrial sector can be competitive globally and domestically (Bresser-Pereira et al., 2022).

This article aims to analyze issues related exchange rate dynamics and passthrough in the BRICS, for the period ranging from January 2005 to December 2019, especially after the international financial crisis. A key feature of this period is that the BRICS country-members faced periods of terms-of-trade improvements, especially due to increases in commodity prices. This scenario was favorable for international reserve accumulation and helped mitigate, or even neutralize, excessive exchange rate volatility.

By making use of ARDL Bounds Testing Approach to Cointegration methodology, our results show some important characteristics: i) there is a long run cointegration among the variables analyzed for all estimated models; ii) whenever a short run shock occurs, there is a slow speed of adjustment towards the long run equilibrium, averaging 8.6% for the exchange rate determination model, and 3.1% for the exchange rate passthrough model; iii) there is indication of passthrough from exchange rate to inflation, especially in the long run, but such phenomenon doesn't seem to be so strong as before; iv) short run monetary coefficients show no evidence of exchange rate overshooting; v) the accumulation of international reserves can be considered a partial explanation for not finding exchange rate overshooting.

Besides this introduction, this paper reviews the literature related to exchange rate dynamics and exchange rate passthrough in section 2. Section 3 is dedicated to the econometric methodology and data. Section 4 reports the results and the last section draws some conclusions.

2. LITERATURE

The literature on exchange rate passthrough is extensive and interesting. Goldberg and Knetter (1997), for instance, state that an incomplete passthrough can be a result of consequence of third-degree price discrimination. Burstein et al. (2007) argue that inflation targeting (IT) plays a key role in decreasing passthrough effects, but such a phenomenon is still important for emerging market inflation targets.

Campa and Goldberg (2005) analyze the case of 23 OECD countries and find evidence of higher passthrough elasticities within countries that exhibit high levels of exchange rate volatility, despite a decrease in the importance of macroeconomic variables in the determination of passthrough elasticities. The authors also say that changes in the composition of imported goods are more relevant for passthrough dynamics. Jašová et al. (2019) found that, after the 2007-08 global financial crisis, exchange rate passthrough remained stable and low in advanced countries, and decreased in emerging market economies, mainly due to inflation reduction.

Ha et al. (2019) analyze 47 economies and find that exchange rate passthrough to inflation varies substantially amongst countries, mainly because of economic policy characteristics and sensitivity to exchange rate fluctuations. The authors also report that passthrough ratios tend to be lower with a credible IT framework, central bank independence, and flexible exchange rate regimes.

Caselli and Roitman (2019) examine data from 27 emerging market economies, from 1990 to 2013, finding that appreciation and depreciation episodes have asymmetric impacts on inflation and, therefore, cause asymmetric exchange rate passthrough effects. The authors also observe that IT seems to cause some reduction in exchange rate passthrough.

Jiménez-Rodríguez and Morales-Zumaquero (2020) study the exchange rate passthrough hypothesis for the BRICS countries. Brazil, Russia, and South Africa are the ones with the most exchange rate volatility, which might influence the magnitude of their passthrough cases. The authors state that, differently from the case of China and India, the exchange rate plays an important role in explaining inflation variability in Brazil, Russia, and South Africa. Finally, as the BRICS countries have had a growing share in global trade, the degree of openness is a key macroeconomic variable for exchange rate passthrough determination.

Nogueira Jr. (2007) searches for evidence of exchange rate passthrough in emerging market economies and finds that the phenomenon declines after the adoption of IT, but it has not disappeared, especially in the long run. Reyes (2007) sees IT adoption as important for a decrease in exchange rate passthrough in emerging market countries, but it is still relevant and cannot be neglected.

Egert and Macdonald (2009) conclude that the exchange rate passthrough mechanism decreased considerably over time in Central and Eastern European countries, mainly due to lower inflation rates. Aron et al. (2014a) surveyed the literature related to exchange rate passthrough for several countries and found little difference between the cases of emerging and advanced economies. The authors detect some correlation between exchange rate volatility and higher exchange rate passthrough in emerging market countries.

Other articles have examined the exchange rate passthrough phenomenon in the BRICS countries individually: i) Brazil: Belaisch (2003), Muinhos (2004), Correa and Minella (2010); ii) Russia: Dobrynskaya and Levando (2008); iii) India: Mallick and Marques (2008); Dash and Narasimhan (2011), Yanamandra (2015). iv) China: Jiang and Kim (2013); Bouvet et al. (2017); v) South Africa: Karoro et al. (2009); Aron et al. (2014b); Aron et al. (2014c).

Besides the exchange rate passthrough phenomenon, it is also important to analyze how exchange rates are determined and how these dynamics can help us understand Dornbusch's (1976) overshooting phenomenon and the role of international reserves to help prevent exchange rate volatility. But we must emphasize that this article will not investigate a single hypothesis of overshooting and non-overshooting. Our aim in this matter is to use the ARDL methodology to analyze Dornbusch's main hypothesis, which states that, under short run price rigidity, an expansionary monetary policy (a temporary demand shock) will change the exchange rate to a level above its long run equilibrium level.

After the collapse of the fixed exchange rates system, in the early 1970s, researchers began to investigate how exchange rates could be determined. This gave rise to a vast literature on issues related to monetary models of exchange rate determination, which are usually based on Mundell-Fleming's approach. They can be divided as follows: i) monetary/asset view (flexible price) models, as in Frenkel (1976) and Bilson (1978), with a focus on types of exchange rate determination models more connected with asset markets and the role of expectations and arbitrage conditions; ii) sticky price-asset monetary model, as in Hooper and Morton (1982); iii) sticky price-real interest rate differential model; IV) sticky price-real interest rate differential models, as in Dornbusch (1976) and Frankel (1979), who examined the role of expectations as well as some other characteristics of exchange rate market efficiency.

Flood (1979) analyzes the exchange rate overshooting case and says that, as the process of asset market clearing is much faster than in other markets, exchange and interest rates are usually responsible for short run adjustments to guarantee asset balance. Rogoff (2002) is an excellent reference for an overview of Dornbusch's overshooting model, 25 years after its publication. The article also reports some empirical results related to measures of the paper's impact. Lee (2016) uses a similar approach for the 30th anniversary of Dornbusch's overshooting.

Hairault et al. (2004) build a limited participation model with adjustment costs on money holdings in an international setting. According to the authors, the introduction of this framework increases the magnitude of the overshooting phenomenon, showing that it is crucial for the explanation of extreme nominal exchange rate volatility.

Kim and Roubini (2000) find little evidence of open economy anomalies, with exchange rate responding with appreciation to a restrictive monetary policy. Over time, there is depreciation of exchange rate, in a type of delayed exchange rate overshooting. This "delayed overshooting puzzle" is also examined by Kim (2005) and Kim et al. (2017).

Cavallo et al. (2005) detected some exchange rate overshooting; i) during the 1998-99, in the case of Brazil; ii) during the 1995 India's crisis; iii) in 1996 and 1998 for the South African case; iv) in 1998 for Russia's case. Maitra (2016) finds indication of exchange rate overshooting phenomenon and Barnett et al. (2016) see signs of delayed overshooting in the case of India.

For the Brazilian case, Kim and Kim (2007) conclude that, in the 1994-95 Mexico crisis, Brazil underwent a significant exchange rate overshooting experience, which happened again in the 1998-99 Real devaluation crisis. As for South Africa, the country also faced the same problem during the 1997-98 Asian financial crisis.

Bahmani-Oskooee and Panthamit (2006) analyze the specific case of East Asian countries, for the period 1987-2000, which includes the 1997 financial crisis. The authors see evidence of exchange rate overshooting only in the short run. Bjørnland (2009) makes use of a VAR estimation to study the cases Australia, Canada, New Zealand and Sweden, for quarterly data from 1983 to 2004. Their results show consistency of the overshooting hypothesis, particularly a strong exchange rate appreciation after a contractionary monetary policy shock, with a maximum effect within 1-2 quarters and exchange rate depreciation thereafter.

Feuerriegel et al. (2016) apply a VECM methodology to evaluate how news information can influence the performance of the GBP/USD exchange rate. For the period ranging from July 2003 to May 2012, the authors' results show that a perturbation in news sentiment may lead to exchange rate overshooting.

Regarding Dornbusch's (1976) article, it focuses on how expectations are formed, and it is used to address the implications of temporary monetary shocks, given short-run movements in nominal exchange rates and relative prices, which is a key feature of the exchange rate overshooting phenomenon. The model assumes sticky prices in the short run and purchasing power parity (PPP) in the long run. One should remember that the real exchange rate is constant according to PPP.

But there is also vast literature showing evidence that long-run real exchange rates cannot be taken as constant. In this case, the long-run real exchange rate is modelled using real resource allocation models, such as Balassa (1964), Samuelson (1964), and Stein (1995). Basically, the well-known Balassa-Samuelson effect argues that inflation tends to be higher in poorer countries due to productivity differences. Balassa (1964) shows that the relationship between PPP and exchange rates could be enhanced by including non-traded goods in the discussion. Stein (1995) reports that real exchange rates, in developed and developing countries, are cointegrated along with long-run real factors, such as productivity. Thus, there is evidence that the findings reported by the long-run real exchange rate literature support the PPP literature results that long-run real exchange rates are not constant, i.e., PPP does not hold as a long-run relationship.

In fact, it seems to be incorrect the results of the long-run real exchange rate literature implying that the specifications used in the PPP literature for testing the extent of mean reversion between nominal exchange rates and relative prices, which omits long-run real factors. This raises three important questions: i) is the problem of finding cointegration and mean reversion during floating rate periods related to the omission of long-run real factors from the regression? ii) is the problem of finding slow mean reversion, when mean reversion is found (this is often referred to as the PPP puzzle), connected to the omission of long-run real factors? iii) if long-run real factors are included in the cointegrating regression, then will the estimated coefficients for goods prices become more consistent with the predictions of symmetry and proportionality, i.e., will they be more consistent with the disequilibrium view? The long-run real exchange rate literature suggests that the answers to all three questions may in fact be positive.

The theory suggests that we should find evidence of faster mean reversion of exchange rate towards its equilibrium level, but in reality (post-1973 data) most studies do not find reversion at all for most developed countries or when they find, it is too slow. This is often referred to as the PPP puzzle, as documented by Rogoff (1996), Froot and Rogoff (1995), and Obstfeld and Rogoff (2000).

Ford and Horioka (2016) discuss the real explanation for the PPP puzzle and argue that global financial markets are not able to achieve net transfers of financial capital and real interest rate equalization across countries. The authors argue that frictions in global goods markets can explain why real exchange rates deviate from PPP for long periods and so are part of the PPP puzzle.

Bresser-Pereira et al. (2022) analyze the exchange rate behavior of Brazil, Argentina, Colombia and Chile, for the period ranging from 2000 to 2020. Compared to the current account equilibrium, the authors find evidence of cyclical and chronic appreciation for the first three countries, whereas in Chile depreciation is the case. Their results also show that current account deficits (surpluses) are highly correlated with a positive (negative) exchange rate misalignment, indicating the need of some exchange rate policy management in the four countries analyzed.

3. ECONOMETRIC APPROACH AND DATA

Pesaran and Shin (1999) and Pesaran et al. (2001) proposed a cointegration analysis based on Autoregressive Distributed Lag (ARDL), which originated the so-called ARDL-Bounds Testing Approach to Cointegration. This methodology has some advantages over other cointegration methods, as it allows for the use of a mix of variables (stationary, non-stationary, or mutually cointegrated) and tends to work better with small samples, better capturing the long-run relationship in these cases. On the other hand, it is not suitable for I(2) variables.

The ARDL-Bounds Testing Approach is able to retain information on both short and long-run properties of the estimated model. Whenever there is a short-run shock, an adjustment process takes place to bring back the long-run equilibrium. In other words, once the cointegration is confirmed, it is possible to estimate the long-run equilibrium coefficients, as well as the short-run coefficients together with the Error Correction Mechanism (ECM) itself. The ECM coefficient is responsible for showing the adjustment speed towards the long run.

Therefore, the empirical analysis developed in this work is based on Autoregressive Distributed Lag (ARDL) models applied to cointegration. For the period ranging from January 2005 to December 2019, the following variables will be analyzed:

- **ExchRate =** Nominal Exchange Rate (Local Currency Unit/US$). Source: IFS-IMF.
- **CPI =** CPI index (2010 = 100). IFS (IMF).
- **IndProd =** Industrial Production for all countries, except For South Africa (Manufactured Production) (2010 = 100). Source: IFS-IMF and FRED St Louis.
- **Oil =** Oil Price in US$. Source: Primary Commodity Prices – IMF.
- **M3 =** Broad Money (M3 relative to the US, in US$ million). Source: IFS-IMF and FRED St Louis.
- **InflationDiff =** CPI Inflation Rate (%) minus US CPI Inflation Rate (%). Source: IFS-IMF.
- **Interest =** Money Market Interest Rate (%) minus US rate. For China: Call Money Interbank Rate minus the U.S. Rate. Source: IFS-IMF and FRED St Louis.
- **RelativeProd =** Industrial Production relative to the US. For South Africa: Manufactured Production relative to the US. (2010 = 100). Source: IFS-IMF and FRED St Louis.
- **Reserves =** International Reserves, excluding gold, in US$. Source: IFS-IMF.

Two equations will be estimated for each BRICS country-member. These equations can be represented by the following Error Correction Model (ARDL-ECM):

Exchange Rate Passthrough

$$\Delta CPI_t = \alpha_0 + \alpha_1\tau + \delta_1 CPI_{t-1} + \delta_2 ExchRate_{t-1} + \delta_3 IndProd_{t-1} + \delta_4 Oil_{t-1} + \sum_{i=1}^{n}\theta_1 \Delta CPI_{t-i} +$$

$$\sum_{i=1}^{m}\theta_2 \Delta ExchRate_{t-i} + \sum_{i=1}^{p}\theta_3 \Delta IndProd_{t-i} + \sum_{i=1}^{q}\theta_4 \Delta Oil_{t-i} + \varepsilon_{2t}$$

Exchange Rate Determination – Monetary Model

$$\Delta ExchRate_t = \alpha_0 \; + \alpha_1\tau + \delta_1 ExchRate_{t-1} + \delta_2 M3_{t-1} + \; \delta_3 InflationDiff_{t-1} + \delta_4 Interest_{t-1} + \delta_5 RelativeProd_{t-1} + \delta_6 Reserves_{t-1} + \sum_{i=1}^{n}\theta_1 \Delta ExchRate_{t-i} + \sum_{i=1}^{m}\theta_2 \Delta M3_{t-i} + \sum_{i=1}^{p}\theta_3 \Delta InflationDiff_{t-i} + \sum_{i=1}^{q}\theta_4 \Delta Interest_{t-i} \;\; \sum_{i=1}^{r}\theta_5 \Delta RelativeProd_{t-i} + \sum_{i=1}^{s}\theta_6 \Delta Reserves_{t-i} + \varepsilon_{1t}$$

The choice of variables in our ARDL price model is similar to the one from Belaisch (2003). The only difference is that Belaisch (2003) makes use of a VAR methodology, while we apply an ARDL Bounds Testing Approach to Cointegration. For the exchange rate passthrough model, we use CPI as dependent variable and exchange rate, industrial production, and oil price as explanatory variables. As for the exchange rate determination model, its control variables are inflation differential, M3, interest rate and relative industrial production. All of them are expressed relative to the US. The model is extended with international reserves since it has been a relevant variable, especially after the 2007-08 international financial crisis, to reduce future risks related to financial crisis and/or to serve as a cushion to minimize external shocks to the exchange rate.

Again, we must emphasize that with estimation of the exchange rate determination model we will the able to evaluate the role of a monetary shock under the hypothesis of price rigidity, in the short run. By looking at the short run coefficient related to M3, our proxy for broad money, it is possible to analyze whether our estimated results corroborate Dornbusch's main prediction, which argues that, under short run price rigidity, an expansionary monetary policy will change the exchange rate to a level above its long run equilibrium level. Therefore, we are not testing a single hypothesis for overshooting and non-overshooting, but only using the ARDL model to investigate Dornbusch's main hypothesis.

As for the specific characteristics of each country, Brazil experienced a pegged exchange rate regime during the Real Stabilization Plan, between 1994 and 1998. At that time, the exchange rate was successfully used as a nominal anchor to stabilize prices in the period. As a result of low foreign reserve levels, together with several other economic problems, in January 1999 the country was forced to adopt a managed floating exchange rate regime and, since June 1999, Brazil has been under an inflation targeting system. The country's exchange rate system has had its ups and downs in the last two decades, with periods of depreciation, such as during the 2008 global financial crisis and during the coronavirus pandemic, and appreciation, such as in 2010-1 with the quantitative easing policy in advanced economies. Brazil benefited from capital inflows, from investments and basic commodity exports, accumulating a great large of foreign reserves. Tough it is important for the balance of payments, the emphasis on basic commodity exports has led to some rapid change in the country's productive structure, with some indication of deindustrialization and Dutch Disease, as discussed by Bresser-Pereira (2013). On the other hand, volatile capital inflows also put some pressure on the exchange rate. This scenario reveals that the Brazilian exchange rate has shifted in different directions significantly throughout the last two decades.

As for Russia, since the 1998 debt crisis, the country has been under some type of managed floating exchange rate system, and mainly market driven. However, from 2002 to 2005, Russia decided to soften its capital control policy, which resulted in a continuous exchange rate appreciation and forced the Bank of Russia to intervene in the foreign exchange market. A dual currency basket was introduced in 2005, aiming at reducing exchange rate volatility. After the 2008 global financial crisis the trend was to reduce the degree of exchange rate depreciation, when monetary authorities decided to increase interest rates. Consequently, Russia experienced more exchange rate flexibility.

The Indian exchange rate regime went through a major exchange rate movement in the beginning of the 2000s. After 2003, the country implemented a new exchange rate policy, apart from the long run appreciation trend of the nineties. India started to apply a two-way movement in its managed floating exchange rate policy, with significant foreign reserve accumulation, aimed at reducing the country's risk. In 2004, the government officially declared that India had a managed floating exchange rate policy. Nevertheless, 2007 was marked by a significant exchange rate appreciation, followed by new depreciation during the 2008 global financial crisis. The period after 2014 was marked by the longest sustained real exchange rate appreciation, with a partial reversion in 2018.

China's exchange rate policy has been widely known as a successful experience of keeping its currency at a depreciated level for a sustainable period of time (from 1980 to 2005), regardless of the worldwide pressure for exchange rate appreciation. Since 2005, China has been experiencing periods of exchange rate appreciation and depreciation, but appreciation has been the overall trend. China has also kept high levels of international reserves, which is an additional pressure for exchange rate appreciation. The country has been successful in keeping recurrent surplus in its trade and current account balances throughout the last decades, which is an exception among most emerging economies.

As for South Africa, it has experienced a floating exchange rate regime since the apartheid era, but more recently there has been a significant currency depreciation of the Rand, resulting in a downgrade of South Africa's sovereign rating. It seems that real exchange rate appreciation (depreciation) is hand-to-hand with higher (lower) GDP growth rates. Agriculture and mining are the main foreign exchange sectors of the South African economy. Mineral prices are subject to commodity cycles, and so international demand for commodities has a significant impact on South Africa's Rand, compared to other currencies of major trading partners. The trend for the real effective exchange rate after 2005, and after the great financial crisis, is towards considerable depreciation, 23% and 7%, based on the BIS real effective exchange rate index.

4. RESULTS: ARDL-BOUNDS TESTING APPROACH

As Table 1 makes clear, the unit test results are mixed, especially those associated to Industrial Production (South Africa), CPI (South Africa), Interest Rate (South Africa), M3 (India and Russia), Relative Industrial Production (India and Russia), and International Reserves (India and South Africa). This makes ARDL-Bounds Testing Approach applicable.

Table 1: Unit Root Tests

		Brazil	China	India	Russia	S. Africa
Exchange Rate	ADF	0.449	-2.291	-2.787	-2.735	-2.645
	PP	0.488	-2.271	-2.456	-2.220	-2.367
	KPSS	0.344**	0.410**	0.151*	0.233**	0.158*
Industrial Production	ADF	-2.465	-6.452**	-2.488	-2.563	-2.463
	PP	-2.304	-6.914**	-1.986	-2.831	-2.930*
	KPSS	0.318**	0.060	0.280**	0.065	0.107
CPI Index	ADF	-2.160	-2.316	-1.718	-1.953	-3.838*
	PP	12.520	-2.215	-0.956	-2.699	-0.825
	KPSS	0.225**	0.293**	0.364**	0.273**	0.235**
Interest Rate	ADF	-2.306	-1.075	-0.340	-2.175	-2.704
	PP	-1.727	-0.915	-0.394	-2.077	-0.585
	KPSS	0.132	0.335**	0.367**	0.981**	0.137
M3	ADF	-2.551	0.059	-3.084*	-2.873*	-2.497
	PP	-2.735	0.256	-2.770	-2.962*	-2.358
	KPSS	0.383**	0.438**	0.228**	0.349**	0.273**
Relative Industrial Production	ADF	0.065	0.034	-3.584**	-3.258	-3.875**
	PP	0.216	-1.657	-3.781**	-4.481**	-7.550 **
	KPSS	0.382**	1.289**	0.310**	0.287**	0.288
Inflation Differential	ADF	-7.054**	-3.390 *	-10.283**	-6.995**	-10.165**
	PP	-6.737**	-9.441**	-10.228**	-6.349**	-10.422**
	KPSS	0.276	0.088	0.161	0.078	0.151
International Reserves	ADF	-2.167	-2.261	-2.859	-2.770	-2.750
	PP	-2.435	-2.498	-1.001	-2.643	-2.986*
	KPSS	0.406**	0.413**	0.141	0.276 **	0.401**
Oil Price	ADF = -2.764; PP = -2.544; KPSS = 0.227**					

Notes: * and ** mean rejection of the null hypothesis at 5% and 1% respectively.
ADF, PP and DF-GLS: H0 – unit root; KPSS: H0 – stationarity.

We begin our empirical investigation by running basic ARDL estimations for the models related to equations 1 and 2. The variable ordering used is: i) Exchange Rate Passthrough Model: CPI, exchange rate, industrial production, and oil price; ii) Exchange Rate Determination Model: exchange rate, M3, inflation, interest rate, relative industrial production, and international reserves.

The initial empirical exercise is to decide the number of lags needed to avoid autocorrelation in the estimation (Table 2). Akaike Information Criterion is used as a first tool to help make this decision. The “lag number” column in Table 2 reports these results and shows some differences and similarities amongst the BRICS countries. For the exchange rate determination model, lagged exchange rate and M3 are significant for all five countries, and lagged international reserves are also significant, except for China. Inflation and industrial production are not relevant for Brazil and China, and interest rate does not play a role for Brazil and India. As for the exchange rate passthrough model, all lagged dependent and explanatory variables are significant for Brazil and South Africa. For India, only the lagged CPI is significant. In the Chinese case, the lagged exchange rate is not significant and oil price does not play a role in the Russian case.

To make sure that the use of selection criteria was able to eliminate any autocorrelation problem, we ran some conventional autocorrelation LM tests. Table 2 reports these results and shows no signs of autocorrelation in all estimated models. As for parameter stability diagnostic tests, our Cusum and CusumSq test results (Table 2 and Appendix) show that all estimated models are stable, except for Russia (CusumSq) and China (Cusum).

Table 2: Lags and Diagnostic Tests

	Exchange Rate Passthrough Model			Exchange Rate Determination Model		
	Lag Number ARDL Model	Autocorr LM Test	Stability Tests	Lag Number ARDL Model	Autocorr LM Test	Stability Tests
		Coeffic. [Prob]	Cusum/ CusumSq		Coeffic. [Prob]	Cusum/ CusumSq
Brazil	(5,6,6,2)2	0.232 [0.792]	Stable/Stable	(3,3,0,0,0,3)3	1.642 [0.196]	Stable/Stable
Russia	(6,5,4,0)3	0.982 [0.376]	Stable/Instable	(3,3,0,5,7,3)1	1.094 [0.337]	Stable/Stable
India	(2,0,0,0)3	0.295 [0.744]	Stable/Stable	(3,1,2,0,5,6)1	1.473 [0.232]	Stable/Stable
China	(2,0,1,3)1	0.321 [0.725]	Instable/Stable	(4,1,0,2,0,0)1	1.279 [0.280]	Stable/Stable
South Africa	(2,4,2,4)3	0.699 [0.498]	Stable/Stable	(6,6,0,2,0,6)1	0.905 [0.406]	Stable/Stable

Note: 1 = with constant and trend; 2 = with constant and no trend; 3 = no constant. no trend. Autocorrelation LM Test: (H0 – no autocorrelation).

Table 3 reports the results for all results related to the estimated exchange rate determination and passthrough models. As the F-statistics for all estimated ARDL bounds tests are higher than the I(1) bound, at 5%, there is clear indication of rejection of the null hypothesis of no cointegration for all estimations. It means that there is a long run relationship among the variables analyzed for each BRICS country-member.

After confirming the long run relationship (cointegration) for all estimated models, the next step is to analyze the specific estimated coefficients in the long run

(Tables 4 and 5) and in the short run (Table 6) together with the Error Correction Coefficient (ECM).

Table 3: Cointegration Test (ARDL-Bounds Testing Approach)

Country	Exchange Rate Passthrough					Exchange Rate Determination				
	F-Statistics	Critical Values				F-Statistics	Critical Values			
		I(0) Bound		I(1) Bound			I(0) Bound		I(1) Bound	
		10%	5%	10%	5%		10%	5%	10%	5%
Brazil	9.24*	2.37	2.79	3.2	3.67	9.37*	1.81	2.14	2.93	3.34
Russia	9.31*	2.01	2.45	3.10	3.63	4.77*	2.49	2.81	3.38	3.76
India	12.47*	2.01	2.45	3.10	3.63	5.77*	2.49	2.81	3.38	3.76
China	4.52*	2.97	3.38	3.74	4.23	5.35*	2.49	2.81	3.38	3.76
S. Africa	20.67*	2.01	2.45	3.10	3.63	7.23*	2.49	2.81	3.38	3.76

Notes: H0 (no long-run relationship). *means long run cointegration at 5%.

Table 4 reports the long run coefficients related to the exchange rate passthrough model. Firstly, by looking at the control variables (industrial production and oil prices), they are statistically significant only for South Africa, with positive and inelastic long run coefficients. As for the long run exchange rate variable, it is statistically significant only for China (-0.153) and South Africa (0.877). Regarding the non-expected negative sign for the Chinese exchange rate coefficient (-0.153), one possible explanation has to do with its currency policy. As mentioned previously, China has faced a significant pressure from US and Europe to appreciate its currency, due to increasing and recurrent trade surplus for China vis-à-vis the American and European case, which is not the case of other countries in Asia.

Table 4 also shows that considering only the magnitude (exchange rate elasticity) of the estimated long run coefficients related to prices, Brazil, Russia and India's prices are elastic relative to the exchange rate, with coefficients greater than 1, while China (0.153 in absolute value) and South Africa (0.877) exhibit inelastic prices.

Specifically, regarding the long run exchange rate passthrough phenomenon, if we consider each long run exchange rate coefficient in its absolute value, in Table 4, and calculate the average related to the five countries, the result is 1.47. It means that a 10% change in the exchange rate, will change prices by 14.7%. Therefore, the average long run exchange rate passthrough to inflation for the BRICS countries is about 15%. This low passthrough rate has been detected by several other articles for the emerging market economies, such as Nogueira Jr. (2007), Reyes (2007), Egert and Macdonald (2009), Jiménez-Rodríguez and Morales-Zumaquero (2020) and Jašová et al. (2019).

Table 4: ARDL Long Run Coefficients
(Exchange Rate Passthrough – Dep. Variable: CPI)

Country (Lags)	Brazil (5, 6, 6, 2)	Russia (6, 5, 4, 0)	India (2, 0, 0, 0)	China (6, 0, 1, 3)	S. Africa (2, 4, 2, 4)
	Coeffic. [Prob.]	Coeffic. [Prob.]	Coeffic. [Prob.]	Coeffic. [Prob.]	Coeffic. [Prob.]
Exchange Rate	3.180 [0.118]	-1.047 [0.723]	-2.096 [0.837]	-0.153* [0.009]	0.877* [0.000]
Industrial Production	20.010 [0.259]	2.722 [0.516]	1.450 [0.764]	0.374 [0.107]	0.341* [0.000]
Oil Price	-1.661 [0.366]	-0.682 [0.689]	2.376 [0.806]	0.020 [0.115]	0.331* [0.000]
Trend	-79.779 [0.272]			0.002** [0.000]	

Note: * and ** means significant at 5% and 10% respectively.

The long run estimated coefficients for the exchange rate determination model for each country, reported in Table 5, reveal that M3 (broad money) is statistically significant for Brazil, India and China, with negative coefficients. Inflation is statistically significant for Brazil, Russia and India with positive coefficients. The only two statistically significant coefficients for the interest rate variable are related to the cases of Russia and India, with positive values. As for the remaining countries, their interest rate coefficients are negative and without statistical significance. Industrial production plays an important long run role for the Brazilian, Indian and Chinese exchange rates, respectively, with negative coefficients for the first two countries and positive for China. In the long run, the coefficients related to international reserves show no statistical significance for all five BRICS countries.

Table 5: ARDL Long Run Coefficients
(Exchange Rate Determination – Dep. Variable: Exchange Rate)

Country (Lags)	Brazil (3,3,0,0,0,3)	Russia (3,3,0,5,7,3)	India (3,1,2,0,5,6)	China (4,1,0,2,0,0)	S. Africa (6,6,0,2,0,6)
	Coeffic. [Prob.]	Coeffic. [Prob.]	Coeffic. [Prob.]	Coeffic. [Prob.]	Coeffic. [Prob.]
M3	-0.512** [0.004]	-0.194 [0.537]	-0.273* [0.001]	-0.252* [0.022]	-0.322 [0.270]
Inflation	0.241* [0.081]	0.129** [0.093]	0.031* [0.005]	-0.001 [0.741]	0.001 [0.978]
Interest Rate	-0.007 [0.586]	0.019** [0.058]	0.012* [0.002]	-0.006 [0.116]	-0.005 [0.757]
Relative Industrial Production	-1.148* [0.075]	-0.750 [0.676]	-0.563* [0.002]	0.246* [0.007]	0.020 [0.974]
International Reserves	2.16E-07 [0.610]	-1.36E-06 [0.169]	3.53E-07 [0.364]	-3.63E-08 [0.151]	-2.52E-05 [0.101]
Trend		0.005* [0.000]	0.004* [0.000]	0.001* [0.004]	0.005* [0.016]

Note: * and ** means significant at 5% and 10% respectively.

The next step is to analyze the short run dynamics of each estimated model, focusing on the Error Correction Representation (ECM). In fact, this is another important characteristic of cointegration models. The ARDL Bounds Testing Approach showed that there is long-run equilibrium in all estimated models, i.e., the variables cointegrate. If this is the case, any short run disequilibrium shock cannot be permanent, as there must be some adjustment towards the long run. This adjustment is given by the ECM coefficient, and it can be faster or slower, depending on specific features of each BRICS country-member.

These short run coefficient results are reported in Table 6. As expected, all lagged error correction terms (ECM_{t-1}) are negative and statistically significant. On average, 3.1% (exchange rate passthrough model) and 8.6% (exchange rate determination model) of the short run shocks are corrected within a month's time. It means that, whenever a short run perturbation occurs, there is a slow speed of adjustment towards the long run equilibrium for both systems (exchange rate passthrough and exchange rate), and even slower for the estimations related to the exchange rate passthrough model.

The existence of this slow speed of adjustment can also be associated to the discussion of the PPP puzzle, which argues that despite theoretical suggestions of a faster exchange rate mean reversion towards its equilibrium level, most empirical investigations are not able to detect this mean reversion at all, for most developed countries, or they find the reversion to be too slow. One of the reasons for the very slow speed of adjustment detected in our results can be associated to the use of aggregate prices.

For the exchange rate passthrough estimations the exception would be the ECM related to China (-0.136), which is small but much higher when compared to its counterparts. As for the exchange rate determination estimations, the ECM coefficients vary from -0.016 (Brazil) to -0.179 (India), suggesting a much faster convergence to equilibrium in India.

We can now focus on some important short run coefficients for the models estimated. We have found that there is an average 15% exchange rate passthrough to inflation in the long run. By looking at the short run contemporaneous exchange rate coefficients, named ΔExch. Rate in Table 6, the first noticeable aspect is that there is no coefficient related to India nor China, due to the lags chosen when estimating their specific exchange rate passthrough equation. This is an indication that there is no specific short run exchange rate passthrough to inflation in these two cases. For the remaining countries, only the Russian coefficient (ΔExch. Rate = 0.018) shows statistical significance. If we consider the three short run exchange rate coefficients, in Table 6, and calculate the average, the result is 0.011. It means that a 10% change in the exchange rate, will change prices by only 0.11%, which is the average short run exchange rate passthrough to inflation.

As for the exchange rate determination estimations, the emphasis is on the short run coefficients related to the M3 variable and international reserves. They are in Table 6, in first difference. By analyzing the coefficients for M3, we are able to assess whether there is evidence of exchange rate overshooting in each BRICS country-member, given a monetary shock. As mentioned previously, we are not testing a single hypothesis for either overshooting or non-overshooting. Our purpose is to evaluate whether an expansionary monetary policy (a monetary shock), under the assumption of short run price rigidity, will change the exchange rate to a level above its long run equilibrium level. This is exactly Dornbusch's main prediction in his overshooting model. Table 6 reports that estimated M3 coefficients, our measure of broad money, are all negative and statistically significant, in first difference, ranging from -0.205 (India) to -0.922 (Brazil). This is an indication of lack of evidence of exchange rate overshooting on the grounds predicted by Dornbusch (1976).

Table 6: Short Run Error Correction Representation (ECM)

	Exchange Rate Passthrough		Exchange Rate Determination		
	ECMt-1 [Prob]	ΔExch. Rate [Prob]	ECMt-1 [Prob]	ΔM3 [Prob]	ΔReserves [Prob]
Brazil	-0.001 [0.000]	0.0055 [0.286]	-0.016 [0.000]	-0.922 [0.000]	-8,61E-08 [0.617]
Russia	-0.002 [0.000]	0.018 [0.032]	-0.064 [0.000]	-0.796 [0.000]	2,29E-07 [0.149]
India	-0.001 [0.000]	n.a	-0.179 [0.000]	-0.205 [0.000]	-7,84E-07 [0.0002]
China	-0.136 [0.000]	n.a	-0.115 [0.000]	-0.475 [0.000]	n.a
South Africa	-0.013 [0.000]	0.0051 [0.461]	-0.054 [0.000]	-0.867 [0.000]	-3,58E-06 [0.0002]
Average	-0.031		-0.086		

Note: i) Δ means first difference of the variable; ii) India: there is no short run coefficient for exchange rate; iii) China: there are no short run coefficients for exchange rate nor international reserves.

Regarding the short run coefficients related to international reserves, they can be analyzed as additional evidence of the presence, or not, of exchange rate overshooting. Table 6 reports that these coefficients are negative in three out of four estimated models (Brazil, India, South Africa), despite the lack of statistical significance for Brazil. It means that increases (decreases) in international reserves are associated to exchange rate appreciation (depreciation). Therefore, the majority of negative short run coefficients for international reserves corroborates our feeling that higher foreign reserve levels accumulated by the BRICS countries, since 2005, can be a possible explanation for no exchange rate overshooting, at least partially.

Given the results reported in Table 4, which showed China's passthrough coefficient as negative and statistically significant (-0.153), we performed a robustness test to test for this negative passthrough coefficient. The alternative model specification for China included two additional variables (interest rate and international reserves), already available in the exchange determination model reported in Table 5. The results are found in Table A1, in the Appendix, and show that the only case for a positive exchange rate coefficient is without constant and trend, with significance is achieved only at 10%. As for the two added variables, the results showed positive (negative) and significant coefficients for international reserves (interest rates). The adjustment speed for this new model, given by the ECM_{t-1} coefficient, is -0.037, below the original estimated coefficient (-0.136) reported in Table 6.

Table A2 shows the correlation matrix for the series related to China. There is a negative correlation between inflation and exchange rate (-0.73). A possible explanation for this is that through the last decades, China adopted a strong exchange rate management policy, keeping the exchange rate undervalued to achieve better current (trade) account results. Keeping this in mind, and considering that China has become a price maker, instead of a price taker, for many industrialized products in the international market, this argument can be used to understand such unexpected correlation between prices (inflation) and the country's exchange rate. Other than this, China has experienced a sharp increase in international reserves in the past decades, which brings pressures towards an exchange rate appreciation. However, Chinese authorities have constantly adopted different policies and instruments to avoid this trend and to keep the real exchange rate undervalued.

Regardless of the non-significant negative exchange rate passthrough coefficients for the Russian and Indian cases, we followed the same strategy applied to the Chinese case and extended the CPI model, including interest rate and international reserves for Russia and China. Table A1 shows that the passthrough statistically significant coefficient for Russia is 0.407, compared to the previous -1.047 reported in Table 4. The adjustment speed (ECM t-1) found is equal to -0.023, which is the same value estimated in the original model. As for the case of India, the passthrough coefficient remains negative (-0.224) and without statistical significance, with an ECM t-1 of -0.099, similar to the original model.

CONCLUSION

This article's main goal was to investigate issues related to exchange rate dynamics and passthrough in the BRICS countries for the period ranging from January 2005 to December 2019 and using an ARDL Bounds Testing Approach to Cointegration methodology. One of the motivations of this research was to better understand phenomena related to exchange rate determination, including Dornbusch's overshooting in a different world economy and for a set of emerging economies. The BRICS countries faced periods of favorable terms of trade and accumulation of international reserves, as a general trend, helping curb severe volatility in foreign currency. Other than this, most countries adopted expansionary monetary and fiscal policies, especially after the 2007-08 financial crisis, but these actions did not lead to increasing inflation. This can be considered as an indication that the monetary transmission mechanism did not have its expected impact on prices, even after a significant number of years.

A second motivation for the paper was associated with the investigation of the exchange rate passthrough for the BRICS. The argument was that, in a more globalized world environment, exchange rate movements are more likely to have an impact on domestic prices, which could affect inflation rates.

The results of our estimated models showed a clear long run (cointegration) relationship in all estimated models. The long run estimated coefficients for the exchange rate determination models revealed that our broad money measure (M3), was statistically significant for Brazil, India and China, with negative coefficients, and inflation was statistically significant for Brazil, Russia and India, with positive coefficients. On the other hand, there was no statistical significance for international reserves, for all five BRICS countries. The short run dynamics showed a slow speed of adjustment towards the long run equilibrium, for the exchange rate determination model, with an average of 8.6%. The short run estimated coefficients for M3 were all negative and significant, showing lack of evidence related to exchange rate overshooting.

As for exchange passthrough results, the long run exchange rate coefficients were statistically significant only for the Chinese and South African cases. Industrial production and oil price were statistically significant only for South Africa. Overall, if we consider the long run exchange rate passthrough in absolute value, the average found was 1.47, which is an indication that for a 10% change in the exchange rate, prices will change by an average 14.7%. As for short run dynamics, there was also a slow speed of adjustment towards the long run equilibrium, as in the exchange rate determination model, with an average of 3.1%. The average short run exchange rate passthrough to inflation was extremely low. It means that there was some evidence of exchange rate passthrough, mainly in the long run, but not so strong as before.

Given the results reported in Table 4, we extend the CPI inflation models for China, India, and Russia, including two additional variables (interest rates and international reserves), with previous negative passthrough coefficients. The new estimated coefficients were positive for China (only at 10%) and Russia (at 5%), but there was no change for the Indian case.

If one must address this result, it is necessary to keep in mind that the world economy is quite different from the period after Bretton Woods. The adoption of flexible exchange rates by advanced economies in the mid-1970s and the rising of BRICS as emerging economies with different macroeconomic characteristics, make it difficult to compare them with advanced economies four decades ago. The role of monetary policy and its transmission mechanisms has also changed substantially during this period, meaning that its impact on prices, including the exchange rate, has also changed.

REFERENCES

Aron, J.; Creamer, K.; Muellbauer, J.; Rankin, N. (2014a). Exchange rate pass-through to consumer prices in South Africa: Evidence from micro-data. *Journal of Development Studies*, 50: 165-185.

Aron, J.; Farrel, G.; Muellbauer, J.; Sinclair, P. (2014b). Exchange rate pass–through to import prices, and monetary policy in South Africa. *Journal of Development Studies*, 50:144-164.

Aron, J.; Macdonald, R.; Muellbauer, J. (2014c). Exchange rate pass-through in developing and emerging markets: A survey of conceptual, methodological and policy issues, and selected empirical findings. *Journal of Development Studies*, 50: 101-143.

Bahmani-Oskooee, M.; Panthamit, N. (2006). Exchange rate overshooting in East Asian countries. *Emerging Markets Finance and Trade*, 42: 5-18.

Balassa, B. (1964). The Purchasing Power Parity Doctrine: A Reappraisal. *The Journal of Political Economy*, 72:584-596.

Barnett, W. A.; Bhadury, S. S.; Ghosh, T. (2016). An SVAR Approach to Evaluation of Monetary Policy in India: Solution to the Exchange Rate Puzzles in an Open Economy. *Open Economies Review*, 27:871-893.

Belaisch, M. A. (2003). Exchange rate pass-through in Brazil. *IMF Working Paper WP/03/141*. Access: https://www.imf.org/external/pubs/ft/wp/2003/wp03141.pdf

Bilson, J. F. O. (1978). Rational Expectations and the Exchange Rate: In: Frenkel, J. A.; Johnson, H.G. (eds.), *The Economics of Exchange Rates*. Reading, MA, USA, Addison-Wesley.

Bjørnland, H. C. (2009). Monetary policy and exchange rate overshooting: Dornbusch was right after all. *Journal of International Economics*, 79:64-77.

Bouvet, F.; Ma, A. C.; Van Assche, A. (2017). Tariff and exchange rate pass–through for Chinese exports: A firm level analysis across customs regimes. *China Economic Review,* 46:81-96.

Bresser-Pereira, L. C. (2012). A taxa de câmbio no centro da teoria do desenvolvimento. *Estudos Avançados*, 26:7-28.

Bresser-Pereira, L. C. (2013). The value of the exchange rate and the Dutch disease. *Brazilian Journal of Political Economy*, 33:371-387.

Bresser-Pereira, L. C.; Gala, P. (2010). Macroeconomia estruturalista do desenvolvimento. *Revista de Economia Política*, 30(4):663-686.

Bresser-Pereira, L. C.; Marconi, N.; Oreiro, J. L. (2014). *Developmental Macroeconomics: New Developmentalism as a Growth Strategy*. Vol. 1. London: Routledge.

Bresser-Pereira, L. C.; Marconi, N.; Porto, T.; Araujo, E.; & Leao, R. (2022). Current equilibrium exchange rate: methodology and estimations for Latin American countries. *Brazilian Journal of Political Economy*, 42(4): 809-834.

Burstein, A.; Eichenbaum, M.; Rebelo, S. (2013). Modeling exchange rate passthrough after large devaluations. *Journal of Monetary Economics*, 54:346-368.

Campa, J. M.; Goldberg, L.S. (2005). Exchange rate pass-through into import prices. *Review of Economics and Statistics*, 87:679-690.

Caselli, F. G.; Roitman, A. (2019). Nonlinear exchange–rate pass–through in emerging markets. *International Finance*, 22:279-306.

Cavallo, M.; Kisselev, K.; Perri, F.; Roubini, N. (2005). Exchange rate overshooting and the costs of floating. *FRB of San Francisco Working Paper Series 2005-07*.

Cicek, S.; Boz, Ç. (2013). A New Test of Exchange Rate Pass-through in a Small Open Economy: Evidence from Asymmetric ARDL Bounds Approach. *Iktisat Isletme ve Finans*, 28:43-64.

Correa, A.; Minella, A. (2010). Nonlinear mechanisms of the exchange rate pass-through: a Phillips curve model with threshold for Brazil. *Revista Brasileira de Economia*, 64:231-243.

Dash, A. K.; Narasimhan, V. (2011). Exchange rate pass-through: How much do exchange rates changes affect the prices of Indian exports and imports? *South Asian Economic Journal*, 12:1-23.

Delatte, A.; López-Villavicencio, A. (2012). Asymmetric exchange rate pass-through: Evidence from major countries. *Journal of Macroeconomics*, 34:833-844.

Dornbusch, R. (1976). Expectations and exchange rate dynamics. *Journal of Political Economy*, 84:1161-1176.

Dobrynskaya, V. V.; Levando, D.V. (2008). Exchange rate pass-through effect and monetary policy in Russia. In: Karadeloglou, P.; Terraza, V. (eds.) (2008). Exchange Rates and Macroeconomic Dynamics". Palgrave Macmillan, London, 115-138.

Egert, B.; Macdonald, R. (2009). Monetary transmission mechanism in Central and Eastern Europe: Surveying the surveyable. *Journal of Economic Surveys*, 23:277-327.

Flood, R. P. (1979). An example of exchange rate overshooting. *Southern Economic Journal*, 46:168-178.

Feuerriegel, S.; Wolff, G.; Neumann, D. (2016). News sentiment and overshooting of exchange rates. *Applied Economics*, 48:4238-4250.

Frankel, J. A. (1979). On the Mark: A Theory of Floating Exchange Rates Based on Real Interest Differences. *American Economic Review*, 69:610-622.

Frenkel, J. A. (1976). A Monetary Approach to the Exchange Rate: Doctrinal Aspects and Empirical Evidence. *Scandinavian Journal of Economics*, 78:200-224.

Ford, N.; Horioka, C. Y. (2016). The 'Real' Explanation of the PPP Puzzle. NBER Working Paper 22198.

Froot, K.; Rogoff, K. (1995). Perspectives on PPP and Long-Run Real Exchange Rates." In: Grossman, G.; Rogoff, K. (eds). *Handbook of International Economics*, III, 1646-88, North-Holland, Amsterdam.

Gardeazabal, J.; Regúlez, M. (1992). The Monetary Model of Exchange Rate Determination. In: Fandel, G; Trockel, W. (eds). The Monetary Model of Exchange Rates and Cointegration. *Lecture Notes in Economics and Mathematical Systems*, v. 385. Springer, Berlin, Heidelberg.

Goldberg, P. K.; Knetter, M. M. (1997). Goods prices and exchange rates: What have we learned? *Journal of Economic Literature*, 35:1243-1272.

Ha, J.; Stocker, M.; Yilmazkuday, H. (2019). Inflation and Exchange Rate Pass-Through. *World Bank Policy Research Working Paper* n. 8780.

Hairault, J-O.; Patureau, L.; Sopraseuth, T. (2004). Overshooting and the exchange rate disconnect puzzle: a reappraisal. *Journal of International Money and Finance*, 23:615-643.

Hooper, P.; Morton, J. (1982). Fluctuations in the Dollar: A Model of Nominal and Real Exchange Rate Determination. *Journal of International Money and Financ*e, 1:39-56.

Jašová, M.; Moessner, R.; Takáts, E. (2019). Exchange Rate Pass-Through: What Has Changed Since the Crisis? *International Journal of Central Banking*, 15:27-58.

Jiang, J.; Kim, D. (2013). Exchange rate passthrough to inflation in China. *Economic Modelling*, 33:900–912.

Jiménez–Rodríguez, R.; Morales–Zumaquero, A. (2020). BRICS: How important is the exchange rate pass–through? *The World Economy*, 43:781-793.

Karoro, T. D.; Aziakpono, M. J.; Cattaneo, N. (2009). Exchange rate pass–through to import prices in South Africa: is there asymmetry? *South African Journal of Economics*, 77:380-398.

Kim, S. (2005). Monetary policy, foreign exchange policy, and delayed overshooting. *Journal of Money, Credit and Banking*, 37:775-782.

Kim, S.; Henry Kim, S. (2007). Financial panic and exchange rate overshooting during currency crises. *International Economic Journal*, 21:71-89.

Kim, S.; Moon, S.; Velasco, C. (2017). Delayed overshooting: is it an 80s puzzle? *Journal of Political Economy*, 125:1570-1598.

Kim, S.; Roubini, N. (2000). Exchange rate anomalies in the industrial countries: A solution with a structural VAR approach. *Journal of Monetary Economics*, 45:561-586.

Lee, J–E. (2016). Exchange rate dynamics with foreign reserves: revisiting the Dornbusch overshooting model. *Review of Development Economics*, 20:406-414.

Maitra, B. (2016). Monetary, Real Shocks and Exchange Rate Variations in India. *Journal of Economic Development*, 41:81-103.

Mallick, S.; Marques, H. (2008). Exchange rate transmission into industry–level export prices: A tale of two policy regimes in India. *IMF Staff Papers*, 55:83-108.

Muinhos, M. K. (2004). Inflation targeting in an open financially integrated emerging economy: the case of Brazil. *Estudos Econômicos*, 34:269-296.

Nogueira Jr., R. P. (2007). Inflation targeting and exchange rate pass-through. *Economia Aplicada*, 11:189-208.

Pesaran, M. H.; Shin, Y. (1999). An Autoregressive Distributed-Lag Modelling Approach to Cointegration Analysis. In: Strøm, S. (ed.). *Econometrics and Economic Theory in the 20th Century*, 371-413.

Pesaran, M. H.; Shin, Y.; Smith, R. P. (1999). Pooled mean group estimation of dynamic heterogeneous panels. *Journal of the American Statistical Association*, 94:621-634.

Pesaran, M. H.; Shin, Y.; Smith, R. J. (2001). Bounds Testing Approaches to the Analysis of Level Relationships. *Journal of Applied Econometrics*, 16:289-326.

Reyes, J. (2007). Exchange rate passthrough effects and inflation targeting in emerging economies: what is the relationship? *Review of International Economics*, 15:538-559.
Rogoff, K. (1996). The Purchasing Power Puzzle", *Journal of Economic Literature*, 34:647-68.
Rogoff, K. (2002). Dornbusch's Overshooting Model after Twenty-Five Years: International Monetary Fund's Second Annual Research Conference Mundell-Fleming Lecture. *IMF Staff Papers*, 49:1-34.
Samuelson, P. A. (1964). Theoretical notes on trade problems. *The Review of Economics and Statistics*, 46:145-154.
Stein, J. L. (1995). The Natural Real Exchange Rate of the United States Dollar, and Determinants of Capital Flows. In: Stein, J. L.; Allen, P. R. (eds): *Fundamental Determinants of the Exchange Rates*, Chapter 2, 38-84, Claredon Press: Oxford.
Tu, W.; Feng, J. (2009). An overview study on Dornbusch overshooting hypothesis. *International Journal of Economics and Finance*, 1:110-116.
Yanamandra, V. (2015). Exchange rate changes and inflation in India: What is the extent of exchange rate pass–through to imports? *Economic Analysis and Policy*, 47:57-68.

APPENDIX

Table A1: ARDL Extended Model – Long Run Coefficients and ECM

Country	China	Russia	India
	Coeffic. [Prob.]	Coeffic. [Prob.]	Coeffic. [Prob.]
Exchange Rate	0.742 [0. 086]	0.407 [0.018]	-0.224 [0.184]
Industrial Production	-0.485 [0.115]	0.886 [0.045]	-0.200 [0.425]
Oil Price	0.003 [0.943]	0.080 [0.405]	0.031 [0.250]
International Reserves	0.379 [0.000]	0.185 [0.009]	-0.046 [0.602]
Interest Rate	-0.037 [0.017]	0.025 [0.000]	0.022 [0.000]
ECMt-1	-0.037	-0.023	-0.099

Table A2: China – Correlation Matrix

Country	CPI	Exchange Rate	Industrial Production	Oil Price
CPI	1.00	-0.73	-0.85	-0.03
Exchange Rate	-0.73	1.00	0.59	-0.36
Industrial Production	-0.85	0.59	1.00	0.26
Oil Price	-0.03	-0.36	0.26	1.00