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Asymmetric Effects in Geopolitical Risk and Foreign Reserves Accumulation Among BRICS Countries

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Abstract

Over the past decade, the rise of Geopolitical Risk (GPR) has had a significant effect on macro financial variables, prompting central banks to accumulate reserves as a "war chest" to protect their economies from the detrimental effects of such shocks. This study examines the asymmetries in the long run, short run, and locational asymmetric effects on foreign reserves in the BRICS countries, using both the Nonlinear ARDL (NARDL) and Quantile ARDL (QARDL) models over the period 2000Q1–2021Q4. The results of the NARDL model suggest that GPR has long-run asymmetric effects for BRICS, while in the short run, all countries display insignificant asymmetries. The QARDL model reveals a quantile-dependent asymmetric relationship both in the long run and short run in the BRICS countries. In the long run, GPR has a significant impact on reserves at the higher quantile for Brazil, lower quantiles for China and South Africa, and had an insignificant impact in Russia and India. In the short run, GPR impacts are located at the lower quantiles in South Africa. The control variables of Real Effective Exchange Rate, M2 Money, Foreign Direct Investment, and Domestic Credit to Private Sector have asymmetric effects on reserves at extreme quantiles both in the long run and short run. Central bankers are advised to consider geopolitical risk when accumulating foreign exchange reserves for precautionary reasons.

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Keywords: geopolitical risk, foreign exchange reserves, BRICS countries.

JEL classification: C54, E58, H63.

1.0 Introduction

This study examines asymmetric effects in the impact of geopolitical risk (GPR) on foreign exchange reserves in countries commonly labeled as BRICS, i.e., Brazil, Russia, India, China, and South Africa. As widely discussed in the literature, GPR has been rising since the end of the Covid 19 pandemic (Caldara & Iacoviello, 2022; Lu et al., 2020; Salisu et al., 2022). The impact of such risk on the world economy, trade, finance, security, and political relations is yet to be fully assessed. Its full impact stems from the recent shocks in the global economy, according to Pierre-Olivier Gourinchas (2022), stemming from disruptions to trade flows, tightening financial conditions, economic slowdown, increasing price pressures on general goods, rising commodity prices, stock market volatilities, as well as food shortages; all exacerbated by Russia's invasion of Ukraine. As supply chain issues and high energy prices persevere, most developing countries are looking to shore up their foreign exchange reserves as their reserves have been dwindling, and currencies are plummeting. Emerging market countries with high levels of debt were also hard hit, with many forced to allow their currency to depreciate and draw down their foreign currency reserves. Amid these events, the U.S. dollar has appreciated almost two-decade high as investors seek a "haven" currency (Fatum and Yamamoto 2016) due to the geopolitical shock.

Caldara and Iacoviello (2022) have established a link between geopolitical risk and macro financial variables across different countries. By this, they mean that when geopolitical risk intensifies, due to occurrences like terrorist acts, wars, and state tensions, it has a direct effect on financial and macroeconomic variables. As a result, nations are compelled to increase their reserves, thus showing a strong relationship between the two indicators. The literature shows that foreign reserves and geopolitical risk have increased significantly in emerging markets in the past few decades. Geopolitical episodes drive macro-financial instability via capital outflows (Caldara & Iacoviello, 2019), exchange rate volatility (Jeanne and Rose 2002, Salisu et al. 2020), trade flow disruptions (Gupta, 2019), domestic capital flight (Lu et al. 2020) and financial market instability (Balcilar et al. 2018). The impact of GPR on international capital or portfolio flows also been studied (Cheng & Chiu, 2018; Aysan et al., 2019). Cheng and Chiu (2018) reported that GPR hurts output, while Bloomberg et al. (2004) also stated that GPR reduces economic activity. Foreign reserves provide foreign currency liquidity in the domestic market during economic crises and volatile financial conditions when access to foreign borrowing is restricted. Most often, Central banks use foreign currency reserves to defend and target the exchange rate, facilitate transactions between countries, and support confidence in the financial markets to ensure that the obligations to creditors are met (IMF, 2016).

Even though there are a number of research conducted on the relationship between geopolitical risk and macroeconomic variables, yet empirical studies that explore the link between geopolitical risk and foreign reserves are scarce. This study investigates the relationship between foreign exchange reserve build-up and geopolitical risk events in BRICS. Geopolitical risk events are infrequent, yet their impact is severe and long-lasting (Astvansh et al., 2022). These events can be transmitted in a variety of ways (Caldara, 2022). In contrast to economic and political uncertainty indicators, which only consider domestic issues, geopolitical risk encompasses both domestic and international occurrences. Furthermore, geopolitical risk is notoriously difficult to predict, as it includes unpredictable events such as terrorist activities (Alsagr & Almazor, 2020). We investigate how geopolitical risk affects the accumulation of foreign reserves in BRICS countries, and if it has both short- and long-term asymmetric effects. Given that geopolitical risk is often associated with tail risk, our aim is to explore the impact it has on different quantiles of the foreign reserve distribution among BRICS countries.

Our study can be interpreted as assessing the relative strength of the precautionary self-insurance motive of the BRICS countries' massive reserves in response to increased geopolitical shock. As it is often hypothesized that countries accumulate reserves as a "war chest" to insulate the economic crisis, the current geopolitical shock in Europe is fueling economic instability worldwide. Therefore, as part of the objective, the study is justified to test the precautionary/Financial stability motive of reserves accumulation in response to the geopolitical risk of the financially integrated BRICS countries.

This study contributes to the literature by bridging the knowledge gap regarding the effects of GPR uncertainty on the foreign reserves of the BRIC countries. Focusing on this group of countries makes our analysis relevant for several reasons. First, the nature of the political economy was taken into consideration. China and Russia's political institutions are less democratic, whereas India, Brazil and South Africa have strong democratic institutions. Again, Russia and South Africa's economy depends on extractive natural resources, while China and Brazil rely more on industrialization, and India is a service-oriented economy. The BRICS countries fall within the top 12 countries globally, with the largest foreign reserves accumulation (China 1st, Russia 4th, India 5th, Brazil 11th) IMF (2021). They attracted 20% of the world's foreign direct Investment (FDI) inflows and saw 17% of the FDI outflows in 2018 (UNCTAD, 2019). Third, the BRICs represent about 41% of the world population and account for over 16% share the world trade, having 24% of the total global GDP in 2022 (BRICS INDIA, 2021). Fourth, with a combined growth rate of 28%, they are the four largest emerging stock markets economies comprising about 24.6% of gross equity market capitalization (World Bank, 2015). Furthermore, from January 1988 to September 2015, the excess returns on stock market returns have been phenomenal in these countries. Given the above characteristics of the BRIC countries, it is reasonable to assume that episodes of geopolitical risk will undoubtedly have important implications on their reserve position.

According to Caldara and Iacoviello (2022), the Geopolitical Index has asymmetric effects on the economy, capital flows, trade, the stock market returns in the industrial sectors of advanced economies. Against this background, the main contribution of this study relates to the use of new econometric methods that evaluate asymmetric and nonlinear linkages between the considered variables. In our model, we take into account three main forms of asymmetries: reaction asymmetry (determined by long-run relationships), adjustment asymmetry (determined by short-run dynamics), and locational asymmetry (captured at different quantiles of the dependent variable). We employ the nonlinear autoregressive distributed lag (NARDL) co-integration model introduced by Shin et al. (2014). The authors of NARDL use negative and positive partial sum decompositions to describe the asymmetric effects in the short and long runs. In addition, we employ the Quantile Autoregressive Distributed Lag (QARDL) model developed by Cho et al. (2015) to examine the relationship between changes in different quantiles of foreign exchange reserves distribution concerning geopolitical risk movements. The QARDL model estimates the relationship between the variables at various quantiles of the whole distribution of the dependent variable while taking non-linearity into account. This aspect is important because the estimated parameters may depend on the quantile location of the dependent variable within its distribution instead of only one average coefficient on the whole series. The QARDL additionally takes into account the dependent variable's skewness, heterogeneity, and outliers. Previous studies that adopt parametric model estimations (e.g., Cointegration and ARDL) might have missed vital information because such models do not incorporate different quantiles across the whole conditional distribution of the dependent variable. Using quantile analysis is beneficial in understanding the asymmetrical effects of GPR on the distribution of foreign exchange reserves. It offers insight into both the upper and lower tail dependencies which can be beneficial in making decisions. The Wald test can be employed to determine if a time-varying relationship of integration is evident, by looking at whether the integration coefficients differ across different quantiles of the distribution. This study aims to improve prediction models to help central banks in their attempts to accumulate reserve funds to safeguard against the effects of geopolitical threats and the channels of transmission linked to financial integration. To the best of our knowledge, this method has not been used in previous studies on the effects of GPR on foreign reserves.

The remainder of the paper is organized as follows. Section 2 provides the literature review. Section 3 describes the methodology and the construction of the NARDL and QARDL models. Section 4 presents the data and the empirical results, and finally, Section 5 provides concluding comments and policy implications.

2.0 Literature Review

2.1 Review of Some Related Literature

The study is related to various strands of the literature. It broadly relates to the literature on the motives behind reserve accumulation and Geopolitical Risk. The literature shows that central bank policy makers accumulate these reserves for several reasons. Traditionally, foreign exchange (FX) reserve accumulation is considered a tool for exchange rate management, notably to ease pressure on the exchange rate during shocks (Levy & Sturzenegger, 2006). However, empirical studies also show that the piling up of reserves plays a much broader role, such as precautionary self-insurance against shocks (Aizeman & Lee, 2008) or mercantilism to spur growth (Dooley et al., 2004). Furthermore, it may be used to back up the domestic banking system and insure against financial instability (Obstfeld et al., 2006) or manages exchange rate volatility (Levy & Sturzenegger, 2006).

The setup of the world economy is such that global trade transactions are invoiced mainly in dollars (Gupta, 2020), and external borrowings are also predominantly structured in dollar currency (BIS, 2020). This has meant that hot capital flows are usually in dollars (IMF 2016). Additionally, many emerging economies' productive and financial sectors have become globalized, leading to greater integration of world financial markets (Beine & Candelon 2011). Such conditions create an environment where the demand for adequate international reserves is even more crucial for emerging markets. Essentially, the world has become a global village where financialization has gone global, with the dollar assuming the role of a global currency. Hence, the amount accumulated of dollar assets may not be adequate for many countries. However, since reserves are liquid assets and pay low returns, holding excess reserves has an opportunity cost. Therefore, the idea that some countries accumulate far more reserves than they require (IMF 2016) has become a puzzle.

Both theory and empirical studies view countries adopting a floating exchange rate regime (Chung & Wang, 2001), would have no motivation to accumulate reserves. However, over the past three decades, total international reserves have surged more than tenfold, and the amount held globally reached $12.9 Trillion at the end of 2021 (IMF COFER). Emerging markets and developing countries' reserves constitute about two-thirds of these reserves, growing from 5% of GDP in 1990 to about 30% in 2018. Within the emerging markets, we have witnessed much sharper increases in such accumulation, from Asian countries to commodity and oil-rich exporting nations, such as Saudi Arabia, Algeria, and others (Arslan et al. 2019). Studies on the global trend in international reserves build-up in size, adequacy, and composition have also gained much attention among policy makers, academics and investors (IMF 2016).

2.2 Theoretical Models

The body of studies investigating the reasons of reserve accumulation is extensive and includes both theoretical and empirical investigations. The studies mainly concentrate on the two primary objectives of reserve accumulation by central banks. These are mercantilist and precautionary objectives. As model specifications, the cost-benefit analysis, reserve function analysis, ratio analysis, and qualitative analysis were all used. The precautionary motive was first discussed by Heller (1966), who also looked at the requirement for reserves as being inversely proportionate to the marginal propensity to import using cost-benefit analysis. Reserve function analysis, a regression-based model, was used by Frankel and Jovanovic (1981) to calculate the required quantity of reserves. This model considered average import trends, the size of foreign exchange trade, and the balance of payments. The findings indicated that maintaining reserves has costs, but it can also guarantee a reduction in adjustment costs in the event of negative shocks. Flood and Marion (2002) improved Frankel and Jovanovic's (1981) research by extending the model to take reserve volatility into account. Ben-Bassat and Gottlieb (1992) disputed this idea, arguing that governments should instead accumulate reserves to safeguard their creditworthiness and avoid defaulting on foreign debt. Jeanne and Rancière (2006) added that reserves also function as insurance, protecting countries from problems with capital flows and regulating their currency rates. As a result, nations build up reserves to prevent default, keep up a stellar credit rating, and lessen their exposure to changes in capital flow.

Obstfeld et al. (2010) place a strong emphasis on reserve accumulation as a strategy for domestic financial stabilization and for reducing exchange rate volatility in a more globally interconnected society. Ratio analysis is used to evaluate how well reserves protect domestic banking and credit markets while minimizing the depreciation of foreign currencies. While the Greenspan-Guidotti rule proposed a ratio of short-term external debt to reserves, Triffin (1960) recommended that reserves should not fall below 20% of import-export volume. Jeanne and Ranciere (2006) suggest that calculating the ratio of the foreign exchange reserve to the country's gross domestic product can help estimate the ideal level of foreign reserves for a small open economy that is susceptible to sudden capital stops (GDP). Ratio measures are popular, simple to use, and can be used to analyze data from any country. However, they have a limitation of only allowing one economic variable to be used at a time and may underestimate the effects when combined with other variables.

Dooley et al. (2004) conducted a qualitative study and found that foreign reserves can act as a form of collateral to offer assurance to private foreign investors that their investments will not be seized. This finding indicates that central banks in emerging markets may accumulate reserves to provide reassurance to foreign investors.

2.3 Empirical Models

Empirical studies have applied econometric analysis to examine the optimal reserve holding of countries on a time-series, panel, or cross-country basis. These studies can be divided into two main categories: univariate ratio analysis and multivariate regression analysis. Univariate ratio analysis measures the optimal reserve holding against a single variable, such as the foreign exchange reserves to short-term external debt ratio (Jeanne & Ranciere, 2011), foreign exchange reserves to broad money supply ratio (Frenkel, 1974), and foreign exchange reserves to imports ratio (Pineau et al., 2006). Multivariate regression analysis, on the other hand, includes several explanatory variables to test their impact on reserves. These variables can be classified into economic size, current account vulnerability, capital account vulnerability, exchange rate flexibility, and the opportunity cost of holding reserves (Prabheesh et al., 2007). Cheung and Ito (2009) studied reserves for 100 developed and emerging market economies, categorizing the explanatory variables into four buckets: traditional macro variables, financial variables, institutional variables, and dummy variables. Bussière et al. (2015) studied 112 developing countries to test how financial crisis impacted reserves, finding that countries with high reserves fared well during the crisis. Delatte and Fouquau (2009) adopted a nonlinear panel smooth transition model (PSTR) to test the dynamics of the foreign reserves held in 20 emerging markets from 1980-2004, supporting the mercantilist view rather than the precautionary motive of reserve accumulation. Steiner (2013) argued that the "fear of capital mobility" is why the central bank builds reserves, while Levy-Yeyati and Sturzenegger (2007) introduced the concept of asymmetry and stated that a "fear of appreciation" was the determinant of reserves accumulation.

2.4 Geopolitical Risk

The growing relevance of geopolitical risk as a scientific field has led to the development of a Geopolitical Risk Index (GPI) by Caldara and Iacovello (2022). This index measures the likelihood of wars, terrorist acts, and tensions between states that can disrupt the normal course of international relations. It has been found to have a direct impact on the world economy, and is a key factor in investment decisions, affecting financial markets (Berkman et al., 2011; Pastor and Veronesi, 2012; Huang et al., 2015). Geopolitical risk can transmit its impact through several channels, such as trade, capital flows, and business cycles. Studies have shown that it can reduce foreign direct investment (Afsar et al., 2021), domestic credit to the private sector (Zhou et al., 2020), and economic growth (Soltani et al., 2021). It can also affect the outlook on the government's fiscal position, inflation dynamics, and exchange rate (Jeanne & Rose, 2002; Salisu et al., 2020).

This research builds on existing research on the precautionary motive, exploring how geopolitical risk affects reserves. We go beyond linear models to investigate if there are any short and long run as well as locational asymmetric effects.

2.5 Data Description

2.5.1 Data Period and Sources

This study covers a period of 88 quarters, from 2000Q1 to 2021Q4. We follow the work of Behera et al. (2008), Goyal (2012), and Inoue et al. (2015) in using quarterly data instead of monthly data, as policy variables in large economies, such as India and China, require a longer period to reflect changes in the economic and political environment. To convert the Global Political Risk (GPR) index sourced in monthly format to quarterly data, we use quadratic-match sum interpolation in

EViews, as suggested by Shahbaz et al. (2018). The dependent variable of this study is foreign reserves as a percentage (%) of GDP, with the main regressor being the GPR index of Caldara and Iacoviello (2022). Additionally, we use the following control variables following Prabheesh et al. (2009) classification: Real Effective Exchange Rate (REER) as a proxy for exchange rate flexibility, Foreign Direct Investment (FDI) as a percentage (%) of GDP for capital flows, Broad Money Supply as a percentage (%) of GDP (M2), and Domestic Credit to the Private Sector as a percentage (%) of GDP (DCP) as a proxy for financial development and integration. For this study, we use the log forms for only REER and GPR, since the rest of the variables are expressed as percentages.

We do not include traditional explanatory variables such as interest rate, population, short-term external debt, log GDP, imports, and exports in the regression analysis. This is due to Obstfeld et al. (2010) finding that variables such as population and short-term external debt were insignificant in explaining foreign exchange reserves. Additionally, interest rates are insignificant since most of the world capital markets are well integrated, with observed co-movement of interest rates across countries (Caceres et al., 2016). Our analysis showed that GDP was significant when M2 was omitted, but insignificant when M2 was included, thus providing strong evidence as a proxy for M2 and justifying its exclusion. We also omitted variables such as imports and exports since they became insignificant when the exchange rate was included. This is because economic theory indicates that the exchange rate is a function of the difference between exports and imports (net exports). Green and Torgerson (2007) confirmed that imports and exports measurements were only useful in low-income countries with limited access to the international capital market. Rodrik (2006) showed that the size of the domestic financial sector significantly impacted foreign reserves build-up more than the level of international trade. Therefore, it is reasonable not to include the level of imports and exports as part of our control variables.

We retrieved GPR indexes from Caldara and Iacoviello (2022), Domestic Quarterly Credit to the Private Sector data from the World Bank Indicators (WDI) database, Foreign Reserve as a % of GDP, Foreign Direct Investment as a % of GDP, and Broad Money Supply as a % of GDP from CEIC data.com, and the Real Effective Exchange Rate from DataStream.

2.5.2 Geopolitical Risk

Caldara and Iacoviello (2022) developed a Geopolitical Risk (GPR) index by searching for phrases related to geopolitical risks and military threats in electronic archives of newspapers from January 1985 to April 2016. This index was created by counting the frequency of words related to geographical and political tensions in major national and international newspapers, such as The Guardian, The Washington Post, The Times, The Wall Street Journal, Financial Times, Chicago Tribune, Los Angeles Times, The New York Times, The Boston Globe, The Globe and Mail, and The Daily Telegraph. The index was then normalized to an average of 100 from 2000 to 2009. It was found to be impacted by events such as the Gulf War, the September 11 attack, the invasion of Iraq in 2003, the Russia and Ukraine crisis in 2014, and the terrorist attacks in Paris. It has two components: Geopolitical Threats (GPRT) and Geopolitical Acts (GPRA). GPRA shock refers to the implementation of harmful political events that could cause an increase in political threat, while GPRT shock captures geopolitical threats that were not connected simultaneously with geopolitical actions, such as tensions that occurred before a war or after a terrorist attack. It is expected that geopolitical risk negatively affects foreign reserves, just as financial instability has a negative effect on them.

2.5.3 Capital flows and Reserves

The influx of capital into emerging economies can be beneficial to economic growth. However, these flows can be volatile due to global liquidity and risk aversion. When capital flows rapidly, it can lead to credit booms and asset price inflation. In times of geopolitical tension, these flows can reverse, causing a depreciation of the exchange rate, equity price drops, and an increase in financial volatility, which can lead to a decrease in investment and GDP growth. To combat this, Central Banks have foreign reserves as a tool to manage capital flows, which is a key factor in the accumulation of reserves. Dooly et al. (2004) and Wang (2019) both found a positive correlation between capital inflows and reserve holdings, with reserves being a form of collateral to secure FDI inflows from industrial countries, and protect against sanctions.

2.5.4 Real Effective Exchange Rate and Foreign Reserves

We employ the real effective exchange rate (REER) to gauge the exchange rate of the BRIC countries. The REER is the weighted average of the currency’s exchange rate for a basket of major foreign currencies, adjusted for inflation, with the weight determined by the balance of international trade. Exchange rate fluctuations can have an effect on the demand for reserves, but the magnitude and direction of the demand will depend on whether the exchange rate has appreciated or depreciated. Studies have found that a local currency depreciation can lead to a higher reserve build-up. We use the REER to examine the asymmetry, persistence, and non-linearity that was observed in exchange rate movements during geopolitical episodes. Research has suggested that the dynamics of exchange rate adjustment are characterized by nonlinearity, with different nonlinearity sources potentially influencing exchange rate dynamics (Obstfeld & Taylor, 1997).

2.6 Reserves and Broad Money Supply (M2 as a % of GDP)

The role of broad money supply (M2) in determining reserve accumulation has become increasingly important. Wijnholds and Kapteyn (2001) argue that money stock in an economy is a measure of potential capital flight by domestic residents and can be used as a proxy for "internal drain." This study uses M2 as a percentage of GDP. Additionally, M2 is a proxy for the self-insurance target proposed by Obstfeld et al. (2009). Lane and Burke (2001) found a positive correlation between reserves and money supply, and this was confirmed by Yao and Abdul Rashid (2018) and Obstfeld et al. (2010).

2.6.1 Domestic Credit to Private Sector and Foreign Reserves

The accumulation of foreign reserves can lead to an imbalance in the domestic economy, particularly if interventions are not fully sterilized and too much liquidity is created. This excess liquidity may encourage domestic intermediaries to be more lenient when assessing the creditworthiness of borrowers, thus increasing the supply of credit. Low interest rates and increased liquidity can also spur excessive investment in tradable and real estate assets. Sinah (2017) found that growth in domestic credit is positively correlated with foreign reserves. However, too much credit growth can put pressure on the level of reserves, as seen in the work of Gourinchas and Obstfeld (2012) and Mohanty and Turner (2006). Ghosh et al. (2012) found that when domestic credit is more restricted, foreign reserves are more likely to increase. Their empirical study also revealed that the flow of domestic credit to the private sector had a negative impact on foreign reserves.

3.0 Methodology

3.1 NARDL and QARDL Estimation

In order to capture the nonlinear and asymmetric effects of economic variables on foreign reserves, the current study adopts the nonlinear ARDL model of Shin, Yu, and Greenwood-Nimmo (2014). This model decomposes negative and positive partial sums to describe the asymmetric effect in both the short and long run. Previous research has demonstrated that economic variables do not follow a linear trend, but rather display nonlinear and asymmetric behaviors (Arize & Malindretos, 2012; Bahmani-Oskooee et al., 2017; Kapetanios et al., 2003; Sollis, 2009). For instance, geopolitical events may spike or be absent, exchange rates may appreciate or depreciate, capital flows may surge or suddenly stop, and credit may be squeezed or boomed depending on the economic situation. All of these periods could potentially have different impacts on foreign reserves. Therefore, the nonlinear ARDL model of Shin, Yu, and Greenwood-Nimmo (2014) is adopted in this study to capture the asymmetric effects of economic variables on foreign reserves.

Therefore, the NARDL model developed by Shin, Yu, and Greenwood-Nimmo (2014) is an effective way to take into account both positive and negative effects on reserves. This model has two major advantages over traditional cointegration techniques. Firstly, even with a limited sample size, the nonlinear ARDL model is highly efficient and deals with the issue of potential endogeneity well. Secondly, the nonlinear ARDL boundary test approach does not require all series to be I(1) in order to identify a long-term relationship between variables. The variables can be a combination of I(0) and I(1) but must not be integrated to order 2 [I(2)].

Shin et al. (2014) proposed the Nonlinear Autoregressive Distributed Lag (NARDL) model to estimate long-run or reaction asymmetry and adjustment asymmetry in the short-run. This model considers the interaction of impact and reaction asymmetries concerning the error correction coefficient. In order to further explore the tail impact of geopolitical risk on reserves, we employed Quantile ARDL (QARDL) method developed Cho et al. (2015). This method combines ARDL and quantile regression, allowing for the examination of both short-run and long-run asymmetries across the entire conditional distribution of the dependent variable. Unlike the NARDL model, the QARDL method takes into account multiple time-varying conditional quantiles at different quantile points to assess the relationship between geopolitical risk and reserve accumulation.

We start our analysis with the estimation of an Autoregressive Distributed Lag (ARDL) model, followed by a Nonlinear Autoregressive Distributed Lag (NARDL) model, and conclude with a Quantile Autoregressive Distributed Lag (QARDL) model. The QARDL model is used to capture the nuances of the relationship between changes in international reserves and geopolitical risk episodes. This model allows us to investigate the asymmetric effects of exchange rates on foreign exchange reserves, as well as the level of foreign reserves' importance in relation to other determinants. To ensure the models are stable, we conducted a unit root test, followed by CUSUM and CUSUM squared tests. We also established the appropriate lag length.

The Foreign Reserve demand function is estimated as follows:

$$\mathrm{FXI} = f(REER, GPR, \mathrm{M2}, \mathrm{DCP}, \mathrm{FDI},)$$

$$\mathrm{FXI} = \alpha_0 + \alpha_1 \mathrm{FXI}_{t-1} + \alpha_2 \mathrm{REER} + \alpha_3 \mathrm{GPR} + \alpha_4 \mathrm{M2} + \alpha_5 \mathrm{DCP} + \alpha_6 \mathrm{FDI} + \varepsilon_t. \quad (1)$$

Where, FXI_t are the foreign reserves as a % of GDP, $REER_{i,t}$ is the Real Effective Foreign Exchange and GPR is the Geopolitical Risk Index. FDI_t is Foreign Direct Investment as a % of GDP, $M2_t$ defines Broad Money as % of GDP and α_0 is the constant term. The $\alpha_1 - \alpha_6$, are the coefficients to be determined, while ε_t is the stochastic error term representing the unaccounted factors not listed in the model. We also include FXI_{t-1}, an autoregressive function of the lag value of foreign reserves. To model NARDL, we first estimate the standard ARDL model. This standard equation is specified as follows:

$$\Delta \mathrm{FXI}_t = \alpha_0 + \alpha_1 \mathrm{FXI}_{t-1} + \alpha_2 \mathrm{REER}_{t-1} + \alpha_3 \mathrm{GPR}_{t-1} + \alpha_4 \mathrm{FDI}_{t-1} + \alpha_5 \mathrm{M2}_{t-1} + \alpha_6 \mathrm{DCP}_{t-1} + \sum_{i=1}^{q} \theta_1 \Delta \mathrm{FXI}_{t-1} + \sum_{i=0}^{q} \theta_2 \Delta \mathrm{REER}_{t-1} + \sum_{i=0}^{q} \theta_3 \Delta \mathrm{GPR}_{t-1} + \sum_{i=0}^{q} \theta_4 \Delta \mathrm{FDI}_{t-i} + \sum_{i=0}^{q} \theta_4 \Delta \mathrm{M2}_{t-i} \ldots \ldots + \varepsilon_t, \quad (2)$$

where $\alpha_1 - \alpha_8$ are long-run coefficients and $\theta_1 - \theta_8$ represent short-run coefficients. FXI_t , REER_t, GPR_t, $\mathrm{M2}_t$, DCP_t, and FDI_t, are the variables shown earlier and remain the same at time *t* for the BRIC countries. The delta symbol (Δ) represents the lag operator for short-run effects.

The ARDL model (equation 2) is a linear model, which is a concept based on linear and symmetric relationships between variables. However, as stated earlier, several recent studies have shown that most economic fundamentals have non-linear (asymmetric) dynamics and as Caldera (2018) argued, GPR showed an asymmetric effect. Furthermore, most economic variables have structural breaks, as shown by Shahbaz et al. (2018) and Golit et al. (2019). With this in mind, we select the non-linear version of the ARDL called NARDL, which is appropriate for asymmetric data. The NARDL considers non-linearity by generating a series of both positive and negative partial sums. The positive and negative decomposed variables are computed as $\text{GPU}_t^+ = \sum_{j=1}^{t} \Delta GPR_j^+ = \sum_{j=1}^{t} \max(\Delta GPR_j, 0)$, $REER_t^+ = \sum_{j=1}^{t} \Delta REER_j^+ = \sum_{j=1}^{t} \max(\Delta REER_j, 0)$, $M2_t^+ = \sum_{j=1}^{t} \Delta M2_j^+ = \sum_{j=1}^{t} \max(\Delta M2_j, 0)$, $FDI_t^+ = \sum_{j=1}^{t} \Delta FDI_j^+ = \sum_{j=1}^{t} \max(\Delta FDI_j, 0)$, and $DCP_t^+ = \sum_{j=1}^{t} \Delta DCP_j^+ = \sum_{j=1}^{t} \max(\Delta DCP_j, 0)$, whereas negative partial sums are computed as $GPR_t^- = \sum_{j=1}^{t} \Delta GPR_j^- = \sum_{j=1}^{t} \min(\triangle GPR_j, 0)$, $REER_t^- = \sum_{j=1}^{t} \Delta REER_j^- = \sum_{j=1}^{t} \min(\Delta REER_j, 0)$, $M2_t^- = \sum_{j=1}^{t} \Delta M2_j^- = \sum_{j=1}^{t} \min(\Delta M2_j, 0)$, $FDI_t^- = \sum_{j=1}^{t} \Delta\, FDI_j^- = \sum_{j=1}^{t} \min(\Delta FDI_j, 0)$ and $DCP_t^- = \sum_{j=1}^{t} \Delta\, DCP_j^- = \sum_{j=1}^{t} \min(\Delta DCP_j, 0)$. The asymmetric error correction model is defined the following way:

$$\Delta \text{FXI}_t = \alpha_0 + \alpha_1^+ GPR_t^+ + \alpha_2^- GPR_t^- + \alpha_3^+ REER_t^+ + \alpha_4^- REER_t^- + \alpha_5^+ FDI_t^+ + \alpha_6^- FDI_t^- + \alpha_7^+ DCP_t^+ + \alpha_8^- DCP_t^- + \sum_{i=1}^{p} \Delta \text{FXI}_{t-i} + \sum_{i=0}^{q_1} \theta_1^+ \Delta GPR_{t-i}^+ + \sum_{i=0}^{q_2} \theta_2^- \Delta GPR_{t-i}^- + \sum_{i=0}^{q_3} \theta_3^+ \Delta REER_{t-i}^+ + \sum_{i=0}^{q_4} \theta_4^- \Delta REER_{t-i}^- + \sum_{i=0}^{q_5} \theta_5^+ \Delta FDI_{t-i}^+ + \sum_{i=0}^{q_6} \theta_6^- \Delta FDI_{t-i}^- + \sum_{i=0}^{q_7} \theta_7^+ \Delta DCP_{t-i}^+ + \sum_{i=0}^{q_8} \theta_8^- \Delta DCP_{t-i}^- + \varepsilon_t \quad (3)$$

The error correction model in equation (3) enables the study to establish both short- and long-run asymmetries in line with the study's primary objective. The long-run symmetry of each of the considered determinants would be tested using the Wald test of the respective null hypotheses $\rho^{+}_{GPR} = \rho^{-}_{GPR}$, $\rho^{+}_{REER} = \rho^{-}_{REER}$, $\rho^{+}_{M2} = \rho^{-}_{M2}$, $\rho^{+}_{FDI} = \rho^{-}_{FDI}$, $\rho^{+}_{DCP} = \rho^{-}_{DCP}$, while the short-run symmetries also tested using the Wald test of the respective null hypotheses $\sum_{i=0}^{q-1}\beta^{+}_{GPR,i} = \sum_{i=0}^{q-1}\beta^{-}_{GPR,i}$, $\sum_{i=0}^{q-1}\beta^{+}_{REER,i} = \sum_{i=0}^{q-1}\beta^{-}_{REER,i}$, $\sum_{i=0}^{q-1}\beta^{+}_{M2,i} = \sum_{i=0}^{q-1}\beta^{-}_{M2,i}$, $\sum_{i=0}^{q-1}$ $\beta^{+}_{FDI,i} = \sum_{i=0}^{q-1}\beta^{-}_{FDI,i}$ and $\sum_{i=0}^{q-1}$ $\beta^{+}_{DCP,i} = \sum_{i=0}^{q-1}\beta^{-}_{DCP,i}$

Unlike the standard linear ARDL model that considers only the average effects, this enhanced technique (QARDL) provides a robust analysis of the short- and long-run linkages for the entire conditional asymmetric distributions of foreign reserves and its determinants in the BRIC countries. The QARDL model based on the work of Cho et al. (2015) analyzes locational asymmetries by converting equation 2, which is presented below.

$$Q_{\mathrm{FXI}} = \theta_0(\tau) + \sum_{i=1}^{n1} \theta_1(\tau)\Delta\mathrm{FXI}_{t-i} + \sum_{i=0}^{n2} \theta_2(\tau)\Delta\mathrm{GPR}_{t-i} + \sum_{i=0}^{n3} \theta_3(\tau)\Delta\mathrm{REER}_{t-i} + \sum_{i=0}^{n4} \theta_4(\tau)\Delta\mathrm{M2}_{t-i} + \sum_{i=0}^{n5} \theta_5(\tau)\Delta\mathrm{FDI}_{t-i} + \alpha_1(\tau)\mathrm{FXI}_{t-i} + \alpha_2(\tau)\mathrm{GPR}_{t-i} + \alpha_3(\tau)\mathrm{REER}_{t-i} + \alpha_4(\tau)\mathrm{M2}_{t-i} + \alpha_5(\tau)\mathrm{FDI}_{t-i} + \alpha_6(\tau)\mathrm{DCP}_{t-i} + \alpha_7(\tau)\mathrm{MC}_{t-i}\ e_t(\tau) \quad (4)$$

where Δ signifies the lag operator, (τ) is a quantile index, θ_0 is the drift coefficient and n1 – n6 are the respective lag orders determined by the Akaike (AIC). The $\theta_1 - \theta_6$ are short-run coefficients and $\alpha_1 - \alpha_6$ are long-run coefficients, whilst the remaining variables are as defined previously.

The above QARDL specification shows the quantile interactions of foreign reserves and geopolitical risk as well as the other explanatory variables, in the BRIC countries. This study estimates 11 quantiles as follows: —τ∈{05, 10, 20, 30, 40, 50, 60, 70, 80, 90, 95}, to assess the quantile interactions of foreign reserves and geopolitical risk, as well as the other explanatory variables, in the BRIC countries. We use the Pesaran et al. (2001) bounds test process to estimate the long-run relationship between the variables, and the Wald test to test for the null hypothesis of parameter constancy for both the short- and long-run of the QARDL Model: [τ 05]FXI=[τ 10]FXI = ⋯ =[τ 95] FXI=[τ 05]GPR=[τ10]GPR = ⋯ = [τ95] GPR=[τ 05] REER=[τ 10]REER = ⋯ = [τ 95]REER=[τ 05]M2=[τ 10]M2 = ⋯ = [τ 95]M2= [τ 05]FDI=[τ 10]FDI = ⋯ = [τ 95]FDI=[τ 05]DCP=[τ 10]DCP = ⋯ = [τ 95]DCP =[τ 05]MC=[τ 10]MC = ⋯ = [τ 95]MC=0. This allows us to assess the quantile asymmetric effects of geopolitical risk and exchange rate variations on foreign reserves. The null hypothesis is outlined as follows:

Short-run parameter constancy test:

$$H_0^s: b_1(0.05) = \theta_1(0.10) = \cdots = \theta_1(0.95); H_0^s: \theta_2(0.05) = \theta_2(0.10) = \cdots = \theta_2(0.95)$$
$$H_0^s: \theta_3(0.05) = \theta_3(0.10) = \cdots = \theta_3(0.95); H_0^s: \theta_4(0.05) = \theta_4(0.10) = \cdots = \theta_4(0.95)$$

Long-run parameter constancy test:

$$H_0^l: \alpha_1(0.05) = \alpha_1(0.10) = \cdots = \alpha_1(0.95); H_0^l: \alpha_2(0.05) = \alpha_2(0.10) = \cdots = \alpha_2(0.95)$$
$$H_0^l: \alpha_3(0.05) = \alpha_3(0.10) = \cdots = \alpha_3(0.95); H_0^l: \alpha_4(0.05) = \alpha_4(0.10) = \cdots = \alpha_4(0.95)$$

3.2 Unit root test

The unit root test was employed to ascertain the stationarity of the data. In order to use the QADRL approach, it is necessary to determine the order of integration in the given data set. Thus, the augmented Dickey-Fuller (ADF) and Zivot-Andrews (1992) (ZA) unit root tests were conducted, and the results are reported in Table 1. The ZA test has the advantage of taking into account structural breaks in the data. According to Uche (2020), all the regressors used in the QADRL approach must be integrated at level I (0) or at the first difference I (1). The results of the tests showed that the QADRL approach is suitable for this data set, due to its non-linear and dynamic trend nature, as well as the presence of structural breaks.

.... insert Table 1 around here ….

4.0 RESULTS AND ANALYSIS

4.1 Descriptive Statistics

Table-2 indicates that the GPR dataset exhibits a nonlinear relationship, which is supported by the Jarque–Bera values. The null hypothesis of normality is rejected for GPR in all BRICS countries. The REER data displayed normality, apart from India and China. In the case of M2 data, nonlinearity was found in China and South Africa, while the rest of the countries passed the normality test. When it comes to FDI series, Russia, India and South Africa all failed the normality test. Lastly, DCP failed the normality test in all countries apart from South Africa. The data also reveals that whereas DCP is left-tailed or negatively skewed in Brazil, GPR, REER, M2, and FDI are positively skewed or right-tailed. Except for GPR, DCP, and FDI, which are positive skewed, all variables (FXI, REER, and M2) in Russia are left-tailed or negatively skewed. According to India's data, FXI, REER, M2, and DCP all showed negative skewness whereas GPR and FDI showed positive skewness. FXI, REER, and M2 are left-tailed in China, while the other variables exhibit right skewness. For REER, M2, and DCP, South Africa's output showed negative skewness, whereas the rest of the data showed positive skewness.. Kurtosis suggests that the GPR is leptokurtic in all the countries. According to leptokurtic data, these distributions produce more or more extreme outliers than a normal distribution. Except for Brazil, where FDI exhibits platykurtic behavior, FDI is leptokurtic in all other nations. Whereas FXI displayed leptokurtic in India and South Africa, M2 is leptokurtic in China and South Africa. Leptokurtic was also detected in South Africa's REER. Considering the nonlinear nature of the variables, OLS-based estimation may be inappropriate, thus the use of NARD and QARDL approaches. The mean, median, and maximum of M2, DCP, and FXI are highest, respectively.

….. insert Table 2 around here ….

4.2 NARDL Analysis

The NARDL model from **table 3** showed that all the BRICS country's speed of adjustment parameter ECM is negative and significant, implying a long-run cointegrating relationship. The ECT for India readjustment of 63% has the quickest correction, followed by Russia (57%), South Africa (56%), Brazil (32%), and China (26%) from deviations in the long-run equation. Again, we find the computed F-statistics for Brazil (7.57), Russia (4.37), India (4.33), China (4.51), and South

Africa (4.47) exceed the upper bound critical value (3.040) at a 5% significant level. Hence, we reject the null hypothesis indicating a cointegration relation between the variables and foreign reserves. These results reveal a long-run relationship between the variables and reserve holdings in BRICS countries. **Table 3** also provides all the diagnostic statistics of the model for each country. The results show that the null hypothesis cannot be rejected for all diagnostic tests, i.e., Breusch-Godfrey, Serial Correlation LM Test, and ARCH effects, indicating that our NARDL model is in good fit.

The results of the study demonstrate that GPR has a significant impact on foreign reserves in Brazil, Russia, India, and China. For Brazil, a 1% increase in GPR leads to a 1.99% decrease in the reserve to share of GDP, while a fall in the GPR index causes an increase of 6.98% share of GDP. In Russia, a fall in the GPR index causes an increase of 14.56% reserve to GDP. In India, a fall in GPR index leads to an increase of 7.91% reserve to GDP, and in China, a fall in GPR index results in a decrease of 10.89% reserve to GDP. South Africa's results were not significant. Every 1% appreciation in the Brazilian Real, Indian Rupee, and Chinese Yuan would lead to an increase of 0.06%, a decrease of 27.28%, and an 8.2% decrease in reserve to GDP, respectively. This corroborates with Jeanne and Rose (2002), Salisu (2022), and Hui (2022) where reserves respond to changes to exchange rate. Countries with export-oriented growth strategies often employ foreign reserves to intervene heavily in the market with the intent of preventing their currency from appreciating and, and consequently reducing imports. This is also in line with Dooley et al. (2004) and Aizenman et al. (2003). Russia and South African currencies did not show any significant impact. In India, a 1% increase in M2 results in a 1.1% gain reserve to GDP, while in China, a 1% decline in M2 results in a 0.32 reduction in reserve to GDP. In South Africa, an increase in M2 causes the reserve to GDP to fall by 0.9%. The findings of Obstfeld (2010) and Gosselin and Parent (2005), which contend that M2 can act as a stand-in for capital flight, show that M2 can have a detrimental impact on foreign reserves. Russia and Brazil, however, did not exhibit any significant outcomes. FDI inflows to Brazil, Russia, India, China, and South Africa would increase their reserves to GDP by 0.2 %, 1.7 %, 0.62%, 1.86 %, and 0.06% respectively. This confirms the work of Dooly et al. (2004) and Wang (2019) where there is a positive relationship between capital inflows and reserve holdings. In contrast, outflows of FDI would decrease their reserves to GDP by 0.46%, 1.26%, 0.62%, and 0.05% respectively. Evidence suggests that in times of heightened geopolitical risk, foreign capital moves away from emerging economies and towards advanced economies, thus reducing foreign reserves in the former. These findings are in line with those of Caldera (2018) and Afsar et al. (2021). In Russia and India, an increase in domestic credit to the private sector caused a decrease in the reserve to GDP, with Russia's decrease being 0.99% and India's being 0.37%. This is in line with the work of Mohanty and Turner (2006). Ghosh et al. (2012), where the flow of domestic credit to the private sector had a negative impact on foreign reserves. However, in South Africa, the opposite occurred; a growth in domestic credit to the private sector resulted in an increase of reserve to GDP by 0.02%. This outcome supports Sinah's (2017) hypothesis that growth in domestic credit is more likely to produce a positive shift in foreign reserves.

….. insert Table 3 around here ….

The findings in **Table 3** show that, with the exception of South Africa, where there were no long-term asymmetric impacts, geopolitical risk had asymmetric effects on the foreign reserves of Brazil, Russia, India, and China. Only Brazil had both positive and negative short-term effects; the other nations only had negative long-term impacts. This suggests that Brazil is more sensitive to geopolitical risk in relation to its foreign reserves, whereas Russia, India, and China are more vulnerable to only long-term negative effects of geopolitical risk.

Analysis of the Real Effective Exchange Rate (REER), M2, reveals no significant long- and short-term asymmetries. Brazil (with a negative coefficient) and China (with a positive coefficient) exhibited long-run asymmetric effects of FDI on reserves (with a positive coefficient). Among the BRICS, only India showed notable long-run asymmetric effects for DCP.

The NARDL model applied the conditional mean, which sometimes can provide limited information when some variables are quantile dependent. We, therefore, employ the QARDL to uncover the missing details at each quantile.

4.3 Quantile ARDL Estimation output

4.3.1 Quantile ARDL Outcome

The QARDL model from **table 4** showed the quantile interactions of foreign reserves and geopolitical risk as well as the other explanatory variables, in the BRIC countries.

Panel 1 of the study presents an analysis of the long-run and short-run impacts of GPR on Brazil's reserves, with mixed results. In the long-run, the lower quantiles (05th, 10th, 20th) had positive, albeit insignificant, while the 70th and 80th quantiles had a significant effect with increasing negative coefficients. This implys that reserves are adversely impacted in an increasingly severe and asymmetric manner as the level of geopolitical risk grows. In the short-run, the coefficients ranged from negative to positive, with decreasing negative impacts as the quantiles increased from -0.006 (05th) to -0.003 (95th). This suggests that past values have a greater impact on the current values. The results of the analysis of Brazil's Real effective exchange rate, M2, FDI, and DCP revealed a varied impact on reserves. In the long run, the REER had a persistent negative effect, which was significant at the 05th, 80th, 90th, and 95th quantiles. M2 had a heterogeneous response with significant negative coefficients at the 80th and 95th quantiles. FDI had a mixed reaction with positive responses at the 80th to 95th quantiles. DCP had a negative and positive, but insignificant effect on reserves, with the negative from 05th to median quantiles and the positive from median to higher quantiles. In the short run, the REER had a significant positive influence at the 80th and 95th quantiles, M2 had mixed results with negative coefficients and was significant at the first lagged 05th quantile, FDI had both negative and positive responses with a significant impact at the 80th, 90th, and 95th quantiles, and DCP had a positive but insignificant impact across the whole quantile distribution of reserves. In all, as we progress from lower to higher quantiles, the negative effect of these factors is more severe than the positive effect of decreasing uncertainty, with a considerable overall impact. This indicates a quantile-dependent asymmetric relationship with increasing severity and detriment, demonstrating pronounced negative impact on reserves in Brazil. In light of this, maintaining a sufficient reserve level would be necessary as a precautionary measure to control the detrimental consequences during periods of geopolitical uncertainties.

Insert here

In Panel 2, the impact of Geopolitical Risk (GPR) on China's reserves was significant in the 05th to 20th quantiles, and then became insignificant afterwards. The coefficient values were positive across the entire range of 05th to 95th quantiles in the long run. As we progressed to higher quantiles, the positive coefficients decreased. In the short run, the responses varied with positive and negative coefficients, but the negative coefficients occurred only at the extreme quantiles. Taking into account the lagged one values, GPR had a negative effect on the majority of quantiles, except for the 60th, 70th, and 80th. This implies that GPR had an asymmetrical effect on reserves in the short run. China has built up a substantial reserve as a form of self-protection from potential geopolitical threats, use its reserves to pursue foreign policy goal among others. GPR showed a significant positive coefficient at lower quantiles, suggesting that reserve accumulation is adequate and the decreasing coefficient indicating a smaller impact on the reserve. China's REER revealed that the reserve experienced a significant negative reaction at the 40th and 50th quantiles, and the coefficient values were negative throughout the entire quantile distribution. In the short run, there was a considerable negative effect on reserves at the 10th quantile. On the other hand, M2 output only had a negative and significant impact at 70th and 80th quantiles in the long run, with no notable effect in the short run. FDI in the long run had both negative and positive impacts, with the most significant impacts at the 05th and 95th quantiles. In the short run, insignificant positive and negative impacts on reserves were observed. Lastly, DCP had both positive and negative coefficient values, with significant impacts at 70th, 80th, and 95th quantile. It was also revealed that the 05th quantile DCP had a significant impact at Lag 1 in the short run.

Insert here

In Panel 3 for Russia, the long-term impact of GPR on reserves was positive but insignificant. In the short-term, GPR had both positive and negative impacts on reserves, with the positive impacts being more pronounced at the lower quantiles. The lagged one outcome showed a mixed response, with a positive impact at the 40th, 50th, and 60th quantiles, and a negative impact at the remaining quantiles. This suggests an asymmetric effect of GPR on reserves in the short-term. With the annexation of Crimea, Russia began to diversify its reserves away from US assets in order to incorporate gold and assets from other emerging nations. The insignificant effects seen could be partly explained by the western nations' sanctions against Russia during the Russia-Ukraine war, which forced Russia to undertake transactions in rubles and yuan. In Russia's it was observed that there is a negative and insignificant effect of the real exchange rate (REER) on reserves in the long run which could be attributed Russia buying their own currency to stabilize the rubble. In the short run, a significant negative effect was observed at the 70th, 80th, 90th and 95th quantiles at lag 2, implying a sharp drop which was attributed to the imposition of sanctions. The Rubble briefly declined due to sanctions imposed by western nations, but this was restored when Russia raised its interest rates and instituted capital controls. The raising interest rate stabilized inflation and strengthened the rubble. Money supply (M2) had both insignificant positive and negative impacts in the long run, with the median quantile 50th having a negative value. Additionally, FDI had a negative and insignificant effect on reserves in the long run, but had a significant positive impact at the higher quantiles (50th-95th) in the short-term. DCP displayed both positive and negative effects in both the long and short runs, with evidence of asymmetric effects in both.

Insert here

In Panel 4 for India, the long-term effects of GPR on reserves are both positive and negative, but insignificant. In the short-term, GPR has both positive and negative effects on reserves, indicating an asymmetric effect. These effects are seen at the extreme quantiles of the 05th, 10th, 90th and 95th. Similar to other BRICS countries, India's de-dollarization strategy to settle trade in the Rupee could partially explain the insignificance. The results of the study suggest that changes in India's REER, M2, FDI, and DCP have an impact on the distribution of reserves. In the long run, REER had an insignificant effect, with negative responses observed at the 5th and 50th quantiles, and positive outcomes at the other values. Short-run REER had both positive and negative effects on reserves, with the first lagged outcomes showing a negative response across all quantiles. M2 had a significant positive response to reserves at the 60th quantile in the long run and a positive effect throughout the quantiles in the short run. FDI was found to have a significant negative effect at the lower quantiles (5th and 10th) and at the higher quantiles (90th and 95th). DCP had a significant negative impact on reserves at the 60th quantile in the long run and a mixed response in the short run.

Insert here

In Panel 5 for South Africa shows that in the long run, GPR has a significant negative effect at the lowest quantiles (05th and 10th) of reserves in South Africa. In the short run, the impact of GPR on reserves is not uniform, with negative responses observed at the lowest quantiles (05th and 10th), and positive responses at the 20th, 30th, 40th, 50th, 60th, and 70th quantiles. This indicates an asymmetric effect of GPR on reserves in the short run. The study of South African reserves revealed that the long-run effect of the REER on reserves is negative and significant at the 05th and 10th quantiles. In the short-run, it was observed that reserves respond significantly and negatively to the REER at the lower and higher quantiles (05th, 10th, 80th, 90th, and 95th). This pattern of asymmetry and tail-dependence was also noted in the first and second lagged outcomes. The country's M2 had a significant negative effect on reserves at the 10th quantile in the long run. However, in the short term, M2 appears to have a positive effect on reserves at the

40th, 50th, 60th, 70th, and 80th quantiles. This suggests that M2 has an asymmetrical effect on reserve levels over the long term. Moreover, the long-run response of reserves to FDI was found to be negative and significant at the 05th and 10th quantiles. In the short run, FDI had insignificant effects on reserves. Lastly, the DCP report indicated an insignificant long-run impact, while in the short run there was a significant positive effect at the 90th and 95th quantiles.

Insert here

4.4 Asymmetries using WALD Test

We used the Wald test to assess the heterogeneity of the quantiles. Rejecting the null hypothesis implies that the long-run and short-run parameters between the variables of interest vary across quantiles, indicating the presence of nonlinearities or asymmetries. The test revealed that the effects of GPR on reserves and other control variables, were not uniform over time. In the short run, the test showed the effects of the past value of reserves on its present value. Foreign exchange reserves, GPR, and other control variables had heterogeneous effects in all quantiles of foreign reserve distributions in both the long- and short-run. In China, Brazil, and South Africa, M2, FDI, and DCP have significant asymmetric effects on reserves in the long run. In the short run, exchange rate has a significant asymmetry effect in all the BRICS countries. FDI and DCP also display an asymmetric effect on reserves in Brazil, India, China, and South Africa. Moreover, Russia and China showed significant results for asymmetric effects for M2.

Geopolitical instability can have a major impact on the global economy. Russia-Ukraine war, for example, caused disruption to supply chains, influencing commodity markets and leading to inflation, currency depreciations, defaults on international obligations, financial instability, and capital flight, all of which can place strain on the banking system. Consequently, most central banks may need to increase their reserves in order to protect the economy from shocks and maintain macro-financial stability. The International Monetary Fund's 2023 stability report suggests that the emergence of economic blocs as a result of geopolitical risk particularly from the USA- China relations and the Russia -Ukraine war might hamper investors' ability to reduce global risks by diversifying their capital flows. This could have an adverse effect on significant economic growth and financial market integration.

The potential threats to financial stability that could result from escalating geopolitical tensions should be taken into consideration by policymakers. They can help to prevent any disruptive effects of geopolitical events by better understanding the links between geopolitical risks and other conventional risks related to reserves, exchange rates, interest rates, markets, liquidity, and supply chain networks.

Given the interconnected nature of the financial markets, a rise in geopolitical tensions could have a negative impact on foreign reserve and for that matter macro-financial stability. Governments and financial institutions should make sure they have enough liquidity, and foreign exchange reserves in place as a precautionary measure to mitigate crises.

4.5 Conclusions

We investigated the potential for non-linear and asymmetric effects of geopolitical risk on foreign reserves for BRICS countries. Our empirical analysis, based on quarterly time series data from 2000 to 2021, employed NARDL and QARDL models. With the NARDL model, the results indicated that GPR had long-run asymmetric effects for Brazil, Russia, India, and China, with Brazil showing both positive and negative effects. South Africa had no long-run effects. In the short run, Brazil had a significant impact, while the other countries had insignificant asymmetry effects. The QARDL model revealed a quantile-dependent asymmetric relationship in the BRICS countries in the long and short run. These results suggest that Brazil's reserves are non-linearly sensitive and respond to GPR at high quantiles, while in China, the impact of GPR on reserves had only long-run negative effects at lower quantiles. Russia, and India has insignificant impact possibly due to diversification away from dollar asset to gold assets.

The asymmetry suggests a significant difference between the responses to positive and negative impacts, showing that the negative effect of the increasing GPR is stronger than the positive effect of the decreasing uncertainty and the magnitude is unequal. Also, the coefficients were heterogeneous rather than uniform throughout time. Past values impact the current values at the short run at a decreasing impact. This level of detail cannot be revealed using a linear model. Again, the GPR and the control variables such as REER, M2, FDI, and DCP have asymmetric effects on reserves, and the severity could be extremely high. Therefore, central bankers should factor geopolitical risk into their reserve demand function as a precautionary motive. This is because geopolitical Risk can create macro-financial instability. Hence, adequate reserve is needed to shield the economies from the negative impact of geopolitical risk.

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Appendix 1

Table 1: Unit Root Tests

ADF Unit Root Tests					Zivot-Andrew Unit Root Test			
C'try	**Series**	**Stats**	Prob	I(d)	**Stats**	Prob	I(d)	**Break Point**
Brazil	FXI	-5.1882	0.000	I(1)	-5.3278	0.0001	I(0)	2007Q1
	GPR	-7.5950	0.000	I(1)	-4.6129	0.0001	I(0)	2014Q1
	REER	-6.2926	0.000	I(1)	-4.4227	0.0140	I(0)	2009Q1
	M2	-5.6048	0.000	I(1)	-4.6818	0.0130	I(0)	2008Q2
	FDI	-5.9294	0.000	I(0)	-5.2844	0.0098	I(0)	2006Q4
	DCP	-2.7856	0.000	I(0)	-3.8335	0.0160	I(0)	2010Q1
Russia	FXI	-8.5403	0.000	I(1)	-3.5459	0.0037	I(0)	2010Q1
	GPR	-7.5950	0.000	I(1)	-4.6129	0.0001	I(0)	2014Q1
	REER	-9.8119	0.000	I(1)	-4.4356	0.0003	I(0)	2014Q4
	M2	-4.0827	0.009	I(0)	-4.3791	0.0206	I(1)	2011Q1
	FDI	-7.5598	0.000	I(0)	-6.2724	0.0004	I(0)	2004Q4
	DCP	-27.527	0.000	I(1)	-4.5672	0.0002	I(0)	2006Q1
India	FXI	-8.8204	0.000	I(1)	-3.9175	0.0011	I(0)	2010Q1
	GPR	-7.5950	0.000	I(1)	-4.6129	0.0001	I(0)	2014Q1
	REER	-4.3278	0.004	I(0)	-5.2052	0.0174	I(0)	2011Q4
	M2	-9.7560	0.000	I(1)	-10.077	0.0001	I(1)	2009Q2
	FDI	-14.368	0.000	I(1)	-4.2218	0.039	I(0)	2006Q2
	DCP	-10.665	0.000	I(1)	-4.3860	0.0120	I(0)	2004Q1
China	FXI	-5.8837	0.000	I(1)	-6.1306	0.0001	I(1)	2007Q2
	GPR	-7.5950	0.000	I(1)	-4.6129	0.0001	I(0)	2014Q1
	REER	-7.6181	0.000	I(1)	-2.7121	0.0391	I(0)	2011Q3
	M2	-9.5711	0.000	I(1)	-5.2251	0.0000	I(1)	2009Q1
	FDI	-10.665	0.000	I(1)	-3.9976	0.0034	I(0)	2008Q1
	DCP	-9.5351	0.000	I(1)	-3.6591	0.0071	I(0)	2007Q2
S.Africa	FXI	-3.9579	0.013	I(0)	-4.7710	0.0005	I(0)	2004Q1
	GPR	-7.5950	0.000	I(1)	-4.6129	0.0001	I(0)	2014Q1
	REER	-8.3828	0.000	I(1)	-4.0896	0.0179	I(0)	2012Q4
	M2	-3.0483	0.034	I(0)	-3.8843	0.0247	I(0)	2005Q1
	FDI	-9.2556	0.000	I(0)	-10.344	0.0016	I(0)	2018Q3
	DCP	-9.1642	0.000	I(1)	-3.6861	0.0106	I(0)	2004Q1

Table 2: Descriptive Statistics

Variable	C'try	Mean	Median	Max	Min	SD	Skew	Kurt	JB	Prob	Obs
FXI	**BRAZIL**	13.3385	13.1504	23.7578	4.9448	5.2927	0.1059	1.9273	4.3832	0.1111	88
GPR		1.9822	1.9493	2.5463	1.7020	0.1386	1.2846	6.0906	59.2282	0.0000	88
REER		2.0165	1.9979	2.2112	1.8613	0.0875	0.2982	2.2371	3.4389	0.1791	88
M2		100.4002	104.8406	159.1166	68.4995	23.2276	0.4234	2.6385	3.1087	0.2113	88
FDI		3.2264	3.1560	5.9611	0.7778	1.2640	0.2018	2.2221	2.8157	0.2446	88
DCP		50.1565	55.42	70.1879	27.6856	15.27	-0.261	1.4596	9.7029	0.0078	88
FXI	**RUSSIA**	21.8987	22.3267	33.5022	8.7157	6.3800	-0.353	2.7122	2.1409	0.3428	88
GPR		1.9822	1.9493	2.5463	1.7020	0.1386	1.2846	6.0906	59.2282	0.0000	88
REER		2.0140	2.0189	2.1358	1.7805	0.0789	-0.512	2.7861	4.0128	0.1344	88
M2		11.6987	12.0856	17.5952	5.9769	3.5519	-0.106	1.9126	4.5012	0.1053	88
FDI		2.1682	1.9415	7.4559	-1.8079	1.7687	0.5947	3.4345	5.8810	0.0528	88
DCP		40.6631	43.3770	59.9683	16.8377	14.2711	-0.431	1.8303	7.7484	0.0207	88
FXI	**INDIA**	15.7350	15.7179	21.5539	7.9520	3.2000	-0.455	3.4185	3.6884	0.1584	88
GPR		1.9822	1.9493	2.5463	1.7020	0.1386	1.2846	6.0906	59.2282	0.0000	88
REER		1.9749	1.9787	2.0295	1.9161	0.0337	-0.204	1.7274	6.5526	0.0377	88
M2		18.2714	18.8244	22.0395	13.6612	2.1451	-0.386	2.6611	2.6138	0.2706	88
FDI		1.6974	1.5281	4.2655	0.4124	0.8777	1.0088	3.6364	16.4129	0.0002	88
DCP		45.5437	49.3303	54.8045	28.3395	8.4680	-0.958	2.4550	14.5629	0.0006	88
FXI	**CHINA**	31.0501	30.7947	47.5602	13.5695	10.5316	-0.054	1.6399	6.8264	0.0329	88
GPR		1.9822	1.9493	2.5463	1.7020	0.1386	1.2846	6.0906	59.2282	0.0000	88
REER		2.0949	2.0826	2.1908	1.9930	0.0641	-0.015	1.5293	7.9340	0.0189	88
M2		165.0817	174.8095	211.3871	0.0000	43.1668	-2.409	10.1575	272.9676	0.0000	88
FDI		2.8809	2.8544	6.9352	0.7167	1.1711	0.4547	3.4769	3.8669	0.1464	88
DCP		131.3659	125.6714	182.4326	102.0036	21.9114	0.6699	2.4405	7.3795	0.0249	88
FXI	**South Africa**	2.3265	2.3918	4.4578	0.7746	0.8272	0.1658	3.4383	1.1080	0.5746	88
GPR		1.9822	1.9493	2.5463	1.7020	0.1386	1.2846	6.0906	59.2282	0.0000	88
REER		2.0346	2.0356	2.1137	1.9245	0.0413	-0.253	2.6750	1.3284	0.5146	88
M2		15.2232	16.5437	18.6494	0.00000	3.7979	-2.927	12.1261	431.0995	0.0000	88
FDI		1.7570	1.1086	35.5114	-1.9248	4.3109	6.2101	46.3020	7440.869	0.0000	88
DCP		120.4819	121.6889	142.4220	97.3173	10.3997	-0.169	3.1834	0.5449	0.7614	88

Table 3: Nardl Asymmetry

Coefficient	**Long-run Effect [+]**		**Long-run Effect [-]**		**Long-Run Asymmetry**		**Short-Run Asymmetry**	
Panel A: Brazil								
	Coef.	**P>F**	**Coef.**	**P>F**	**F-Stat**	**P>F**	**F-Stat**	**P>F**
GPR	-1.9989	0.0704*	-6.98130	0.0000***	4.0387	0.0002***	6.449	0.014***
REER	7.0721	0.0643**	2.8537	0.3955	0.6830	0.4980	.02157	0.884
M2	-0.0084	0.6201	0.09527	0.2197	-1.3807	0.1740	1.713	0.197
FDI	0.2026	0.0215**	0.4630	0.0001***	-5.2378	0.0000***	3.415	0.071**
DCP	0.0526	0.1060	-0.0041	0.9538	0.6271	0.5337	2.506	0.120
Diagnostics stats								
LM: 1.6429 0.2051	ARCH: 0.6883 0.4092	RESET: 0.7774 0.4412	BPG 0.7710 0.7890	DW 2.1261	BOUND 7.5725 3.040	ECM -0.3240 0.0000	R-SQ 0.8769	
Panel B : RUSSIA								
Coefficient	**Long-run Effect [+]**		**Long-run Effect [-]**		**Long-Run Asymmetry**		**Short-Run Asymmetry**	
	Coef.	**P>F**	**Coef.**	**P>F**	**F-Stat**	**P>F**	**F-Stat**	**P>F**
GPR	-1.9860	0.6834	-14.566	0.0327	3.3062	0.0022	0.1518	0.699
REER	-19.148	0.5667	-0.4848	0.9435	-0.5901	0.5589	0.4228	0.519
M2	1.2008	0.1778	0.6773	0.7374	0.2171	0.8294	1.07	0.306
FDI	1.7009	0.0020	1.2674	0.0014	0.6755	0.5037	0.3251	0.571
DCP	-0.9943	0.0147	0.6278	0.5190	-1.3682	0.1800	0.060	0.807
Diagnostics stats								
LM: 0.1419 0.8682	ARCH: 1.7254 0.1928	RESET: 1.7321 0.0923	BPG 2.274 0.064	DW 2.0520	BOUND 4.3664 3.040	ECM -0.5743 0.0000	R-SQ 0.9777	
Panel C : INDIA								
Coefficient	**Long-run Effect [+]**		**Long-run Effect [-]**		**Long-Run Asymmetry**		**Short-Run Asymmetry**	
	Coef.	**P>F**	**Coef.**	**P>F**	**F-Stat**	**P>F**	**F-Stat**	**P>F**
GPR	2.1946	0.1529	-7.9104	0.0018***	5.4552	0.000***	1.461	0.233
REER	-27.285	0.0366***	5.0766	0.6511	-1.7556	0.0864	.4442	0.508
M2	1.0571	0.0035***	-0.6879	0.5415	1.3667	0.1790	1.039	0.313
FDI	0.3653	0.2098	0.6202	0.0261	-1.2489	0.2186	6.425	0.014***
DCP	-0.3765	0.0046***	1.0803	0.0061***	-3.2884	0.0020***	1.742	0.193
Diagnostics stats								
LM: 0.0968 0.9079	ARCH: 1.4330 0.2348	RESET: 0.8846 0.3815	BPG 0.8827 0.6532	DW 2.006	BOUND 4.3334 3.040	ECM -0.6383 0.0000	R-SQ 0.7883	
Panel D : China								
Coefficient	**Long-run Effect [+]**		**Long-run Effect [-]**		**Long-Run Asymmetry**		**Short-Run Asymmetry**	
	Coef.	**P>F**	**Coef.**	**P>F**	**F-Stat**	**P>F**	**F-Stat**	**P>F**
GPR	3.2209	0.1457	10.8984	0.0028***	-3.9115	0.0003***	0.5234	0.473
REER	-81.668	0.0000***	-42.6306	0.0154	-1.5924	0.1177	0.1033	0.749
M2	0.1228	0.0925	0.3160	0.0008***	-17104	0.0935	0.0221	0.882
FDI	1.8698	0.0000***	0.1154	0.6041	4.6055	0.0000***	1.024	0.316
DCP	-0.0990	0.1901	0.0697	0.5563	-0.9703	0.3319	0.065	0.799
Diagnostics stats								
LM: 1.4524 0.2443	ARCH: 0.1915 0.6628	RESET: 0.6262 0.5341	BPG 1.0360 0.4478	DW 2.2019	BOUND 4.5054 3.040	ECM -0.2682 0.0000	R-SQ 0.7806	
Panel E : South Africa								
Coefficient	**Long-run Effect [+]**		**Long-run Effect [-]**		**Long-Run Asymmetry**		**Short-Run Asymmetry**	
	Coef.	**P>F**	**Coef.**	**P>F**	**F-Stat**	**P>F**	**F-Stat**	**P>F**
GPR	-0.0076	0.9707	-0.1534	0.6945	0.4401	0.6620	1.052	0.310
REER	0.2152	0.8755	-1.2179	0.3449	0.7230	0.4736	0.987	0.325
M2	-0.0902	0.0215***	0.0491	0.6122	-1.3344	0.1891	0.02116	0.885
FDI	0.0565	0.0232***	0.0548	0.0185***	0.1609	0.8729	0.09037	0.765

DCP	0.0167	0.0024***	0.0105	0.1025	0.5876	0.5599	0.5613	0.457
Diagnostics static								
LM: 1.3347 0.2744	ARCH: 0.2750 0.6014	RESET: 0.7012 0.4870	BPG 0.7439 0.8241	DW 1.8885	BOUND 4.4725 3.040	ECM -0.5655 0.00000	R-SQ 0.8049	

Note. We followed the Lag length criteria to model the QARDL in stata. Below are the estimation output for the BRICS countries. We used Stata to model the QARDL. The highlighted are significant at 1%, 5% and 10% with ***, **, * respectively at different quantiles.

Table 4: Qardl Asymmetry

Panel 1	**Brazil**										
Quantile	**.05**	**.10**	**.20**	**.30**	**.40**	**.50**	**.60**	**.70**	**.80**	**.90**	**.95**
$\alpha_0(\tau)FXI$	0.098 1.18	0.057 0.75	0.010 0.16	0.094 1.11	0.054 0.58	0.062 0.52	0.120 1.01	0.223* 1.78	0.358*** 2.71	0.374*** 3.80	0.372*** 3.42
$\alpha_1(\tau)$GPR	0.007 0.16	0.001 0.16	0.001 0.30	-0.001 -0.45	-0.003 -0.91	-0.003 -0.82	-0.003 -0.90	-0.006* -1.87	-0.006** -1.97	-0.006 -1.63	-0.005 -1.26
$\alpha_2(\tau)$REER	-0.017*** -2.02	-0.016 -1.34	-0.013 -0.97	-0.015 -1.29	-0.007 -0.59	-0.009 -0.66	-0.007 -0.46	-0.008 -0.64	-0.021* -1.70	-0.022** -1.89	-0.026*** -2.08
$\alpha_3(\tau)$M2	-0.013 -0.46	0.002 0.06	0.010 0.36	-0.012 -0.33	-0.011 -0.32	-0.013 -0.32	-0.040 -0.94	-0.088 1.84	-0.125*** -2.68	-0.128*** -2.98	-0.120*** -2.75
$\alpha_4(\tau)$FDI	0.299 0.25	0.026 0.23	0.064 0.55	-0.063 -0.55	-0.083 -0.66	-0.106 -0.72	-0.148 -0.99	-0.171 -1.17	-0.296*** -2.84	-0.305*** -3.04	-0.370*** -3.27
$\alpha_5(\tau)$DCP	-0.031 -1.40	-0.035 -1.26	-0.027. -0.90	-0.028 -0.74	-0.010 -0.31	-0.008 -0.27	0.009 0.34	0.034 1.36	0.028 0.89	0.027 0.74	0.009 0.26
$\theta_1(\tau)$dGPR	-0.003 -0.85	-0.002 -0.85	-0.003 -1.64	-0.001 -0.71	-0.000 -0.02	-0.000 -0.11	-0.001 -0.41	0.000 0.12	0.001 0.21	0.001 0.13	0.001 0.30
$\theta_2(\tau)$ dGPR1	-0.006* -1.70	-0.006* -1.75	-0.006*** -2.75	-0.006*** -2.13	-0.005** -1.98	-0.004 -1.43	-0.005 -1.52	-0.004 -1.50	-0.003 -0.94	-0.003 -0.84	-0.003 -0.65
$\theta_3(\tau)dREER$	0.018 1.09	0.016 0.80	0.013 0.70	0.014 0.71	0.008 0.33	0.024 1.01	0.028 1.03	0.025 1.30	0.045*** 2.02	0.038 1.62	0.049*** 2.04
$\theta_4(\tau)dREER$	0.047*** 2.55	0.045*** 2.26	0.037*** 2.09	0.036*** 1.97	0.031 1.48	0.023 1.00	0.020 0.74	0.014 0.55	0.020 0.75	0.022 0.69	0.038 1.15
$\theta_5(\tau)dREER$	0.023 1.26	0.018 1.08	0.023 1.24	0.046*** 2.87	0.052*** 2.97	0.054*** 3.06	0.065*** 3.02	0.069*** 3.96	0.075*** 4.23	0.071*** 3.72	0.070*** 3.93
$\theta_6(\tau)dREER$	0.068*** 2.86	0.071*** 3.27	0.059*** 2.67	0.057*** 3.57	0.065*** 4.50	0.066*** 5.20	0.046*** 3.48	0.044*** 3.53	0.043*** 2.93	0.036*** 2.82	0.041*** 3.32
$\theta_7(\tau)$dM2	-0.076 -1.05	-0.066 -0.84	-0.034 -0.35	0.033 0.36	0.065 0.72	0.054 0.69	0.054 0.57	0.097 0.99	0.144 1.33	0.138 1.25	0.109 1.00
$\theta_8(\tau)$dM21	0.098** 1.88	0.077 1.37	0.020 0.21	0.041 0.43	0.033 0.35	0.043 0.48	0.060 0.61	0.104 1.06	0.133 1.27	0.138 1.42	0.134 1.37
$\theta_9(\tau)$dM22	-0.063 -1.23	-0.065 -1.05	-0.038 -0.44	-0.063 -0.72	-0.069 -0.79	-0.049 -0.72	-0.038 -0.61	-0.007 -0.14	0.023 0.36	0.029 0.51	0.029 0.52
$\theta_{10}(\tau)$dFDI	-0.053 -0.53	-0.067 -0.60	-0.107 -1.00	-0.077 -0.61	-0.090 -0.71	-0.073 -0.54	0.034 0.22	0.129 0.97	0.184** 2.02	0.188*** 2.31	0.181*** 1.90
$\theta_{11}(\tau)$dFDI1	-0.075 -1.02	-0.071 -0.71	-0.048 -0.65	-0.036 -0.41	-0.084 -0.91	-0.064 -0.70	-0.011 -0.11	0.058 0.52	0.052 0.58	0.060 0.60	0.095 0.91
$\theta_{12}(\tau)$dDCP	0.028 0.41	0.025 0.30	0.003 0.04	0.017 0.21	0.066 0.78	0.024 0.34	0.068 1.25	0.068 1.47	0.047 0.95	0.029 0.68	0.014 0.32
$\theta_{13}(\tau)$dDCP1	0.055 0.50	0.055 0.52	0.019 0.21	0.027 0.29	0.053 0.66	0.058 0.93	0.077 1.16	0.106 1.46	0.057 0.74	0.095 1.12	0.127 1.46
R^2/Pseudo R^2 Squared	0.55	0.53	0.45	0.43	0.42	0.43	0.44	0.47	0.53	0,59	0.64

Panel 2	**China**										
Quantile	**.05**	**.10**	**.20**	**.30**	**.40**	**.50**	**.60**	**.70**	**.80**	**.90**	**.95**
$\alpha_0(\tau)FXI$	0.055 0.93	0.050 0.79	0.002 0.04	-0.003 -0.07	0.010 0.27	0.006 0.17	0.029 1.08	0.079*** 2.48	0.082** 1.90	0.101 1.54	0.187*** 2.95
$\alpha_1(\tau)$GPR	0.011***	0.011***	0.005* 1.70	0.004 0.98	0.004 0.88	0.003 0.48	0.001 0.21	0.001 0.17	0.000 0.07	0.004 0.50	0.006 0.63

	2.69	3.20									
$\alpha_2(\tau)$REER	-0.020 -0.35	-0.034 -0.59	-0.065 -1.15	-0.061 -1.66	-0.058** -1.89	-0.055 -1.97**	-0.034 -1.14	-0.013 -0.37	-0.030 -0.73	-0.025 -0.61	-0.017 -0.41
$\alpha_3(\tau)$M2	-0.80 -1.26	-0.066 -0.90	-0.014 -0.20	-0.003 -0.05	-0.006 -0.15	-0.010 -0.30	-0.031 -1.05	-0.073*** -1.99	-0.064 -1.29	-0.082 -1.32	-0.153*** -2.64
$\alpha_4(\tau)$FDI	-0.95* -1.76	-0.757 -1.62	-0.107 -0.17	-0.159 -0.29	-0.004 -0.01	0.026 0.05	0.045 0.10	-0.383 -0.80	-0.374 -0.76	-0.655 -0.99	-1.200* -1.82
$\alpha_5(\tau)$DCP	0.061 1.49	0.063 1.32	0.048 1.09	0.029 0.84	0.033 1.16	0.033 1.56	0.037 1.58	0.055*** 2.37	0.052* 1.68	0.058 1.42	0.111*** 2.73
$\theta_1(\tau)$dGPR	-0.006 -0.80	-0.006 -0.63	0.001 0.07	0.001 0.14	0.002 0.44	0.002 0.37	-0.000 -0.09	-0.002 -0.49	0.001 0.31	-0.002 -0.36	-0.004 -0.71
$\theta_2(\tau)$ dGPR1	-0.004 -1.14	-0.002 -0.67	-0.002 -0.46	-0.002 -0.39	-0.000 -0.08	-0.000 -0.06	0.002 0.48	-0.002 -0.43	0.003 0.49	-0.003 -0.42	0.000 0.04
$\theta_3(\tau)dREER$	-0.141 -1.57	-0.136* -1.69	-0.070 -0.88	0.047 -0.67	-0.039 -0.51	-0.014 -0.22	-0.075 -1.16	-0.121 -1.28	-0.054 -0.48	-0.031 -0.25	-0.120 -0.86
$\theta_4(\tau)dREER$	0.016 0.19	0.050 0.92	0.056 1.29	0.039 0.70	-0.006 -0.09	-0.022 -0.36	-0.079 -1.20	-0.064 -1.22	-0.045 -0.82	0.025 0.32	0.040 0.56
$\theta_5(\tau)dREER$	-0.072 -0.77	-0.059 -0.63	-0.004 -0.04	-0.007 -0.09	-0.019 -0.27	-0.036 -0.58	-0.021 -0.31	0.043 0.59	0.003 0.05	0.000 0.00	-0.021 -0.25
$\theta_6(\tau)$dM2	0.052 0.52	0.030 0.29	0.033 0.49	0.046 0.88	0.025 0.37	0.021 0.35	0.039 0.61	0.080 1.23	0.029 0.35	-0.009 -0.10	0.051 0.61
$\theta_7(\tau)$dM21	0.220 1.55	-0.001 -0.01	0.090 0.75	0.084 1.15	0.046 0.78	0.041 0.65	0.022 0.43	-0.001 -0.02	-0.001 -0.01	0.007 0.09	0.080 1.23
$\theta_8(\tau)$dFDI	0.578 1.19	0.050 1.23	-0.003 -0.01	0.083 0.19	0.059 0.15	-0.009 -0.02	0.022 0.05	0.527 1.32	0.271 0.67	0.494 0.78	0.884 1.35
$\theta_9(\tau)$dFDI1	0.650*** 2.21	0.683*** 2.27	0.376* 1.71	0.374 1.47	0.222 0.85	0.175 0.56	0.388 1.40	0.802*** 2.59	0.433 1.26	0.488 0.87	0.754 1.25
$\theta_{10}(\tau)$dFDI2	-0.167 -0.58	-0.049 -0.16	-0.066 -.024	0.016 0.06	0.059 0.22	0.083 0.39	0.080 0.36	0.439** 1.91	0.310 1.52	0.252 0.87	0.263 0.79
$\theta_{11}(\tau)$dDCP	-0.003 -0.03	-0.002 -0.02	-0.038 -0.47	-0.064 -0.98	-0.037 -0.54	-0.033 -0.44	-0.002 -0.02	-0.038 -0.54	-0.001 -0.01	0.001 0.01	-0.053 -0.57
$\theta_{12}(\tau)$dDCP1	-0.213*** -2.17	-0.037 -0.38	-0.059 -0.67	-0.043 -0.82	-0.003 -0.07	0.010 0.27	0.058 1.17	-0.005 -0.10	0.065 0.93	0.037 0.46	-0.104 -1.24
R^2/Pseudo R^2 Squared	0.54	0.48	0.45	0.41	0.40	0.40	0.40	0.41	0.46	0.51	0.61

Panel 3	**Russia**										
Quantile	**.05**	**.10**	**.20**	**.30**	**.40**	**.50**	**.60**	**.70**	**.80**	**.90**	**.95**
$\alpha_0(\tau)FXI$	0.214 1.29	0.185 1.18	0.059 0.84	0.065 1.26	0.051 0.98	0.088 1.26	0.076 0.90	0.128 1.57	0.117 1.29	0.190** 1.91	0.190** 1.88
$\alpha_1(\tau)$GPR	0.005 0.25	0.004 0.41	0.001 0.14	0.001 0.24	0.001 0.09	0.001 0.25	0.004 0.32	0.005 0.38	0.007 0.50	0.007 0.42	0.007 0.41
$\alpha_2(\tau)$REER	-0.081 -0.19	-0.081 -1.27	-0.005 -0.17	-0.006 -0.33	-0.004 -0.27	-0.006 -0.47	-0.014 -0.92	-0.007 -0.38	-0.012 -0.79	-0.012 -0.61	-0.013 -0.56
$\alpha_3(\tau)$M2	-0.427 -0.47	-0.017 -0.03	0.061 0.14	0.025 0.07	0.055 0.17	-0.064 -0.19	-0.180 -0.48	-0.425 -1.15	-0.493 -1.54	-0.613 -1.45	-0.613 -1.47
$\alpha_4(\tau)$FDI	-1.873 -1.21	-0.529 -0.42	-0.194 -0.45	-0.241 -0.78	-0.203 -0.60	-0.470 -1.36	-0.290 -0.71	-0.480 -1.17	-0.410 -1.15	-0.569 -1.31	-0.569 -1.28
$\alpha_5(\tau)$DCP	0.057 0.23	0.008 0.04	-0.035 -0.30	-0.023 -0.26	-0.025 -0.34	0.012 0.15	0.051 0.62	0.097 1.16	0.127 1.65	0.145 1.42	0.145 1.46
$\theta_1(\tau)$dGPR	0.012 0.73	0.008 0.65	-0.000 -0.04	-0.000 -0.08	0.00 0.02	-0.001 -0.22	-0.003 -0.34	-0.002 -0.30	-0.003 -0.38	-0.002 -0.24	-0.002 -0.25
$\theta_2(\tau)$ dGPR1	-0.006 -0.45	-0.005 -0.55	-0.000 -0.00	-0.000 -0.02	0.000 0.00	0.000 0.04	0.001 0.10	-0.002 -0.12	-0.004 -0.28	-0.002 -0.10	-0.002 -0.09
$\theta_3(\tau)dREER$	-0.044 -0.38	-0.021 -0.17	0.010 -0.10	-0.002 -0.03	0.011 0.21	0.004 0.09	0.010 0.21	-0.045 -0.83	-0.024 -0.50	-0.049 -0.99	-0.049 -0.90
$\theta_4(\tau)dREER$	-0.066 -0.68	-0.003 -0.04	-0.008 -0.10	-0.005 -0.09	-0.002 -0.05	0.002 0.04	0.026 0.57	0.012 0.25	0.213 0.43	-0.014 -0.28	-0.014 -0.27

$\theta_5(\tau)dREER$	-0.044 -0.83	0.003 0.70	-0.012 -0.18	-0.008 -0.16	-0.003 -0.08	-0.034 -0.83	-0.030 -0.59	-0.081* -1.84	- 0.076** * -2.17	-0.061** -1.93	-0.061* -1.68
$\theta_6(\tau)$dM2	0.496 0.34	0.407 0.26	0.246 0.13	0.250 0.13	0.283 0.14	-0.026 -0.01	0.052 0.02	2.958 1.41	2.951 1.38	1.66 0.78	1.661 0.80
$\theta_7(\tau)$dM21	0.330 0.40	0.249 0.36	0.063 0.15	0.053 0.30	0.15 0.08	0.054 0.33	0.054 0.26	0.157 0.58	0.163 0.56	0.190 0.60	0.190 0.61
$\theta_8(\tau)$dFDI	1.380 1.06	0.420 0.39	0.161 0.45	0.191 0.74	0.186 0.74	0.431* 1.75	0.315 1.08	0.495* 1.68	0.447* 1.67	0.534* 1.77	0.534* 1.83
$\theta_9(\tau)$dFDI 1	1.410 1.12	0.408 0.39	0.101 0.35	0.131 0.41	0.129 0.47	0.326 1.38	0.124 0.47	0.305 1.12	0.267 0.94	0.331 1.13	0.332 1.14
$\theta_{10}(\tau)$dFDI 2	1.154 1.22	0.314 0.36	0.063 0.23	0.094 0.33	0.092 0.37	0.255 1.06	0.102 0.43	0.239 1.08	0.182 0.69	0.174 0.62	0.175 0.61
$\theta_{11}(\tau)$dFDI 3	0.562 0.86	0.152 0.27	0.024 0,12	0.552 0.26	0.071 0.38	0.197 1.10	0.080 0.45	0.174 1.01	0.101 0.46	0.117 0.51	0.117 0.49
$\theta_{13}(\tau)$dFDI 4	-0.331 -1.14	-0.355 -1.37	-0.018 -0.12	0.005 0.04	0.017 0.18	0.072 0.64	0.080 0.75	0.096 0.88	0.12 1.13	0.074 0.64	0.074 0.68
$\theta_{14}(\tau)$dDC P	0.015 0.02	-0.010 -0.02	-0.005 0.01	0.001 0.00	-0.021 -0.04	0.103 0.19	0.071 0.15	-0.016 -0.03	-0.007 -0.01	0.522 0.88	0.522 0.85
R^2/Pseudo R^2 Squared	0.54	0.26	0.14	0.10	0.07	0.08	0.12	0.30	0.45	0.62	0.73

Panel 4	**India**										
Quantile	**.05**	**.10**	**.20**	**.30**	**.40**	**.50**	**.60**	**.70**	**.80**	**.90**	**.95**
$\alpha_0(\tau)FXI$	-0.017 -0.23	-0.012 -0.18	0.017 0.29	0.030 0.68	0.016 0.37	-0.000 -0.01	0.027 0.55	0.023 0.37	0.070 0.59	0.225 1.57	0.225 1.53
$\alpha_1(\tau)$GPR	0.003 0.38	0.002 0.35	-0.002 -0.29	-0.003 -0.64	-0.001 -0.17	-0.000 -0.07	-0.003 -0.38	-0.002 -0.30	-0.002 -0.021	0.006 0.56	0.006 .55
$\alpha_2(\tau)$REE R	-0.006 -0.14	0.001 0.03	0.372 1.06	0.014 0.39	0.006 0.14	-0.001 -0.02	0.016 0.41	0.000 0.01	0.011 0.34	0.018 0.50	0.018 0.49
$\alpha_3(\tau)$M2	0.299 0.62	0.216 0.55	0.234 0.72	0.199 0.76	0.069 0.29	0.048 0.22	0.587** * 2.29	0.621 1.67	0.511 1.31	0.345 0.82	0.345 0.91
$\alpha_4(\tau)$FDI	-0.540* -1.77	-0.526* -1.72	-0.503 -1.55	-0.160 -0.65	-0.059 -0.19	-0.051 -0.20	-0.413 -1.44	-0.500.2 -1.37	-0.778 -1.59	-1.156*** -2.34	-1.156*** -2.34
$\alpha_5(\tau)$DCP	-0.053 -0.46	-0.047 -0.50	-0.075 -1.01	-0.062 -0.82	-0.024 -0.36	-0.007 -0.12	-0.135** -1.89	-0.122 -1.36	-0.097 -1.11	-0.099 -1.09	-0.099 -1.18
$\theta_1(\tau)$dGPR	-0.001 -0.17	-0.001 -0.25	0.001 0.22	0.002 0.53	0.001 0.15	0.000 0.05	0.000 0.04	-0.000 -0.04	-0.000 -0.03	-0.009 -0.63	-0.009 -0.62
$\theta_2(\tau)$ dGPR1	-0.001 -0.29	-0.001 -0.20	-1.760 -0.00	0.001 0.30	0.000 0.05	0.000 0.04	0.002 0.38	0.003 0.35	0.003 0.39	-0.005 -0.52	-0.005 -0.52
$\theta_3(\tau)dREER$	0.038 0.52	0.007 0.11	-0.013 -0.28	0.007 0.16	-0.000 -0.00	0.001 0.03	-0.018 -0.32	0.006 0.11	-0.002 -0.05	-0.050 -0.77	-0.050 -0.76
$\theta_4(\tau)dREER$	-0.080 -1.32	-0.053 -0.79	-0.054 -0.86	-0.024 -0.41	-0.011 -0.18	-0.000 -0.00	-0.033 -0.52	-0.003 -0.04	-0.022 -0.31	-0.011 -0.15	-0.011 -0.15
$\theta_5(\tau)$dM2	0.661 0.85	0.900 1.54	0.979 1.03	0..752 0.69	0.763 0.50	0.872 0.57	0.798 0.50	1.046 0.56	2.349 1.33	2.170 1.41	2.169 1.39
$\theta_6(\tau)$dM21	0.168 0.24	0.047	0.403 0.83	0.147 0.36	0.050 0.13	0.064 0.20	0.185 0.52	0.220 0.67	0.113 0.28	0.347 0.62	0.347 0.63
$\theta_7(\tau)$dFDI	0.661* 1.76	0.605** 1.99	0.569** 1.91	0.199 0.81	0.066 0.24	0.064 0.29	0.456 1.43	0.467 1.24	0.629 1.47	0.851*** 2.19	0.851*** 2.18
$\theta_8(\tau)$dFDI 1	0.977** * 2.71	0.933** * 3.40	0.700 2.39	0.224 0.98	0.027 0.14	0.042 0.37	0.310** 1.89	0.302 1.22	0.463 1.55	0.681* 1.71	0.681* 1.68
$\theta_9(\tau)$dFDI 2	0.736** * 2.48	0.834** * 3.27	0.680** * 2.64	0.130 0.58	0.020 0.09	0.014 0.09	0.151 0.66	0.209 0.73	0.443* 1.75	0.312 1.06	0.313 0.98
$\theta_{10}(\tau)$dFDI 3	0.213 0.88	0.293 1.31	0.396 1.54	0.101 0.45	0.280 0.16	0.035 0.24	0.183 1.04	0.147 0.83	0.332** 2.19	0.623*** 2.87	0.622*** 2.98
$\theta_{11}(\tau)$dDC P	-0.368** -1.88	- 0.413** * -2.61	- 0.578** * -2.02	-0.460 -1.36	-0.428 -1.02	-0.384 -0.93	0.010 0.02	0.101 0.29	-0.020 -0.31	-0.451 -1.61	-0.451* -1.68
$\theta_{12}(\tau)$dDC P1	-0.077 -0.45	-0.037 -0.23	-0.095 -0.82	-0.068 -0.96	-0.005 -0.05	-0.008 -0.09	-0.063 -0.52	-0.047 -0.41	-0.020 -0.14	-0.174 -0.79	-0.174 -0.87

R^2/Pseudo R^2 Squared										

Panel 5	**South Africa**									
Quantile	**.05**	**.10**	**.20**	**.30**	**.40**	**.50**	**.60**	**.70**	**.80**	**.90**	**.95**
$\alpha_0(\tau)FXI$	0.639*** 2.27	0.686*** 2.30	0.00								
$\alpha_1(\tau)$GPR	-0.059*** -7.83	-0.054*** -7.83	-0.011 -0.00	-0.102 -0.00	-0.470 -0.00	-0.083 -0.00	-0.071 -0.00	-0.029 -0.00	-0.085 -0.52	0.279 0.06	-0.064 -0.87
$\alpha_2(\tau)$REER	-0.059*** -7.26	-0.054*** -7.81	-0.011 -0.00	-0.102 -0.00	-0.470 -0.00	-0.083 -0.00	-0.071 -0.00	-0.029 -0.00	-0.085 -0.50	0.279 0.06	-0.064 -0.89
$\alpha_3(\tau)$M2	-0.174 -2.04	-0.210*** -3.07	-0.466 -0.00	-0.041 -0.00	-0.801 -0.00	-0.217 -0.00	-0.134 -0.00	-0.181 -0.00	0.077 0.06	-8.529 0.05	0.710 0.42
$\alpha_4(\tau)$FDI	-0.222*** -3.37	-0.225** -3.45	-0.534 -0.00	-0.396 -0.00	-2.108 -0.06	-0.545 -0.14	-0.044 -0.21	-0.312 -0.00	0.378 0.28	-0.569 -0.06	0.314 0.31
$\alpha_5(\tau)$DCP	0.000 0.01	0.006 0.87	0.100 0.00	-0.078 -0.00	0.368 0.00	-0.022 -0.00	-0.015 -0.00	0.010 0.00	-0.009 -0.07	1.417 0.05	-0.173 -0.46
$\theta_1(\tau)$dGPR	-0.011*** -1.95	-0.011** -1.91	0.000 -0.00	0.000 -0.00	0.000 -0.00	0.000 -0.00	0.000 -0.00	0.000 -0.00	-0.000 -0.18	-0.001 -0.58	-0.003 -0.22
$\theta_2(\tau)$ dGPR1	-0.006** -1.87	-0.006** -1.81	0.000 -0.00	0.000 -0.00	0.000 -0.00	0.000 -0.00	0.000 -0.00	0.000 -0.00	-0.000 -0.17	-0.001 -0.79	-0.001 -0.46
$\theta_3(\tau)dREER$	-0.009 -1.21	-0.015* -1.71	0.000 -0.00	0.000 -0.00	0.000 -0.00	0.000 -0.00	0.000 -0.00	0.000 -0.00	-0.005 -0.68	-0.017*** -2.38	-0.017*** -2.45
$\theta_4(\tau)dREER$	0.001 0.07	-0.008 -0.80	0.000 -0.00	0.000 -0.00	0.000 -0.00	0.000 -0.00	0.000 -0.00	0.000 -0.00	-0.001 -0.24	-0.007 -1.52	-0.004 -0.71
$\theta_5(\tau)dREER$	-0.023** -1.93	-0.019* -1.71	0.000 -0.00	0.000 -0.00	0.000 -0.00	0.000 -0.00	0.000 -0.00	0.000 -0.00	-0.001 -0.27	-0.010*** -2.01	-0.012*** -3.17
$\theta_6(\tau)$dM2	-0.565 -1.14	-0.488 -1.01	0.133 0.28	0.173 0.69	0.173* 1.69	0.173*** 2.05	0.192*** 2.76	0.192*** 2.14	0.178*** 2.57	0.091 1.19	0.046 0.29
$\theta_7(\tau)$dM21	-0.091 -0.66	-0.036 -0.29	0.000 -0.00	0.000 -0.00	0.000 -0.00	0.000 -0.00	0.000 -0.00	0.000 -0.00	-0.032 -0.55	-0.059 -0.64	-0.071 -0.61
$\theta_8(\tau)$dFDI	-0.071 -1.58	-0.080 -1.45	0.000 -0.00	0.000 -0.00	0.000 -0.00	0.000 -0.00	0.000 -0.00	0.000 -0.00	0.001 0.05	-0.004 -0.38	0.005 0.33
$\theta_{11}(\tau)$dDCP	-0.008 -0.55	-0.002 -0.17	0.000 0.04	0.000 0.10	0.001 0.13	0.001 0.11	0.001 0.15	0.001 0.12	0.008 1.01	0.021*** 2.57	0.022*** 2.81
$\theta_{12}(\tau)$dDCP1	0.022 1.30	0.021 1.26	0.000 0.00	0.000 0.00	0.000 -0.00	0.000 -0.00	0.000 -0.00	0.000 -0.00	0.004 0.72	0.019*** 2.29	0.015*** 1.69
R^2/Pseudo R^2 Squared											

Table 5: Parameter Constancy Test

	Brazil		**India**		**Russia**		**China**		**South Africa**	
Panel 6	**Coeff**	**F-stat**	**Coeff**	**F-stat**	**Coeff**	**F-stat**	**Coeff**	**F-stat**	**Coeff**	**F-stat**
$\alpha_0(\tau)FXI$	2.21	0.0283	0.83	0.6044	1.05	0.4102	5.66	0.000	1.12	0.3626
$\alpha_1(\tau)$GPR	1.36	0.2209	0.85	0.5849	0.05	1.000	0.68	0.7393	1.27	0.2652
$\alpha_2(\tau)$REER	0.89	0.5495	0.79	0.6380	1.64	0.1155	2.99	0.0037	2.38	0.0177
$\alpha_3(\tau)$M2	1.97	0.0518	1.25	0.2748	0.52	0.8681	8.98	0.0000	2.04	0.0425
$\alpha_4(\tau)$FDI	4.11	0.0002	1.58	0.1326	1.33	0.2321	1.88	0.0635	0.70	0.7201
$\alpha_5(\tau)$DCP	3.84	0.0004	0.81	0.6187	0.58	0.8266	1.94	0.0556	1.32	0.2390
$\theta_1(\tau)$dGPR	0.50	0.8835	1.14	0.3468	0.15	0.9988	1.19	0.3139	1.29	0.2544
$\theta_2(\tau)$ dGPR1	0.24	0.9908	0.56	0.8439	0.19	0.9961	2.36	0.0188	0.74	0.6844
$\theta_3(\tau)dREER$	2.35	0.0197	1.29	0.2568	2.76	0.0068	1.41	0.1975	0.95	0.4925
$\theta_4(\tau)dREER1$	2.42	0.0166	2.57	0.0110	0.88	0.5537	1.09	0.3816	1.42	0.1910
$\theta_5(\tau)dREER2$	2.12	0.0353			6.33	0.0000	0.51	0.8802	2.93	0.0042
$\theta_6(\tau)dREER3$	1.39	0.2075			2.76	0.0068				
$\theta_7(\tau)$dM2	0.75	0.6778	0.58	0.8237	2.16	0.0322	1.23	0.2877	1.65	0.1129
$\theta_8(\tau)$dM21	0.69	0.7270	0.31	0.9767	0.23	0.9929	2.41	0.0167	0.44	0.9200
$\theta_9(\tau)$dM22	0.40	0.9432								
$\theta_{10}(\tau)$dFDI	0.96	0.4841	1.40	0.1996	1.50	0.1611	1.89	0.0632	1.67	0.1059
$\theta_{11}(\tau)$dFDI1	1.73	0.0924	1.95	0.0534	3.83	0.0004	2.51	0.0127		
$\theta_{12}(\tau)$dFDI2			2.58	0.0106						
$\theta_{13}(\tau)$dFDI3			2.91	0.0045						
$\theta_{14}(\tau)$dDCP	0.77	0.6581	1.10	0.3731	0.98	0.4719	0.91	0.5251	1.73	0.0916
$\theta_{15}(\tau)$dDCP1	2.03	0.0448	1.40	0.199			3.89	0.0004	1.20	0.3098
Cumulative Short-Run Effects										

Note. The constancy test is measured by the use of Wald test. The following highlighted Wald test shows the asymmetries.

Figure 1: Brazil Cusum

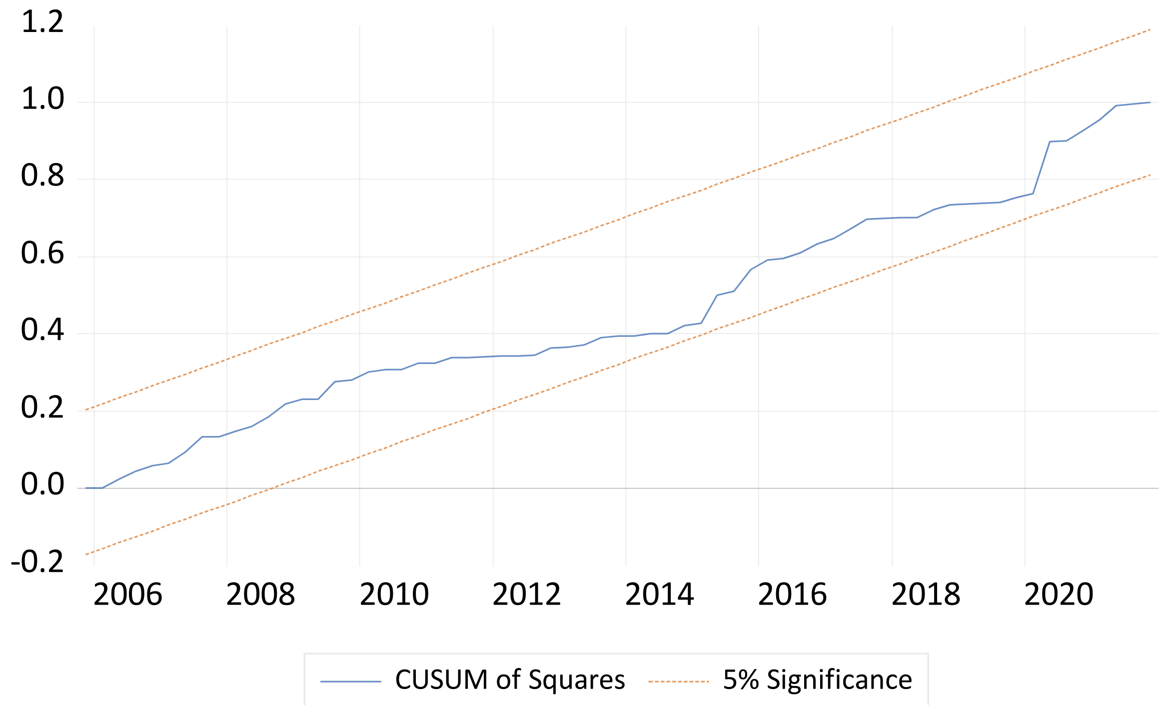

Figure 2: Brazil Cusum

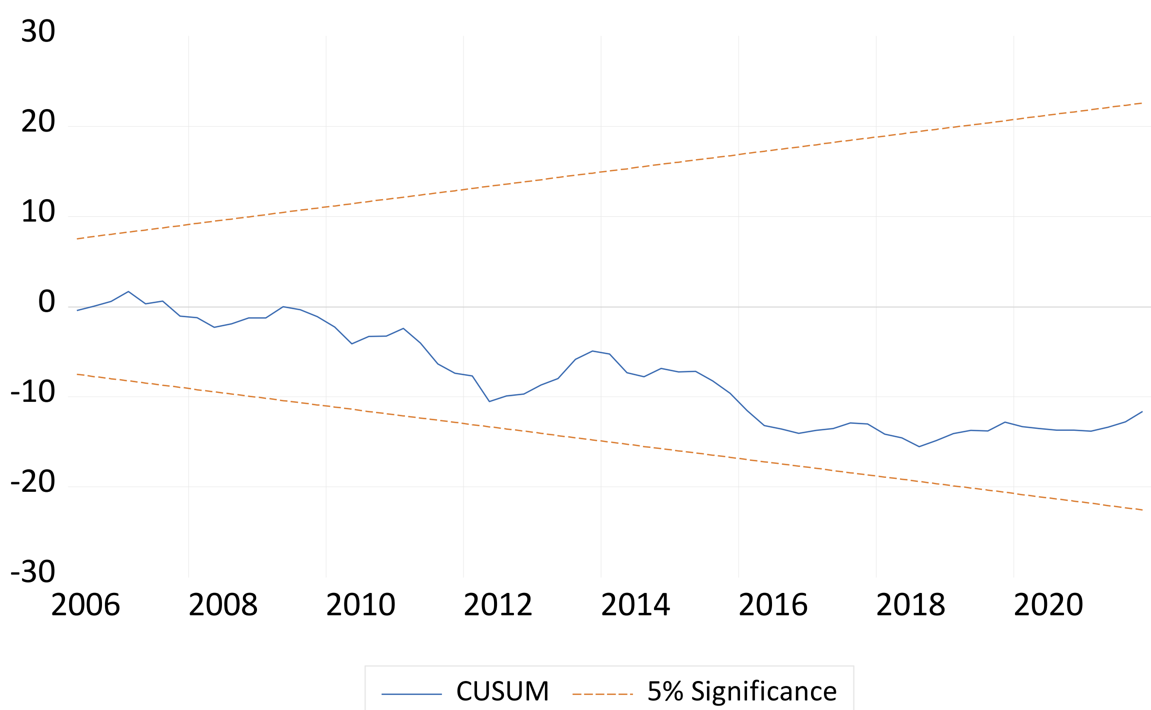

Figure 2: China

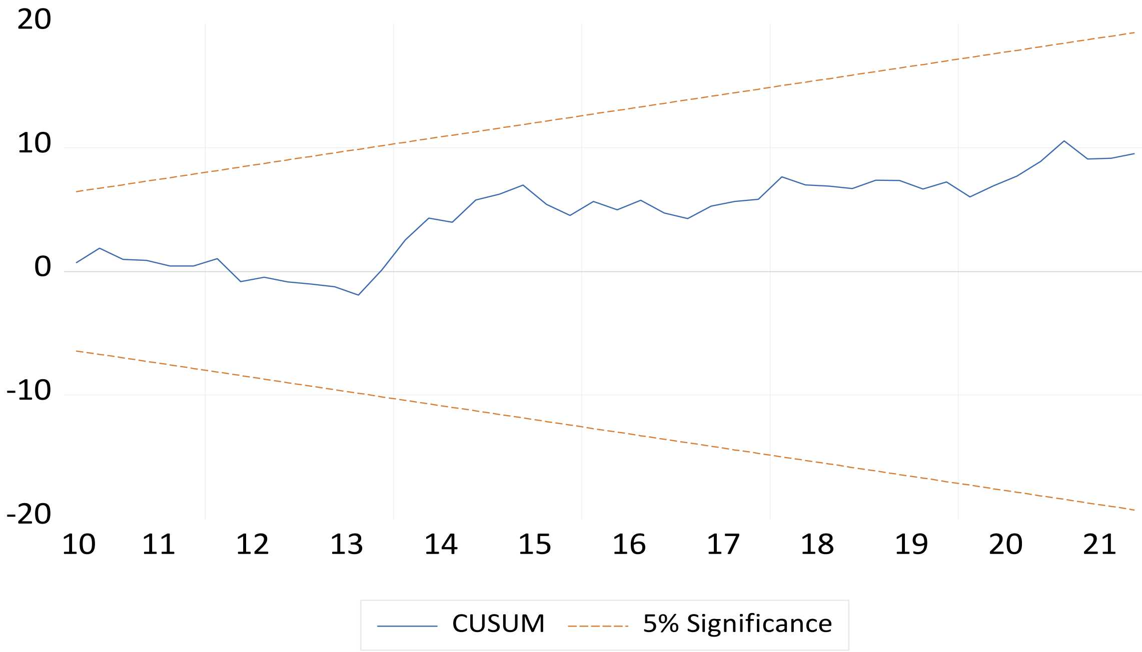

Figure 3: India

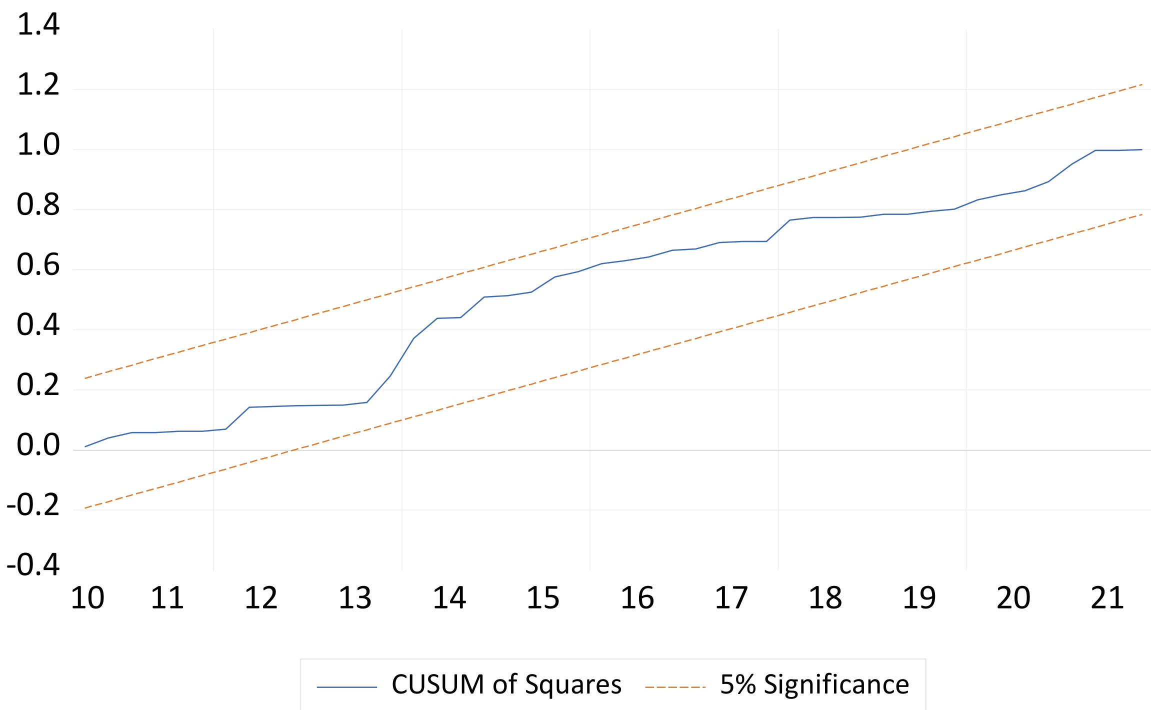

Figure 4: India CusumSQ

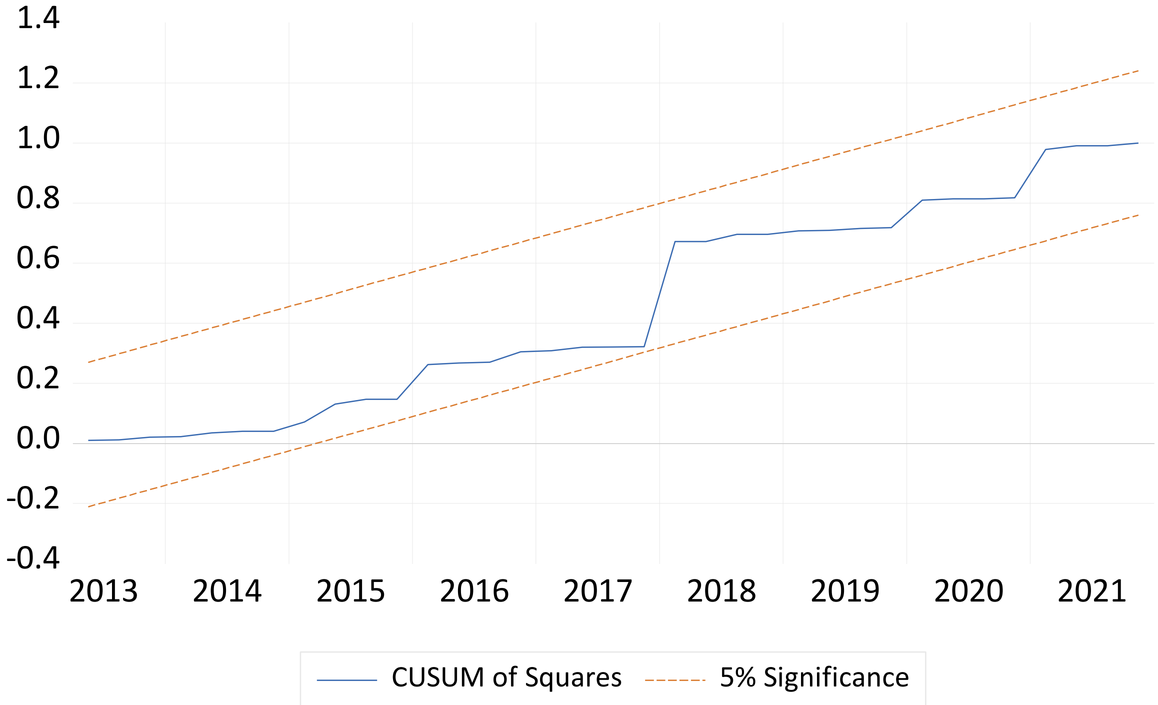

Figure 5: Russia Cusum

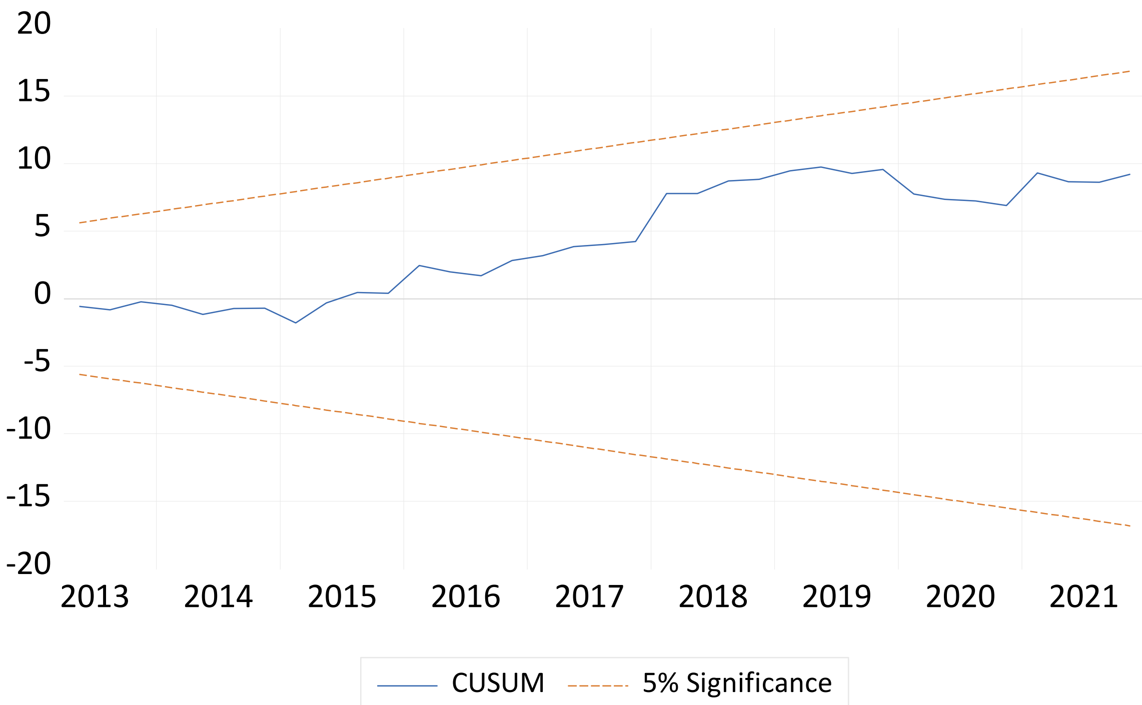

Figure 6: Russia CusumSQ

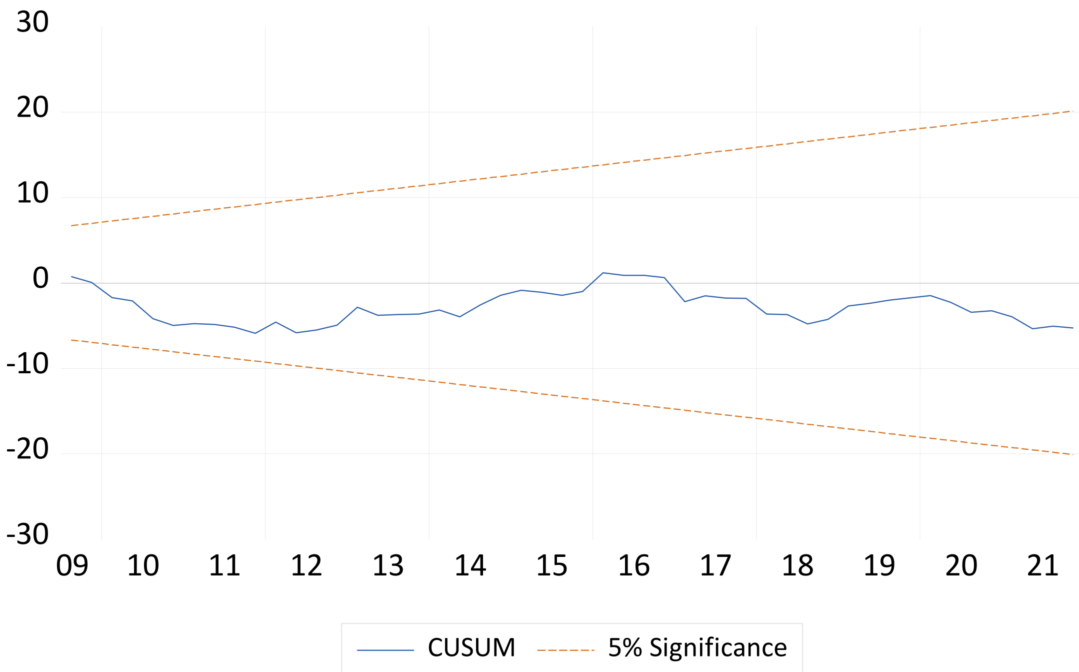

Figure 7: South Africa Cusum

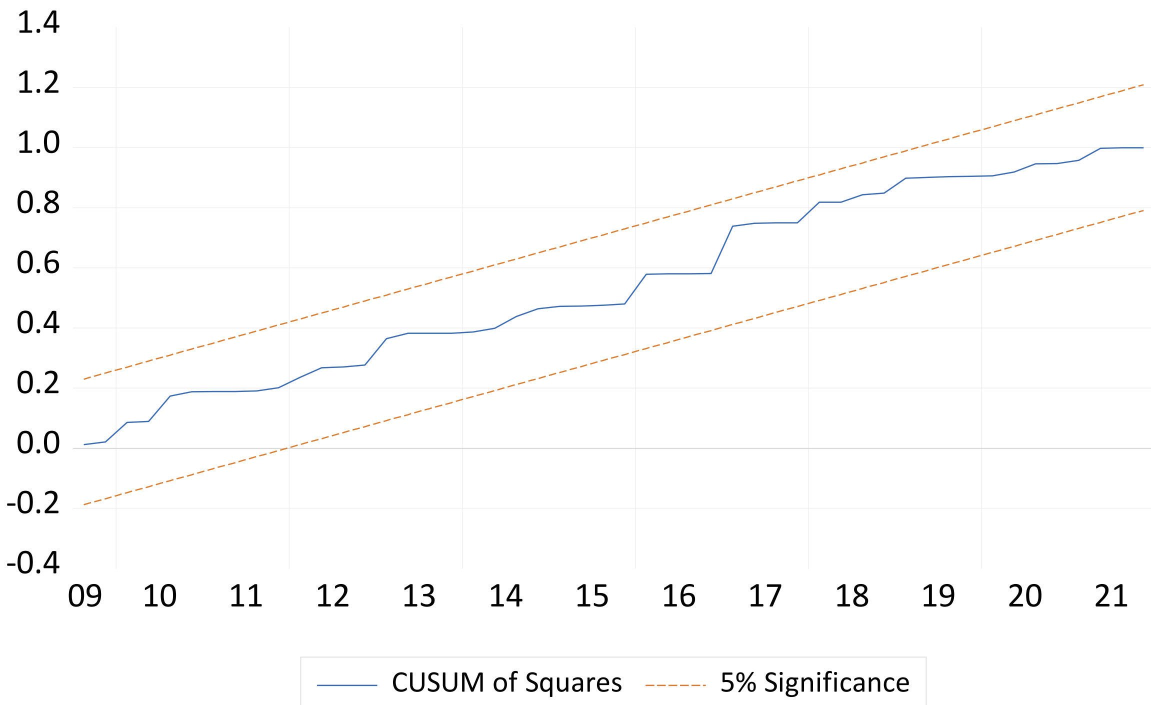

Figure 9: Quantile process for Brazil

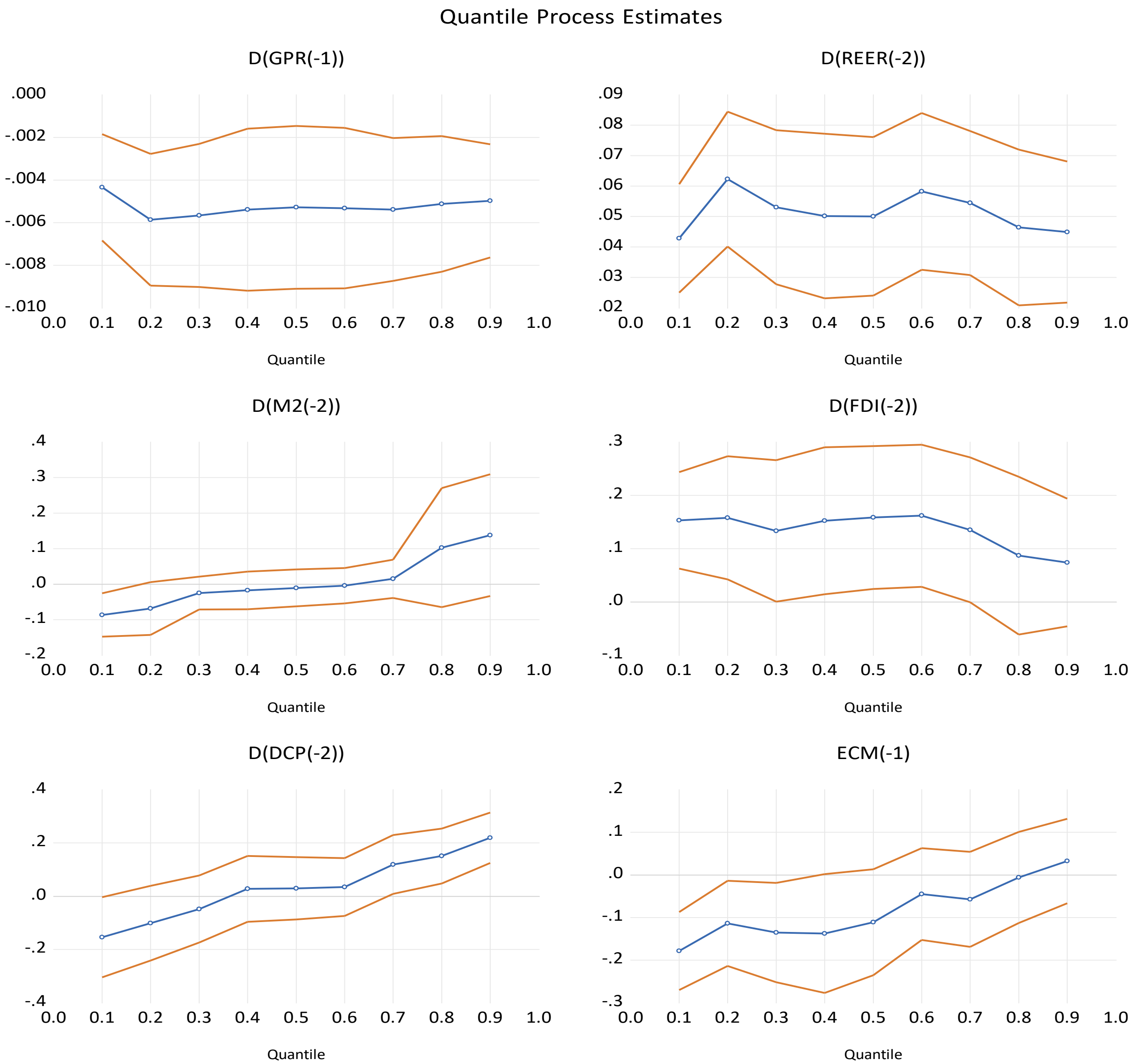

Figure 10: Quantile process for India