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Research article

Exchange rates and stock markets in emerging economies: new evidence using the Quantile-on-Quantile approach

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Abstract: This study aims to reconsider the relationship between exchange rate and stock market returns for selected emerging countries. The quantile-on-quantile approach is employed to present an inclusive and detailed image of the association between the variables under investigation. This approach can reveal the heterogeneous and the varying relationship between the variables at different quantiles. The estimation outcome demonstrates that the examined countries' stock market performances are not affected by the exchange rate changes unless certain market conditions are established. The empirical results suggest that the exchange rate flexibility has a crucial role in determining the market returns depending on the bearish or bullish conditions. Considering the asymmetric nature of the relationship between the exchange rate and the stock market, presented results can aid governmental authorities and investors to design dynamic economic policies and investment strategies.

Keywords: emerging economies; stock market return; exchange rate; asymmetry; Quantile-on-Quantile approach

JEL Codes: C22; E44; F31; G15

1. Introduction

Exchange rate and stock market have essential roles in economic development (Nieh and Lee, 2001), implementation of monetary and fiscal policies (Wong, 2017), and the development of the financial system (Afshan et al., 2018). Given their importance, these variables have always been the focus of empirical research. According to the literature, developments in one of the markets can rapidly spread to the other one (Andriansyah and Messinis, 2019). Such behavior is important especially from a policy perspective because it implies that volatilities in either stock or exchange rate market might have significant implications on the economy through several transmission channels (Dahir et al., 2018; Leung et al., 2017). Moreover, the relationship between the two markets has important implications for portfolio construction, hedging strategies, and investment plans (Reboredo et al., 2016).

Although researchers have investigated the relationship between stock and foreign exchange markets intensely, the literature has mostly focused on developed markets. Despite the increasing importance of emerging markets for the global economy through trade and capital flow (Sui and Sun, 2016), the literature on these markets is comparatively limited. Also, existing studies suggest mixed results (Afshan et al., 2018; Mikhaylov, 2018; Sui and Sun, 2016; Živkov et al., 2018). The absence of robust findings on the relationship between stock and foreign exchange markets can be deceiving, especially for the international investors and multinational corporations subject to exchange rate risk. In response to the gap in the literature, the current study applies the recently proposed Quantile-on-Quantile (QQR) approach (Sim and Zhou, 2015) to examine the effects of exchange rates on stock markets in eight selected emerging markets with the aim of robust empirical findings to benefit international corporations, investors and policymakers.

The literature proposes several models to explain the interaction between stock and the exchange rates market. The flow-oriented model (Dornbusch and Fischer, 1980) suggests that exchange rate volatilities affect global trade, impacting firms' real income and output. Assuming the discounted present value of a firm's expected future cash flows as the primary determinant of its stock price, the impact of fluctuations in the exchange rate on the firm's balance sheet will be reflected in its stock price. Thus, the flow-oriented model suggests a positive relationship between exchange rates and stock prices. In contrast, the portfolio balance model (Branson et al., 1977) states a negative relationship between stock prices and exchange rates. In this model, variations in stock prices can affect the capital account transactions, which is claimed to be the key determinant of exchange rates. According to this model, a good performing stock market brings foreign capital into the economy, which causes the stock market to ascend, and in return, the currency to appreciate. Unlike the above-mentioned theories, the stock-oriented theory (Frankel, 1992) assumes no relationship between the exchange rates market and the stock market. According to this theory, a common factor, such as interest rate, causes changes in both markets (Ajayi and Mougoue, 1996). Empirical findings provide mixed evidence related to the relationship between the exchange rates market and the stock market, and there is partial support for each theory.

In contrast to the well-developed literature on the relationship between the exchange rates market and the stock market in developed countries (Antonakakis, 2012; Bajo-Rubio et al., 2017; Tule et al., 2018; Grobys, 2015; Lean et al., 2011), the number of studies on developing countries is

still limited. Due to globalization, financial markets (including stock and foreign exchange) of the developing countries have been closely linked with those of developed economies. The facilitation of foreign capital movements and implementing floating exchange rate regimes by emerging economies have increased their importance for the global economy. In recent years, as a result of fast development in their stock markets, emerging economies have become an attractive destination for foreign investors and witnessed substantial capital inflows from developed markets (Beckmann et al., 2015). Furthermore, since the global financial crisis, emerging markets have increased their share of the global economy as the advanced economies' major trading partners. They are currently considered the impelling cause of world economic growth (Sensoy and Tabak, 2016). Developing economies suffer from higher economic and political uncertainty, less competition, inefficient information flow, lower transparency, and liquidity than developed economies (Lagoarde-Segot and Lucey, 2008). Mentioned problems may reduce efficiency in emerging markets (Oztekin et al., 2016). Also, emerging markets are quick to respond to speculative investments, policy modification to manage exchange rates, and capital movement, reacting to economic uncertainties (Reboredo et al., 2016). Given their increasing importance to the global economy and relative scarceness of the studies, this study aims to investigate the relationship between exchange rates and stock market of the developing countries.

Although previous studies employed many different estimation methods to investigate foreign exchange-stock market nexus such as cointegration and vector error correction models (Acikalin et al., 2008; Sui and Sun, 2016); GARCH model (Hsing, 2011; Zhao, 2010); Johansen cointegration and Granger causality test (Brahmasrene and Jiranyakul, 2007); wavelets approach (Afshan et al., 2018); and VAR (Delgado et al., 2018); these methods are not adequate to provide a complete picture of this relationship, and they keep some interesting characteristics of the relationship unrevealed (see, Afshan et al., 2018). Due to complex behaviors of exchange rates and stock prices, assessing the relationship between these variables utilizing standard econometric techniques is difficult. For instance, the stock prices' reaction to exchange rate shocks can be dissimilar depending on the state of the market (whether it is bullish or bearish) and the size of the shock. Therefore, an asymmetric response of different stock markets to exchange rate changes is assumed. This assumption is consistent with the earlier studies that revealed an asymmetric or nonlinear link between the variables, especially in financial markets (Chang, et al., 2020).

The present study reinvestigates the effect of the exchange rates market on stock markets by applying the recently developed QQR approach that accounts for the market state and the sign and size of the shocks. The QQR approach merges quantile regression and nonparametric estimation techniques and regresses one variable's quantiles on the quantiles of the other variable. Hence, the QQR method can present an inclusive and detailed image of the general association between the variables under investigation and expose the heterogeneous and the varying relationship between the variables at different quantiles. The QQR approach's advantages make it an appropriate technique to examine the association between variables during high volatility periods of the market and for the assets that are affected by the shocks frequently. In this study, by using the QQR approach, we can analyze the response of the entire conditional distribution of stock market index (SMI) to variations in effective exchange rates (EER) for each quantile. Therefore, each stage of conditional distribution for SMI and EER can be considered, which gives us a comprehensive explanation of the state-dependent and tail effect of

exchange rates on stock markets. In comparison to previous studies, we provided a more comprehensive explanation of the state-dependent and tail effect of exchange rates on stock market returns.

To the best of the authors' knowledge, this is the first study to investigate the effect of the exchange rates market on the stock markets of the emerging economies based on a QQR method controlling for several types of biases caused by nonlinearity, asymmetry, regime shifts, and structural breaks (Sim and Zhou, 2015). This study contributes to the literature mainly in two ways: First, compared to other studies, it provides more detailed and robust findings regarding the effect of EER on SMI owing to the novel QQR estimation technique. While other econometric methods, such as OLS regression, can only conclude the presence or absence of the effect of exchange rates on the stock market returns, QQR reveals further by decomposing this effect for each quantile combination. Second, the present study investigates a sample of emerging economies, i.e., Brazil, China, India, Malaysia, Mexico, South Africa, Thailand, and Turkey. The main reason to choose these countries as our sample is their recent economic reformations of stock and foreign exchange markets. Since the flow of foreign capital into the domestic market will affect the stock market (Agarwal and Mohtadi, 2004), the interaction between EER and SMI is of high importance to investors and policymakers. Moreover, exchange rate regimes made emerging markets more disposed to exchange rate volatility (Hajilee and Al Nasser, 2014), impacting the stock market returns (Chen et al., 2004). In this regard, understanding the associations between exchange rates and stock markets can help international investors, multinational firms, and portfolio managers to assess the investment risks in emerging markets.

The remainder of this paper is as follows. The second section presents an overview of the literature. Section 3 summarizes the methodology for the QQR model. Section 4 provides the empirical results, and section 5 outlines the conclusion of the study.

2. Literature review

Most empirical studies on the relationship between stock markets and exchange rates have followed the pioneering work of Frank and Young (1972), who suggested no significant link between the two markets. On the other hand, Dornbusch and Fischer (1980) suggested the flow-oriented theory explaining a causal relationship from exchange rates to stock markets. This theory argues that when the domestic currency depreciates (appreciates), the costs of export become lower (higher), the local firms become more (less) competitive and increase (decrease) their exports. This development results in an increase in the stock prices of domestic firms. In contrast, portfolio balance theory (Branson, 1983; Frankel, 1983) states that a well-functioning stock market stimulates the demand for the stocks and encourages foreign investment and capital inflows, making the domestic currency appreciates.

Early empirical studies on the subject yielded different results. For example, Aggarwal (1981) claimed that the U.S. Dollar depreciation caused stock prices to decline between 1974 and 1978. In contrast, Soenen and Hennigar (1988) argued that the depreciation of the U.S. Dollar helps American industrial companies export more and increase their profit. Later, Bahmani-Oskooee and Sohrabian (1992) revisited the exchange rate-stock price nexus and reported bidirectional Granger causality between the S&P 500 and the U.S. Dollar exchange rate; however, they could not find any evidence for a cointegrating relationship between them. Following these pioneering studies, the exchange rate-stock price nexus has been extensively examined in developed economies. With a theoretical proposition

rooted in the flow-oriented model (Dornbusch and Fischer, 1980), many studies have presumed the exchange rate as a critical factor in stock market fluctuations (Phylaktis and Ravazzolo, 2005; Dellas and Tavlas, 2013; Korhonen, 2015; Türsoy, 2017; Delgado et al., 2018; Zheng et al., 2019). Conversely, as financial markets become more integrated, the portfolio balance model started to receive empirical support as well (see, e.g., Caporale et al., 2014; Tsagkanos and Siriopoulos, 2013; Hau and Rey, 2005; Liang et al., 2013; Cenedese et al., 2015; Lou and Luo, 2018; Cavusoglu et al., 2019).

The Asian financial crisis of 1997 sparked discussions about the relationship between exchange rates and stock markets in developing countries (Bahmani-Oskooee and Saha, 2015) and triggered research efforts. Kasman et al. (2011) examined the effects of exchange rate fluctuations on Turkey's stock prices between 1999 and 2009 using the OLS and GARCH estimation models. Their results suggest that the fluctuations in the exchange rate have negative impacts on the stock returns. Lin (2012) investigated the association between exchange rates and stock prices in India, Indonesia, Korea, the Philippines, Taiwan, and Thailand from 1986 to 2010. The ARDL model's findings showed that the association between the markets is generally driven by capital account balance rather than trade balance. Unlike the mentioned studies, Tsai (2012) did not use a conventional method and used the quantile regression model to examine the relationships between foreign exchange and stock markets in Singapore, Thailand, Malaysia, the Philippines, South Korea, and Taiwan from 1992 to 2009. His results indicated that the presence of extremely high or low exchange rates triggers a negative relationship between exchange rates and stock markets. Liang et al. (2013) employed panel Granger causality and panel DOLS methodologies to investigate the exchange rates and stock markets relationship in Indonesia, Malaysia, Philippines, Singapore, and Thailand between 2008 and 2011 and found supportive evidence for "portfolio balance theory".

More recently, Akel et al. (2015) assessed the linkages between stock prices and exchange rates for Brazil, India, Indonesia, South Africa, and Turkey. Their results indicate a positive association between stock prices and exchange rates in the long run, except Brazil. Similarly, Sui and Sun (2016) found evidence for a significant spillover effect from exchange rates to stock prices in the short-run for the BRIC countries by applying VAR and VECM models. Tang and Yao (2018) investigated eleven emerging markets (Argentina, Brazil, China, India, Indonesia, South Korea, Mexico, Russia, Saudi Arabia, South Africa, and Turkey) with cointegration and multivariate Granger causality tests. They found a positive relationship between the real exchange rate and the domestic stock market except for Brazil and China. Nguyen (2019) recently reinvestigated the long- and short-run dynamics between exchange rates and stock prices over the period 2007 to 2013 for six countries. The results of multivariate causality tests indicated that there is no short-run relationship between the variables in the case of China and India. However, in the case of Brazil, there is bi-directional causality between stocks and exchange rates.

The relationship between the exchange rate and the stock price has been studied using different time series and panel data econometrics (Wong, 2017). Granger causality tests, Johansen and Engle-Granger cointegration tests, mainly within a VECM context, are the most broadly conducted techniques in this field (Bahmani-Oskooee and Saha, 2015). The first shortcoming of the above-mentioned studies is the assumption of the effect of exchange rates on stock prices is symmetric (Bahmani-Oskooee and Saha, 2016). In other words, the common assumption indicates that if currency appreciation has negative effects on stock prices, depreciation has a similar opposite

effect. Until recently, the asymmetry in the relationship between the two variables has not been taken enough attention (Shahbaz et al., 2018). In their early study, Apergis and Rezitis (2001) suggested an asymmetric effect of foreign exchange rates on the New York and London stock markets. To find more evidence on the asymmetric exchange rate effect, Koutmos and Martin (2003) employed the partial sum concept to break down the exchange rate volatilities into two as depreciation and appreciations and reported noticeable asymmetries for Germany, Japan, the United Kingdom, and the United States. By applying a nonlinear ARDL approach, Bahmani-Oskooee and Saha (2015) confirmed the presence of an asymmetric effect from the nominal effective exchange rate of the U.S. Dollar to the S&P 500 index. They also suggested consideration of the asymmetric effect of exchange rates on stock prices for other markets.

The second inadequacy in the literature is to neglect the effect of potential structural breaks (Bahmani-Oskooee and Saha, 2016). As a result of domestic and global economic shocks, it is likely for exchange rates and stock prices to have a structural break(s) (Lean et al., 2011). Especially for high-frequency series, it is important to take the structural breaks into account (Paye and Timmermann, 2006; Giacomini and Rossi, 2009). It makes the forecasts more precise (Pesaran et al., 2013). In this study, we aim to fill the above-mentioned gaps and advance the literature on the relationship between the exchange rates and stock prices using the QQR approach, which demonstrates distribution-to-distribution effects (Shahzad et al., 2017) and allows for asymmetry, structural breaks, nonlinearity, and regime shifts (Shahbaz et al., 2018).

3. Data and methodology

The data used in this research are monthly figures that cover the January 1994–March 2019 period. Although the sample initially planned to contain the biggest ten emerging market economies; China, India, Brazil, Russia, Mexico, Indonesia, Turkey, Thailand, South Africa, and Malaysia, we removed Russia and Indonesia due to missing data for the given period from the sample. Each country's stock market performance was measured by its corresponded stock exchange indices and the data collected from the Thomson Reuters EIKON database. To measure the countries' currency strength, we used EER that is reported by the Bank for International Settlements using geometrically weighted averages of bilateral exchange rates adjusted by relative consumer prices.

The present study employed the QQR methodology, recently proposed by Sim and Zhou (2015). By merging the conventional quantile regression with local linear regression, the QQR methodology stands as a novel alternative to obtain more information about the effect of exchange rates on stock markets. Compared to ordinary least squares (OLS), the conventional quantile methodology (Koenker and Basset, 1978) enables one to examine the influence of an independent variable on different quantiles of a dependent variable. The quantile regression derives a more detailed relationship between the variables. It provides a more comprehensive picture by examining the quantile coefficients at tail distributions rather than the average effect. Another advantage of the quantile approach is its applicability to the parameters that are not subject to shape restrictions. OLS estimation generates robust outcomes when the errors follow the classical linear regression assumptions such as zero-mean and normal distribution (Xu and Lin, 2018). However, these assumptions do not hold for most financial and economic variables as the series usually suffer from heteroskedasticity, autocorrelation, long-tail

distribution, or high kurtosis. The quantile regression methodology does not oblige errors to fulfill the strict classical linear regression assumptions and provides more flexibility.

Although quantile regression has superior features to OLS, Sim and Zhou (2015) argued that both OLS and conventional quantile regressions fall short of revealing the complete picture of the relationship between oil prices and the US stock market returns. In response, they proposed a single equation regression model by integrating the quantile regression approach into a nonparametric estimation framework. Their methodology uses a dimension reduction technique in the form of local linear regression to avoid the "curse of dimensionality," which is inherited from nonparametric models. The QQR approach conveys more information since it can estimate each quantile's influence on the conditional quantiles of the other variable. Compared to the QQR methodology, the conventional quantile regression's biggest shortcoming is its inability to disintegrate the explanatory variable into separate quantiles in a regression analysis.

In the context of this study, the QQR methodology was employed to examine the impact of the effective exchange rate on the stock index for the selected countries. First, ρ-quantile of the SMI as a function of the exchange rate in a nonparametric setting can be written as follows:

$$SMI_t = \beta^{\rho} EER_t + \varepsilon_t^{\rho} \tag{1}$$

where SMI and EER represent stock index and effective exchange rate, respectively, and ε_t^{ρ} is the error term with a zero ρ-quantile. Since there is no prior information about how the EER and the stock index are related, the function β^{ρ} is allowed to be unknown. Then, the function β^{ρ} is linearized by capturing the first-order Taylor expansion of β^{ρ} around EER^{μ}, which generates the following:

$$\beta^{\rho}(EER_t) \approx \beta^{\rho}(EER^{\mu}) + \beta^{\rho}(EER^{\mu})(ER_t - EER^{\mu}) \tag{2}$$

v (2) can be re-written by redefining both $\beta^{\rho}(EER^{\mu})$ terms as $\beta_0(\rho,\mu)$ and $\beta_1(\rho,\mu)$.

$$\beta^{\mu}(EER_t) \approx \beta_0(\rho,\mu) + \beta_1(\rho,\mu)(EER_t - EER^{\mu}) \tag{3}$$

Afterward, Equation (3) can be substituted into Equation (1) to get the following equation:

$$SMI_t = \beta_0(\rho,\mu) + \beta_1(\rho,\mu)(EER_t - EER^{\mu}) + \varepsilon_t^{\rho} \tag{4}$$

In Equation (4) the part $\beta_0(\rho,\mu) + \beta_1(\rho,\mu)(EER_t - EER^{\mu})$ captures the connection between the ρ-quantile of effective exchange rate index and the μ-quantile of the SMI, given that β_0 and β_1 are mutually indexed in ρ and μ.

β_0 and β_1 in Equation (4) can be estimated by replacing the terms EER_t and EER^{μ} with their estimated counterparts $\widehat{EER_t}$ and $\widehat{EER^{\mu}}$, respectively.

$$min_{b_0,b_1} \sum_{i=1}^{n} \partial_{\rho}\left[SMI_t - b_0 - b_1(\widehat{EER_t} - \widehat{EER^{\mu}})\right] JG\left(\frac{F_n(\widehat{EER_t}) - \mu}{h}\right) \tag{5}$$

where ∂_{ρ} represents the tilted absolute value, which provides the ρ-conditional quantile of SMI_t as a solution. Based on the approach of Sim and Zhou (2015), a Gaussian kernel G (GKG) is used to weight the observations next to $\widehat{EER^{\mu}}$, depending on a bandwidth h. The given weights are opposite to the distance of $\widehat{EER_t}$ from $\widehat{EER^{\mu}}$, or more conveniently, the distance of the empirical distribution function from μ, where μ is the input of the distribution function that relates to EER^{μ}.

$$F_n\left(\widehat{EER_t}\right) = \frac{1}{n}\sum_{k=1}^{n} I\left(\widehat{EER_t} < \widehat{EER_k}\right) \quad (6)$$

4. Empirical results

Table 1 reports descriptive statistics for the stock index for all the emerging markets under study. The differences in standard deviations imply dispersion in volatility behavior across markets. Similarly, differences between max and min stock indices indicate that price ranges were larger for Brazil and Turkish stock markets than other stock markets. Considering the EER, we mostly observe non-positive skewness except for China, India and Malaysia. Results also indicate a normal tail for the variables based on both skewness and kurtosis statistics. Hence, we failed to reject the null hypothesis of Jarque-Bera test which suggests normality for the given variables.

Table 1. Descriptive statistics of the stock market returns and effective exchange rate.

	Mean	*Median*	*Max*	*Min*	*Std*	*Skewness*	*Kurtosis*	*J-B*
Stock Market Returns								
BRAZIL	36,468.46	37,403.55	97,393.00	375.5	25,311.55	0.22	1.76	22.00*
CHINA	2,081.63	1,992.23	5,954.76	333.92	1,008.66	0.74	3.65	33.07*
INDIA	13,201.77	10,145.06	38,672.91	2,810.66	10,255.77	0.71	2.32	31.73*
MALAYSIA	1,186.92	1,113.71	1,882.71	302.91	421.47	0.12	1.71	21.86*
MEXICO	22,483.42	20,122.85	51,328.29	1,519.52	17,074	0.22	1.41	34.32*
SOUTH AFRICA	25,400.43	22,212.00	59,772.83	4,479.85	17,945.08	0.47	1.78	28.32*
THAILAND	931.97	805.26	1,830.13	214.53	463.39	0.2	1.65	24.98*
TURKEY	39,419.49	35,271.42	119,528.80	140.87	33,704.35	0.45	1.93	24.63*
Effective Exchange Rates								
BRAZIL	81.34	83.44	109.92	42.03	15.49	-0.41	2.25	15.79*
CHINA	99.29	95.95	130.93	65.81	15.66	0.34	2.31	11.79*
INDIA	93.87	93.27	104.59	82.16	4.73	0.29	2.45	8.10*
MALAYSIA	99.58	97.81	130.71	84.06	9.69	1.18	4.14	87.58*
MEXICO	100.36	101.31	133.23	62.4	13.81	-0.11	2.59	2.72
SOUTH AFRICA	89.54	90.6	118.14	60.28	12.36	-0.049	2.34	5.22*
THAILAND	97.29	99.48	122.07	68.2	9.25	-0.16	2.33	6.96*
TURKEY	78.81	80.74	103.9	43	13.7	-0.31	2.18	13.45*

Notes: Monthly data covers the period of January 1994–March 2019. J–B denotes the Jarque–Bera statistics for normality. An asterisk (∗) indicates rejection of the null hypothesis at 5%.

The empirical outcome of the QQR analysis of the relationship between the exchange rate changes and the stock market performance is presented in Figure 1. The figure displays the slope estimates $\widehat{\beta_1}(\rho, \mu)$, which identify the impact of the μ^{th} quantile of effective exchange rate on the ρ^{th} quantile of the SMI for a broad range of combinations. The slope coefficients for eight countries under the analysis lie down on the z-axis, and the quantiles of effective exchange rate and SMI are depicted on the x and y-axes, respectively.

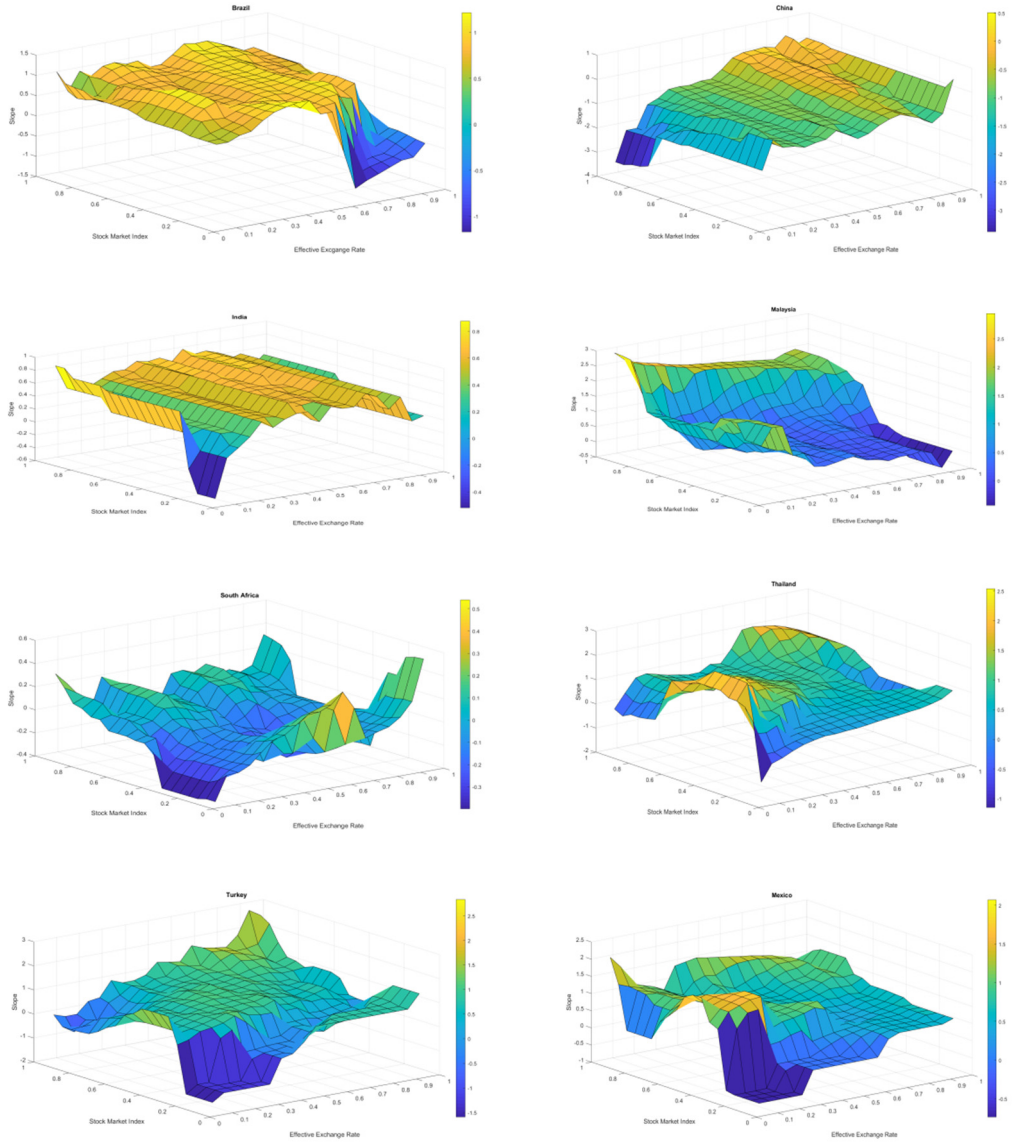

Figure 1. Quantile on Quantile Regression (QQR) estimates. Note: These graphs show the estimates of the slope coefficient $\widehat{\beta_1}(\rho, \mu)$ on the z-axis against the quantiles of growth of SMI (ρ) on the x-axis and the quantiles of EER (μ) on the y-axis.

The results demonstrate that the countries under examination share several similarities regarding the exchange rate-stock market nexus. More specifically, the obtained slope coefficients take positive values for the majority of quantiles. It is also evident that slope variations at mid-tier quantiles are quite minor in most countries. However, at the tail quantiles of the variables, the variations seem to be increasing significantly. In other words, variations in the exchange rate affect the stock market performance more drastically when a certain set of market conditions are established. It is important to note that fluctuations of the slope estimates do not occur at the same quantiles for every country in the sample. Obtained findings revealed that the relationship between exchange rate changes and the stock market is not homogeneous among all quantiles; also, it shows differences across countries.

In the case of India and Mexico, the impact of the effective exchange rate on the SMI appears weak for the most quantile combinations. This can be observed from the large plane areas where the countries' stock markets are neutral and not affected by the exchange rate shocks. Furthermore, the slope coefficient estimates in these areas remain steadily positive. Interestingly, however, there is a sharp decrease in the slope estimates at the lower quantiles of both EER and SMI for both countries. In India's case, this decrease is observed when the quantiles of EER range from 0.05 to 0.10, and the quantiles of the stock market range from 0.05 to 0.15. Similarly, for Mexico, the slope coefficient falls drastically, and its sign turns from positive to negative between the lower quantiles of EER (0.05–0.25) and the lower quantiles of the SMI (0.05–0.40). These results imply that exchange rate shocks are being effective in India and Mexico's financial markets when their stock markets and currencies perform inadequately.

The estimation output of South Africa shows that the stock market is quite responsive to effective exchange rate changes. The estimated slope coefficient becomes positive in the area that combines the highest quantiles of EER (0.90–0.95) and the lower quantiles of the SMI (0–0.30). Moreover, during the low-performing stock market phases, there is an upward spike after the quantiles of EER pass the median point (0.50–0.70). This finding can be interpreted as an upward trend in the bullish stock market as the local currency grows stronger. A similar impact can also be seen during the well-performing periods of the stock market and EER, which is an obvious increase in the SMI between the upper quantiles of EER (0.90–1) and the upper quantiles of the SMI (0.70–1). It is also showed that the South African stock market is not affected by the negative exchange rate shocks when the stock market is resilient. Even at the lowest quantiles of EER, the slope coefficient remains steady at the upper quantiles of the stock market. On the contrary, there is a sharp decrease in SMI at tail quantiles of the variables. The obtained outcome indicates the country's vulnerability in terms of the negative exchange rate shocks when the market is pessimistic.

The estimation output for Turkey shows a great resemblance to the South African case. At the lower quantiles of both SMI and EER variables, the Turkish equity market experiences a severe downturn. As the area of mid-tier quantile coefficients is examined, the impact of EER is less significant for Turkey's stock market. The highest positive coefficient estimate is observed between the SMI's upper quantiles (0.85–1) and the upper quantiles of EER (0.90–1). Although the equity returns tend to increase at the lower quantiles of the stock market and the upper quantiles of EER, the impact is not as significant as it is in the South African case.

In Malaysia's case, the SMI is not affected by changes in EER during the high performing periods of the stock market. The plane area is observed in the graphical representation at the upper quantiles of the SMI (0.90–1). The figure also shows that at 0.80 and 0.90 quantiles of SMI (0.80–0.90), any change in the EER leads to a fall in the stock market. Below the median of SMI, quantile combinations produce another plane area where the EER does not significantly influence the Malaysian stock market. Similarly, in Brazil's case, the stock market is almost non-responsive to the EER changes for the majority of the quantile combinations. However, a sudden decrease in the slope estimates between the lower quantiles of SMI (0–0.15) and the higher mid-tier quantiles of EER (0.60–1).

In Thailand's case, the slope estimates are at the highest between the upper quantiles of SMI (0.80–1) and the quantiles of EER that are above the median. According to estimation output, there are two areas where the local exchange rate changes affect the stock market more significantly. The

first area locates between the lower quantiles of both variables where the slope estimate decreases to less than zero. The other area is between the SMI's upper quantiles (0.70–0.95) and the lower quantiles of EER (0.10–0.20), where the slope coefficient also becomes negative.

In China's case, the majority of the quantile combinations between SMI and the EER produce a flat looking figure. It should be noted that the exchange rate in China fluctuates around a controlled band, and the stock market participants are not subject to exchange rate shocks. Therefore, the large plane area can be explained by the currency policy of China. The only noticeable impact of the EER occurs between the lower quantiles of EER (0.05–0.15) and the upper quantiles of SMI (0.80–0.95). Considering China's highly export-oriented economy, a cheaper local currency should be translated as "good news" for the stock markets. However, the observed downward spike suggests that the equity market is negatively affected when the local exchange rate is shallow. A possible reason behind this outcome is the market expectations toward international trade restrictions such as high tariff rates imposed by the importing countries.

4.1. Validation of the obtained QQR results

The QQR approach regresses the μ-quantile of the stock market on the ρ-quantile of EER, and therefore, its parameters will be indexed by both μ and ρ. Because the standard quantile regression parameters are only indexed by μ, the QQR methodology can be referred to as the "decomposition" of the standard quantile regression estimates (Sim and Zhou, 2015). Based on this principle, approximate estimates of the standard quantile regression should be recovered from the QQR estimates. Denoting the slope coefficient of the standard quantile regression as $\partial_1(\mu)$, the impact of the effective exchange rate on the SMI can be measured as follows:

$$\partial_1(\mu) \equiv \widehat{\widehat{\beta}}_1(\mu) = \frac{1}{S}\sum_{\rho} \hat{\beta}_1(\mu, \rho) \tag{7}$$

where S = 19 is the number of quantiles ρ = [0.05, 0.10, …, 0.95].

Figure 2 plots the estimates of both standard quantile regression and the quantile on quantile regression. As the graphs revealed, the standard quantile regression's slope coefficients follow the slope coefficients of the QQR approach. This outcome confirms the validity of the QQR methodology, which provides more disaggregated information regarding the exchange rate-stock market nexus.

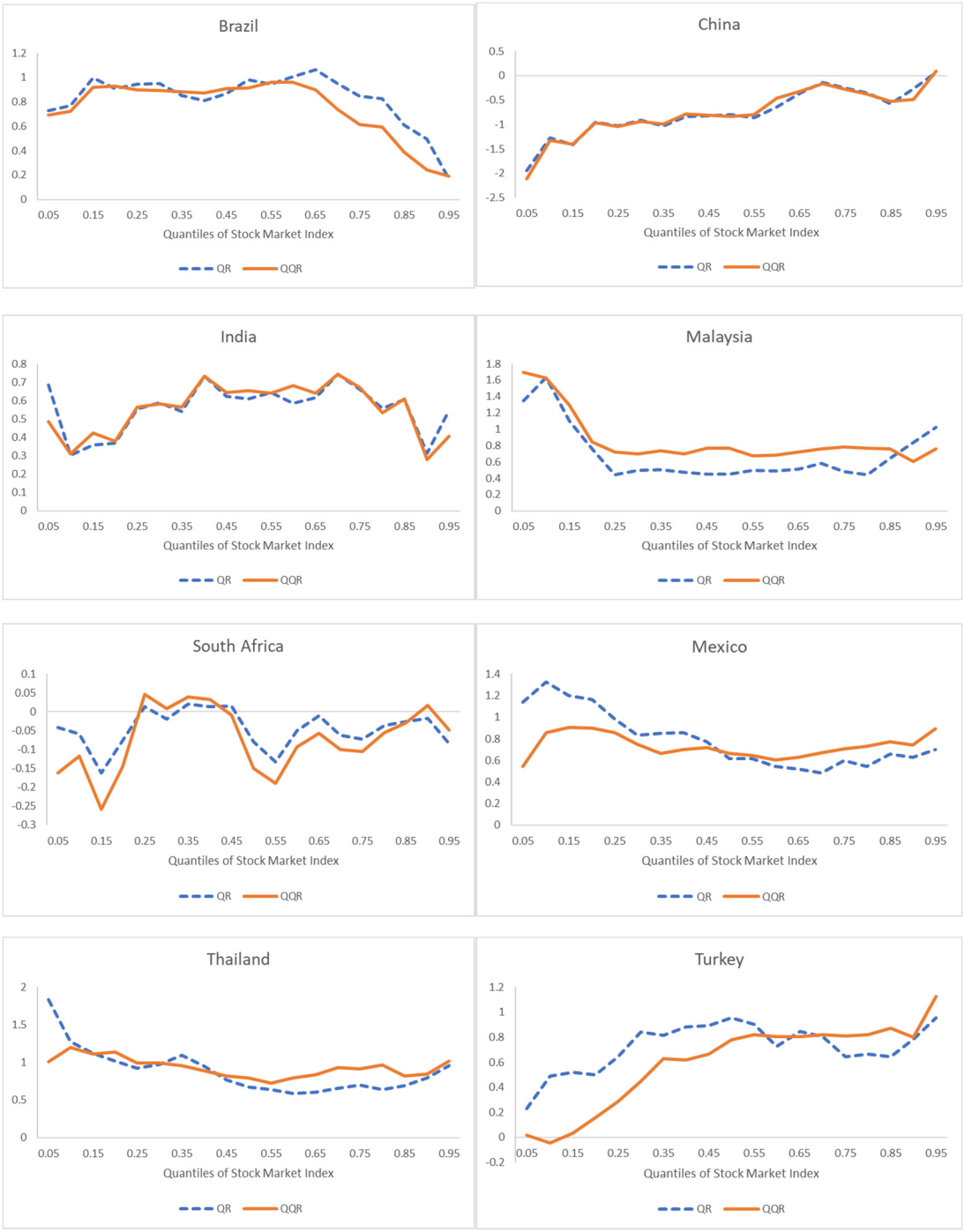

Figure 2. Comparison of Quantile on Quantile Regression (QQR) and Standard Quantile Regression (QQ). Note: Estimations of parameters for standard quantile regression are presented by dashed blue lines. Continuous orange lines present the averaged standard quantile regression estimations at various quantiles of the SMI.

5. Conclusion

The relationship between exchange rates and stock prices has instigated a widespread debate in the empirical literature since both variables have an essential role in many macroeconomic fundamentals and investment decisions. Motivated by the need to employ more advanced econometric techniques to examine the exchange rate and stock market nexus, this study contributes to the literature by applying the novel QQR regression. The QQR approach provides more detailed information than conventional methodologies in investigating the effect of exchange rate changes on stock market returns. Due to the lack of evidence about the relevance of exchange rate changes on stock market performance for emerging economies, this study conducts an empirical investigation on selected emerging countries: Brazil, China, India, Malaysia, Mexico, South Africa, Thailand, and Turkey.

The QQR approach results show that the stock market performances of the examined emerging economies are not affected by the exchange rate changes unless certain market conditions are established. More specifically, it is observed that variations of the slope estimates tend to deviate significantly at tail quantiles of both variables. The heterogeneity among countries in terms of the exchange rate-stock market nexus may be credited to differences in each economy's openness, the efficiency of the stock markets in each country, and the relevance of international trade in each country. Although the stock markets of examined economies are not always responsive to the exchange rate changes, our results imply that the flow-oriented approach (Dornbusch and Fischer, 1980) cannot be discarded completely. The empirical outcome showed that the impact of exchange rates on stock market returns is minimal in most quantile combinations. However, significant exchange rate shocks are observed in some specific circumstances. For instance, we found that exchange rate shocks can affect the stock market returns when the market is bearish. On the other hand, the explanatory power of high quantiles of exchange rates is weak in most examined countries. In other words, the effect of low and high exchange rates on the stock market returns suggests that the exchange rate flexibility has a key role to play in determining the market returns depending on the bearish or bullish conditions. Besides, exchange rate changes are more effective in stock market performance for some countries such as South Africa and Turkey. This could be related to the point that when the exchange rate is not in very low or very high quantiles, the foreign capital movements are not effective enough to observe a relationship supporting the flow-oriented approach.

Possible impacts of exchange rate fluctuations on both businesses and economies are varied. Depending on the economic structures of countries, exchange rate changes affect existing firms differently. For instance, firms that import their raw material and only sell their final product in local markets are likely to experience financial distress when there is currency depreciation. On the other hand, if these firms can sell most of their final products overseas, then currency depreciation makes them profit. Exchange rate fluctuations are also significant for firms that are not involved in international trading transactions. For example, if firms operate in an economy that lacks sufficient oil reserves, currency depreciation will cause the price of imported oil to be more expensive. While a certain currency movement affects some industries negatively, it becomes advantageous for others. The tourism industry can be given as a relevant example since it benefits from currency depreciation instead of import-oriented industries.

Given that the consequences of exchange rate volatility are not identical across different firms, it is challenging for policymakers to determine the appropriate monetary policy decisions. More importantly, as the results of this study showed, the impact of exchange rate changes varies depending on the state of both exchange rate and stock markets. Therefore, the results obtained in this study can be used by policymakers to avoid making monetary policy decisions when it is not necessary. Since our results pinpoint the slope coefficients at quantiles, policymakers can identify a suitable time to intervene in the exchange rate and ease the adverse effects of exchange rate fluctuations on listed firms. Investors and portfolio managers can also benefit from the documented empirical outcome since understanding the dynamics between the two financial markets can help to take measures on stock market behavior. As a result, investors and portfolio managers can actively manage and reconstruct their portfolios according to the market conditions to hedge against spillover effects from exchange rates to the stock markets.

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Conflict of interest

The authors declare no conflicts of interest in this paper.

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