Chapter 12

The Impact of Exchange Rate Uncertainty on Domestic Investment: Panel Evidence from Emerging Markets and Developing Economies

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Additional information is available at the end of the chapter

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Abstract

This study attempts to suggest empirical evidence about the impact of exchange rate uncertainty on the domestic investment for 25 emerging markets and developing economies (EMDEs) for the time line covering the years between 2004 and 2014. Exchange rate uncertainty is modeled by selecting one of the volatility models of GARCH(1, 1), EGARCH(1, 1), or GJR-GARCH(1, 1) for individual countries. The study aims to offer a broad point of view about the impact of exchange rate uncertainty on domestic investment through a feasible generalized least square panel data model by deeming the economic growth, real interest rate, and 2008/2009 global financial crisis (GFC). The empirical results show that the impact of exchange rate uncertainty on domestic investment for EMDEs is found to be positive and significant, which may indicate the existence of risk neutral or insensitive domestic investors to exchange rate uncertainty in these countries. On the other hand, the study also proves that the effect of economic growth is positive and significant on domestic investment, whereas the impact of GFC on domestic investment is negative and significant. However, the impact of real exchange rate on domestic investment is found to be negative but insignificant.

Keywords: exchange rate, uncertainty, domestic investment, emerging markets and developing economies, panel data model

1. Introduction

Although the effects of exchange rate uncertainty on the economic variables such as economic growth, trade, export, and foreign direct investment have been investigated broadly in the existing literature, the researches examining the impact of exchange rate uncertainty on the domestic investment have been limited. The existing studies suggest mixed and inconclusive evidence on the relationship between uncertainty and investment. Hartman [1] and Able [2] argue that heightened uncertainty about the price of output gives rise to higher investment and, in turn, enhances economic activity under the assumptions of risk-neutral competitive firms and constant returns to scale production function. Their assumptions ensure convexity of the marginal profitability of capital in output price and input costs. On the other hand, a larger body of literature provides explanation for the response of investment to uncertainty by focusing on the real option feature of investment. Making an analogy between an investment opportunity and a stock option in a financial market, Dixit and Pindyck [3] argue that if investment is irreversible, uncertainty raises the value of accumulating cash and waits for new developments that would dispel uncertainty. Heightened uncertainty is likely to increase the value of this "wait and see" option and thus reduce investment spending temporarily. Building on the model of Dixit and Pindyck [3], Darby et al. [4] examine impacts of exchange rate uncertainty on domestic investment. They argue theoretically that rising exchange rate volatility may increase or decrease investment, depending on particular industry involved. Furthermore, Campa and Goldberg [5] show that exchange rate variability has relatively weak and insignificant effects on investment in US manufacturing sectors, depending on the size and sign of sectoral exposure to exchange rates.

In order to observe the impact of flexible exchange rate regime on the real economic activity, Lafrance and Tessier [6] aim to reveal the reaction of investments such as manufacturing industry, machinery and equipment sectors, and foreign direct investment to the levels of Canadian dollar and the volatility of Canadian dollar by implementing VAR structures. They conclude that the exchange rate and their volatility do not really impact the investment activities in Canada. Harchaoui et al. [7] offer another study that focuses on the general impact of exchange rates on the investment in Canada for the time line between 1981 and 1997 by examining industry level data of 22 Canadian manufacturing industries. First, their findings suggest that the response of investment to exchange rate fluctuations rely on whether there exist high or low exchange rate uncertainties. Second, the findings conclude that the impact of exchange rate depreciation on the total investment is positive, when exchange rate uncertainty is at low levels. Furthermore, Caglayan and Torres [8] investigate the association between exchange rate and exchange rate volatility and capital investment of Mexican manufacturing firms. They conduct a panel data analysis on the firms for the period of 1994–2003. Their findings indicate that exchange rate depreciation affects the investment positively (negatively) through export (import) channel. In addition, they find that the investments of export-oriented firms and the firms producing nondurable goods are more sensitive to the exchange rate volatility.

There are also researches investigating the direct impact of exchange rate uncertainty on the domestic investment at macro level. Serven [9] conducts a study investigating the real exchange rate uncertainty and private investment for 61 developing countries in a panel data set for the time span between 1970 and 1995. The real exchange rate volatility is retrieved by employing GARCH(1, 1) model. He finds that the impact of real exchange rate uncertainty on the private investment is negative and significant. In additionally, this impact gets larger at higher levels of uncertainty underlying "threshold effects." He also concludes that the real exchange rate impact on the investment depends on the level of trade openness and financial sector development. The significant and negative linkage between the exchange rate uncertainty and investment gets stronger as the environment of higher trade openness and weaker financial system. Soleymani and Akbari [10] investigate this relationship by constructing a fixed effect panel data model covering only 15 Sub-Saharan countries for the time span between 1975 and 2006. They employ GARCH(1, 1) model when measuring the exchange rate volatility. They conclude that these low-income countries allocate considerable amount of their spending for imported goods. Safdari and Soleymani [11] also study the exchange rate uncertainty and domestic investment relationship for six Middle East and North African countries, namely Algeria, Egypt, Iran, Morocco, Syrian Arab Republic, and Tunisia for the time period between 1975 and 2006. As for methodology, they build fixed effect approach of panel model, and they measure the exchange rate volatility GARCH(1, 1) model for each country. Their findings suggest that domestic investments in these countries suffer from the exchange rate uncertainty, since investments depend on the imported capital goods in these countries. Furthermore, Bahmani-Oskooee and Hajilee [12] investigate 36 countries (involving both developed and developing economies) individually for the time line between 1975 and 2008 by employing ARDL approach. Their findings reveal that effect of exchange rate volatility on domestic investment is negative and significant in Chile, France, Malawi, South Africa, and UK, while this impact is found positive and significant in Colombia, Italy, Singapore, Sweden, and United States. More recently, Chowdhury and Wheeler [13] examine the exchange rate and output uncertainty on the fixed private investments for Canada, Germany, the United Kingdom, and the United States by implementing VAR models. They conclude that neither shocks of output uncertainty nor exchange rate uncertainty has a significant impact on the fixed private investments for these selected countries.

All in all, the impact of exchange rate uncertainty on investment is not clear cut both in the theoretical and empirical literature. This study aims to contribute to the existing literature by exploring the impact of exchange rate uncertainty on the domestic investment for EMDEs in several aspects. First, 25 countries, within the group of emerging and developing countries and employing floating exchange rate regimes, are considered in order to construct panel data model for the time span of 2004–2014. Since the study is not confined to a specific region in the world and pools the countries under panel data model, it attempts to offer a general view about the impact of exchange rate uncertainty on the domestic investment for EMDEs. The time span of the study also offers more recent results. Second, exchange rate volatility of each country is modeled with GARCH(1, 1), EGARCH(1, 1), and GJR-GARCH(1, 1) models. The most appropriate model for volatility measure is selected for each country. Third, this study also employs feasible generalized least square (GLS) panel model approach, which may suggest more robust results when compared to fixed effect panel data models.

2. Data and exchange rate uncertainty measure

The countries studied in this study are EMDEs that implement floating exchange rate regimes, namely Brazil, Chile, Colombia, Georgia, Hungary, India, Indonesia, Kenya, Madagascar, Mexico, Moldova, Mongolia, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Serbia, Seychelles, South Africa, Tanzania, Thailand, Turkey, Uganda, and Uruguay.[1] The countries are determined due to the availability of the data. The time span covers the period of 2004–2014. The econometric model is defined in Eq. (1)

$$INV_{it} = \delta_i + \beta_1 GPD\_G_{it} + \beta_2 RIR_{it} + \beta_3 VOL_{it} + v_{it} \quad (1)$$

$$INV_{it} = \delta_i + \beta_1 GPD\_G_{it} + \beta_2 RIR_{it} + \beta_3 VOL_{it} + \beta_4 CRI + u_{it} \quad (2)$$

The domestic investment, INV, is the gross capital formation as a percentage of GDP. As a controlling variable, the growth of gross domestic product (GDP_G) and real interest rate (RIR) in percentages is included in the model. The data related to these variables are obtained from World Development Indicator and IMF statistical databases[2]. In addition, a dummy variable (CRI) is added to the model as in Eq. (2) in order to control the effects of the GFC. As the impacts of the crisis deepened in the aftermath of collapse of Lehman Brothers in September 2008, the most severe impacts are observed in 2009. Hence, the dummy variable for the crisis is put for the year 2009.

VOL represents the volatility (i.e., uncertainty) of nominal domestic exchange rate against US Dollar, EXC. The daily returns of each country's nominal exchange rate, employed for the volatility models, are obtained as in Eq. (3):

$$R_t = \ln\left(\frac{EXC_t}{EXC_{t-1}}\right) \times 100 \quad (3)$$

In the literature of volatility models, generalized autoregressive heteroskedasticity (GARCH), exponential GARCH, and GJR-GARCH models are the most prominent ones. Therefore, GARCH(1, 1), EGARCH(1, 1), and GJR-GARCH(1, 1) models are implemented on each country's exchange rate returns.

The GARCH model, proposed by Bollerslev [14], is based on that the conditional variance of returns depends on the lagged values of conditional variance and error terms. The GARCH(1, 1) model is expressed as in Eq. (4):

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 \quad (4)$$

The GARCH(1, 1) model is defined, where $\omega > 0, \alpha \geq 0, \beta \geq 0$, and $\alpha + \beta < 1$.

In order to detect asymmetries of returns on the volatility, Nelson [15] developed EGARCH model. The EGARCH(1, 1) model is defined as in Eq. (5):

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[1] Country classification is based on International Monetary Fund (IMF) country classifications. Exchange rate classifications follow the de facto classification of the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER) 2016.

[2] Only the real exchange rate data for Turkey and Poland are retrieved from the Borsa Istanbul and National Bank of Poland.

$$\ln\left(\sigma_t^2\right) = \omega + \alpha\left|\frac{\varepsilon_{t-1}}{\sigma_{t-1}}\right| + \gamma\left[\frac{\varepsilon_{t-1}}{\sigma_{t-1}}\right] + \beta\ln\left(\sigma_{t-1}^2\right) \tag{5}$$

The γ coefficient indicated the asymmetry in the EGARCH model. $\gamma > 0$ implies that positive shocks on the returns of exchange rate induce the volatility more when compared to the negative shocks, whereas $\gamma < 0$ indicates that negative shocks have more effect on volatility than positive shocks [16].

The GJR-GARCH, developed by Glosten, Jagannathan and Runkle [17], is another model that attempts to reveal asymmetry in the volatility modeling. The GJR–GARCH(1, 1) is modeled as in Eq. (6):

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \gamma I_{t-1}^{-}\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 \tag{6}$$

I_{t-1}^{-}, which is a dummy variable, equals to 1 where $\varepsilon_{t-1} < 0$ and zero otherwise. The asymmetry effect is measured by γ coefficient. If $\gamma > 0$ indicates that negative shocks on the exchange rate returns have more impact on the volatility than positive shocks, while $\gamma < 0$ is the sign that positive news has more impact on the volatility than negative news [16].

Since each country's exchange rate data show different patterns, each country's exchange rate volatility is modeled with GARCH(1, 1), EGARCH(1, 1) and GJR-GARCH(1, 1) models. The exchange rate uncertainties of Chile, Georgia, Kenya, Philippines, Thailand, Uganda and Uruguay are modeled with GARCH(1, 1), since exchange rate volatilities of these countries' provide the assumptions of GARCH(1, 1) models more when compared to the other volatility models. Each GARCH(1, 1) model provides that $\alpha + \beta < 1$, and the α and β terms in each GARCH(1, 1) model are found to be statistically significant as in **Table A1**. The Ljung-Box-Q statistics (Q^2) of squared standardized residuals are not found to be statistically significant for lags of 1 and 10, which may indicate no autocorrelation between residuals for all GARCH(1, 1) models. In addition, the ARCH-LM (Lagrange Multiplier) test statistic for each country is found to be statistically insignificant, which points out that there is no ARCH effect in the residuals up to order two for all GARCH(1, 1) models.

Brazil, Hungary, Madagascar, Moldova, Papua New Guinea, Paraguay, Peru, South Africa, and Tanzania give the most reliable results for EGARCH(1, 1) model as in **Table A2** and **Table A3**. The coefficients of ω, α, and β are found to be statistically significant in each model. The asymmetry coefficients (γ) of Brazil, Hungary, Madagascar, Papua New Guinea, Paraguay, South Africa, and Tanzania are found to be negative and statistically significant, which indicates leverage effect and implies that the negative news on the exchange rate returns has more impact on the volatility than positive news. On the other hand, the asymmetry coefficients (γ) of Moldova and Peru are found positive and significant, which indicates that positive shocks on the returns affect volatility more when compared to the negative shocks. As for autocorrelation between residuals, the estimated Ljung-Box-Q statistics (Q^2) of squared standardized residuals are found to be statistically insignificant for each country under EGARCH(1, 1) model. Furthermore, there exists no ARCH effect in residuals up to order two for all estimated EGARCH(1, 1) models according to ARCH-LM test.

On the other hand, the exchange rate volatilities of Colombia, India, Indonesia, Mexico, Mongolia, Poland, Serbia, Seychelles, and Turkey are most properly modeled with GJR-GARCH(1, 1) model as offered in **Table A4** and **Table A5**. The ω, α, and β coefficients are found to be statistically significant. The asymmetry coefficient (γ) is found positive and statistically significant for Colombia, India, Indonesia, Mexico, Mongolia, Poland, Serbia, and Turkey, which points out leverage effect and is a sign that negative shocks on the exchange rate returns have more impact on the volatility when compared to the positive shock. On the other hand, for only Seychelles, the asymmetry coefficient (γ) is found negative and statistically significant, which suggests that positive news has more impact on volatility than the negative shocks. The acquired Ljung-Box-Q statistics (Q^2) of squared standardized residuals imply that no autocorrelation between the residuals for these GJR-GARCH(1, 1) models. Additionally, no ARCH effect exists in the residuals of GJR-GARCH(1, 1) model of each country.

As a summary, the exchange rate uncertainties of the countries, which are estimated by selecting the most appropriate volatility models, are offered in **Table 1**[3]:

Country	Exchange rate uncertainty model	Country	Exchange rate uncertainty model
Brazil	EGARCH(1, 1)	Paraguay	EGARCH(1, 1)
Chile	GARCH(1, 1)	Peru	EGARCH(1, 1)
Colombia	GJR-GARCH(1, 1)	Philippines	GARCH(1, 1)
Georgia	GARCH(1, 1)	Poland	GJR-GARCH(1, 1)
Hungary	EGARCH(1, 1)	Serbia	GJR-GARCH(1, 1)
India	GJR-GARCH(1, 1)	Seychelles	GJR-GARCH(1, 1)
Indonesia	GJR-GARCH(1, 1)	South Africa	EGARCH(1, 1)
Kenya	GARCH(1, 1)	Tanzania	EGARCH(1, 1)
Madagascar	EGARCH(1, 1)	Thailand	GARCH(1, 1)
Mexico	GJR-GARCH(1, 1)	Turkey	GJR-GARCH(1, 1)
Moldova	EGARCH(1, 1)	Uganda	GARCH(1, 1)
Mongolia	GJR-GARCH(1, 1)	Uruguay	GARCH(1, 1)
Papua New Guinea	EGARCH(1, 1)		

Table 1. Countries and their exchange rate uncertainty models.

3. Methodology and empirical results

When investigating the exchange rate uncertainty on the domestic investment under the panel data model expressed as in Eq. (1), the panel data analysis is carried out by following the steps in Aktas et al. [19]. The panel data consist of countries which may involve individual effects of

[3] The annual volatility for each country is derived by multiplying σ_{daily} and $\sqrt{T}$ since the volatility escalates with the square root of time [18].

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countries (denoted as δ_i). Therefore, F-test is implemented so as to determine whether the model is fixed effect model or pooled least square model [20]. The null hypothesis and test result of F-test having degrees of freedom as F (n-1, nT-n-k)[4] are given in **Table 2**. F-test statistic is statistically significant at 1% significance level, which indicates the model can be fixed effect model.

The model can also include random effect. In order to test whether the model involves random individual effects, Breusch and Pagan (1980) Lagrange Multiplier (LM) test having Chi-square distribution with a degree of freedom of 1 is employed [20]. The null hypothesis and test statistics of the Breusch Pagan LM are given in **Table 3**. The test result, statistically significant at 1% significance level, points out that the model can include random individual effects.

Since the model could involve either fixed effect or random effect, a well-known test Hausman (1978) is conducted. The Hausman test, having a null hypothesis of no correlation between unobservable individual effects and regressors (i.e., Random effect model), has a chi-square distribution with degrees of freedom of k [21]. The null and alternative hypotheses and test statistics of Hausman specification test are suggested in **Table 4**. The Hausman test indicates that the model is a fixed effect model, since the test statistic is significant at 5% significance level.

The fixed effect model is found to be appropriate to estimate the parameters in the main model. After constructing fixed effect model, the Wald test for groupwise heteroskedasticity is implemented in order to detect heteroskedasticity of the residual of fixed effect model [22]. The test has a chi-square distribution with a degree of freedom of n. The chi-square test statistics (25) is found to be 1833.61 with a prob. value of 0.000, which indicates the existence of groupwise heteroskedasticity in the residuals of the fixed effect model. It is also necessary to check the serial correlation in the panel data model, since serial correlation may offer biased

The null hypothesis	F statistics	Prob. value
Ho: $\delta_i = 0$ (no individual effect)	F(24, 247) = 24.01	0.000

Table 2. Null hypothesis and test result of F-test.

The null hypothesis	F statistics	Prob. value
Ho: $\sigma^2_{\delta i} = 0$ (no random effect)	Chi (1) = 544.93	0.000

Table 3. Null hypothesis and test result of Breusch Pagan LM test.

Null and alternative hypotheses	F statistics	Prob. value
Ho: Random effect model Ha: Fixed effect model	Chi (3) = 8.11	0.0439

Table 4. Null and alternative hypotheses and test result of Hausman test.

[4] n, T and k are number of groups (countries), number of years and number of regressors in the model, respectively.

standard errors, hence indicating less efficient parameter estimations. Thus, the serial correlation test developed by Wooldridge (2002) is utilized under the null hypothesis of no serial correlation [23]. The Wooldridge test for autocorrelation in panel data has a test statistic of F (1, 24) that equals to 35.434 with a prob. value of 0.000, which is found to be statistically significant at 1% significance level, thereby denoting existence of autocorrelation in the panel model.

Due to the existence of heteroskedasticity and autocorrelation problems in the fixed effect panel model, the acquired fixed effect model results may offer biased results. Therefore, the feasible generalized least square (GLS), which allows the estimations of panel data model under heteroskedasticity across panels and autocorrelation presence, is employed so as to conclude the results of the model [21, 24].[5] The feasible GSL estimators are obtained as in Eq. (7).

$$\widehat{\beta_{FGLS}} = \left(X'\widehat{\Omega}^{-1}X^{-1}\right)^{-1} X'\widehat{\Omega}^{-1}y \quad (7)$$

where $\Omega = \sum_{n \times n} \otimes I$, which is the error variance matrix and obtained as in Eq. (8).

$$\widehat{\sum}_{i,j} = \frac{\widehat{\epsilon}_i{}' \widehat{\epsilon}_j}{T} \quad (8)$$

The estimated test results from the Feasible GLS for both two models are suggested in **Table 5**.

As observed in the estimation results of model 1, the impact of economic growth on the domestic investment is positive and significant at 1% significance level. This result is anticipated, since growing economy such as emerging markets and developing economies may offer valuable prospects for private investors to obtain profitable returns, when they invest in these countries. Similarly, the studies of Bahmani-Oskooee and Hajile [12] and Safradi and

Variables	INV (Model 1)	INV (Model 2)
GDP_G	0.376* (0.049)	0.319* (0.062)
RIR	−0.017 (0.027)	−0.015 (0.027)
VOL	0.118* (0.045)	0.118** (0.456)
CRI	—	−0.856*** (0.500)
Constant	20.073* (0.735)	20.377 (0.755)
Observations	275	276
Number of country	25	25
Wald chi-squared	60.29*	62.29*

Notes: Robust standard errors are given in square parentheses.
*,**,*** denote the significance level at 1%, 5% and 10% respectively.

Table 5. The feasible GLS estimation results.

[5] See also http://www.stata.com/manuals13/xtxtgls.pdf.

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Soleymani [11] also prove positive association between GDP and domestic investment. As for real interest rate, the impact of real interest rate on the domestic investment is found to be negative; however, this impact is statistically insignificant. When considering the real interest rate and investment linkage, it is inevitable to observe that increases in real interest rates lead to declines in domestic investment due to the increasing cost of capital stock. Finally, it is observed that an increase in the exchange rate uncertainty leads to an increase in domestic investment in these EMDEs. The result is found to be statistically significant at 1% significance level. In general, it is expected that heightened uncertainty in exchange rates may constrain the investors from involving in domestic investments, if the investors hold the position of "wait and see." But, if the investors are risk-neutral or risk appetent, they may perceive the volatile environments in terms of exchange rates as lucrative opportunities to engage in investments. Likewise, Bahmani-Oskooee and Hajile [12] find the impact of exchange rate uncertainty on the domestic investment as positive for Colombia, Italy, Singapore, Sweden, and US in the long run. For the positive linkage, they suggest that some investors may tend to invest more in order not to be exposed to the future price volatility arising from exchange rate uncertainty. When considering model 2, the effect of exchange rate uncertainty, economic growth, and real interest rate on domestic investment is found similar to the results of model 1. The impact of GFC on domestic investment of these countries is negative and statistically significant at 10% level.

4. Conclusion

Although the effects of exchange rate uncertainty on the macroeconomic variables such as economic growth, capital flows, and international trade are examined vastly in the literature, the number of studies associated with the impact of exchange rate uncertainty on the domestic investment is rather sparse to our knowledge. The evidence on the effects of exchange rate uncertainty on the domestic investment is inconclusive. Hence, this study attempts to provide some new evidence on this topic for 25 EMDEs under a panel data model for the time span of 2004 and 2014 by regarding the economic growth, real interest rate, and GFC as controlling variables. Rather than examining the countries individually, this study gives a broad scanning about the impact of exchange rate uncertainty on the domestic investment in EMDEs by employing feasible generalized least square panel data method, which offers more robust result compared to fixed effect panel data method. Exchange rate uncertainties for the selected countries are modeled by GARCH(1, 1), EGARCH(1, 1), or GJR-GARCH(1, 1) model, depending on the individual exchange rate patterns. This study finds that the impact of exchange rate uncertainty on domestic investment for EMDEs is found to be positive and statistically significant. This may imply that domestic investors in these countries are risk neutral and insensitive to adjustment costs related to the exchange rate fluctuations and the irreversibility of the investments in case the conditions worsen. Furthermore, exchange rate volatility could potentially provide a profitable opportunity for risk-appetent investors. In some cases, movements in the exchange rate could be beneficial for the domestic investors, particularly for the sophisticated ones.

A. Appendix A

See **Tables A1–A5**.

Country	Chile	Georgia	Kenya	Philippines	Thailand	Uganda	Uruguay
Mean equation							
(C)	0.0051 (0.5834)	0.0162 (0.1499)	−0.0196 (0.0441)	0.0057 (0.3218)	0.0063 (0.2287)	−0.0202 (0.0066)	−0.0001 (0.9936)
Variance equation							
ω	0.0024* (0.0001)	0.0819* (0.0000)	0.0221* (0.0000)	0.0012* (0.0000)	0.0032* (0.0000)	0.0192* (0.0000)	0.0475* (0.0000)
α	0.0530* (0.0000)	0.2107* (0.0000)	0.1501* (0.0000)	0.0770* (0.0000)	0.1374* (0.0000)	0.2088* (0.0000)	0.0670* (0.0000)
β	0.9419* (0.0000)	0.4500* (0.0000)	0.8273* (0.0000)	0.9175* (0.0000)	0.8488* (0.0000)	0.7705* (0.0000)	0.8841* (0.0000)
Q^2(1)	1.395 (0.237)	0.000 0.993	1.382 (0.240)	3.339 (0.068)	0.466 (0.495)	0.708 (0.400)	1.081 (0.298)
Q^2(10)	2.613 (0.989)	0.022 1.000	2.245 (0.994)	11.623 (0.311)	6.568 (0.765)	7.545 (0.673)	1.127 (1.000)
ARCH_LM (2)	0.7363 (0.4790)	0.0007 (0.9993)	0.6929 (0.5002)	3.3374 (0.0678)	1.5956 (0.2030)	0.4433 (0.6419)	0.5434 (0.5808)

Notes: The p-values are given in parentheses.
*, **, *** denote 1%, 5% and 10% significance levels, respectively.

Table A1. Test results for GARCH(1, 1) model.

Country	Brazil	Hungary	Madagascar	Moldova	Papua New Guinea
Mean equation					
(C)	0.0064 (0.6120)	−0.0126 (0.4045)	−0.0154 (0.3655)	0.0087** (0.0328)	−0.0604** (0.0000)
Variance equation					
ω	−0.1718* (0.0000)	−0.0595* (0.0000)	−0.1870* (0.0000)	−0.4689* (0.0000)	−0.1867* (0.0000)
α	0.2108* (0.0000)	0.0751* (0.0000)	0.1925* (0.0000)	0.4394* (0.0000)	0.3360* (0.0000)
γ	−0.0737* (0.0000)	−0.0373* (0.0000)	−0.0588* (0.0000)	0.0177** (0.0482)	−0.0958* (0.0000)
β	0.9746* (0.0000)	0.9942* (0.0000)	0.7837* (0.0000)	0.9232* (0.0000)	0.9693* (0.0000)
Q^2(1)	0.157 (0.692)	0.1728 (0.678)	0.046 (0.829)	2.847 (0.092)	0.706 (0.401)
Q^2(10)	5.332 (0.868)	7.0918 (0.717)	0.332 (1.00)	7.372 (0.690)	2.979 (0.982)
ARCH_LM(2)	1.6679 (0.1888)	0.1832 (0.8326)	0.0254 (0.9749)	1.4528 (0.2341)	0.3683 (0.6919)

Notes: The p-values are given in parentheses.
*, **,*** denote 1%, 5% and 10% significance levels, respectively.

Table A2. Test results for EGARCH(1, 1) model.

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Country	Paraguay	Peru	South Africa	Tanzania
Mean equation				
(C)	−0.0258* (0.0000)	0.0062* (0.0082)	−0.0339*** (0.0527)	−0.0376* (0.0000)
Variance equation				
ω	−0.3817* (0.0000)	−0.5954* (0.0000)	−0.0874* (0.0000)	−0.2078* (0.0000)
α	0.3836* (0.0000)	0.5014* (0.0000)	0.1131* (0.0000)	0.2792* (0.0000)
γ	−0.0519* (0.0000)	0.0226** (0.0448)	−0.0555* (0.0000)	−0.0429* (0.0000)
β	0.8853* (0.0000)	0.9054* (0.0000)	0.9851* (0.0000)	0.9754* (0.0000)
Q^2(1)	0.171 (0.679)	0.003 (0.954)	1.197 (0.274)	2.494 (0.114)
Q^2(10)	4.736 (0.908)	0.842 (1.000)	14.378 (0.156)	3.991 (0.948)
ARCH_LM(2)	0.2964 (0.7434)	0.0334 (0.9671)	1.8915 (0.1510)	1.2477 (0.2873)

Notes: The p-values are given in parentheses.
*, **,*** denote 1%, 5% and 10% significance levels, respectively.

Table A3. Test results for EGARCH(1, 1) model.

Country	Colombia	India	Indonesia	Mexico	Mongolia
Mean equation					
(C)	0.0039 (0.6909)	0.0019 (0.7708)	−0.0090 (0.2340)	−0.0041 (0.6598)	−0.0045 (0.3579)
Variance equation					
ω	0.0053* (0.0000)	0.0019* (0.0000)	0.0044* (0.0000)	0.0047* (0.0000)	0.0004* (0.0000)
α	0.0777* (0.0000)	0.0796* (0.0000)	0.0804* (0.0000)	0.0303* (0.0003)	0.1756* (0.0000)
γ	0.0444* (0.0000)	0.0216** (0.0128)	0.1327* (0.0000)	0.0803* (0.0000)	0.1074* (0.0000)
β	0.8978* (0.0000)	0.9052* (0.0000)	0.8624* (0.0000)	0.9154* (0.0000)	0.9030* (0.0000)
Q^2(1)	3.2730 (0.070)	1.324 (0.250)	0.702 (0.402)	0.035 (0.851)	0.031 (0.859)
Q^2(10)	5.7863 (0.833)	7.439 (0.683)	2.599 (0.989)	14.292 (0.160)	0.327 (1.000)
ARCH_LM(2)	1.6470 (0.1928)	2.4714 (0.0846)	0.4738 (0.6227)	2.6023 0.0743	0.0390 (0.9617)

Notes: The p-values are given in parentheses.
*, **,*** denote 1%, 5% and 10% significance levels, respectively.

Table A4. Test results for GJR-GARCH(1, 1) model.

Country	Poland	Serbia	Seychelles	Turkey
Mean equation				
(C)	0.0096 (0.4946)	−0.0181 (0.1867)	0.0307 (0.5809)	−0.0152 (0.2477)
Variance equation				
ω	0.0041* (0.0004)	0.0072* (0.0000)	2.3273* (0.0000)	0.0126* (0.0000)
α	0.0315* (0.0001)	0.0162* (0.0001)	0.3578* (0.0000)	0.0541* (0.0000)

Country	Poland	Serbia	Seychelles	Turkey
γ	0.0361** (0.0001)	4.3485* (0.0000)	−0.2691* (0.0002)	0.0681** (0.0000)
β	0.9456* (0.0000)	0.9564* (0.0000)	0.1587* (0.0001)	0.8923* (0.0000)
Q^2(1)	3.350 (0.067)	0.506 (0.477)	0.000 (0.982)	0.066 (0.796)
Q^2(10)	11.476 (0.322)	3.330 (0.973)	0.012 (1.000)	11.973 (0.287)
ARCH_LM(2)	1.6651 (0.1894)	0.3007 (0.7403)	0.0005 (0.9994)	0.8228 (0.4393)

Notes: The p-values are given in parentheses.
*, **,*** denote 1, 5 and 10% significance levels, respectively.

Table A5. Test results for GJR-GARCH(1, 1) model.

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