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Key words: Currency stability, Volatility, Relative volatility, Country risk, Monetary factors, Exchange rate index

JEL Classification: F23, F31, G12
Monitoring Exchange Rate Instability in 12 Selected Islamic Economies

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Monitoring Exchange Rate Instability in 12 Selected Islamic Economies

Abstract

Exchange rate instability has become a key concern within economic policy circles ever since the 1973 breakdown of Bretton Woods agreement; after 47 years, central bankers realize the deleterious effect of exchange rate on the economy in the 12 selected OIC member countries we studied. The aim of this paper is to report the findings on a proposed measure of currency instability, namely the relative volatility, to test it with data relating to 12 OIC member Muslim-majority economies using more than 28 years data. We find that relative volatility is an effective measure for tracking currency instability and exchange rate targeting could be enhanced by including policy bands as well as recommended actions for each movement outside the policy band. Further, relative volatility is significantly correlated with monetary factors suggested by strong theories that drive the exchange rate equilibrium.

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1. Introduction

Pursuing exchange rate stability has become a major concern within economic policy circles ever since countries moved away from the Bretton Woods Agreement (BWA) in 1973, replacing the US$-cum-gold standard with free-floating or other currency-linked management regimes going forward some 47 years later. This increased volatility since 1973 led to currency side instability becoming more widespread and the derailing of sustainable growth in various economies, both effects persisting even today. Evidence for this is demonstrated by the prevalence of double-digit levels of inflation and associated high costs of capital throughout the world economies in the 1970s and 1980s. Eventually, these were brought down to more manageable levels as central banks implemented inflation targeting popularized by Milton Friedman to partly manage exchange rate indirectly: exchange rate is partly influenced by relative inflation across two countries so success in inflation targeting has part-beneficial effect on exchange rate as is well known among central bank interventionists using the Fisher's Theory on relative inflation. The potential of currency volatility to destabilize developing country economic growth severely\(^1\) should be enough reason to investigate ways in which it can be better managed. In our case, we propose a more appropriate measure for tracking currency instability by examining the effectiveness of a monitoring measure which could

\(^1\) Global economies are strongly interlinked and coupled with complexity that a small shock or changes in exchange rate can bring a country’s economies to its knees. For example, recent Trump government’s decision to doubling of Tariffs on Steel and Aluminum resulted in a collapse of 20% in Turkish lira against US$ in one day in 10 August and put Turkish economy in crises. https://www.investopedia.com/trading/why-collapse-turkish-lira-matters.
facilitate more timely policy interventions by central authorities as an additional action to the inflation targeting.

Efforts to achieve this goal have been frustrated due to the marked increase in general exchange rate instability as evidenced in a recent publication (Ariff & Zarei, 2018, Ariff et al. 2019, Park et al. 2020 and Kalemli-Ozcan et al. 2021). Among other things, this makes it difficult to separate the factors exacerbating exchange rates from those which are merely correlated with it. Moreover, existing research into currency exchange rates emphasizes the use of unit-based measures for tracking instability when other forms of measures could be more effective, in our opinion.2

Although the study of exchange rate dynamics has been extensive and spans over a century of research, there is a dearth of published materials on how to measure exchange rate volatility beyond using the standard deviation (SD) or the coefficient of variation (CoV) of a given currency over a given period or apply value-at-risk (VaR) measure. Industry uses the simple moving average measure as that reduces the spikes to show underlying changes. These measures are inadequate because of two reasons. What matters for tracking instability of an economic (or even physical) phenomenon such as exchange rate is how to relate one currency’s measure relative to a class to which a currency belongs. Such a measure would be more appropriate for not just tracking but also for ranking a given currency against a benchmark considered to be appropriate for any set of linked economies such as the EU (possibly the most closely linked central currency) or the US dollar. What matters to the Muslim countries studied, the US dollar is the best target as the benchmark (although others may be justified). That is, the proposal is a measure of volatility of a currency must be in relation to a country (or grouping) with which the currency has relevance or importance, say, through trade linkages as argued in this paper. The link could well be capital flow or other economic benefits that accrue to a country in relation to the comparator unit. Consequently, the stability of UK’s British pound, for example, should be measured relative to, say, the EU currency or US dollar because these two nations have intense trade relations with Britain.

The other reason why SD or CoV is inappropriate is that these measures are one currency’s behavior against itself, so these do not qualify as a more accurate ranking devise across a meaningful group that should be the economically-relevant benchmark based on common linkages such as trade or capital flows. Besides, making a measure relative to a desirable target enables a more meaningful way of representing the relationship of a currency with the target of comparison as for example done by environmental scientist to measure the oil spillage relative the level of observed pollution before the oil spill. So is the VaR, which measures the impact on, say an entity’s core capital, from an x% depreciation.

For these reasons, a measure relative to a benchmark (be it the currency of a trade-linked country or the average currency value of a group of trade-linked countries such as the NAFTA) is required. This benchmark is illustrated in this paper by using the US dollar (US$). Any other currency may be used as long as the chosen benchmark currency is appropriate. More details of how this is done is found in the methodology section in this paper and in Ariff & Zarei (2016) and Ariff et al. (2019). As for the measure itself, substantial advances in econometrics and monetary economics have conceived more sophisticated alternatives such as relative

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2 There is scant literature on relative measures. The two we found are: Ariff and Lau (1996) and Ariff and Can (2009).
volatility, degree of cointegration, speed of adjustments, and the threshold effect. We examine our proposal by applying them to the experiences of 12 major Muslim-majority economies due to their sensitivities to exchange rate mechanism, geopolitical structure, increase in youth population and then growth of Islamic Finance products coupled with US dollar pegging, making this study very important. In our analysis we have used quarter a century data of over 28 years covering various extreme events.

The rest of the paper is divided into five sections. The ensuing sections are about literature review followed by concept development, data and the development of suitable models used for the analysis purpose. It then concentrates on the description of how the proposed measures could be used for ranking and other analyses using 12 basket-managed currencies selected for this paper. The final section contains some concluding remarks.

2. Theoretical Literature

This study focuses on major international finance theories as well use time series data on the proposed measure to first validate if the measure is consistent with existing monetary and risk theories. We follow the theories of exchange rate determination as in Cassel (1918) for purchasing power parity (PPP) and in Fisher (1930) for International Fisher effect (IFE). We believe a parsimonious approach for testing these theories may be valid before exploring the exchange rates as being determined by many variables across the board. The existing literature on exchange rate determination suggests strong evidence of large variations in the behavior of several exchange rates, which started in earnest in 1973 following a breakdown of the BWA. The review reports on this issue are authored by Taylor & Taylor (2004) and Burnside et al. (2011) among others who suggest there is a continuing interest on this topic in the current times. After the global financial crisis (GFC) and the subsequent rise in the trade volume of foreign currency exchange rates, researchers have paid special attention to study exchange rates, both theoretically and empirically. The monetary approach to exchange rate determination points to the importance of the so-called parity factors (i.e. PPP and IFE) in explaining the movements of currencies. “Do they” or “Don’t they” are the outcome we explore by relating those factors to relative volatility.

The PPP and IFE theories are often found to hold in the long-run, using novel approaches as in Manzur & Ariff (1995), Hall et al. (2013), Ariff & Zarei (2016) and just recently Kalemli-Ozcan et al. (2021) being among others who provide supporting evidence there is a long-run mean-reverting behavior of the PPP and IFE. The empirical support for the IFE is also provided in Edison & Melick (1999). The following section provides an overview of the existing literature relevant to the effect of inflation and interest rate differences on exchange rates.

2.1 Purchasing Power Parity

The PPP theorem is about the effect of relative price differences arising from traded goods and services across trade-linked economies on the currency exchange rates (Cassel, 1918). The core of the PPP theorem is from the Spanish literature on inflation during the periods of importation of gold by Spain from the New World. It is a measure to test the relationship between pairwise currency exchange rates across different economies. The theory states that the differences in
the relative inflation – the price level of the same basket of goods traded across any two economies - should be offset by the exchange rate movements. As a result, the base-price of any two identical products produced in any two countries is similar, resulting in the economic law of one price.

The theorem has been used as a means for international comparison of income and expenditures, given an equilibrium condition, where there is efficient arbitrage condition in the goods market. The theorem is also used by the authorities to set the nominal exchange rates so as to satisfy the level of international competition. The PPP relies on the adjustment of currencies on the basis of the inflation of the trading partners. The PPP is expected to hold only in the long-run given the substantial periodic (short-run) variations in the behavior of real exchange rates. The focus of this study is on testing and evaluation of the relative PPP based on the following equation:

\[
\ln E_{jt} = a_j + b_j \ln \left( \frac{P^d_t}{P^f_t} \right)_{jt} + \mu_{jt}
\]

(1)

where, \(E\) represents the country \(j\)’s exchange rate over time \(t\), \(P^d\) is the proxy for domestic price level or inflation rate, and \(P^f\) denotes foreign inflation rate.

### 2.2 International Fisher Effect

The Fisher’s “theory of interest” (1930) suggests evidence of a theoretical relation between nominal interest rates and inflation by demonstrating nominal interest rate as equal to the summation of real interest rate and expected inflation, which is the domestic Fisher effect. Accordingly, a theoretical parity linkage between the interest rate differences across any two economies, and foreign currency exchange rate is further predicted in Fisher (1930) as the international fisher effect. These hypotheses play crucial roles, because, in the presence of a significant correlation between real interest rate and inflation, there will not be a full adjustment in the nominal interest rate following the change in the expected inflation.

Any deviation from the parity condition in the level of interest rates across two countries would result in a disequilibrium in the exchange rate market, which would adjust in the long-term to an equilibrium. The ratio of changes in the exchange rates of any two trade-linked economies is determined by the ratio of domestic to foreign (relative) interest rates as shown in the following equation:

\[
\frac{E_{t+1}}{E_t} = \left( \frac{1+i^d}{1+i^f} \right)
\]

(2)

where \(i^d\) denotes the domestic-denominated interest rate, \(i^f\) represents foreign interest rate, and \(E\) is defined as in Eq. (1). Testing this theorem calls for the presence of a significant correlation between interest rate differences across any two countries and their exchange rates.

Much of the findings in the literature emanates from the use of existing methodology of cross sectional or time-series regression as widely used in past studies. Only in recent years, researchers have begun to apply robust regression methodologies. Hence knowing the
correlation of these PPP and IFE factors with relative volatility will provide a theory support to the proposed measure.

3. Empirical Literature

3.1 Purchasing Power Parity

The basic empirical studies on the PPP prior to 1980s relied on the absolute type with results rejecting the PPP hypothesis in most cases. The most influential study of this type (Frenkel, 1976) obtained estimates of coefficients that would not suggest a rejection of the null hypothesis, even after employing non-inflationary economies as the sampled countries. However, in the early 1980s, several studies managed to partially address the nonstationarity using the proposed test approaches of unit-root by Dickey and Fuller (1981). There were only few cases of empirical evidence of significant long-run relationship between relative prices and exchange rates to validate the PPP, given the temporary nature of deviations of real exchange rates from its mean value.

Using the error-correction mechanism (ECM), Edison (1987) estimated the dollar-sterling relationship over a long period (1890 to 1978) and found evidence of a significant PPP effect. Consistent with this study, many other studies in the early 1990s attempted to test the PPP over longer-time horizons while using several new and sophisticated methods such as cointegration, variance ratios, fractional integration as well as error correction models. The results of these studies favored the PPP predictions: these also supported the real exchange rate mean-reverting behavior (Rogoff, 1996). Mollick (1999) used data from Brazil and analyzed long-period data over 1885 to 1990. The results, however, were found to be mixed: there was no evidence of stationary residuals from the results obtained using the formal unit-root test, however, the deterministic trend of the data favored the stationarity of the residuals.

Lothian & Taylor (1996) further applied the annual bilateral real exchange rate data of franc-sterling as well as dollar-sterling over a period of two centuries, and found satisfactory results once applying the ADF test and Phillips-Perron (PP) test of unit root (Phillips & Perron, 1988). In a separate study, Lothian & Taylor (2000) further supported their belief on the PPP’s reliability in the long run and the method of faster speed of mean reversion or adjustment for the real exchange rate. Andersson & Lyhagen (1999) applied a panel unit-root test, and found evidence of long-run relationship (cointegration) between the domestic and foreign price levels of few sampled countries. Using a relatively similar sample as the one applied by Andersson & Lyhagen (1999) using a longer time horizon along with real exchange rate data of 21 countries, Shively (2001) also found evidence of consistent PPP.

Further evidence on PPP (Hall et al., 2013) suggests long-run homogeneity of price and exchange rates using monthly data over 1999-2011 in a sample of nine Euro-area countries and over 1957-2011 for Canada, Japan and Mexico. Dimitriou & Simos (2013) examine the weak and strong- form PPP using dynamic ordinary least square (DOLS) method along with other particular cointegration methods (Gregory & Hansen, 1996; Hatemi-J, 2008 and Ariff et al. 2018) over 2000-2012. Test results are in favor of weak-form, but not the strong-form PPP. Furthermore, the Johansen cointegration approach is used in a study (Canarella et al., 2014) to validate the presence of long-run relationship between price, interest rates and exchange rates.
The study failed to verify a significant relationship between interest rate and price, while finding significant cointegration between price and inflation differentials.

3.2 International Fisher Effect

The relationship between real interest rate and real exchange rate has been a matter of crucial importance in several studies using post-Bretton Wood data. The seminal studies that led to the verification of Fisher Effect are motivated by modelling exchange rate under the sticky price model of Dornbusch (1976). Under a free-floating exchange rate regime, prices of goods in a country are subject to slower (meaning stickier) adjustments than those of non-capital assets, therefore initiating arbitrage opportunities in the short run, as suggested by the IFE (see Manzur & Ariff (1995)).

Mishkin (1984) considers the assumption of real interest rate equality across a sample of major economies to indicate that risk premium for comparable securities in different currencies of denomination may differ from one another. Mark (1985) proposes a testing approach for the conditions of high capital mobility and short-term ex ante real interest rates’ equality and net of tax real rates among flexible and specific market-linked exchange rates. The findings are found to be consistent with those of Mishkin in that the IFE hypothesis of parity conditions was rejected considering its joint relationship with the ex-ante PPP.

Several studies applied cointegration method (Hansen & Hodrick, 1980; Edison, 1987; Meese & Rogoff, 1988; Throop, 1993). Applying the maximum likelihood estimation using Johansen cointegration test, the findings were somewhat more favorable to support the theory (Johansen & Juselius, 1992; Edison & Melick, 1999).

Similar to the PPP, there is evidence in several empirical studies that the long-run relationship between exchange rate and interest rate change appears to hold well (Hill, 2004). On the other hand, in the short run, the IFE has not been proven to hold (Cumby & Obstfeld, 1981). A recent study by Koráb & Kapounek (2013) suggests that the IFE does not hold for countries that possess a rigid exchange rate policy and less frequent adjustments using central parity. Such mixed evidence motivated us to reconsider re-testing also for the IFE.

3.3 The Concept Development

Instability of a phenomenon is usually measured by the volatility as the rate of change of a phenomenon X across time (as ln (X_t /X_{t-1})) with t indicating interval of time used for measurement – in this paper, monthly intervals. The square root of volatility is then a measure of instability of the item measured as in Eq. (3) below:

\[
\sigma_{\frac{x_t}{x_{t-1}}} = \sqrt{\frac{\sum\left[\ln\left(\frac{x_t}{x_{t-1}}\right) - \bar{\left(\ln\frac{x_t}{x_{t-1}}\right)}\right]^2}{n-1}}
\]

where x represents the ratio of a target currency over the US dollar. This measure of population standard deviation (SD) indicates how volatile a currency is at a given test period. SD has been
commonly used as an indicator of instability. Another measure, again limiting to the same currency, is the coefficient of variation (CoV) which is the ratio from dividing the SD of a currency with its own average rate of change in the same test period. CoV is often used as a measure of risk of a currency, meaning the higher this ratio, the higher is the risk of a currency compared to the CoV of another currency. CoV is measured as in Eq. (4):

\[
\text{Coefficient of Variation (COV)} = \frac{\sigma_{\ln(x_t)} / \mu_{\ln(x_t)}}{\mu_{\ln(x_t)}}
\]  

(4)

The larger the CoV ratio, the greater is the likely instability of the currency. Note that this measure is relative to the first two statistical moments of the same phenomenon, that is, one currency with no regard to how the currency is behaving in relation to another currency of importance to the country of the currency concerned. The larger the CoV ratio, the greater is the likely instability of the currency.

The next measure is preferred when the volatility of a currency is relativized to the volatility of another currency of importance (close trade-linkage is the basis on which another currency may be important, so may be chosen). If both currencies are having the same level of volatility at a given period, then the relative volatility would equal unity. Otherwise, it will either be greater than unity if the given currency is more volatile or less than one if the given currency is less volatile than the benchmarked currency’s volatility. It is our assumption that most currencies would have slightly higher relative volatility (RV) than unity, given the lower volatility of the US dollar (US$), if indeed the comparison unit is the dollar. Hence the relative volatility can be measured as the standard deviation RV as the ratio of the standard deviation (SD) of a currency \( x \) over the SD of a benchmark currency \( y \):

\[
\text{Relative Volatility (RV)} = \frac{\sqrt{\sum_{t=1}^{8} \left[ \ln \left( \frac{x_t}{x_{t-1}} \right) - \ln \left( \frac{\bar{x}_t}{x_{t-1}} \right) \right]^2}}{\sqrt{\sum_{t=1}^{8} \left[ \ln \left( \frac{y_t}{y_{t-1}} \right) - \ln \left( \frac{\bar{y}_t}{y_{t-1}} \right) \right]^2}}
\]  

(5)

This measure is a unit for comparing, say British pound SD with the US currency SD. If the RV of pound against the dollar is the same across time, then the RV would be 1.00. Any deviation around 1.00 is an indicator of exchange rate instability of the pound sterling currency. Similarly, by measuring the RV of EU dollar, we would have two numbers respectively for the pound and EU dollar to compare. The size of this measure would be used to measure the instability of pound and the instability of the EU dollar. That would show which currency is more or less volatile as measured for a given time period.

\[3\] There are several versions of this measure: semi-variance; Parkinson’s measure; Kunitomo measure; etc., all of which are some innovations to make the SD appropriate for different purposes: these are found in advanced statistics books. Extreme values at the tails of the frequency distributions could also be used: fractals, cupola, etc. The property of these measures as indicators of instability could be done by comparing the same measures of another currency to make judgment about that the other currency is more or less volatile as measured for a given time period.
more unstable than the other, which is a practical and very useful measure for ranking a given number of countries with significant trade linkages with the USA.

The resulting ranking could be done periodically, say every 3 months, to create a time series to provide a benchmark-relevant measure for policy making. In this study, we apply this simply to show how this measure looks like for a sample of 12 Muslim-countries over some 28 years.

4. Data and Methodology

The measure of RV could be used to devise trade policies or currency management strategies or even devise correct exchange rate management policy for the central banks. Central banks are known to estimate forward inflation rates as well as forward interest rates to formulate inflation targeting decision. The ranking of countries based on RV would represent a measure of relative instability of a currency. To track the adjustment towards equilibrium in the exchange rate volatility across pairs of countries, we run an auto-regressive distributed lag (ARDL) regression. The process is normally used in econometrics to estimate the adjustment process between the series in the long run. Our test procedure further follows a regression approach using the RV against relative inflation and interest rates to verify the explanatory power from the monetary factors in the determination of currency riskiness and instability. The regression equation is:

\[ RV_{it} = \alpha_i + \beta_1 \left( \frac{CPI_{id}}{CPI_{it}} \right)_{it} + \beta_2 \left( \frac{1+i_{id}}{1+i_{if}} \right)_{it} + u_{it} \quad (6) \]

where RV represents the relative standard deviation, CPI stands for the consumer price index, and the relative CPI represents the relative PPP among the two trading partners, \( i_d \) denotes the real domestic interest rates, \( i_f \) is the real foreign interest rate, and the ratio represents the relative interest rate parity among the two trading partners. We use an advanced common factor modelling specification following a panel-data methodology proposed by Ditzen (2016) to allow for dynamic effect, unobserved heterogeneity and control for endogeneity and cross-sectional dependence. The error term \( u_{it} \) from the Eq. (6) can be specified as follows:

\[ u_{it} = \gamma_i f_{it} + e_{it} \quad (7) \]

where \( f_{it} \) is an unobserved common factor, and \( \gamma_i \) is a heterogeneous factor loading for each country within the panel. The heterogeneous coefficients are randomly distributed around a common mean, \( \beta_i = \beta + v_i, v_i \sim IID(0, \Omega_v) \).

Our estimation strategy is based on an evaluation of numbers of estimators satisfying different assumptions underlying data generation processes. The proposed test models are known as time-series panel approaches suitable for our data structure with time dimension T being large, and small cross-sectional dimension N. This method has been evolved over time since the very seminal study of Zellner (1962) who proposed the traditional Seemingly Unrelated Regressions

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4 The model has included a variable for inflation as the ln on CPI. Hence, using nominal relative interest rate in the test for IFE would mean that the inflation factor is again included in the second variable. To rectify this, we subtracted the expected inflation from the domestic and the foreign nominal interest rates so that we test the IFE on the real interest rates.
(SUR) to control for cross-sectional heterogeneity. Pesaran and Smith (1995) followed by Pesaran et al. (1999) provided supporting evidence for panel heterogeneity. The recent development of financial databases allowing for widespread access to time-series data led to further development of these models to offer efficiency gains against unobserved dependencies across countries, which are likely to arise from common shocks and/or financial market integrations. Pesaran (2006) suggests that a consistent estimate of factors in equations 6 and 7 can be obtained by approximating the unobserved common factors with cross-sectional averages \( \bar{x}_1t, \bar{x}_2t \) and \( \bar{y}_t \) under strict exogeneity, such that the Eq. (6) can be specified as follows:

\[
RV_{it} = \alpha_i + \beta_1 \left( \frac{\text{CPI}_i^d}{\text{CPI}_i} \right)_{it} + \beta_2 \left( \frac{1+i^d_t}{1+i^t_t} \right)_{it} + \delta_1 \left( \frac{\text{CPI}_i^d}{\text{CPI}_i} \right)_t + \delta_2 \left( \frac{1+i^d_t}{1+i^t_t} \right)_t + \eta_i RV_t + u_{it} \tag{8}
\]

where
\[
\frac{\text{CPI}_i^d}{\text{CPI}_i} = \frac{1}{N} \sum_{i=1}^{N} \left( \frac{\text{CPI}_i^d}{\text{CPI}_i} \right)_{it}, \quad \frac{1+i^d_t}{1+i^t_t} = \frac{1}{N} \sum_{i=1}^{N} \left( \frac{1+i^d_t}{1+i^t_t} \right)_{it}
\]

and \( RV_t = \frac{1}{N} \sum_{i=1}^{N} RV_{it} \).

Chudik and Pesaran (2015) proposed that the dynamic common correlated effect (DCCE) as in the Eq. (9) could suffer from consistency because the assumptions of strict exogeneity in presence of lagged dependent variable will no longer hold.

\[
RV_{it} = \alpha_i + \lambda_i RV_{i,t-1} + \beta_1 \left( \frac{\text{CPI}_i^d}{\text{CPI}_i} \right)_{it} + \beta_2 \left( \frac{1+i^d_t}{1+i^t_t} \right)_{it} + u_{it} \tag{9}
\]

As a result, the Eq. (10) can gain consistency only if \( p_T = \frac{3}{T} \) cross section means are added, such that:

\[
RV_{it} = \alpha_i + \lambda_i RV_{i,t-1} + \beta_1 \left( \frac{\text{CPI}_i^d}{\text{CPI}_i} \right)_{it} + \beta_2 \left( \frac{1+i^d_t}{1+i^t_t} \right)_{it} + \sum_{l=0}^{l=0} \delta_{l,t} \bar{z}_{t-1} + u_{it} \tag{10}
\]

where
\[
\bar{z}_t = \left( RV_{it}, RV_{t-1}, \frac{\text{CPI}_i^d}{\text{CPI}_i} \right)_t, \quad \frac{1+i^d_t}{1+i^t_t}_t.
\]

The Eq. (11) can also be specified based on an error correction mechanism following the pooled mean-group (PMG) estimation approach,

\[
\Delta RV_{it} = \theta_0 RV_{it-1} - \theta_1 \left( \frac{\text{CPI}_i^d}{\text{CPI}_i} \right)_{it} - \theta_2 \left( \frac{1+i^d_t}{1+i^t_t} \right)_{it} + \delta_{0,i} + \delta_{1,i} \Delta \left( \frac{\text{CPI}_i^d}{\text{CPI}_i} \right)_{it} + \delta_{2,i} \Delta \left( \frac{1+i^d_t}{1+i^t_t} \right)_{it} + \epsilon_{it} \tag{11}
\]

where \( \delta_i \) in (11) above is the error correction speed of adjustment.

We use three different estimators with different specifications, namely mean group (MG), pooled mean group (PMG) and dynamic common correlated effect (DCCE). The MG estimates common correlated effects across countries. However, it does not account for pooled long-run coefficients as well as dynamic common correlated effects. The PMG allows for long-run
homogeneity and short-run heterogeneity, while not allowing for cross-sectional dependence. Using DCCE, however, the dynamic common correlated effects are estimated while controlling for homogeneity and heterogeneity of the countries. The estimator is further robust to cross-sectional dependence and allows for endogenous regressors in the mean equation. As a result, the asymptotic properties of the DCCE are robust and efficient.

The DCCE specification is slightly different from Eq. (11), as in the following:

\[ \Delta R_{it} = \phi_i R_{it-1} + \theta_1 \left( CV_{it} - CV_{it-1} \right) + \theta_2 \left( C^{d}_i t + C^{f}_i t \right) + \delta_0,0 + \delta_1,1 \left( C^{d}_i t + C^{f}_i t \right) + \delta_2,1 \left( C^{d}_i t + C^{f}_i t \right) + \epsilon_{it} \]

(12)

The estimator further accounts for a test of cross-sectional dependence (CD), with the null hypothesis of weak cross-sectional dependence in the error terms:

\[ H_0 = E(u_{it}, u_{jt}) = 0, \forall \ t \text{ and } i \neq j. \]

(13)

with the CD test statistics developed by Pesaran (2015) as follows,

\[ CD = \sqrt{\frac{2T}{N(N-1)}} \left( \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij} \right) \]

(14)

where

\[ \hat{\rho}_{ij} = \frac{\sum_{t=1}^{T} u_{it} u_{jt}}{(\sum_{t=1}^{T} u_{it}^2)^{1/2} (\sum_{t=1}^{T} u_{jt}^2)^{1/2}} \]

(15)

The CD test statistic is asymptotically \( CD \sim N(0,1) \) under the null.

The test model is based on monetary theories of exchange rate determination. As an extension of the measures proposed in the equations (1) and (2), one could also link these measures to the theory of exchange rate dynamics: a published paper (Ariff & Zarei, 2016) has shown the reliability of this model.

We use data on 12 countries (Algeria; Bangladesh; Egypt; Ghana; Indonesia; Iran; Kuwait; Malaysia; Morocco; Nigeria; Pakistan; Turkey). The data series are monthly and annual frequencies. Data are collected on exchange rates, consumer price index as proxy for inflation, and the government T-bill yields representing interest rates. The data span over 1990-2018. We use two panel unit-root tests of Maddala & Wu (1999) known as Fisher test and cross-sectionally augmented IPS (CIPS) test proposed by Pesaran (2007) to test for stationarity in the series. The statistics suggest that the order of integration is mixed. IFE for instance is stationary at level while the PPP is integrated of order one and stationary at first difference.

4.1 Test of Nonlinearity:

We further extend our test procedure to evaluate the non-linear relationship. Using the squared term of the PPP (PPP2) as well as that of the IFE (IFE2) in the Eq. (17) as additional regressors within two separate equations, we test for the evidence of non-linearity and determine if the relationship in the effect of relative inflation and interest rates on relative volatility has U-
shaped or inverted U-shaped behavior (Law et al., 2018). Eq. 17 is used to test the nonlinear relationship and evidence of threshold effect between relative inflation and relative volatility.

\[
RV_{it} = \alpha_i + \beta_1 \left( \frac{CPI_i^d}{CPI_i^f} \right)_{it} + \beta_2 \left( \frac{CPI_i^d}{CPI_i^f} \right)_{it}^2 + \beta_3 \left( \frac{1+i_i^d}{1+i_i^f} \right)_{it} + u_{it} 
\]  

(16)

If the \( \beta_1 \) and \( \beta_2 \) are found to be statistically significant and have opposing sign or direction of correlation, there will be evidence of threshold in the relationship between relative inflation and relative volatility. Using the Eq. (17), an identical nonlinear association between relative interest rate and relative volatility can be evaluated based on the direction and significance of \( \beta_2 \) and \( \beta_3 \). We have used the DCCE, given its robustness, to estimate the equations 16 and 17.

\[
RV_{it} = \alpha_i + \beta_1 \left( \frac{CPI_i^d}{CPI_i^f} \right)_{it} + \beta_2 \left( \frac{1+i_i^d}{1+i_i^f} \right)_{it} + \beta_3 \left( \frac{1+i_i^d}{1+i_i^f} \right)_{it}^2 + u_{it} 
\]  

(17)

In order to obtain the statistics reporting the marginal effect of relative inflation and interest rate on relative volatility, we use the partial derivatives of equations 16 and 17 with respect to relative inflation and relative interest rates, respectively, such that:

\[
\frac{\partial RV_{it}}{\partial \left( \frac{CPI_i^d}{CPI_i^f} \right)_{it}} = \beta_1 + 2\beta_2 \left( \frac{CPI_i^d}{CPI_i^f} \right)_{it} 
\]  

(18)

\[
\frac{\partial RV_{it}}{\partial \left( \frac{1+i_i^d}{1+i_i^f} \right)_{it}} = \beta_1 + 2\beta_2 \left( \frac{1+i_i^d}{1+i_i^f} \right)_{it} 
\]  

(19)

Using the specifications used in the equations 18 and 19, we can determine the optimal turning point (or threshold value), where the slope is equal to zero. At the margin, the total effect of increasing relative inflation and interest rate beyond the optimal point, would result in the opposite direction of relative exchange rate volatility from its initial behavior. Using the obtained covariance matrix from equations 16 and 17, we can further calculate the variance (or standard errors) of the marginal effect when the relative inflation and interest rates are at the minimum, at the mean and at the maximum level, and thereby obtain the respective t-statistics values:

\[
\sigma_{\hat{y}|x}^2 = \text{var}(\hat{\beta}_1) + 4X^2\text{var}(\hat{\beta}_2) + 4X\text{cov}(\hat{\beta}_1\hat{\beta}_2) 
\]  

(20)

where \( X \) represents the minimum, the mean, and the maximum level of relative inflation (PPP) and relative interest rates (IFE), used to obtain the (t-statistic) significance value of each marginal effect.
5. Findings and discussion

The above-developed measure for understanding currency instability as well as tracking currency behavior over time is the relative volatility (RV): to that we can apply rank order using RV and measure the time to equilibrium (ECT), as well as the threshold effect. These results are presented in that order in this section.

A priori value for the RV should be equal to 1.00 for a currency with similar relative volatility as that of the benchmark (in this paper, it is the US$). The graphs, one for each country, are drawn in relation to the unity value of 1.00 if two currencies behave the same way, for each of the 12 currencies tested.

(Insert Figure 1)

The currencies included in Figure 1 represent a sample of Islamic managed currencies. The plots of these currencies are above the equilibrium line 1.00 most of the time since switching from pegged to “basket management”. That means all the managed currencies have higher volatility in relation to the US$. Thus, it appears that the world’s most favorite US$ as the trade-linked benchmark could be used to relativize the movements (appreciation and depreciation) of individual currencies relative to the US$.

5.1 Using a Riskiness Measure

In Table 1, we provide the mean values of the relative volatility in the bilateral exchange rate of the selected countries against the benchmark currency. Note that in table below the RV rank is by size of the average RV during the test period of 1990-2016.

(Insert Table 1 about here)

5.2 Cointegration and Time to Equilibrium

Our tests of cointegration and error correction comprises two parts. In the first part, we report findings on the pairwise long-run relationship between the time-series RV of the sampled currencies and that of the US dollar, followed by the measure of speed of adjustment or convergence of the two volatilities to the long-run equilibrium, which is the point when the two currencies would have an identical (unity) behavior in terms of exchange rate volatility. We report statistics for each country separately in Table 3. We have followed an ARDL bound testing approach using monthly data, with distributed lags being specified based on the Schwarz information criterion leading to high R-squared statistics and representing appropriate model fit.

(Insert tables 2 and 3 about here)

The findings from Table 3 suggest that there is evidence of significant long-run relationship between all paired volatilities, with the speed of adjustment being negative and significant at 1 percent. The magnitude of the adjustment-time of the currency volatility of any sampled country to the US$ volatility ranges over 6 months in the case of Pakistani rupee to 20 months in the case of Malaysian ringgit. This would indicate that following any disequilibrium arising from a shock or monetary disarrangement, in the volatilities of sampled currencies, the time to equilibrium could be as long as half a year to about 2 years.
The second part of our testing is on the estimation of the dynamic panel models, to determine the short-run as well as the long-run effects of the monetary-theory suggested variables, relative inflation (PPP) and relative interest rates (IFE), on relative volatility (RV) (Ariff & Zarei, 2016). Moreover, an estimate of the error correction term (ECT) is provided to measure the speed to which the RV adjusts to the long-run equilibrium relationship with the PPP and IFE, that is the currency volatility of the sampled countries would adjust over time to a level where the relative or cross-border level of inflation and interest rates are almost identical suggesting a parity relationship. The results of these analyses are provided in Table 4.

We found that the DCCE2 offers higher consistency gain compared to the other estimators, as it accounts for heterogeneity of the sampled countries as well as presence of insignificant (weak) cross-sectional dependence across the countries. This test is conducted on the annual data series, with lag parametrization suggested by the Schwarz criterion, which is based on an ARDL (2,1,1) model specification. The results affirm evidence of significant short-run and long-run effect of the relative inflation and interest rates on the relative volatilities. In particular, the RV in the bilateral currencies is derived from the relative movements in the PPP and IFE. The effect of relative inflation on relative volatility is found to be close to one-to-one relationship, that is with every unit increase/decrease in the difference between any economies’ inflation rate, the relative volatility increases/decreases by one unit both in the short run and long run. As for the interest rate difference, we observe that the higher pairwise interest rate differences will lead to a greater short-term increase in the RV, while the degree of correlation will be smaller than unity in the long-run.

5.3 Threshold Effect and Nonlinearity

The final section of our findings is about the extension of the linear panel-data model to the dynamic nonlinear specification, following Law et al. (2018). We have evaluated two different models and obtained the optimal turning point or the threshold values as well as the minimum, mean and the maximum marginal effects for each model. We find evidence of significant nonlinearity in the behavior of variables. Table 5 reports statistics on the test of nonlinearity and threshold effect.

We find that there is an inverted U-Shape relationship between relative inflation (PPP) and relative volatility. The coefficient sign of PPP is initially positive and turns negative after the optimal threshold point (1.02964), where the slope is equal to zero. In other words, the relative volatility in the exchange rates is initially high followed by the increasing change in the difference between the inflation of the selected countries against that of the USA. Any additional increase in the relative inflation beyond the optimal point would cause a decline in the RV, which could be the result of adjustment of sticky prices to the new information about the inflation. As a result, the currencies of selected economies will be eventually volatile to a lesser extent, compared to the first time when the high inflation was induced.

There is also an evidence of nonlinearity in the behavior of relative volatility as a result of the change in the cross-border interest rates. This behavior is found to be U-shaped. We find that following an initial rise in the home country’s interest rates against the US interest rate, there will be an initial decline in the relative exchange rate volatility, as the demand for investment
in the home country’s capital market increases. However, any subsequent increase in the interest rate relative to the benchmark beyond the optimal point (0.2023) would result in higher relative exchange rate volatility. That would represent that the country suffers from high riskiness arising from lack of foreign investors’ trust in the domestic trade and capital market, high government borrowing, current account deficit, and tightened capital control policies, and so on. In recent days, one can see the example of Turkey going through this scenario post Trump event effect of 10 August 2018.

6. Conclusion: Instability Revealed by Relative Measures

Volatility measures as an indicator of instability have a long history in all sciences. In the period following the demise of the orderliness in currency markets from the Bretton Woods agreement, currency volatility has been at the center of several episodes of systemic instability spilling over to economic and fiscal derailments of countries. Yet, to the best of our knowledge, there are no significant publications on how to track the instability emanating from currency using relative measures. Indeed, no more than 2 countries pursue exchange rate targeting and these are financial centers. In the mainstream economics, there are models of capacity slack that are a boon to measuring economic instability. What do we have in currency management?

In this paper, we develop four measures of currency instability and tested these measures using data over 28 years of 12 Muslim-majority countries using actual changes in currency values (and US$ index values). What we have done in this paper is to show the internal cohesiveness of our models to theoretical factors. However, we also attempted to link these stability measures to verify if these measures are correlated with the riskiness of currency as well as the monetary and trade theories. We found that indeed the proposed relative measures co-move with the exchange rate variables in the long run, which indeed is good news for using our RL measure for tracking exchange rate. All we need as the next step is to adopt this measure and see from a hold-out sample how intervention to keep the RL within policy bands would have stabilized the extreme volatility: this is continuing project.

This study has included a relatively large number of currencies to establish a broader definition of currency risk measure applicable beyond the traditional (often weaker) measures of volatility. Relative instability is very likely to be useful for describing past behavior, for tracking current behavior to take intervention actions, for benchmarking against a reference currency that is important for a given country (for example, Nepal may find Indian Rupee to be more relevant as would East Timor find Indonesian currency relevant than the US dollar), and managing instability in currencies, as shown in this study.
Figure 1: Relative Volatility to Unity, 1990-2016

DZD/USD

BDT/USD

EGP/USD

Unity

Algeria

Bangladesh

Egypt
Table 1: Ranks (By Mean and Median) of the 12 Islamic currencies by Relative Volatility, 1990-2016

<table>
<thead>
<tr>
<th>Country</th>
<th>Mean</th>
<th>Median</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kuwait</td>
<td>0.3085 (1)</td>
<td>0.2453 (2)</td>
<td>0.2236</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>0.4076 (2)</td>
<td>0.3044 (3)</td>
<td>0.3863</td>
</tr>
<tr>
<td>Pakistan</td>
<td>0.7141 (3)</td>
<td>0.3395 (4)</td>
<td>0.8312</td>
</tr>
<tr>
<td>Malaysia</td>
<td>0.8904 (4)</td>
<td>0.5661 (7)</td>
<td>1.3240</td>
</tr>
<tr>
<td>Ghana</td>
<td>0.9303 (5)</td>
<td>0.5668 (8)</td>
<td>1.1455</td>
</tr>
<tr>
<td>Egypt</td>
<td>1.0520 (6)</td>
<td>0.1682 (1)</td>
<td>2.4360</td>
</tr>
<tr>
<td>Morocco</td>
<td>1.1960 (7)</td>
<td>1.1379 (11)</td>
<td>0.4023</td>
</tr>
<tr>
<td>Algeria</td>
<td>1.2566 (8)</td>
<td>0.9344 (9)</td>
<td>1.5541</td>
</tr>
<tr>
<td>Nigeria</td>
<td>1.5390 (9)</td>
<td>0.3553 (5)</td>
<td>4.4286</td>
</tr>
<tr>
<td>Turkey</td>
<td>2.0810 (10)</td>
<td>1.4243 (12)</td>
<td>2.1132</td>
</tr>
<tr>
<td>Indonesia</td>
<td>2.1318 (11)</td>
<td>0.9891 (10)</td>
<td>4.0124</td>
</tr>
<tr>
<td>Iran</td>
<td>3.3442 (12)</td>
<td>0.4278 (6)</td>
<td>10.8326</td>
</tr>
</tbody>
</table>
### Table 2: Results from Unit-Root Test

**Panel A: Variables in Level**

<table>
<thead>
<tr>
<th>Lags</th>
<th>RV</th>
<th>PPP</th>
<th>IFE</th>
<th>Lags</th>
<th>RV</th>
<th>PPP</th>
<th>IFE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>134.15***</td>
<td>6.51</td>
<td>225.65***</td>
<td>0</td>
<td>106.64***</td>
<td>7.30</td>
<td>206.08***</td>
</tr>
<tr>
<td>1</td>
<td>162.97***</td>
<td>7.05</td>
<td>109.75***</td>
<td>1</td>
<td>132.48***</td>
<td>9.02</td>
<td>99.66***</td>
</tr>
<tr>
<td>2</td>
<td>154.63***</td>
<td>6.75</td>
<td>77.51***</td>
<td>2</td>
<td>125.11***</td>
<td>7.60</td>
<td>67.50***</td>
</tr>
</tbody>
</table>

**Pesaran (2007) CIPS Test**

<table>
<thead>
<tr>
<th>Lags</th>
<th>RV</th>
<th>PPP</th>
<th>IFE</th>
<th>Lags</th>
<th>RV</th>
<th>PPP</th>
<th>IFE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-6.96***</td>
<td>1.92</td>
<td>-9.55***</td>
<td>0</td>
<td>-5.58***</td>
<td>1.88</td>
<td>-9.04***</td>
</tr>
<tr>
<td>1</td>
<td>-8.92***</td>
<td>0.48</td>
<td>-7.31***</td>
<td>1</td>
<td>-7.72***</td>
<td>0.22</td>
<td>-6.29***</td>
</tr>
<tr>
<td>2</td>
<td>-8.35***</td>
<td>1.04</td>
<td>-5.62***</td>
<td>2</td>
<td>-7.15***</td>
<td>0.62</td>
<td>-3.48***</td>
</tr>
</tbody>
</table>

**Panel B: Variables in First Difference (With Drift)**

<table>
<thead>
<tr>
<th>Lags</th>
<th>RV</th>
<th>PPP</th>
<th>IFE</th>
<th>Lags</th>
<th>RV</th>
<th>PPP</th>
<th>IFE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>483.98***</td>
<td>806.42***</td>
<td>99.45***</td>
<td>0</td>
<td>15.46***</td>
<td>15.46***</td>
<td>15.46***</td>
</tr>
<tr>
<td>1</td>
<td>886.86***</td>
<td>779.08***</td>
<td>570.96***</td>
<td>1</td>
<td>15.46***</td>
<td>15.46***</td>
<td>15.46***</td>
</tr>
<tr>
<td>2</td>
<td>734.88***</td>
<td>573.58***</td>
<td>726.52***</td>
<td>2</td>
<td>15.46***</td>
<td>15.46***</td>
<td>15.46***</td>
</tr>
</tbody>
</table>

**Note:** Tests on differenced variable at lag zero and one does not give any output. Tests are implemented with lag 2 to 4. The fisher test follows a Chi-square probability distribution and Pesaran’s test is based on t-bar statistics.
Table 3: Long-run Relationship between Volatility of Currency Pairs

<table>
<thead>
<tr>
<th>Model Specification</th>
<th>ARDL</th>
<th>R²</th>
<th>Bound-test F-Statistic</th>
<th>Long-run ECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>σDZD = f(σUSD)</td>
<td>(2,1)</td>
<td>0.855</td>
<td>8.632***</td>
<td>-0.083***</td>
</tr>
<tr>
<td>σBDT = f(σUSD)</td>
<td>(2,0)</td>
<td>0.786</td>
<td>8.825***</td>
<td>-0.107***</td>
</tr>
<tr>
<td>σEGP = f(σUSD)</td>
<td>(2,1)</td>
<td>0.846</td>
<td>8.588***</td>
<td>-0.091***</td>
</tr>
<tr>
<td>σGHS = f(σUSD)</td>
<td>(3,1)</td>
<td>0.913</td>
<td>9.751***</td>
<td>-0.071***</td>
</tr>
<tr>
<td>σIDR = f(σUSD)</td>
<td>(2,0)</td>
<td>0.934</td>
<td>3.612</td>
<td>-0.098***</td>
</tr>
<tr>
<td>σIRR = f(σUSD)</td>
<td>(1,0)</td>
<td>0.757</td>
<td>11.817***</td>
<td>-0.131***</td>
</tr>
<tr>
<td>σKWD = f(σUSD)</td>
<td>(1,4)</td>
<td>0.885</td>
<td>10.024***</td>
<td>-0.101***</td>
</tr>
<tr>
<td>σMYR = f(σUSD)</td>
<td>(2,2)</td>
<td>0.918</td>
<td>5.083*</td>
<td>-0.051***</td>
</tr>
<tr>
<td>σMAD = f(σUSD)</td>
<td>(1,1)</td>
<td>0.902</td>
<td>8.826***</td>
<td>-0.103***</td>
</tr>
<tr>
<td>σNIN = f(σUSD)</td>
<td>(1,0)</td>
<td>0.766</td>
<td>13.217***</td>
<td>-0.131***</td>
</tr>
<tr>
<td>σPKR = f(σUSD)</td>
<td>(3,0)</td>
<td>0.751</td>
<td>16.151***</td>
<td>-0.171***</td>
</tr>
<tr>
<td>σTRY = f(σUSD)</td>
<td>(4,1)</td>
<td>0.851</td>
<td>15.226***</td>
<td>-0.121***</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td></td>
<td>-0.0943</td>
</tr>
</tbody>
</table>

**Pesaran et. al (2001) Critical Value**

<table>
<thead>
<tr>
<th>(k = 1)</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I(0)</td>
<td>I(1)</td>
</tr>
<tr>
<td>99% Level</td>
<td>6.84</td>
<td>7.84</td>
</tr>
<tr>
<td>95% Level</td>
<td>4.94</td>
<td>5.73</td>
</tr>
<tr>
<td>90% Level</td>
<td>4.04</td>
<td>4.78</td>
</tr>
</tbody>
</table>

*** indicates acceptance level set at 0.01; and ** at 0.05.
<table>
<thead>
<tr>
<th>Variables</th>
<th>MG</th>
<th>PMG</th>
<th>DCCE₁</th>
<th>DCCE₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Convergence Coefficient</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.996***</td>
<td>-0.760***</td>
<td>-0.838***</td>
<td>-0.720***</td>
</tr>
<tr>
<td></td>
<td>(0.12)</td>
<td>(0.09)</td>
<td>(0.08)</td>
<td>(0.08)</td>
</tr>
<tr>
<td>Long-run Coefficients</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PPP</td>
<td>1.045***</td>
<td>1.044***</td>
<td>0.940***</td>
<td>1.011***</td>
</tr>
<tr>
<td></td>
<td>(0.16)</td>
<td>(0.05)</td>
<td>(0.11)</td>
<td>(0.07)</td>
</tr>
<tr>
<td>IFE</td>
<td>-0.006</td>
<td>0.161</td>
<td>-0.427*</td>
<td>-0.653*</td>
</tr>
<tr>
<td></td>
<td>(0.30)</td>
<td>(0.12)</td>
<td>(0.17)</td>
<td>(0.29)</td>
</tr>
<tr>
<td>Short-run Coefficients</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DₚRV(-1)</td>
<td>-0.223**</td>
<td>-0.300**</td>
<td>-0.273***</td>
<td>-0.358***</td>
</tr>
<tr>
<td></td>
<td>(0.09)</td>
<td>(0.09)</td>
<td>(0.08)</td>
<td>(0.09)</td>
</tr>
<tr>
<td>Dₚ₁.PPP</td>
<td>0.478*</td>
<td>0.848***</td>
<td>0.729***</td>
<td>1.007***</td>
</tr>
<tr>
<td></td>
<td>(0.28)</td>
<td>(0.23)</td>
<td>(0.21)</td>
<td>(0.24)</td>
</tr>
<tr>
<td>Dₚ₁.IFE</td>
<td>6.942*</td>
<td>6.909</td>
<td>10.66*</td>
<td>7.486**</td>
</tr>
<tr>
<td></td>
<td>(3.61)</td>
<td>(4.19)</td>
<td>(4.35)</td>
<td>(3.61)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.173</td>
<td>0.061</td>
<td>0.360**</td>
<td>0.486***</td>
</tr>
<tr>
<td></td>
<td>(0.17)</td>
<td>(0.10)</td>
<td>(0.12)</td>
<td>(0.09)</td>
</tr>
<tr>
<td>CD</td>
<td>-</td>
<td>-</td>
<td>1.638*</td>
<td>1.274</td>
</tr>
<tr>
<td>p-value</td>
<td>-</td>
<td>-</td>
<td>(0.10)</td>
<td>(0.21)</td>
</tr>
<tr>
<td>No. of Countries</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>No. of Observations</td>
<td>240</td>
<td>240</td>
<td>240</td>
<td>240</td>
</tr>
</tbody>
</table>

**Note:** The first two estimators in column 2 and 3 do not allow for cross-sectional dependence. DCCE₁ does not involve country-specific cross-sectional averages while DCCE₂ offers robustness against cross-section dependence as it includes country-specific cross-sectional averages as additional regressors in the equation following Eberhardt (2012) and Ditzen (2016). The obtained CD test statistics reveal evidence of no cross-section dependence using DCCE₂.
Table 5: Results from the Sample of Managed-Floating Currencies

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
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<td>PPP</td>
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<td>7.487***</td>
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<td>(7.62)</td>
<td>(2.38)</td>
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<tr>
<td>PPP&lt;sup&gt;2&lt;/sup&gt;</td>
<td>-17.12***</td>
<td>-</td>
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<td>(4.10)</td>
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<tr>
<td>IFE</td>
<td>2.824***</td>
<td>-2.517**</td>
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<tr>
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<td>(0.51)</td>
<td>(1.02)</td>
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<td>Max</td>
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References


