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Exchange rate uncertainty and foreign direct investment in Africa: Does financial development matter?

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Abstract

The orthodox view is that uncertainty deters investments and, by extension, private capital inflows. Paying specific attention to the volatility of the domestic exchange rate, foreign direct investment (FDI), and financial development indicators, this study investigates the impact of exchange rate uncertainty on FDI and whether financial development matters in such association. We establish our empirical relationship with a system general methods of moments (GMM) two-step robust estimator with orthogonal deviations. We found evidence supporting a nonlinear U-shaped relationship between uncertainty and FDI and that the impact of uncertainty on FDI depends on varying levels of uncertainty. We also document that uncertainty deters FDI flows and that countries with a well-functioning financial development can transform the adverse impact of volatility on FDI. However, curbing the adverse effect depends on the specific indicator and the threshold value of financial development (financial institutions or financial markets).

KEYWORDS

exchange rate, financial development, foreign direct investment, marginal effects, nonlinearity, systems GMM, uncertainty

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JEL CLASSIFICATION
O2; O24

1 | INTRODUCTION

The unpredictability of volatilities associated with capital flows adversely affects the quantum of inward capital flows to destination countries. Macroeconomic uncertainties can lead to sudden stops and reversal of capital flows resulting in a change in quantum and direction. Uncertainties can hinder the attraction of private capital, which can adversely impact the growth of countries that hugely depend on them. Shocks affecting capital flows may impede the directional movement of the flows. According to a UNDP (2011) report, "A financial shock can result in the sudden reversal of capital flows and also in a sharp decline in inflows" (p. 86). The report further admonished, "For this reason, policy measures to build a country's resilience to private capital-related shocks should focus on stabilizing the volatility associated with private capital flows" (UNDP, 2011, p. 87). Such volatilities could result from the devaluation of the exchange rate, inflationary pressures, and growth volatility. Lensink and Morrissey (2006) posit that countries deemed political and economically volatile attract few foreign investors. Instabilities associated with capital flows could also lead to distortions in the economic progress of countries (Forbes & Warnock, 2012).

The theory of investment irreversibility primarily influences the adverse impact of volatilities on investment and, by extension, capital flows. According to the proponents of investment irreversibility and the "options to wait," future uncertainty leads to a postponement of current investment as economic agents will hold onto additional investment until the level of uncertainty has been dispelled. Again, since the returns on investment are unpredictable during uncertainty, investors will curtail additional financing. The unpredictability of returns indicates an inverse relationship between investments and uncertainty (Dixit et al., 1994; Nickell, 1978; Pindyck, 1993). In line with the aforementioned theoretical stance, some empirical studies have found a negative relationship between uncertainty and private capital flows (Asamoah et al., 2016; Cavallari & d'Addona, 2013; Jehan & Hamid, 2017). However, the empirical conclusions on the uncertainty-investment dynamics do not support a vigorous one-sided conclusion of a negative relationship. Some studies have found volatility to positively affect investment and capital flows (Corden, 1990; Daly & Vo, 2013). The positive association results from the theories of risk neutrality and investment reversibility. Hartman (1972) and Abel (1983) posit that uncertainty causes the desire to increase current investment, as the marginal product of capital and profits is expected to increase with increasing uncertainty.

Considering these opposing theories, we contend that the association between capital flows and volatility may not be strictly monotonic (positive or negative). With a prime focus on the domestic exchange rate, the study seeks to reexamine the dynamics between macroeconomic uncertainty and private capital flows in Africa by testing the two contrasting theories (investment irreversibility and investment reversibility). Many existing studies take a linear relationship as given, raising doubt on the validity of the conclusions from such studies. Therefore, the study contends that there exists a U-shaped relationship between exchange rate volatility and foreign direct investment (FDI), where both theories could exist at extreme ends of the curve. First, the study focuses on a more stringent nonlinear procedure proposed by Lind and Mehlum (2010) to examine the two opposing theories (i.e., investment irreversibility and risk neutrality) (Table A1).

Second, we examine the structural dynamics in host countries to shape the macroeconomic volatilities–capital flows relationship. Based on the investment irreversibility theory and the empirical works of Asamoah et al. (2016) and Kyereboah-Coleman and Agyire-Tettey (2008), exchange rate volatility deters FDI flows. However, on the notion of absorptive capacities (Durham, 2004) and the perceived positive impact of financial development (FD) on capital flows (Agbloyor et al., 2014; Dutta & Roy, 2011), we employ FD as the mediating variable in the volatility–FDI nexus. Lane (2015) and Guichard (2017) note that the adverse impact from capital flows could be profound in the *absence* of weak institutions and FD. Consequently, the study focuses on the mediating role of FD in dealing with any adverse impact of exchange rate volatility on FDI flows. Thus, this study is concerned with the impact of exchange rate volatility on FDI and whether FD moderates the relationship. Regarding FD, the study employed recently developed indicators that overcome the limitations of single indices. These indicators account for the complexities and multifaceted characteristics of FD regarding financial access, efficiency, and depth. The study is the first to employ these indicators as mediating variables in the exchange rate volatility–FDI relationship.

Finally, the study fills a void in African literature. In separate studies, Caporale et al. (2015) and Demir (2009) posit that empirical conclusions on the linkage between capital flows and economic uncertainties are considerably very few, especially in the African context. Our study, therefore, seeks to expand the scope of literature with a focus on the volatilities associated with capital flows in Africa. The study thus differs from previous African studies in varied aspects. First, Kodongo and Ojah (2012) study the linkages between the exchange rate and equity flows in Africa; they did not consider the impact of exchange rate volatility and the mediating role of FD. Even though Kyereboah-Coleman and Agyire-Tettey (2008) and Udoh and Egwaikhide (2008) concentrated on exchange rate uncertainty and FDI inflows in two separate countries, Ghana and Nigeria, both studies did not consider the effect of a moderating variable. Second, these studies did not account for the nonlinear impact of exchange rate volatility. In a recent study on exchange rate volatility and FDI flows in Africa, Asamoah et al. (2016) accounted for the moderating effects of institutional quality and not FD. Again, their study failed to examine the marginal effect of the moderating variable in the association between exchange rate uncertainty and FDI inflows.

The study, therefore, seeks to address the following issues:

1. What is the nature of the relationship between FDIs and exchange rate volatility?
2. Can FD moderate the association between exchange rate volatility and inward FDI?
3. At what points or critical values can FD neutralize the potential adverse impact of exchange rate volatility on FDI?

The rest of the study is structured as follows. Section 2 explains the data and estimation procedures. Section 3 focuses on the results from the econometric estimations. Section 4 concludes the study and proffers policy directions.

2 | DATA AND ESTIMATION TECHNIQUE

The study consists of 40 African countries[1] for the period 1990–2018. The choice of the study period was influenced by two issues. First, the assertions of Gourinchas and Jeanne (2013) on when most countries were deemed to be financially open. Gourinchas and Jeanne (2013) contend that measures of financial openness show that from the mid-1980s through the 1990s, most countries had liberalized their economies and were open to external financial inflows. Second, the Chinn and Ito (2008) measure of financial openness indicates that the levels of financial openness for the samples in our study ranged between −1.917 and 2.347, indicating a high level of financial openness among our sample.[2] Our dependent variable is FDI, which is the decision by a foreign entity to acquire a lasting interest in another entity other than one in its home country, where such interest is usually not less than a 10% stake. The interest consists of accumulating equity capital, reinvestment of earnings, and other long- and short-term capital as shown in the balance of payments. FDI is net inflows scaled by gross domestic product (GDP).

2.1 | Exchange rate volatility

Though Multi National Enterprises (MNEs) desire to invest abroad as a form of diversification, the domestic exchange rate volatility may lead to increases in the cost of international business transactions, a decrease in profits, and a decrease in the volumes of cross-border capital flows. We first estimate the real effective exchange rate (REER) using the purchasing price parity (PPP) approach. According to the PPP, a country's REER is a function of its nominal exchange rate (NER) relative to a foreign price level ratio to the national price levels. We proxy our foreign price levels by the United States producers' price index and adjust the NER by the price differentials between the United States and each of our sample countries. Following Elbadawi (1992), we define the REER for each country as follows:

$$RERR_i = NER_i \times \frac{PPI^{US}}{CPI_i} \tag{1}$$

where NER_i denotes the NER of a country, which is the value of the domestic currency needed to exchange a unit of the U.S. dollar. PPI^{US} represents the producers' price index of the United States, which is our proxy for foreign price levels. CPI_i denotes the domestic price level, which is captured by the consumer price index. It implies that a decrease (an increase) in the REER leads to a real appreciation (depreciation) of the domestic currency. We obtain data on the United States producers' price index from Federal Reserve Economic Data.

Following Bah and Amusa (2003) and McKenzie (1999), we employ the GARCH family models developed by Bollerslev (1986) to capture REER volatility. The GARCH procedures allow current volatility to depend on its previous volatility. Using the GARCH process, we derive our volatility as follows:

$$VOL_t = \delta + \phi VOL_{t-1} + \varepsilon_t \tag{2}$$

where $\varepsilon_t \approx iid\, N(0, h_t)$

$$h_t = \beta + \psi \varepsilon_{t-1}^2 + \chi h_{t-1} \tag{3}$$

Note that $\beta > 0$; $\psi \geq 0$; $\chi \geq 0$.

From Equation 3, our conditional variance (h_t) is a function of the mean (β) of the conditional variance, information about the past volatility, which is the lag of the squared residual

ε^2_{t-1} (ARCH term), and the previous forecast error variance, χh_{t-1} (GARCH term). We first test for stationarity to ensure that our REER is stationary to avoid the incidence of spurious regression. Thus, we perform a unit root test by applying an augmented Dickey–Fuller test (Dickey & Fuller, 1979). Suppose the REER is not stationary in levels or integrated at order zero. In that case, it must be differenced at the first level (integrated at order 1) or the second level (integrated at order 2). Once it is deemed stationary, we estimate the mean-variance equation. The mean-variance equation allows us to generate the mean-variance series, which captures the volatilities in our REER variable. A GARCH (1,1) shows the presence of a first-order moving average ARCH term and a first-order autoregressive GARCH term. Based on Equation 3, the ARCH term denotes ψ, while the GARCH term denotes χ. The ARCH term captures current news on volatility, while the GARCH term captures the impact of previous volatility on the current volatility.

We determine the evidence of volatility clustering and persistence by adding the sum of the coefficients of the ARCH (ψ) and GARCH (χ) terms. According to Enders (2015), volatility shocks are deemed to be persistent when the sum of the coefficients is close to unity ($\psi + \chi \approx 1$). That means the impact from volatility will linger over a long period. Significantly, we found the sum of all ARCH and GARCH terms to be closer to unity. Again, we use the Ljung–Box statistics to confirm that our series does not suffer from autocorrelation up to a lagged value of 12. Also, the ARCH LM statistics for heteroscedasticity test the null hypothesis that there is no ARCH effect present in the residuals. The insignificance of the observation $\times R^2$ settles on the absence of conditional heteroscedasticity. Thus, we derive our volatility variables with the correct specifications and procedures.

2.2 | Financial development

The literature has primarily focused on either banking or stock market–specific indicators as proxies for FD while neglecting the impact of other equally essential indicators such as insurance, pension funds, bonds, and mutual funds (Ito & Kawai, 2018). Equally important are the additional roles of nonbank financial institutions such as venture capitals, microfinance institutions, investment banks, credit unions, and savings and loan institutions. However, the concept of FD is multidimensional and should not be confined to only traditional indicators. The current proxies are also skewed mainly in terms of the quantity aspect of FD (size and depth) to the neglect of the qualitative aspects of FD such as efficiency, liquidity, cost-profit performance, diversity, and the institutional environment, including legal systems (Hasan et al., 2009; Ito & Kawai, 2018). We, therefore, employ a broad-based index of FD that overcomes the limitations of single indices while accounting for the complexities and multifaceted characteristics of FD. Recently developed by the International Monetary Fund (IMF), the index considers financial markets' and institutions' development in terms of depth (liquidity and size of markets), efficiency (low-cost financial services amid sustained revenues, and capital market activities), and access (i.e., the ability to access financial services) (Svirydzenka, 2016). The index is constructed using data from various sources, including the IMF's financial access survey, the BIS debt securities database, the Dealogic corporate debt database, and the World Bank FinStats 2015. The index has recently been deployed as the ultimate measure of FD (Hannan, 2017; Tchamyou et al., 2019). For an in-depth understanding of the impact of the development of the financial sector, we further assess the conditional impact of FD from the two subindices (financial institutions and the financial markets) making up the broad FD index. Therefore, Svirydzenka (2016) transcripts that these two subindices focus on the development of financial markets and financial institutions in terms of access, depth, and efficiency. While financial institutions focus on the standard banking sector, financial markets are concerned with stock and debt market development. On the relative importance of the new indicators, Svirydzenka (2016) is convinced that "the indices are an improvement over the traditional measures of financial development. Conceptually, they incorporate information on a broader range of financial development features for a wider array of financial agents" (Svirydzenka, 2016, p. 20). The index has recently been employed in the capital flows–Africa literature (see Asamoah & Alagidede, 2021; Asamoah et al., 2021b).

2.3 | Controls

We employ relevant control variables as consistent with the capital flow literature. We measure trade as the sum of imports and exports of goods and services scaled by GDP and financial openness by the Chinn and Ito (2008) index of financial openness. We expect a positive impact of both trade and financial openness as we control for both. We account for natural resources endowment as the sum of natural gas, minerals, coal, forest, and oil rents, expressed as a percentage of GDP. Though natural resource is one of the driving factors of FDI in the extractive sector, the literature remains inconclusive on the directional effect. We measure human resources based on the years of schooling and return to education. We anticipate a positive impact of human capital on FDI inflows to Africa. We also control for the REER and expect a positive effect on FDI inflows. All data except for human capital, financial openness, and FD were sourced from the World Development Indicators of the World Bank. Data on FD are from the IMF. In contrast, human capital and financial openness are obtained from Penn World Tables 9.1 (Feenstra et al., 2015) and the Chinn and Ito (2008) financial openness index, respectively.

2.4 | Regression model and data estimation procedure

Beginning with Equation 5, we first test the evidence of a linear association between exchange rate volatility and private capital flows to examine whether exchange rate volatility deters FDI inflows to Africa.

$$FDI_{it} = \alpha FDI_{it-1} + \Sigma\beta_1 EXRV_{it} + \Sigma\beta_2 X_{it} + U_i + \varepsilon_t + \lambda t_{it} \quad (4)$$

FDI_{it} measures FDI for country i at time t. FDI_{it-1} is a lag of FDI testing for convergence and reinforcing effects in a dynamic panel data setting. $EXRV_{it}$ indicates exchange rate volatility. X_{it} denotes a set of controls in a standard capital flow model that includes trade openness, financial openness, human capital, and natural resources. U_i, ε_t, and $\lambda \mathrm{t}_{it}$ signify country effects, a time-varying idiosyncratic shock with the standard iid assumption, and a model error term.

2.4.1 | Evidence of nonlinearity

We test for the existence of nonlinearities in Equation 4. The principal question is whether any adverse effect of volatilities on FDI depends on the levels of volatilities or whether the relationship decreases at the start of the interval and increases at the end of the interval, or vice versa. To test this hypothesis of nonlinearity, we follow Lind and Mehlum (2010) and test for evidence of a U-shaped or an inverted U-shaped relationship, as Nier et al. (2014) recently employed in the capital flows literature. We extend Equation 4 to include the quadratic term of the exchange rate volatility. Equation 5 is specified as follows:

$$FDI_{it} = \alpha FDI_{it-1} + \Sigma\beta_1 EXRV_{it} + \Sigma\delta\left(EXRV_{it}\right)^2 + \Sigma\beta_2 X_{it} + U_i + \varepsilon_t + \lambda t_{it} \quad (5)$$

where $EXRV^2$ is a quadratic term for the domestic exchange rate volatility. The remaining variables are as explained previously. Regarding the existence or otherwise of a nonlinear relationship, Lind and Mehlum (2010) propose a set of three-step procedures of regressing the variable to be explained (FDI) on the explanatory variable of interest (exchange rate volatility).

The first is the sign and direction of the quadratic term. For the existence of a U-shaped relationship on a given interval of values, Lind and Mehlum (2010, p. 110) contend that "we need to test whether the relationship is decreasing at low values within this interval and increasing at high values within the interval." Therefore, a U-shaped relationship exists when the coefficient of the linear term is negative and that of the quadratic term is positive and significant. In contrast, an inverted U-shape exists when the coefficient of the linear term is positive and that of the quadratic term is negative and significant. The quadratic term must be significant. The second step notes that the slopes at the extreme ends of the data (minimum and maximum) must be sufficiently steep. Lind and Mehlum (2010, p. 111) note that "the requirement for a U shape is that the slope of the curve is negative at the start and positive at the end of a reasonably chosen interval" of the explanatory variable of interest. Our study employs the observed data range as our chosen interval, that is, $EXRV_{min}$ and $EXRV_{max}$. Therefore, for a U-shaped relationship, the slope at the minimum data point must exhibit adverse and significant effects, while the slope and the maximum data point should be positive and significant. The opposite holds under an inverted U-shaped relationship. Using the *EXRV* in the regression model (Equation 5), the joint null hypothesis at the extreme ends of the data under an inverse U-shaped relationship according to Lind and Mehlum (2010) and further by Arcand et al. (2015) is stated in Equations 6 and 7:

$$H_0\colon \left(\beta_1 + 2\delta EXRV_{min} \leq 0\right)\ U\ \left(\beta_1 + 2\delta EXRV_{max} \geq 0\right) \quad (6)$$

$$H_1\colon \left(\beta_1 + 2\delta EXRV_{min} > 0\right) \cap \left(\beta_1 + 2\delta EXRV_{max} > 0\right) \quad (7)$$

$EXRV_{min}$ and $EXRV_{max}$ are the minimum and maximum values of the exchange rate volatility, respectively. The corresponding *t*-statistics, which also corresponds to the rejection zone, can also be estimated. Following Kuo et al. (2014), let θ_1 represent the variance estimation of $\widehat{\beta_1}$, θ_2 the estimated variance of $2\widehat{\delta}$, and θ_3 the covariance estimation of $\widehat{\beta_1}$ and $2\widehat{\delta}$. The values $\widehat{\beta_1}$ and $2\widehat{\delta}$ represent the corresponding estimated values of β_1 and 2δ. Therefore, the corresponding *t*-statistics at the minimum and maximum values of *EXRV* is stipulated in Equation 8:

$$T_i = \frac{\widehat{\beta_1 + 2\widehat{\delta}(EXRV)}}{\sqrt{[\theta_1 + 2\theta_3\left(EXRV_i\right) + \theta_2(EXRV_i)^2]}};\ i = \max\ or\ \min\ point \quad (8)$$

The procedure further suggests the estimation of the point of inflection of the quadratic term at minimum and maximum values, which must lie within the range of the data set. To achieve this, we take the partial derivative of Equation 5, which yields the threshold or turning point at which the effect of volatilities on capital flows becomes nonmonotonic. The partial derivative is presented in Equation 9:

$$\frac{d(FDI)}{d(EXRV)} = \beta_1 + 2\delta EXRV \tag{9}$$

At this point, any additional negative surges in volatilities will have no adverse impact on FDIs. Such a relationship could be concave or convex. That point of inflection is achieved by setting Equation 9 to zero and making *EXRV* the subject, as shown in Equation 10.

$$\beta_1 + 2\delta EXRV = 0;\ EXRV = \frac{\widehat{\beta_1}}{\widehat{2\delta}} \tag{10}$$

We test this condition at a 95% confidence interval of the turning point. There is evidence of a nonlinearity once the confidence interval lies within the range of the data (Haans et al., 2016; Kuo et al., 2014). Even though the relationship could be decreasing at the left and increasing at the right within the minimum and maximum intervals of the data, the relationship may not be U-shaped. The third and final procedure is to perform the overall test of the presence of a U- or inverse U-shaped relationship. This is executed using the stata command (Utest). In our case, the null hypothesis supports the presence of a U-shaped relationship. The alternative hypothesis tests the presence of an inverse U-shaped relationship. Thus, a rejection of the null hypothesis confirms the existence of an inverted U-shaped relationship regarding the impact of exchange rate volatility on FDI flows to Africa. Our hypothesis supports the existence of a significant nonlinear association between exchange rate volatility on FDI flows, which is U-shaped.

Furthermore, Brambor et al. (2006) posit that we can also interpret Equation 9 by studying the interpretation of the interaction models, where the effect of *EXRV* on the attraction of FDI is dependent on varying levels of *EXRV* itself.

2.4.2 | FDI, macroeconomic volatility, and FD

Following Durham (2004), Alfaro et al. (2010), and Asamoah et al. (2021a), we assess the ability of a host country's structural characteristics to deal with any form of volatilities associated with FDI. We, therefore, determine the moderating effect of FD in the FDI-exchange rate volatility dynamics in two simple steps. The first is to include an interaction term of volatility and FD in the linear equation in Equation 4. We thus estimate Equation 11:

$$FDI_{it} = \alpha FDI_{it-1} + \Sigma\beta_1 EXRV_{it} + \Sigma\beta_3 X_{it} + \beta_4 FD_{it} + \beta_5 (EXRV \times FD)_{it} + U_i + \varepsilon_t + \lambda \mathrm{t}_{it} \tag{11}$$

From Equation 11, while β_4 and β_1 examine the direct effect of FD and *EXRV* on FDI, our variable of interest β_5 evaluates the effect of the volatility on FDI conditioned on varying levels of FD. The assessment of the conditional varying points (marginal effects) indicates that the effect of *EXRV* on FDI in the presence of FD is not static, as may be in the case of Equation 4, but the impact of any change in FDI resulting from the volatility of the domestic exchange rate depends on the different levels of FD.

Therefore, the marginal effect in our case is the partial derivative of Equation 11, where we take the first derivative of FDI with respect to *EXRV*, which results in Equation 12.

$$\frac{d(FDI)}{d(EXRV)} = \beta_1 + \beta_5 FD \tag{12}$$

Should we find both β_1 and β_5 to be positive, then fractional increases in volatilities will lead to increases in FDI based on increasing FD values up to the point where FDI is optimized. However, with the hindsight that volatilities deter capital inflows (Asamoah et al., 2016; Cavallari & d'Addona, 2013) and that FD attracts FDI (Agbloyor et al., 2014; Asamoah & Alagidede, 2021; Asamoah et al., 2021b), there is the probability of an adverse effect of *EXRV* and positive effect of FD on FDI. In such a scenario, we seek to determine the percentile levels of FD necessary to reduce any adverse impact of volatility on FDI and, if possible, to completely eradicate the negative impact. Brambor et al. (2006) further require that standard errors for the multiplicative term be captured separately from the standard errors of the constitutive terms. Equation 13 shows the standard errors for the interactive term:

$$se\left(\frac{d\,(FDI)}{d\,(EXRV)}\right) = \sqrt{var\left(\widehat{\beta_1}\right) + FD^2 var\left(\widehat{\beta_5}\right) + 2FD_{cov}\left(\widehat{\beta_1}\widehat{\beta_5}\right)} \tag{13}$$

From Equation 13, a negative covariance indicates the possibility of a significant marginal effect ($\beta_1 + \beta_5 FD$) from FD, even if all other indicators are insignificant. Thus, the analysis of such a multiplicative term equation needs further study. Given the continuous nature of the measures of FD, we assess the marginal effect of *EXRV* on FDI at the different percentiles of FD (25th, 50th, mean, 75th,' and 90th percentiles).

2.4.3 | Estimation procedure—Systems GMM

We perform the aforementioned analysis using the system GMM estimation technique. We opt for the two-step GMM estimator because it is known to be asymptotically more effective and vigorous for heteroskedasticity. We further use the Windmeijer (2005) finite-sample correction to obtain efficient standard errors and apply the small option to correct small sample bias to the covariance matrix (Roodman, 2009). We use the forward orthogonal deviations to improve the efficiency of our results due to the availability of gaps in our panel sample. To check the validity of the system GMM estimator, we report the *p*-values of two significance tests. The first is the second-order serial correlation [AR(2)], which tests whether the error terms are serially correlated. If there are serial correlations in the first order, it may not count, unlike in the second order. The second is the Hansen J test, for overidentification restrictions on the validity of instruments employed in the regression estimation. Hansen J tests the null hypothesis that overidentifying restrictions in instruments do not correlate with the error term. The cogency of these tests depends on the nature of the relationship between the sample size and the number of instrument counts. Thus, to avoid instrument proliferation and model overfitness, we follow Roodman (2009) and collapse our instrument matrix. The appropriate relationship is that the ratio (r) of the sample size (n) to the number of instrument counts (i) should be higher than or equal to one (i.e., $r = n/I \geq 1$). In the GMM estimator, the first difference of the exogenous variables, the lags of all endogenous variables, and lagged difference of the endogenous variables are used as standard instruments in the dynamic panel estimation (Arellano & Bond, 1991). We treat all variables, except for the indicator of volatility, the levels of the volatility variables, and FD as exogenous.

We use only internal instruments as we seek to maintain the assumption of fewer instruments relative to the sample size (Roodman, 2009).

3 | REGRESSION RESULTS

We first determine the linear and nonlinearity relationship between FDI flows and REER volatility. We then determine the conditional effect of FD in the volatility–FDI dynamics. We end the discussion with our marginal effect analysis.

3.1 | Linear and nonlinear effects of exchange rate volatilities on capital flows

From Table 1, the linear estimation in model 1 provides credence to the theoretical proposition that uncertainty hurts investment. We found evidence at conventional significance levels that *EXRV* tends to reduce FDI to Africa. The negative relationship between exchange rate volatility and FDI is consistent with real options and investment irreversibility theories. These theories suggest that the level of uncertainty allows investors to postpone current investments, causing a decrease in current investment levels. Thus, economic agents are likely to invest less (Akkina & Celibi, 2002; Dixit et al., 1994). From model 2, we show evidence of nonlinearity in the association between uncertainty and investments. We found the coefficient of the linear exchange rate volatility to be negative and the coefficient of the squared exchange rate volatility to be positive and significant on FDI flows. The significant negative coefficients for the linear terms and the subsequent significant positive coefficients of the quadratic terms indicate a nonlinear relationship between volatility and FDI flows. The results indicate that the impact of volatilities on FDI in Africa is dependent on varying levels of volatility. Model 2 shows the points of inflection at 95% confidence interval. Reflecting on the maximum functions, the point of inflection for exchange rate volatility is 23.408. There is evidence of a nonlinear relationship once the confidence interval lies within the range of the data (Haans et al., 2016; Kuo et al., 2014; Lind & Mehlum, 2010). The points of inflection imply that beyond the estimated values, increasing volatilities in the exchange rate will lead to increasing levels of FDI to Africa, conditioned on the current volatilities.

However, for evidence of a U-shaped relationship, the inflection point must lie within the confidence interval and with a negative slope at the minimum bounds and positive slope at the maximum bounds, both significant at conventional levels of significance (Kuo et al., 2014; Lind & Mehlum, 2010).

From model 2 of Table 1, the analysis exhibits a nonlinear and a U-shaped relationship between the exchange rate volatility and FDI flows. This is because the linear exchange rate volatility is significantly negative, while the squared exchange rate volatility is positively significant, both at 5% levels. Furthermore, the U-shaped relationship is supported by the negative slope experience at the $EXRV_{min}$ and positive slope at the $EXRV_{max}$ and the point of inflection within the data intervals. Finally, Table 1 presents the rejection of an inverted U-shaped relationship based on the overall test of the U-shape. The nonlinear relationship exhibited by *EXRV* on FDI suggests that the association is not strictly linear. Beyond the point of inflection, foreign investors are mainly insensitive to exchange rate volatility. Investors could increase investments during increasing macroeconomic volatilities, as benefits also tend to increase with the increasing volatility of the domestic exchange rate. The results suggest that the investment irreversibility theory

TABLE 1 FDI and exchange rate volatility—Linear and nonlinear relationships

Dependent variables	Linear model (1) FDI	Quadratic model (2) FDI
Constant	−3.895 (1.118)***	−4.465 (1.160)***
Lag dependent variable	0.087 (0.034)**	0.086 (0.030)***
Exchange rate	0.148 (0.069)**	0.196 (0.081)**
Exchange rate volatility	−0.068 (0.01)**	−0.117 (0.045)**
Exchange rate volatility^2		0.003 (0.001)**
Financial openness	0.114 (0.055)**	0.093 (0.056)
Human capital	0.831 (0.391)**	0.76 (0.448)*
Natural resources	0.165 (0.041)***	0.156 (0.048)***
Trade openness	0.769 (0.226)***	0.881 (0.253)***
Diagnostics		
Observations	740	740
Number of groups (n)	35	35
Number of instruments (i)	15	15
Instrument ratio (n/i)	2.33	2.33
AR(1): p-value	0.003	0.003
AR(2): p-value	0.573	0.558
Hansen J: p-value	0.976	0.930
F	15.420	10.530
Probability > F	0.000	0.000
The slope at minimum bound		−0.149 (0.056) ***
The slope at maximum bound		0.538 (0.004)
Inflection points		23.408
Overall test for the presence of an inverse U-shape		0.45(0.329)
[95% confidence interval]		[−6.320, 26.593]

Notes: Values in parentheses represent Windmeijer (2005) robust standard corrected errors. AR(1) = test of first-order autocorrelation; AR(2) = test of second-order autocorrelation; Hansen J = test of overidentifying restrictions. *, **, and *** denote significance levels at 1%, 5%, and 10%, respectively. The slope represents the lower and upper bounds of *EXRV*.

Abbreviation: FDI, foreign direct investment.

dominates the initial relationship between exchange rate volatility and FDI flows, where the impact is detrimental. This implies that until the point of inflection, increases in the volatility of the domestic exchange rate harm the influx of FDI. However, the risk neutrality theory dominates after the point of inflection, as increasing domestic exchange rate volatility leads to increases in FDI flows.

Consistent with the requirements of interactive coefficients,[3] we determine the marginal effect of *EXRV* on FDI at varying levels of volatility. We also use the marginal effect to validate our assertion of a nonlinear relationship, where at lower levels of volatility, the effect of volatility on capital flows is high, but the negative effect decreases at increasing levels of volatility. The

TABLE 2 Marginal effects of *EXRV* on FDI at varying levels of *EXRV*

EXRV @	25th percentile (0.088)	50th percentile (0.133)	Mean value (0.142)	75th percentile (0.161)	90th percentile (0.265)
FDI	−0.096***	−0.092***	−0.089***	−0.086***	−0.073***
	(1.033)	(1.046)	(1.060)	(1.070)	(1.123)

Notes: Values in parentheses under FDI represent standard corrected errors. *, **, and *** denote significance levels at 1%, 5%, and 10%, respectively.

Abbreviation: FDI, foreign direct investment.

marginal analysis will further indicate the critical points at which the negative impact of volatilities on FDI flows will be positive. From Table 2, we observe that at lower levels of the *EXRV* (25th percentile), the adverse impact of volatilities on FDI flows is high. However, at the upper levels of volatility (90th percentile), the adverse impact of *EXRV* on FDI decreases. Thus, at a 1% significance level, the adverse impact of exchange rate uncertainty on the attraction of FDI is reduced at increasing levels of volatility, from the 25th to the 90th percentiles of volatility. The results are consistent with the conclusions of Nier et al. (2014) that the impact of volatility on capital flows varies at increasing levels of volatility.

3.2 | FDIs, exchange rate volatility, and FD

We present the results of the association between *EXRV* and FDI conditioned on FD. We explore three indices of FD. We first determine the direct effects of both FD and *EXRV* in the presence of other control variables. Table 3 presents the results. Models 1–3 study the unconditional association between exchange rate volatility and FDI flows in the presence of the three indices of FD. In contrast, models 4–6 present the association between *EXRV* and FDI flows conditioned on the levels of each FD index.

From models 1 to 3, we observe a significant direct negative relationship between exchange rate volatility and FDI flows at conventional levels of significance, in the presence of all three measures of FD. In particular, a 1% increase in the levels of the domestic *EXRV* leads to a 0.08% decrease in FDI flows in the presence of the overall FD index, 0.09% in the presence of financial institutions, and 0.37% in the presence of financial markets. The significant adverse relationship supports the investment irreversibility theory (Akkina & Celibi, 2002; Dixit et al., 1994) and the risk-averse nature of many investors (Bénassy-Quéré et al., 2001). These theories predict that where macroeconomic uncertainty abounds, in this case, as captured by the domestic exchange rate, there will be a decrease in volumes of investments (FDI). Therefore, the volatility of the domestic exchange rate increases the risk borne by foreign investors as it leads to a decrease in projected returns on investments. The instability of the local currency affects the investment decision of MNEs by restraining further investments due to the rate of the unpredictability of the exchange rate between the local and foreign currencies. The volatility increases the anticipated cost of production and decreases the value of assets of MNEs.

The impact of volatility is much stronger in cases of profit repatriation by MNEs as much of the volatile domestic currency may be needed for a few of the foreign currencies. The overall effect is that the volatility of the domestic exchange rate automatically triggers “the option to wait” on future investments leading to the observed negative relationship between FDI and the domestic *EXRV*. Our results support earlier studies that have found domestic *EXRV* to discourage

TABLE 3 Foreign direct investments, exchange rate volatility, and financial development

Dependent variable	FDI (1)	FDI (2)	FDI (3)	FDI (4)	FDI (5)	FDI (6)
Constant	−3.368 (2.325)	−1.498 (0.854)	−1.974 (1.481)	−0.584 (1.839)	−0.858 (1.700)	−1.640 (2.715)
Lag FDI	0.091*** (0.042)	0.103** (0.046)	0.097** (0.037)	0.097** (0.036)	0.104*** (0.033)	0.070 (0.045)
Exchange rate volatility (ERV)	−0.083** (0.037)	−0.088** (0.043)	−0.369*** (0.114)	−0.107** (0.048)	−0.120** (0.048)	−0.277** (0.128)
Financial development index (FD)	1.392** (0.596)			1.256** (0.514)		
Financial institutions index (FIN)		1.031** (0.505)			1.125** (0.509)	
Financial market index (FMK)			2.744** (1.105)			−0.390* (0.218)
FD × ERV				0.129** (0.063)		
FIN × ERV					0.145** (0.071)	
FMK × ERV						0.249**
Exchange rate	0.066 (0.105)	0.150 (0.087)	0.001 (0.062)	0.043 (0.062)	0.010 (0.065)	0.109 (0.075)
Financial openness	0.006 (0.133)	0.020 (0.160)	0.169 (0.158)	0.072 (0.086)	0.081 (0.079)	0.083 (0.112)
Human resources	−0.324 (0.824)	−0.015 (0.715)	−0.133 (0.629)	−0.396 (0.590)	−0.284 (0.474)	−0.020 (0.964)
Natural resources	0.242*** (0.075)	0.202*** (0.062)	0.195*** (0.054)	−0.220*** (0.055)	0.198*** (0.052)	0.205*** (0.067)
Trade	0.758* (0.420)	0.770* (0.380)	0.785** (0.362)	0.829** (0.365)	0.750** (0.325)	0.910** (0.391)
Diagnostics						
Observations	751	755	779	755	755	722
Number of groups (n)	35	35	35	35	35	33
Number of instruments (i)	28	28	31	34	27	21
Instrument ratio (n/i)	1.25	1.25	1.13	1.03	1.30	1.57
Critical points				0.829	0.828	1.12
AR(1): p-value	0.008	0.009	0.0.02	0.007	0.006	0.006
AR(2): p-value	0.219	0.201	0.239	0.255	0.220	0.589
Hansen J: p-value	0.187	0.092	0.382	0.475	0.301	0.550
F	6.010	7.710	19.580	5.790	10.770	10.170
Probability > F	0.000	0.000	0.000	0.000	0.000	0.000

Notes: Values in parentheses represent Windmeijer (2005) robust standard corrected errors. FD × ERV is the interaction between the FD index and ERV. FIN × ERV is the interaction between financial institutions index and ERV. FMK × ERV is the interaction between the financial market index and ERV.

Abbreviation: FDI, foreign direct investment.

FDI inflows (Asamoah et al., 2016; Balaban et al., 2019; Cavallari & d'Addona, 2013; Dal Bianco & Loan, 2017; Jehan & Hamid, 2017). However, not all studies are in tandem with our results as it contradicts studies that have found no significant impact of exchange rate volatility on FDI inflows (Abbot et al., 2012; Chowdhury & Wheeler, 2015; Dhakal et al., 2010). It also differs from those studies that have found a positive impact of *EXRV* on FDI inflows (Bénassy-Quéré et al., 2001; Urata & Kawai, 2000).

Regarding the direct linkages between FDI and FD, our expectation was in line with Alfaro et al. (2004), that countries with developed financial markets benefit both directly and indirectly from the growth enhancement of FDI. From models 1 to 3, we observe a significant positive association between FDI and all FD indices. The significance of the positive relationship lies in the fact we employ a new indicator of FD not previously employed in the volatility–FDI nexus, especially in the context of Africa.

The positive correlation shows that foreign investors are willing to partake in the domestic market through borrowing from banks, undertaking insurance agreements, pensions, and generating capital from the domestic market. Developed financial markets provide liquidity to both domestic and foreign investors. This also helps foreign investors to borrow in the local currency and avoid issues of exchange rate uncertainty, where borrowed funds are denominated in foreign currency. Investors become confident that a developed financial market absorbs moral hazard issues, encourages savings and resource mobilization, and reduces borrowing costs. The overwhelming conclusion is that FD in terms of bank and stock market access, efficiency, and depth is a crucial decision foreign investors consider in their decision to invest overseas. Our results support the conclusion of Agbloyor et al. (2014) that advanced banking systems can attract more FDI inflows, while stock market development may also attract FDI inflows. Similarly, Jehan and Hamid (2017) found that the bank and private sector credit attract FDI flows. Though Soumaré and Tchana Tchana (2015) found bidirectional causality between FDI and financial market development, they contend the impact differs based on whether the analysis is focused on bank or stock market development. Further support is the studies of Ezeoha and Cattaneo (2012) on FDI flows to sub-Saharan Africa.

We turn to the indirect association between *EXRV* and FDI conditioned on the domestic financial sector. We interact each of the three FD indicators with exchange rate volatility and assess their combined impact on FDI flows. Based on our estimation results, we expected that conditioned on FD, the indirect impact of *EXRV* on FDI will be positive. Models 4–6 illustrate the results of our indirect analysis. Based on just the coefficient of the interactive terms, we observe a positive and significant relationship with FDI in all models. We can infer from the results that FD is vital in curtailing the potential adverse impact of *EXRV* on FDI flows. The results further suggest that curbing the exchange rate volatility damming impact on FDI is an increasing function of FD. Given the negative coefficient of volatilities and the subsequent positive coefficient of the interactive terms, we can confidently say that improving the level of FD will significantly reduce the adverse impact of exchange rate volatility on FDI flows. Therefore, one can allude that dealing with the impact of volatility on FDI can be attained at increasing levels of FD. Another plausible explanation is that as FD improves, there will be a gradual decline in the adverse impact of exchange rate volatility on the attraction and retention of FDI flows. It also holds that as the quality of FD declines or in the absence of FD, the increasing volatility of the exchange rate leads to a decrease in FDI volumes. We can allude from the coefficient of the interaction term that FD can mitigate the negative impact of exchange rate volatility on FDI flows. Practically, foreign investors can still invest in an environment of exchange rate uncertainty once the domestic financial market is developed. Therefore, it can be said that though instability of the domestic exchange rate may abound, with compliments from the financial sector, countries can still increase the volumes of FDI flows.

3.2.1 | Marginal effect analysis of the effect of exchange rate volatility on FDI at levels of FD

As Brambor et al. (2006) indicated on interaction models, it is impossible to determine if the independent variable impacts the dependent variable by merely focusing on the significance or otherwise of the coefficient of the interactive term. However, they contend that the effect of a change in the independent variable on the dependent variable relies on varying values of the conditional variable. Therefore, we determine the marginal effect of exchange rate uncertainty on FDI at diverse values of all three FD indices. In this case, the marginal effect will indicate the threshold value of FD that can neutralize the negative impact of exchange rate volatility on FDI. We conduct the marginal analysis at the 25th, 50th, mean, 75th,' and 90th percentiles of FD. We estimate the marginal analysis by applying Equation 12, where we evaluate the impact of exchange rate volatility on FDI flows. From Table 4, model A shows that the adverse impact on exchange volatility decreases as the overall FD index increases at the 1% significance level. As the level of FD increases by 1% from the 25th to the 90th percentiles, the negative effect of exchange rate volatility on FDI decreases from −0.096% to −0.073%. However, our observation shows the impact of the exchange rate on FDI remains negative even at the highest (90th) percentile of our FD index. We must, therefore, determine the critical point or threshold level of the FD that completely eradicates the adverse impact. To achieve that optimal point, we set Equation 12 to zero and make FD the subject.

Regarding the FD index, the critical point is ~0.829.[4] We can make two critical observations at this point. Given that the overall FD index ranges between 0 and 1, it suggests that there are periods in the development of the financial sector where the adverse impact of exchange rate volatility on FDI can be wholly eradicated. However, using the minimum (0) and maximum

TABLE 4 Marginal effects of exchange rate volatility on foreign direct investment at varying levels of financial development indicators

Model FD index @	A FDI	Model FIN index @	B FDI	Model FMK index @	C FDI
25th percentile (0.088)	−0.096*** (1.033)	25th percentile (0.161)	−0.097*** (0.822)	25th percentile (0.002)	−0.277*** (0.981)
50th percentile (0.133)	−0.092*** (1.046)	50th percentile (0.203)	−0.091** (0.844)	50th percentile (0.011)	−0.274 (0.983)
Mean value (0.142)	−0.089*** (1.060)	Mean value (0.234)	−0.086*** (0.859)	Mean value (0.048)	−0.265** (0.128)
75th percentile (0.161)	−0.086*** (1.070)	75th percentile (0.274)	−0.080*** (0.879)	75th percentile (0.041)	−0.266*** (0.989)
90th percentile (0.265)	−0.073*** (1.123)	90th percentile (0.411)	−0.060*** (0.948)	90th percentile (0.166)	−0.236** (0.989)

Notes: FD is the overall financial development index; FIN is the financial institutions index; FMK is the financial market index; FDI is foreign direct investment. Values in parentheses under FDI represent standard corrected errors. *, **, and *** denote significance levels at 1%, 5%, and 10%, respectively.

(0.627) values of our data,[5] the apparent analogue is that given the current state of Africa's FD, we can only infer that financial sector development minimizes the exchange rate volatility–FDI negative relationship but cannot eradicate the adverse impact. The same observation holds for models B and C of Table 4, where a substantial increase in the financial institutions and market indices leads to a decrease in the adverse impact of exchange rate volatility on FDI, at 1% and 5% significance levels, respectively. A 1% development in financial institutions from the 25th to the 90th percentile leads to a decrease in the adverse impact of *EXRV* on FDI from −0.097 to −0.060. However, the effect cannot be defused outrightly. The critical point for the financial institutions' index is ~0.828, which also lies within the ranges of the financial institutions' index but outside the ranges (0 and 0.738) of our data. Again, financial institutions' development regarding access, depth, and efficiency can reduce the exchange rate volatility–FDI antagonistic relationship only at the current state on institutions' development but not up to the point of complete eradication.

Regarding financial markets, we see marginal decreases in the adverse effect of exchange rate volatility on FDI flows from the 25th percentile (−0.277) to the 90th percentile (−0.236). The critical or tuning point regarding financial markets is 1.12, which falls outside the index values of 0 and 1. The critical value shows that it is not plausible for financial market development in Africa to eradicate the negative effect of exchange rate volatility on FDI at its current state, even though financial market development can marginally reduce the adverse effect. The results on financial markets only confirm the assertions by Svirydzenka (2016) that financial market development in Africa is fragile when compared to other regions in the world. For instance, while the average financial market development for America, much of Europe, Asia, and Australia was above 0.596, and much of South America ranged between 0.392 and 0.592, the average financial market development for Africa was less than 0.046 (Svirydzenka, 2016). The observation is that financial institutions' development can better neutralize the adverse impact of volatility faster than financial markets and the overall development index. Thus, the slow growth of FD in Africa is a function of the weak, inactive, ill-liquid, and inefficiency of most stock markets on the continent.

4 | CONCLUSIONS AND POLICY RECOMMENDATIONS

The study aimed to determine the linear and nonlinear impact of exchange rate uncertainty on FDI in Africa and whether FD moderates such association. From the linear system GMM estimation, we found evidence that countries with unstable exchange rates are often associated with low FDI inflows. The result from the quadratic analysis shows evidence of a nonlinear relationship between exchange rate volatility and FDI and that there exists a U-shaped relationship between the two. The nonlinear relationship confirms that both theories of investment irreversibility and reversibility have dominant influences on FDI flows. While the former dominates at lower levels of volatility, the latter dominates at higher levels of uncertainty. This implies that although countries may be affected by decreases in FDI flows to initial volatility beyond the point of inflection, increases in uncertainty boost investments due to higher anticipated returns. The results further show that previously mixed findings on the exchange rate volatility–FDI nexus could result from the inadvertent failure to determine a nonlinear association. We further ascertain that in as much as exchange rate volatility significantly decreases FDI flows, countries with strong FD can attract high inflows of FDI as the adverse impact of volatility on FDI will be nullified in the robust financial sector. From the marginal effect analysis, we show that increasing the levels of FD, be it the overall sector, financial institutions, or financial markets, will mitigate the adverse effect of exchange rate uncertainty on FDI flows, with the most significant impact from financial institutions' development.

The findings of the study provide several policy directions. First is the call for methods to stabilize the exchange rate of most economies in Africa. Issues of exchange rate misalignment are a fundamental problem because of the underlying economic regimes of many African countries, such as import dependence and the dollarization of many economies. Efficient management of the economy is critical. It will improve the general economic fundamentals, reduce economic agents' willingness to hedge their wealth in foreign currency, lead to a halt in the scramble for foreign currency, and curb the volatility associated with the domestic exchange rate. Clear-cut policies regarding the use and demand of a foreign currency in the domestic retail environment should be firm in dwarfing the appetite for foreign currency in the domestic space. Growth in manufacturing and industries will reduce the dependence on foreign goods; reduce imports and the scramble for foreign currency; and, ultimately, reduce fluctuations in the exchange rate. Governments should focus on the growth of local industries or encourage foreign entities to establish production plants within. Policies aimed at the stabilization of the exchange rate should be in sync with the overall development of the financial sector. Strengthening financial institutions is a quicker method of curbing the volatilities associated with FDI inflows than the financial market channel. The development of the banking sector can drive the overall development of the financial sector in eradicating volatilities associated with capital flows. Further studies could focus on other forms of capital flows such as portfolio equity and private and public debt flows, as well as other macroeconomic variables such as growth, inflation, and interest rate uncertainty. Regarding nonlinearity, further studies can also consider the application of the sample splitting method, as well as dynamic thresholds that deal with endogeneity.

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CONFLICT OF INTEREST

There are no issues of conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available in the supplementary material of this article.

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ENDNOTES

[1] These countries are Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cape Verde, Cameroun CAR, Chad, Congo DR., Congo Republic, Côte d'Ivoire, Egypt, Equatorial Guinea, Ethiopia, Gabon, Gambia, Ghana, Guinea-Bissau, Kenya, Lesotho, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Niger, Nigeria, Rwanda, Senegal, Seychelles, South Africa, Sudan, Tanzania, Togo, Tunisia, Uganda, Zambia.

[2] According to Chinn and Ito (2008), the index ranges between −2.6 (very closed financially) and 2.6 (very open financially).

[3] Brambor et al. (2006) and Nier et al. (2014).

[4] $\beta_1 + \beta_5 FD = 0; FD = \frac{\widehat{\beta_1}}{\widehat{\beta_5}} = 0.107/0.129 = 0.829.$

[5] Per the summary statistics (see Table A1), the minimum and maximum values are FD index [0, 0.627], financial institutions [0, 0.738], and financial markets [0, 0.586].

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APPENDIX

TABLE A1 Summary statistics

Variable	Mean	Median	Standard deviation	Coefficient of variance	Minimum	Maximum	*N*
Foreign direct investment	3.605	1.996	8.052	2.234	−8.589	161.824	1,119
Real exchange rate	5.324	6.153	2.255	0.424	0.432	14.610	1,143
Exchange rate volatility	4.130	4.268	1.523	0.369	−9.605	8.777	1,076
Financial development index	0.142	0.113	0.095	0.669	0	0.627	1,120
Financial institutions index	0.234	0.203	0.121	0.517	0	0.738	1,120
Financial market index	0.048	0.011	0.090	1.85	0	0.586	1,120
Financial openness	−0.648	−1.210	1.177	−1.816	−1.917	2.347	1,111
Human capital	1.693	1.614	0.410	0.242	1.030	2.885	980
Natural resources	12.531	8.750	12.136	0.968	0.001	84.240	1,116
Trade openness	67.801	59.643	32.338	0.477	11.087	225.023	1,073