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Article

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Is the effect of exchange rate volatility on export diversification symmetric or asymmetric? Evidence from Ghana

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Abstract: Exchange rate volatility has been identified as one of the drivers of export diversification. Previous studies have assumed a symmetric relationship between the two variables. However, because volatility could be positive or negative and economic agents react to these changes differently, recent studies argue for the adoption of an asymmetric approach to the study of the relationship between the two variables. This study employed the partial sum process to create two variables to replace exchange rate volatility (Positive and negative variables) and utilized the Linear Autoregressive Distributed Lag (ARDL) and Nonlinear Autoregressive Distributed Lag (NARDL) techniques to investigate asymmetric effects of exchange rate volatility on export diversification in Ghana for the period 1983 to 2015. The results indicate that exchange rate volatility has asymmetric relationship with export diversification in Ghana. The study revealed that other drivers of export diversification in Ghana are income, investment, infrastructure, openness, and inflation. The paper recommends that the Central Bank should strengthen its efforts at stabilizing the exchange value of the cedi.

Subjects: Economics and Development; Economics; Finance

Keywords: export diversification; symmetric; asymmetric; linear autoregressive distributed lag; nonlinear autoregressive distributed lag; Ghana

ABOUT THE AUTHOR

Camara Kwasi Obeng obtained his PhD in Economics from the University of Cape Coast, Ghana, in 2010 where he has taught since 2001. He was a Global Academic Partnership (GAP) scholar at the University of South Florida, USA in 2010 and AERC/IMF visiting Scholar at the IMF, Washington DC, USA in 2007. His research interests are international trade and finance, fiscal policy reforms, and poverty studies. This research output is derived from a current research that seeks to investigate the effects of export diversification on poverty in Ghana. He has published a number of papers in referred journals and in books. He is an active member of the African Economic Research Consortium (AERC), Kenya, the African Econometrics Society, South Africa, the Poverty and Economic Policy (PEP) Network, Canada, the Global Economic Modeling (ECOMOD) Network, USA and the International Input–Output Association, Austria.

PUBLIC INTEREST STATEMENT

Adding value to exports or increasing export base (export diversification) has long been established as a sure way to stabilizing the export earnings of developing economies for economic growth and development. Exchange rate variation has been identified as one of the determinants of export diversification, but the relationship has always been treated as linear. However, recent studies have proved that the relationship between exchange rate variation and other variables is non-linear. This study, therefore, uses Ghana data on export diversification and exchange rate variation to test this hypothesis. The analysis was done by disaggregating the exchange rate variation into positive variations and negative variations and regressed them on export diversification. The results showed that the effect of exchange rate variation on export diversification is not linear. The implication of the results is that the central bank must allow depreciation of the local currency to encourage export diversification in Ghana.

1. Introduction

The international community and governments of developing countries, especially the commodity-dependent ones, have for a long time identified export diversification as the way to mitigate the vulnerability of these countries to international commodity price volatility and promote economic growth and development. The need for export diversification has become more pertinent now than before, following the recent slump in international prices of major commodities, which has reversed the macroeconomic gains achieved by most of these countries over the years (Agur, 2016; IMF, 2015). Export diversification involves introducing new commodities, adding value to existing ones and notching new markets for export.

It is well documented in the trade literature that exporters react to the movements in exchange rate differently due to differences in their risk attitudes (De Grauwe, 1988). However, earlier studies (Kamuganga, 2012; Rose, 2000) assumed only a linear relationship between export diversification and exchange rate volatility. The picture that emerges from these studies is that both depreciation and appreciation affect export diversification by the same magnitude. In line with De Grauwe (1988), recent studies such as Bahmani-Oskooee and Fariditavana (2014, 2015), Bahmani-Oskooee and Mohammadian (2016), Bahmani-Oskooee, Halicioglu, and Hegerty (2016) have questioned the appropriateness of the symmetric assumption. Intuitively, in a floating exchange rate regime, the exchange rate either depreciates or appreciates. When the local currency depreciates against that of the rest of the world, exports become competitive through reduced export prices. This offers incentives for export diversification. Conversely, appreciation in local currency renders exports uncompetitive thereby discouraging export diversification.

A number of studies have identified domestic investment, per capital income, governance, openness, conflict, inflation, fiscal balance, infrastructure, real exchange rate, exchange rate volatility, terms of trade, share of mining in output, population, human capital, gender inequality, foreign direct investment, and financial development, as the drivers of export diversification (Arawomo, Oyelade, & Tella, 2014; ECA & AU, 2007; IMF, 2014b; Iwamoto & Nabeshima, 2012; Kamuganga, 2012; Kazandjian, Kolovich, Kochhar, & Newiak, M., 2016; Kugler, 2006; Tadesse & Shukralla, 2011). However, none of these paid attention to the case of Ghana. Particularly, the link and the nature of the link between exchange rate volatility and export diversification in Ghana is not clearly known.

This study, therefore, contributes to the extant literature by investigating whether or not exchange rate volatility has symmetric or asymmetric effect on export diversification in Ghana. The paper specifically answers two questions: first, does exchange rate volatility have a symmetric or asymmetric effect on export diversification? Second, what are the other drivers of export diversification in Ghana?

Ghana presents an interesting case study particularly because the issue of exchange rate and the diversification of the export base through non-traditional export promotion was a major component of the IMF and World support economic reform program that was carried out in the early 1980s. The exchange rate was transformed from a fixed regime through auction to currently a managed-floating regime. In addition, diversification of the export base was vigorously pursued with the introduction of a wide range of non-traditional exports. International competiveness improved as a result, providing leverage for exporters of non-traditional exports to expand exports (Jebuni, Oduro, Asante, & Tsikata, 1992). Total exports have since increased consistently from an average of US$829.8 m in 1983–1987 to US$12442 m in 2013–2015. However, the traditional subsector continues to be highest foreign exchange earner. It is estimated that about 70% of all exports earnings are derived from traditional exports of cocoa beans, timber, and gold while non-traditional exports contribute between 15% and 25% per annum (Ministry of Trade & Industry, 2012). The narrow base of exports coupled with fluctuations in their prices has led to instability in export earnings, and macroeconomic volatility. Interestingly, no study has been carried out to investigate the state of export diversification and what factors drive such diversification for Ghana.

The rest of the paper is organized as follows: In Section 2, the methodology is discussed. The results and discussion are presented in Section 3. In Section 4 the summary, conclusions, and recommendations are presented.

2. Methodology

Following the literature, export diversification is expressed as:

$$dindex_t = \beta_0 + \beta_1 lGdpc_t + \beta_2 lGfc_t + \beta_3 Inf_t + \beta_4 Tel_t + \beta_5 Exvol_t + \beta_6 Open_t + v_t \quad (1)$$

where $dindex_t$ represents the export diversification index for Ghana. It was estimated using a modified Normalized-Hirschman index (N-H) and data on export shares for Ghana obtained from SITC 4-digit level. Modification was done to the normalized-Hirschman index by multiplying it by 100. The closer the value is to 100, the higher the level of export concentration. Otherwise, export concentration is low. The index was subtracted from 100 to give us the level of export diversification. The higher the value, the higher the level of export diversification, and the lower the value, the lower the level of export diversification (Arawomo et al., 2014); *l* is log operator; *lGdpc* is log of GDP per capita, a proxy for the level of development, and the market size of the country. It is expected that GDP per capita will have a positive effect on *dindex* because an increase (decrease) in GDP per capita will lead to a rise (fall) in the demand and production of a large number of commodities including exports. *lGfc* is log of gross fixed capital formation, a proxy for investment. It is expected that a rise (fall) of investment will result in an expansion (contraction) in export diversification. *Inf* is inflation *Inf*rate, a proxy for macroeconomic instability. The expectation is that a stable macroeconomic environment will stimulate growth and export diversification. An unstable macroeconomic environment, on the other hand, discourages export diversification. *Tel* stands for the number of telephone lines per 1,000 persons is represented by *Tel,* and it is a proxy for infrastructure. Expectations are that increase in infrastructure, will increase the level of export diversification and reduction in infrastructure will decrease the level of export diversification (Kamuganga, 2012). The variable *Exvol* is the measure of real effective exchange rate volatility. It was generated using GARCH (1, 1). It is the measure of the uncertainty and hence the risk associated with exchange rate variation and its effect on export diversification depends on the extent of risk aversion of exporters. A reduction or negative change in the real effective exchange rate reflects depreciation and hence increase in the profitability of exports, so it is expected to increase export diversification. An increase or a positive change represents appreciation and hence the non-profitability of exports and so, will lead to a decline in export diversification. Integration into the world economy is captured by openness (*Open*). Integration into the world economy opens up new markets and opportunities (IMF, 2017) and so, it is expected that more openness will encourage export diversification while less openness leads to lower level of export diversification.

2.1. Estimation strategy

The study employed the linear and nonlinear autoregressive distributed lag (ARDL) and (NARDL) estimation techniques because of two main reasons: first, the data points used for the study is short. In particular, the data points are 33 and since ARDL has been proven to be efficient when data-set is short, it was employed in this study. Secondly and more important, the NARDL was deemed to be the appropriate methodology to investigate the symmetric and asymmetric effects of exchange rate volatility on export diversification in Ghana. In implementing the strategy, the study assessed the stationarity properties of the variables using the unit root tests, ADF, and PP. The results indicated that the variables were a mixture of I(0) and I(1), justifying the use of the ARDL approach (see Appendix 3). The test for cointegration using the bounds test of Pesaran, Shin, and Smith (2001) revealed that the variables were cointegrated (Refer to Appendix 4). The long run and short run equations were specified and estimated using OLS.

2.2. Long-run and short-run error correction models

The short run and long run results were obtained from estimating Equation (2).

$$\begin{aligned}\Delta dindex = {} & \beta_0 + \beta_1 dindex_{t-1} + \beta_2 lGdpc_{t-1} + \beta_3 lGfc_{t-1} + \beta_4 Inf_{t-1} + \beta_5 Tel_{t-1} + \beta_6 Exvol_{t-1} \\ & + \beta_7 Open_{t-1} + \sum_{i=0}^{\rho} \theta_{1i} \Delta dindex_{t-i} + \sum_{i=0}^{\rho} \theta_{2i} \Delta lGdpc_{t-i} + \sum_{i=0}^{\rho} \theta_{3i} \Delta lGfc_{t-i} \\ & + \sum_{i=0}^{\rho} \theta_{4i} \Delta Inf_{t-i} + \sum_{i=0}^{\rho} \theta_{5i} \Delta Tel_{t-i} + \sum_{i=0}^{\rho} \theta_{6i} \Delta Exvol_{t-i} + \sum_{i=0}^{\rho} \theta_{7i} \Delta Open_{t-i} + \varepsilon_t\end{aligned} \tag{2}$$

where p = optimal lags selection based on the AIC, SBC, and HQC criteria, Δ is the difference operator, and i = 0, 1,2, ...

To investigate the main objective of the study, that is, whether real effective exchange rate volatility has symmetric or asymmetric effects on export diversification in Ghana, the study followed Bahmani-Oskooee and Fariditavana (2015). *Exvol* was decomposed into positive changes and negative changes. Two variables, *ExPos* and *ExNeg*, were therefore created using the partial sum process suggested by Shin, Yu, and Greenwood-Nimmo (2014) as follows:

$$Exvol_t = Exvol_0 + Exvol_t^+ + Exvol_t^- \tag{3}$$

where $Exvol_t^+$ and $Exvol_t^-$ are the partial sum process of positive and negative changes in *Exvol*. *ExPos* and *ExNeg* were then obtained as follows:

$$ExPos = Exvol_t^+ = \sum_{t=1}^{\rho} \Delta Exvol_t^+ = \sum_{t=1}^{\rho} \max(\Delta Exvol_t, 0) \tag{4}$$

$$ExNeg = Exvol_t^- = \sum_{t=1}^{\rho} \Delta Exvol_t^- = \sum_{t=1}^{\rho} \min(\Delta Exvol_t, 0) \tag{5}$$

Exvol in Equation (2) was replaced with *ExPos* and *ExNeg* to obtain the nonlinear ARDL model 6.

$$\begin{aligned}dindex_t = {} & \beta_0 + \beta_1 dindex_{t-1} + \beta_2 lGdpc_{t-1} + \beta_3 lGfc_{t-1} + \beta_4 Inf_{t-1} + \beta_5 Tel_{t-1} + \beta_6 ExPos_{t-1} + \beta_7 ExNeg_{t-1} \\ & + \beta_8 Open_{t-1} \sum_{i=0}^{\rho} \theta_{1i} \Delta dindex_{t-i} + \sum_{i=0}^{\rho} \theta_{2i} \Delta lGdpc_{t-i} + \sum_{i=0}^{\rho} \theta_{3i} \Delta lGfc_{t-i} \\ & + \sum_{i=0}^{\rho} \theta_{4i} \Delta Inf_{t-i} + \sum_{i=0}^{\rho} \theta_{5i} \Delta Tel_{t-i} + \sum_{i=0}^{\rho} \theta_{6i} \Delta ExPos_{t-i} + \sum_{i=0}^{\rho} \theta_{7i} \Delta ExNeg_{t-i} + \sum_{i=0}^{\rho} \theta_{8i} \Delta Open_{t-i} + \varepsilon_t\end{aligned} \tag{6}$$

Equation (6) was estimated using the same procedure Pesaran et al. (2001) suggested for the estimation of linear ARDL models. The coefficients and signs of *ExPos* and *ExNeg* provided clues as to whether real effective exchange rate volatility, *Exvol*, has symmetric or asymmetric relationship with export diversification, *dindex*. When the signs and coefficients of the two newly created variables are different, exchange rate volatility has asymmetric effect on export diversification. Alternatively, if they are found to be the same, then the relationship between exchange rate volatility and export diversification is symmetric.

2.3. Data type and sources

The study employed annual data for the period 1984 to 2015. The data used for the study are export diversification index as the dependent variable, the explanatory variables are real effective exchange rate volatility, gross fixed capital formation, GDP per capita, inflation, tel (proxy for infrastructure), and openness. The export diversification index was calculated using data obtained from

the Standard International Trade Classification (SITC) 4-digit level and equation in Appendix 1. The outcomes of Equation (4) provided export concentration index. Subtracting the concentration index from 100, we obtained export diversification index. The real effective exchange rate volatility was generated using (GARCH (1, 1)) equation in Appendix 2. The remaining data, that is, GDP per capita, gross fixed capital formation, inflation, openness, and tel were sourced from World Bank (2016).

3. Results and discussion

The long run and short run results are discussed in this section.

3.1. Long-run estimation results for Export Diversification (Linear ARDL)

The presence of cointegration among the variables led to estimation of the long run relationship among the variables of interest for both the linear ARDL and nonlinear ARDL. The results are captured in Table 1.

The results from Table 1 indicate that the coefficient of the variable of interest, real effective rate volatility (Exvol) is significant at five percent and it has the expected sign. Specifically, a one percent increase in real effective exchange rate volatility will cause a decrease of 0.07 percent in export diversification in Ghana. The effect of exchange rate volatility on export diversification in Ghana can be explained to mean that because exchange rate volatility introduces risk and exporters are unsure of how much they will earn from exports, they will divert more of their produce to the domestic market when the exchange rate of the local currency gets volatile. This is particularly the case during periods of exchange rate appreciation. The result obtained confirms the finding of Kamuganga (2012), Berthou and Fontagne (2008), Alvarez, Doyle, and Lopez (2009) and Hericourt and Poncet (2013) and Goya (2014) who found that real effective rate volatility negatively affected export diversification. It is however, contrary to the finding of Agosin, Alvarez, and Bravo-Ortega (2009) who found exchange rate volatility to have insignificant effect on export diversification for a large number of countries.

Table 1. Long run results for export diversification

Variable	Linear ARDL model	Nonlinear ARDL model
LGDPca	0.035003**	0.059549*
	(0.014863)	(0.018442)
LGFC	0.126228**	0.130281**
	(0.054488)	(0.063047)
Tel	0.125056**	0.126675***
	(0.061934)	(0.070905)
ExVol	−0.068557**	–
	(0.026729)	
ExPos	–	−0.050065**
		(0.021970)
ExNeg	–	0.047353***
		(0.013701)
INF	−0.011287***	−0.011570***
	(0.001749)	(0.001840)
OPEN	0.003602*	0.013497***
	(0.001784)	(0.002700)
C	0.739595	0.171233

Source: Author's own computation using EVIEWS version 9.

Note: Figures in brackets are standard errors.

*Represent significance at 10%.

**Represent significance at 5%.

***Represent significance at 1%.

Other variables whose coefficients were found to be significant include GDP per capita (*LGDPca*), a proxy for income level or level of development. The expectation was that an increase in income should lead to the production of diversified exports. The result is in line with the findings of Imbs and Wacziarg (2003), Hammouda, Karingi, Njuguna, and Sadni-Jallab (2006) and Elhiraika and Mbate (2014). Specifically, the results show that a percentage increase in per capita income causes export diversification to increase by 0.04 percent. The coefficient of Gross fixed capital formation (LGFC), a proxy for investment, is also significant at the 5 percent level of significance. This means that increase in investment will lead to the production of more diversified exports. The result supports the finding of Hammouda et al. (2006). The coefficient of Infrastructure (Tel) is significant at the 5 percent level of significant and it carries the expected sign. This result is also in line with the findings of Hammouda et al. (2006) and Elhiraika and Mbate (2014). Inflation, a measure of macroeconomic instability does not favor export diversification in Ghana. In particular, a percentage rise in inflation leads to 0.01 percent fall in the export diversification index for Ghana. The negative effect of inflation on export diversification can be explained to mean that an increase in the former will make exports uncompetitive and therefore, discourage export diversification in Ghana. The result validates that of IMF (2017). Finally, openness increases export diversification in Ghana. This finding corroborates the finding of Agosin et al. (2009).

3.2. Short-run estimation results for export diversification

The results of the short run drivers of export diversification in Ghana are presented in Table 2. The appropriate lag length as determined by the Schwarz Bayesian Criterion (SBC) was two.

The results, as presented in Table 2, reveal that the short run drivers of export diversification are exchange rate volatility, GDP per capita, investment, infrastructure, inflation, and openness. Specifically, GDP per capital (GDPca), investment (GFC), infrastructure (TEL), and openness (OPEN) favor export diversification in Ghana in the short run at various levels of significance. However, exchange rate volatility (Exvol) and inflation (INF) depress effort at export diversification in Ghana at the 10 percent and 5 percent levels of significance, respectively. Finally, the error term, that shows how long it takes for the system to revert to equilibrium when disturbed, is negative and significant at the 1 percent significance level. The result indicates that about 75 percent of the deviation from short run equilibrium is corrected in a year.

3.3. Diagnostics test results

Serial correlation, heteroskedasticity, normality, and functional form tests were carried out to ensure that the model and estimates were cleared of any econometric problems, and the results are presented in Table 3.

Table 3 indicates that the model passes all the post estimation tests. In particular, the Breusch–Godfrey Serial Correlation LM test reveals the absence of serial correlation among the variables, as the *F*-statistic of 0.825585 was not statistically significant per the *p*-value of 0.4569. The Breusch–Pagan–Godfrey test for Heteroskedasticity also reported a statistically insignificant *F*-statistics of 1.469171 with a *p*-value of 0.2279, thus indicating the absence of heteroskedasticity among the error terms. The Ramsey-RESET stability test for the correct functional form of the model shows that the model was correctly specified since the *F*-statistics of 1.312920 was insignificant, with a *p*-value of 0.8041. Finally, based on Jacque–Bera normality test, the study found evidence that the series in the model are normally distributed, as the *F*-statistics of 0.435987 was insignificant given a *p*-value of 0.8041. The CUSUM and CUSUMSQ tests reveal that the model is stable.

Table 2. Short run results for export diversification

Variable	Linear ARDL model	Non-Linear ARDL (model)
D(LGDPca)	0.142205**	0.113763**
	(0.069138)	(0.045852)
D(LGDPca(-1))	0.252310***	–
	(0.057661)	
D(LGFC)	0.113417***	0.115675***
	(0.037067)	(0.035245)
D(LGFC(-1))	–	0.165632***
		(0.030508)
D(TEL)	0.092388***	0.088900***
	(0.028239)	(0.025306)
D(ExVol)	−0.011695*	–
	(0.006417)	
D(ExVol(-1)	−0.022531	–
	(0.000588)	
D(ExPos)	–	−0.033028***
		(0.006322)
D(ExNeg)	–	0.014754***
		(0.003940)
D(ExNeg(-1))	–	0.011488***
		(0.004170)
D(INF)	−0.001541**	−0.001318**
	(0.000588)	(0.000539)
D(OPEN)	0.003049***	0.001001
	(0.000974)	(0.000720)
D(OPEN(-1))	–	0.002166***
		(0.000717)
Ecm(-1)	−0.749822***	−0.552692***
	(0.107658)	(0.097200)

Note: Figures in brackets are standard errors.

Source: Author's own computation using EVIEWS version 9.

*Represent significance at 10%.

**Represent significance at 5%.

***Represent significance at 1%.

Table 3. Diagnostic test results

Test	Linear ARDL model		Non-linear ARDL model	
	F-statistic	*p*-value	*F*-statistic	*p*-value
Serial correlation	0.825585	0.4569	0.737009	0.4975
Heteroskedasticity	1.469171	0.2279	0.509019	0.8966
Normality	0.435987	0.8041	1.293267	0.5238
Functional form	1.31920	0.2687	2.593605	0.1128
CUSUM	–	Stable	–	Stable
SUSUMSQ	–	Stable	–	Stable

Source: Author's computation using EVIEWS version 9.

3.4. Non-linear ARDL results

The results presented so far are based on the linear ARDL approach on the assumption that the variable of interest, exchange rate volatility relates to export diversification in linear manner. Following Bahmani-Oskooee and Fariditavana (2015) the nonlinear Equation (5) was estimated, employing the same estimation technique used for the linear ARDL.

The results are presented in Tables 1 and 2 (Nonlinear Model).The variables of interest, ExPos, and ExNeg, suggest the presence of asymmetry in the relationship between exchange rate volatility and export diversification in Ghana because their coefficients are different with different levels of significance. Specifically, in the short run, a one percent depreciation of the local currency, cedi, leads to 0.015 percent increase in export diversification. On the other hand, a one percent rise in the depreciation of the cedi results in 0.050 percent increase in export diversification in the long. In the case of appreciation, the results in Tables 1 and 2, indicate that it has a reducing effect on export diversification in both the short run and in the long run. The result is in line with the assertion that the relationship between exchange rate changes and macroeconomic variables is asymmetric (Bahmani-Oskooee & Fariditavana, 2014, 2015; Bahmani-Oskooee & Mohammadian, 2016; Bahmani-Oskooee et al., 2016).

The other drivers of export diversification from the nonlinear ARDDL model are GDP per capita, investment, infrastructure, inflation, and openness. In particular, while GDP per capita, investment, infrastructure and openness favor export diversification, inflation depresses it. The coefficient of the error correcting term is also significant and finally, the nonlinear model passes all the post-estimation tests as shown in Table 3.

4. Conclusions and recommendations

The debilitating effect of fluctuations in international commodity prices is a pointer to the fact that commodity-dependent economies need to diversify their export base. Ghana's strategy to diversifying her export base has been the promotion of non-traditional exports. One of the policies designed in pursuit of this objective, floating exchange, has introduced a huge exchange rate risk that could discourage export diversification. However, no quantitative study has been done in Ghana to determine whether exchange rate volatility has symmetric or asymmetric relationship with export diversification and investigate the other drivers of export diversification in Ghana. This study, therefore, employed both ARDL and NARDL estimation techniques to investigate the short run and long run effects of exchange rate volatility on export diversification in Ghana for the period 1984 to 2015.

The results indicate that exchange rate volatility has asymmetric effect on export diversification in Ghana. In particular, while exchange rate depreciation encourages export diversification, exchange rate appreciation discourages it. The results further indicate that the other drivers of export diversification are GDP per capita, investment, infrastructure, inflation, and openness.

To aid policy, the study recommends that the Bank of Ghana should stabilize the exchange rate between the cedi and major world currencies, and keep inflation in check in order to promote export diversification in Ghana. There is also the need for government to provide more social, economic, and trade-related infrastructure to promote export diversification.

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Appendices

Appendix 1.

$$N - H_1 = \left| \left(\frac{\sqrt{\sum_i^N P_i^2} - \sqrt{\frac{1}{N}}}{1 - \sqrt{\frac{1}{N}}} \right) * 100 \right|$$

Appendix 2.

$$\Delta(lexrate) = \delta + \lambda \Delta(lexrate)_{t-1} + \psi_t$$

$$\psi \approx N(0, \Omega_t)$$

$$\Omega_t = \delta_2 + \psi_{t-1}^2 + \Omega_{t-1}$$

Appendix 3.

Table 3A. Unit root tests at levels

	Augmented Dickey–Fuller test		Philips–Perron test		Order of cointegration
Variable	**Trend & intercept**	**Intercept**	**Trend & intercept**	**Intercept**	
Dindex	−4.354876	−4.281417	−4.360114	−4.426270	I(0)
LGDPca	−3.892590	−0.046551	−1.751856	−0.261951	
LGFC	−2.427059	−2.869530	−2.396374	−2.871499	
Inf	−3.970342	−3.568561	−3.909136	−3.637215	I(0)
Open	−2.535438	−1.664484	−2.402363	−1.225187	
Tel	−5.198127	−5.276934	−5.198521	−5.281354	

Source: Author's own computation

Table 3B. Unit root tests at first difference

Variable	Augmented Dickey–Fuller test		Philips–Perron test		Order of cointegration
	Intercept	**Trend & intercept**	**Intercept**	**Trend & intercept**	
Dindex	−7.580797	−7.458174	−7.580787	−7.458174	
LGDPca	−4.030291	−1.915286	−3.980966	−3.830023	I(1)
LGFC	−5.417768	−5.469206	−5.440071	−5.520604	I(1)
Inf	−5.029325	−4.901858	−14.30383	−15.52766	
Open	−5.138347	−5.037602	−8.340196	−8.131603	I(1)
Tel	−5.214051	−8.492758	−7.054467	−7.012026	I(1)
Exvol	−8.611608	−8.437094	−14.02546	−19.43890	

Source: Author's own computation using EVIEWS version 9Appendix 4.

Table 4A. Linear ARDL bounds test

Significance	Lower bound	Upper bound
10%	1.99	2.94
5%	2.27	3.28
2.5%	2.55	3.61
1%	2.88	3.99
Test statistic	Value	*k*
F-statistic	3.60	6

Source: Author's own computation using EVIEWS version 9

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