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Exchange-rate volatility and international trade performance: Evidence from 12 African countries

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ABSTRACT

In this paper, we study a sample of twelve African countries to examine the impact of the real exchange-rate volatility on their trade flows. In order to distinguish the distinct impact of the real exchange-rate volatility on their exports and imports, both in the short-run and long-run, we use the bounds-testing approach. We find that while exchange rate volatility affects trade flows of many of the countries in our sample in the short run, the long-run effects were restricted only on the exports of five countries and on the imports of only one country. The level of economic activity in the world and at home were identified to be major determinants of exports and imports, respectively.

1. Introduction

The effect of real exchange-rate volatility on trade flows has become a major source of concern for policymakers and academics alike since the fall of the Breton Woods agreement in 1973. The degree of such concern is more pronounced, especially in countries with relatively low levels of financial development.[2] In the case of African countries that in recent years have shown a glimmer of hope in their growth strategies to transform their economies into a sustainable development, the instability of exchange-rate problem could grow into a more ominous issue for their quest of achieving that objective.

Taking into consideration that the primary source of growth in most African countries has been the sharp rise in the volume of international trade, steered largely by the surging demand for raw materials and higher commodity prices, studying the significance of the relationship between economic performance and exchange-rate volatility is very timely and important for these countries. It is also noteworthy to realize as these countries embark on achieving a steady economic growth, they would more than likely engage in the liberalization of capital flows and cross-border financial transactions, hence, confronting increased exchange-rate movements. On the other hand, the instability of exchange-rate may instigate uncertainty among profit-maximizing traders and curtail the level of their engagement in the export and import sectors, thus leading to a diminished volume of trade and weakened economic growth. While such anticipation is a case for concern, the theoretical

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1 Valuable comments of two anonymous referees are greatly appreciated. Any remaining error, however, is our own.

2 Further current studies have shown that less developed countries are substantially more negatively harmed than advanced countries by the impact of real exchange-rate volatility on trade and the growth of macroeconomic variables. For further insights on the theory and empirical evidence supporting the argument that the effect of real exchange-rate depends on a country's level of development, see Grier and Smallwood (2007) and Aghion et al. (2009) among others.

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literature on the exchange-rate volatility and its effect on trade flows suggests the existence of either a positive or negative outcome. If the uncertainty that is caused by the increased exchange-rate fluctuation induces traders to augment their trade volume in order to offset any anticipated decrease in future revenue, international trade may actually rise. Thus, the two effects of increased exchange-rate volatility on international trade flows can only be established by empirical scrutiny.

In this paper, we investigate these effects of increased exchange-rate volatility on international export and import flows using time series data from twelve African countries for which data are available spanning the early years of 1970s to the present period of 2014 or 2015 for most of these countries. The debate about the exchange-rate instability and how it affects international trade has overlooked the case of African countries thus far. The reason for such omission may have been due to the lack of data, especially their real effective exchange rates that are used to measure volatility. In this study, we use the real effective exchange-rate that we have constructed to expand on some sparsely existing data for these African countries to address the problem.

The remainder of this paper is organized as follows. First, in Section 2 we present a brief overview of the theoretical and empirical literature which is followed by the models and the methodology in Section 3. We then report the results in Section 4 and provide a summary and conclusion in Section 5. Finally, the definition of variables and data sources are provided in the Appendix.

2. A brief overview of the literature

The central controversy of the impact of exchange-rate volatility on trade flows rests on how exactly to predict the behavior of traders. From one point of view, traders with risk-averse behavior respond pessimistically to unanticipated change in exchange-rate such that total output and trade flows would be reduced as a result. For example, Ethier (1973) maintains that risk-averse traders operate in the environment of exchange-rate uncertainty under the floating exchange regime. By incorporating uncertainty into the foreign exchange rate market, he validated the assertion of the adverse impact of exchange-rate volatility on international trade. Clark (1973), Hooper and Kohlhagen (1978) and Gagnon (1993) also have supported the argument that volatility will reduce the volume of trade.

Traders' negative reaction to uncertainty in the exchange-rate market has been disputed by other studies, however. The argument conjectures the prospect of traders with a profit maximizing motive to be more preserving and would increase their trade volume in order to offset any decrease in future revenue resulting from exchange-rate instability. The idea that uncertainty could also boost trade flows has been put forth by several authors including by Frank (1991), Viaene et al. (1992), Sercu (1992), Dellas and Zilberfarb (1993) and Broll and Eckwert (1999).

Other studies point to the inconclusive empirical result regarding the impact of exchange-rate volatility on trade volume as traders tend to respond to unlike the source of risk or volatility in a different way. For instance, Willett (1986) pays attention to the different risk behavior between international and domestic risk effects, which at the aggregate level may not be predictable. Similarly, Barkoulas et al. (2002), conclude that the impact of exchange-rate volatility on international trade is ambiguous due to the countervailing effects of different sources of volatility.

The work of Aghion et al. (2009), and Grier and Smallwood (2007), among others, offers a fourth line of empirical study validating the proposition that the exchange rate volatility impact on real macroeconomic variables has quite different results depending on whether countries are considered developed or less developed. More specifically, they have shown that in countries with relatively low levels of financial development, the exchange rate volatility reduces growth significantly. In contrast, in financially advanced countries, the exchange rate volatility has no effect. In spite of such findings, other studies show a positive relationship between exchange-rate volatility and trade flows in less developed countries (LDCs) with relatively low levels of financial development. Chief examples include, Bahmani-Oskooee (1996), Bahmani-Oskooee and Payesteh (1993), Arize et al. (2000), and Arize et al. (2003). Hence, in the case of LDCs, there is less than a satisfactory number of studies to merit conclusive inference on the nature of the relationship between exchange-rate volatility and trade flows. There still is a lack of existing sufficient time series data that tends to diminish more research in this area in these countries.

For the most part, the existing empirical literature has neglected African countries. To our knowledge, the only contribution worth mentioning is the work of Medhora (1990).[3] He examined the impact of exchange-rate volatility on the imports of six West African Monetary Union member countries for the period 1976–1982. He employed OLS on the pooled import volume and concluded that the adverse effect of volatility was insignificant.[4]

3. Models and methods

With regard to modeling the impact of exchange-rate volatility in the twelve African countries, we follow the literature and begin with an estimation of their real exports as functions of real world-income, relative prices and a measure of exchange-rate volatility as illustrated by Eq. (1) below:

$$\text{Log}\, X_t = \alpha + \beta \ \log W_t + \gamma \ \log R_t + \lambda \ \log \delta_t + \varepsilon_t \quad (1)$$

3 Other examples include, a sample of developing countries comprising four African nations: Malawi, Mauritius, Morocco and Tunisia in the study of exchange-rate volatility and foreign trade by Arize et al. (2000). Likewise, Burkina Faso, Kenya and South Africa were part of ten developing countries that Arize et al. (2003) investigate the impact of exchange-rate volatility on their export flows. Similarly, Bahmani-Oskooee and Payesteh (1993) and Bahmani-Oskooee (1996) include South Africa in a sample of developing countries in a study of the relationship between exchange-rate volatility and trade flows and in an examination of how exchange-rate uncertainty affects trade flows in LDCs respectively.

4 For a review article see Bahmani-Oskooee and Hegerty (2007).

where, X_t denotes export volume at time t.[5] The equation reflects a familiar demand-side specification of exports. It shows that real exports of goods in national currency depend on a measure of real income of foreign countries (advanced countries industrial production is used as a proxy for real world income, designated W_t), a relative price (real effective exchange rate, noted R_t) and a measure of exchange rate volatility, labeled δ_t). We expect the β sign to be positive if an increase in real income of importing country augments export volumes as the theory predicts. The effect that the real effective exchange-rate exerts on real exports is not abstruse. A decrease in R indicates a real depreciation of domestic currency. Thus, if real depreciation induces less imports and boosts more exports, we can predict the expected sign of an estimate of γ to be negative.[6] As we stated earlier, the impact of exchange-rate volatility on international trade flows is not a clear-cut on theoretical view. However, if volatility in exchange-rate has a discouraging effect on the international trade of these African countries by depressing their exports, an estimate of λ is expected to be negative.

Eq. (1) depicts the long-run relations between the countries real exports and the three identified variables. The resulting outcomes are important to study the long-run effects and the short-run effects. First of all, these countries may face export instability that is subsequently derived from increased exchange-rate volatility on a temporary basis, but this admonition may or may not last into the long-run. In order to focus on the effects of exchange-rate volatility on the exports of the twelve countries comprehensively, it is necessary to incorporate the short-run dynamics into the long-run model. For that reason, we follow the bounds testing approach to reformulate Eq. (1) as Eq. (2):

$$\begin{aligned}\Delta \operatorname{Log} X_t = {} & a^0 + \sum_{k=1}^{n1} a_k^1 \Delta \operatorname{Log} X_{t-k} + \sum_{k=0}^{n2} a_k^2 \Delta \operatorname{Log} W_{t-k} + \sum_{k=0}^{n3} a_k^3 \Delta \operatorname{Log} R_{t-k} + \sum_{k=0}^{n4} a_k^4 \Delta \operatorname{Log} \delta_{t-k} \\ & + \nu_1 \operatorname{Log} X_{t-1} + \nu_2 \operatorname{Log} W_{t-1} + \nu_3 \operatorname{Log} R_{t-1} + \nu_4 \operatorname{Log} \delta_{t-1} + \mu_t \end{aligned} \tag{2}$$

An estimation of Eq. (2) makes it more convenient to concurrently test the effects of W, R, and δ on X in the short-run and in the long-run. The short-run effects of exogenous variables on exports are determined by the size of a_k^2, a_k^3, and a_k^4, while the long-run effects are decided by the estimates of ν_2, ν_3, ν_4 normalized on ν_1. The long-run effects are validated only if testing for the joint significance of the four lagged-level variables are supported by the conventional F-test. This process confirms that cointegration among the variables is established. In the context of bounds testing, however, the F-test is based on two distinct critical-values. The two critical values have an upper bound and a lower bound limit. The upper bound critical value results from the assumption that the four variables are to be integrated of order one, I(1), while the lower bound critical value is decided on the assumption that all the variables are to be integrated of order zero or $I(0)$. For cointegration, the calculated F-statistics must be greater than the upper bound critical value. The new critical values for an F-test emanate from an analysis that variables could be $I(1)$ or $I(0)$ as well as a combination of the two supporting cointegration among variables without unit-testing as demonstrated by Pesaran et al. (2001) who also tabulate the new critical values.

We now turn our attention to the import sector and follow the same estimation procedure to specify the short-run and the long-run relationships among variables. We first present the long-run estimation of the twelve countries' real imports as a function of their real income, relative prices and a proxy for exchange-rate volatility in Eq. (3).

$$\operatorname{Log} M_t = \varphi + \phi \, \log Y_t + \eta \, \log R_t + \kappa \, \log \delta_t + \varsigma_t \tag{3}$$

The right hand-side of Eq. (3) is different from the right hand-side of Eq. (1) by the variable Y, which now stands for the real national income of importing country in Eq. (3). It is expected that an estimate of $\phi > 0$. If the real national income improves it should encourage more imports. An estimate of η is also expected to be positive if a depreciation is to reduce imports. Finally, as discussed before, exchange rate volatility can exert a negative or positive effect on the imports of each country in our sample. Hence, an estimate of κ could be negative or positive.

The error-correction model that incorporates the short-run dynamics into the long-run Eq. (3) is outlined by Eq. (4):

$$\begin{aligned}\Delta \operatorname{Log} M_t = {} & b^0 + \sum_{k=1}^{n1} b_k^1 \Delta \operatorname{Log} M_{t-k} + \sum_{k=0}^{n2} b_k^2 \Delta \operatorname{Log} Y_{t-k} + \sum_{k=0}^{n3} b_k^3 \Delta \operatorname{Log} R_{t-k} + \sum_{k=0}^{n4} b_k^4 \Delta \operatorname{Log} \delta_{t-k} \\ & + \theta_1 \operatorname{Log} M_{t-1} + \theta_2 \operatorname{Log} Y_{t-1} + \theta_3 \operatorname{Log} R_{t-1} + \theta_4 \operatorname{Log} \delta_{t-1} + \xi_t \end{aligned} \tag{4}$$

Our interest is to determine the effects of exchange-rate volatility on imports in the short-run and in the long-run by exploiting relationships among variables in Eq. (4). The short-run effects are inferred by the size of b_k^4, and the long-run effects are conjectured by the estimate of θ_4 that is normalized on estimate of θ_1 if cointegration is established. Cointegration among variables is established following the same process as explained in the error-correction model of Eq. (2).[7]

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5 We observe that the data for export volume (as well as for the import volume) are not directly available except for South Africa. In order to obtain these trade volumes for the remaining eleven countries, we divided their export values and import values by a consumer price index. That is, in the case of Eq. (1), X_t represents real exports wherein nominal exports expressed in domestic currency are deflated by the price of domestically produced goods. We employed a consumer price index as a proxy for export price and import price as neither of these prices are available for the twelve countries.

6 A detail of how the real effective exchange-rate is constructed is presented in the Appendix.

7 For some other application of these methods see Adeniyi et al. (2015), Yagi and Takahashi (2015), Yanamandra (2015) and Bahmani-Oskooee et al. (2016a, 2016b, 2017).

4. Empirical results

We first estimate error-correction export demand model (2) using quarterly data, mostly over 1971Q1–2015Q4 with some exceptions noted in the Appendix. Our sample countries cannot be larger than twelve countries because of the dearth of quarterly trade data for other African countries. In estimating each model, we impose a maximum of 10 lags and use Akaike's Information Criterion to select an optimum model. Since there are different critical values for different estimates and different diagnostic statistics, we collect them in the notes to each table and use them to identify a significant estimate by * and ** at the 10% and 5% level, respectively. The results from each optimum model are reported in Table 1. Note that due to the volume of the results, while we report the short-run estimates only for exchange rate volatility in Panel A, long-run estimates attached to all variables are reported in Panel B. Finally, diagnostics are reported in Panel C.

From the short-run estimates we gather that exchange rate volatility carries at least one significant coefficient in all countries except in Burundi, Kenya, Tanzania, and Tunisia. While the short-run effects are positive in some countries (e.g., Egypt), they are negative in some others (e.g., Lesotho), in line with our theoretical expectations. To determine in which country short-run effects translate to long-run significant effects, we consider the long-run estimates in Panel B. Clearly, the measure of exchange rate volatility carries a significant coefficient in the cases of Egypt, Ethiopia, Lesotho, Nigeria, and Sierra Leone. While in the first three countries the effect is positive, in the last two it is negative, again in line with theoretical expectations. As for the long-run effects of the other two variables, a depreciation stimulates exports of only three countries in the long run, i.e., Egypt, Lesotho, and Nigeria. In these three countries, Ln R variable carries significantly negative coefficients. However, the coefficient is positive in the results for Ethiopia, and Sierra Leone, implying an inelastic world demand for these two country's exports. The world income seems to be the main determinant of exports in most of the countries in our sample, as Ln W variable carries a significantly positive coefficient in Ethiopia, Lesotho, Mauritius, Morocco, Nigeria, Sierra Leone, and Tanzania.

All long-run estimates reviewed above are meaningful since in any country in which there is at least one long-run significant estimate, cointegration is supported by the F test (Panel C). In case the F statistic is insignificant, like the case of Egypt, we adhere to an alternative test known as $ECM_{t-1.}$ In this alternative test, we use normalized long-run estimates from Panel B and long-run model (1) and generate the error term, labeled as ECM. We then go back to specification (2) and replace the linear combination of lagged level variables by ECM_{t-1} and estimate this new specification after imposing the same optimum lags on each first-differenced variable. A significantly negative estimate attached to ECM_{t-1} will support cointegration.[8] This test validates long-run estimates in the case of Egypt, but not in the case of Tanzania.

Reported in Panel C are a few additional diagnostic statistics. To establish autocorrelation free residuals, we report the Lagrange Multiplier statistics. As can be seen, it is insignificant in almost all models, indicating lack of serial correlation among the residuals. Most of the optimum models are correctly specified since Ramsey's RESET test is also insignificant in most cases. Short-run and long-run estimates are stable in almost all models, as indicated by the application of CUSUM and CUSUMSQ test. Finally, we have reported size of adjusted R^2 to judge goodness of fit.

We now turn to the import side of the twelve African countries to study the empirical results of the effects of real exchange-rate volatility, real effective exchange rate, and real national income, on their import volumes. Table 2 reports the complete list of these empirical estimates for each of the twelve countries.

As shown in Panel A, the short-run effect of the exchange-rate volatility is significant in seven countries (Egypt, Lesotho, Mauritius, Morocco, South Africa, Tanzania, Tunisia). In these countries, our volatility measure carries at least one significant coefficient. Again, there are positive and negative short-run effects. For example, the real exchange-rate volatility tends to stimulate import volumes of Lesotho but hurt that of Mauritius in the short run. However, in neither country, the short-run effects last into the long run, since the long-run normalized coefficient estimates in both countries are insignificant in Panel B. Indeed, our volatility measure carries a significantly positive long-run coefficient only in the case of South Africa. Therefore, exchange rate uncertainty seems to have no long-run effects on the import volume of African nations. A similar conclusion is also true of the long-run effects of the real effective exchange rate itself as LnR variables carries a significant long-run coefficient in only three countries. In the long-run the most significant determinant of imports in Africa seems to be the domestic income as LnY variable carries a significantly positive coefficient in 10 countries. As each country grows, she imports more. However, in five countries of Ethiopia, Kenya, Lesotho, Sierra Leone, and Tanzania, the long-run estimates are spurious since neither the F test nor the ECM_{t-1} test supports cointegration.[9]

5. Summary and conclusion

Discussions on the exchange-rate volatility and the nature of its nexus with international trade flows have persisted to last despite voluminous theoretical and empirical studies. In this paper, we applied the bounds-testing approach that incorporates the short-run dynamics into the long-run model in order to distinguish the distinct impact of the real exchange-rate volatility on the exports and imports of the twelve African countries, an area that has received the least attention.

The short-run impact of the real exchange-rate volatility either worsens or improves exports in eight out 12 African countries. The list includes Egypt, Ethiopia, Lesotho, Mauritius, Morocco, Nigeria, Sierra Leone, and South Africa. However, short-run effects lasted into long-run meaningful negative effects in Nigeria and Sierra Leon, and positive effects in Egypt, Ethiopia,

8 Note that the t-test to judge the significance of ECM_{t-1} has a new distribution for which Pesaran et al. (2001, p. 303) tabulate new critical values that are used in this paper.

9 Other diagnostic estimates are similar to export demand model and need no further explanations.

Table 1
Coefficient estimates of the export model.

	Burundi	Egypt	Ethiopia Kenya	Lesotho	Mauritius	
Panel A: Short-Run estimates						
Δ Ln δ	−0.32(1.54)	0.7(2.44)**	−0.04(0.48)	0.02(1.43)	0.01(0.03)	−0.04(1.83)*
$t-1$	–	–	−0.09(0.81)	–	−0.13(2.75)**	–
$t-2$	–	–	0.15(1.56)	–	−0.06(1.45)	–
$t-3$	–	–	−0.04(0.41)	–	−0.10(2.59)**	–
$t-4$	–	–	0.12(1.31)	–	−0.01(0.18)	–
$t-5$	–	–	0.08(0.84)	–	−0.07(1.84)*	–
$t-6$	–	–	0.10(1.09)	–	−0.02(0.43)	–
$t-7$	–	–	−0.08(0.76)	–	−0.03(0.92)	–
$t-8$	–	–	0.37(3.51)**	–	−0.04(1.13)	–
$t-9$	–	–	−0.22(2.06)**	–	−0.14(3.61)**	–
Panel B: Long-Run Estimates						
Constant	0.17(0.03)	6.89(2.25)**	14.26(9.51)**	5.54(4.25)**	−17.74(7.34)**	−5.26(1.92)*
Ln δ	−0.45(1.60)	0.32(2.20)**	0.38(3.09)**	0.11(1.30)	0.46(3.62)**	−0.09(1.05)
Ln R	0.84(1.67)*	−1.10(5.07)**	1.56(10.6)**	−0.02(0.08)	−0.62(2.69)**	0.13(0.37)
Ln W	0.42(0.65)	0.64(1.23)	0.66(2.80)**	0.26(1.27)	4.84(11.2)**	2.26(5.52)**
Panel C: Diagnostics						
F	3.77*	3.14	4.67**	1.84	3.63*	2.58
ECM_{t-1}	−0.77(5.36)**	−0.23(3.55)*	−0.65(4.27)**	−0.22(3.48)*	−0.25(4.23)**	−0.22(3.45)*
LM	5.59	7.06	4.41	7.43	1.56	10.51**
RESET	1.05	0.10	7.10**	0.25	0.70	8.00**
CUSUM	stable	stable	stable	stable	stable	stable
CUSUMSQ	stable	stable	stable	stable	stable	stable
Adj. R^2	0.56	0.39	0.66	0.23	0.30	0.73
	Morocco	Nigeria	Sierra Leone	South Africa	Tanzania	Tunisia
Panel A: Short-Run estimates						
Δ Ln δ	−0.10(2.44)**	−0.43(2.54)**	−0.22(3.18)**	0.06(2.26)**	0.01(0.17)	0.01(0.85)
$t-1$	–	0.0.20(3.10)**	–	0.03(1.02)	–	–
$t-2$	–	0.06(0.98)	–	0.08(2.90)**	–	–
$t-3$	–	0.11(2.05)**	–	0.05(1.84)*	–	–
$t-4$	–	0.11(2.07)**	–	–	–	–
$t-5$	–	0.05(0.95)	–	–	–	–
$t-6$	–	0.11(2.12)**	–	–	–	–
$t-7$	–	0.18(3.14)**	–	–	–	–
$t-8$	–	0.17(3.23)**	–	–	–	–
$t-9$	–	0.16(2.98)**	–	–	–	–
Panel B: Long-Run Estimates						
Constant	−12.25(1.66)*	4.30(1.52)	−61.91(5.66)**	14.47(0.43)	−14.63(1.17)	−9.90(0.59)
Ln δ	−0.16(0.98)	−1.03(5.78)**	−1.84(2.87)**	−0.80(0.37)	0.06(0.17)	0.20(0.67)
Ln R	1.01(0.96)	−0.44(1.94)*	3.55(2.16)**	−12.74(0.44)	−0.61(0.79)	−0.25(0.16)
Ln W	2.88(4.46)**	0.83(1.86)*	12.12(6.02)**	−8.28(0.36)	5.84(1.87)*	3.19(1.55)
Panel C: Diagnostics						
F	1.07	5.30**	3.30*	1.02	1.87	1.23
ECM_{t-1}	−0.10(2.44)	−0.18(4.61)**	−0.13(4.30)**	−0.01(2.55)	−0.05(2.71)	−0.06(2.20)
LM	4.19	16.11**	4.41	1.84	3.71	3.93
RESET	0.44	2.96*	18.48**	5.90	8.65*	2.63
CUSUM	stable	stable	stable	stable	stable	stable
CUSUMSQ	stable	stable	unstable	stable	stable	stable
Adj. R^2	0.63	0.26	0.32	0.35	0.40	0.40

Notes:
a. Number inside parentheses are absolute value of the t-ratios. Critical values at the 10% (5%) significance level are 1.64 (1.96).
b. The upper bound critical values of the F test for cointegration are 3.77 and 4.35 at the 10% and 5% level respectively. These come from Pesaran et al. (2001, Table CI, Case III, p. 300).
c. The upper bound critical values of the t-test for significance of ECM_{t-1} are −3.46 and −3.78 at the 10% and 5% level respectively. These come from Pesaran et al. (2001, Table CII, Case III, p. 303).
d. LM is the Lagrange Multiplier test for 4th order autocorrelation. It is distributed as χ^2 and has critical values of 7.77 and 9.48 at the 10% and 5% level respectively.
e. RESET is Ramsey's misspecification test and has a χ^2 distribution with one degree of freedom. Critical values are 2.71 and 3.84 at the 10% and 5% level respectively.
f. CUSUM and CUSUMSQ tests are for stability of all coefficients.

* Indicate significance at the 10% level.

** Indicate significance at the 5% level.

Table 2
Coefficient estimates of the import model.

	Burundi	Egypt	Ethiopia	Kenya	Lesotho	Mauritius
Panel A: Short-Run estimates						
Δ Ln δ	−0.04(1.31)	0.08(1.70)*	−0.03(0.92)	0.04(1.17)	0.02(1.84)*	−0.04(1.69)*
$t-1$	–	−0.06(1.07)	–	–	–	–
$t-2$	–	−0.01(0.16)	–	–	–	–
$t-3$	–	0.06(1.19)	–	–	–	–
$t-4$	–	−0.03(0.62)	–	–	–	–
$t-5$	–	0.12(2.34)**	–	–	–	–
$t-6$	–	−0.09(1.76)*	–	–	–	–
$t-7$	–	0.04.(0.85)	–	–	–	–
$t-8$	–	−0.02(0.44)	–	–	–	–
$t-9$	–	−0.12(2.38)**	–	–	–	–
Panel B: Long-Run Estimates						
Constant	−2.19(1.13)	7.15(2.48)**	2.29(0.37)	6.48(8.53)**	−2.95(0.78)	0.24(0.25)
Ln δ	−0.07(0.40)	0.02(0.18)	−0.16(0.95)	−0.02(0.38)	0.30(1.31)	−0.03(0.67)
Ln R	−0.46(2.63)**	−0.60(1.92)*	−0.93(1.55)	−0.02(0.12)	0.72(1.06)	−0.08(0.52)
Ln Y	1.35(6.78)**	0.24(1.18)	1.19(2.01)**	0.11(8.91)**	0.76(2.93)**	0.89(13.09)**
Panel C: Diagnostics						
F	3.20	5.71**	1.17	2.17	1.63	3.86*
ECM_{t-1}	−0.31(3.68)*	−0.27(4.67)**	−0.17(1.91)	−0.30(2.95)	−0.07(2.49)	−0.28(3.31)
LM	2.66	17.84**	1.19	1.82	4.43	10.50**
RESET	9.62**	0.98	0.03	1.00	3.81*	2.96*
CUSUM	stable	stable	stable	stable	stable	stable
CUSUMSQ	unstable	unstable	stable	stable	stable	stable
Adj. R^2	0.10	0.59	0.25	0.19	0.33	0.58
	Morocco	**Nigeria**	**Sierra Leone**	**South Africa**	**Tanzania**	**Tunisia**
Panel A: Short-Run estimates						
Δ Ln δ	−0.03(0.73)	−0.01(0.17)	−0.03(0.62)	0.07(2.00)**	−0.07(2.69)**	−0.05(1.21)
$t-1$	0.01(0.28)	–	–	–	–	−0.04(0.91)
$t-2$	0.01(0.33)	–	–	–	–	−0.10(2.39)**
$t-3$	0.12(2.67)**	–	–	–	–	−0.03(0.80)
$t-4$	–	–	–	–	–	−0.06(1.38)
$t-5$	–	–	–	–	–	−0.05(1.26)
$t-6$	–	–	–	–	–	−0.08(2.21)**
$t-7$	–	–	–	–	–	−0.07(1.95)*
$t-8$	–	–	–	–	–	0.08(2.19)**
$t-9$	–	–	–	–	–	−0.06(1.69)*
Panel B: Long-Run Estimates						
Constant	−4.46(1.26)	56.23(1.35)	−0.94(0.31)	−9.02(6.07)**	5.20(2.10)**	−2.03(2.61)**
Ln δ	−0.07(0.57)	0.36(1.35)	−0.10(0.61)	0.07(2.00)**	0.33(1.05)	0.04(1.22)
Ln R	0.53(0.96)	−1.13(0.39)	−0.55(1.24)	0.29(1.85)*	−0.17(0.44)	0.02(0.13)
Ln Y	1.10(6.21)**	−14.58(1.38)	1.28(5.38)**	1.47(17.16)**	0.35(2.79)**	1.27(21.96)**
Panel C: Diagnostics						
F	3.09	1.97	1.55	5.35**	2.01	3.17
ECM_{t-1}	−0.21(3.68)*	−0.24(3.24)	−0.24(2.57)	−0.27(4.77)**	−0.05(2.92)	−0.56(4.86)**
LM	0.71	7.95*	2.26	1.96	2.29	3.21
RESET	0.13	2.2	9.65**	0.95	3.84**	0.02
CUSUM	stable	stable	stable	stable	stable	stable
CUSUMSQ	stable	stable	unstable	stable	stable	stable
Adj. R^2	0.38	0.23	0.35	0.46	0.22	0.60

Notes:
a. Number inside parentheses are absolute value of the t-ratios. Critical values at the 10% (5%) significance level are 1.64 (1.96).
b. The upper bound critical values of the F test for cointegration are 3.77 and 4.35 at the 10% and 5% level respectively. These come from Pesaran et al. (2001, Table CI, Case III, p. 300).
c. The upper bound critical values of the t-test for significance of ECM_{t-1} are −3.46 and −3.78 at the 10% and 5% level respectively. These come from Pesaran et al. (2001, Table CII, Case III, p. 303).
d. LM is the Lagrange Multiplier test for 4th order autocorrelation. It is distributed as χ^2 and has critical values of 7.77 and 9.48 at the 10% and 5% level respectively.
e. RESET is Ramsey's misspecification test and has a χ^2 distribution with one degree of freedom. Critical values are 2.71 and 3.84 at the 10% and 5% level respectively.
f. CUSUM and CUSUMSQ tests are for stability of all coefficients.
* Indicate significance at the 10% level.
** Indicate significance at the 5% level.

and Lesotho. Furthermore, currency depreciation was found to stimulate exports of Egypt, Lesotho, and Nigeria but hurt exports of Ethiopia, and Sierra Leon (due to an inelastic demand). The world income was a major determinant of exports in most countries, implying that as the world economy grows, Africa exports more. Unlike many other countries, we found no substitution effects in Africa. Substitution effect would have existed if the world income carried a negative coefficient estimate.

The real exchange-rate volatility produced starkly contrasting results in the import-sector. In the short-run, volatility had significant effects on the imports of seven countries (i.e., Egypt, Lesotho, Mauritius, Morocco, South Africa, Tanzania, and Tunisia. However, short-run effects lasted into long-run positive and meaningful effects only in the case of South Africa. Furthermore, only in South Africa a depreciation reduced imports. Again, domestic income was the main determinant of imports in most African countries with no substitution effects. All in all, our findings are country specific and suffer from aggregation bias. Future research should concentrate on disaggregating the trade flows by each country's major trading partners or between two countries but at commodity level, data permitting.[10]

Our findings do have important policy implications. In countries that exchange rate volatility had adverse effects on their trade flows, more stable exchange rate via intervention in the foreign exchange market will help boost their trade and eventually, economic growth. On the other hand in countries in which exchange rate volatility had positive impact on their trade flows, relatively more flexible exchange rate and less market intervention will be beneficial.

Appendix. Data definitions and sources

Quarterly data over the period 1971Q1–2015Q4 are used to carry out estimation. Due to unavailability of data on some variables, however, the period was restricted to 1971Q1–2014Q4 for Burundi and Morocco, 1971Q1–2006Q4 from Ethiopia, 1974Q1–2012Q4 for Lesotho, 1971Q1–2008Q4 for Nigeria, 1971Q1–2013Q4 for Tanzania and 1975Q1–2014Q4 for Tunisia. They come from the following sources:

a. International Financial Statistics of IMF.
b. The Federal Reserve Bank of New York websites (http://www.economagic.com/fedny.htm).
c. Direction of Trade Statistics of the IMF.

A.1. Variables

$M =$	measure of real imports. In the absence of import price index, nominal imports in domestic currency is deflated by Consumer Price Index (CPI). Data come from source a.
$X =$	measure of real export. Like imports, CPI is used to deflate nominal exports. Data come from source a.
$Y =$	measure of real income in each country. Quarterly figures for the real national income were not available for any of the countries that are in our sample except for South Africa. For that reason, we calculated quarterly data from annual GDP data through **linear** interpolation for each country following Bahmani-Oskooee (1986, p. 123). The resulting nominal data was deflated by CPI in order to generate the real quarterly data. All annual data are from source a.
$W =$	measure of world income. In keeping with the literature we use the index of industrial production in OECD countries as proxy for this variable.
$R =$	measure of real effective exchange-rate. This rate is available on quarterly basis only in the case of South Africa for our study period. For six of the eleven countries (Burundi, Lesotho, Morocco, Nigeria, Sierra Leone, Tunisia), the variable is available Only after the year 2000. In the remaining five countries (Egypt, Ethiopia, Kenya, Mauritius, Tanzania) it is unavailable. Thus, we had to construct this variable for these countries covering the entire study period and for the other six countries covering the period before 2000. To construct, the real exchange-rate for each country j with i trading partner, we followed Bahmani-Oskooee and Gelan (2007) according to the following formula: $$R_j = \sum_{i=1}^{11} \lambda_{ij} \left[\frac{\left(\frac{P_j E_{ij}}{P_i}\right)_t}{\left(\frac{P_j E_{ij}}{P_i}\right)_{2003}} X100 \right]$$ where p_j is the price level in country j, p_i is the price level in trading partner i, and E_{ij} is the nominal bilateral exchange-rate defined as the number of units of i's currency per unit of j's currency. As can be seen, the real bilateral exchange rates are constructed and then set in an index form (2003 = 100). In the Subsequent step, we take the weighted mean of these indexes. These weights are measured by import shares of country j from each of her trading partners and are denoted by λ_{ij} such that $\sum \lambda_{ij} = 1$. Accordingly, a decrease in R is indicative of a real depreciation of j's currency. Note that the trade shares come from source (c); CPI data come from source (a); nominal bilateral exchange rates sources (a) and (b). Furthermore, the bilateral nominal exchange-rate between two non-dollar currencies is unavailable. Therefore, we had to construct them using the rates against the US dollar.
$\delta =$	measure of realeffective exchange-rate volatility. Following Bahmani-Oskooee (1996), for each quarter, this is measured as the standard deviation of the real effective exchange-rate, R, over eight previous quarters that end at current quarter.

[10] Some examples in this line of research are Aftab et al. (2016, 2017).

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