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ON THE LINK BETWEEN REAL EXCHANGE RATE AND DOMESTIC INVESTMENT: ASYMMETRIC EVIDENCE FROM AFRICA

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Exchange rate changes are said to affect the level of domestic direct investment in either direction. In this paper we consider the experience of each of the 18 countries in Africa. When a linear model is used, we find that the real effective exchange rate has significant short-run effects on domestic investment in three countries and long-run effects in five countries. However, when a nonlinear model was used, the number of countries rose to 13 and seven respectively. Furthermore, in almost all countries, the short-run and long-run effects were asymmetric.

Keywords: Domestic investment; Real exchange rate, Asymmetry analysis, Africa
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1. INTRODUCTION

Although most studies in the literature assess the impact of exchange rate changes on the trade balance or capital flows among countries, one strand of the literature concentrates on the impact of exchange rate changes on domestic real direct investment. Theoretical arguments are based on the notion that if a depreciation stimulates net exports of a country, producers of exportable may invest more at home to meet the increased demand for their exports. On the other hand, inflationary effects of a depreciation could increase production cost, hurting profit margins and this in turn, could discourage domestic investment. Depending on which effect is stronger, investment could move in either direction in response to a depreciation and the matter should be settled by empirical analysis. Examples of studies that show a depreciation leads to a decline in domestic investment are: Campa and Goldberg (1995 and 1999), Forbes (2002), Harchaoui et al. (2005), and Landon and Smith (2009), and example of studies that show a depreciation actually stimulates domestic investment are: Nucci and Pozzolo (2001), Bahmani-Oskooee and Hajilee (2010), and Berg et al. (2015).

The above studies were recently reviewed in detail by Bahmani-Oskooee et al. (2018) and criticized for assuming exchange rate changes to have symmetric effects. They argued to the contrary and for asymmetric impact. The main reasons for asymmetric impact were known to be the downward rigidity in prices, such as input prices or export prices, in different sectors of the economy.[1] Clearly, the rate at which the price of inputs, such as wages decline is different than the rate at which they rise. They demonstrated asymmetric response of domestic investment to exchange rate changes by using data from six emerging economies. In this paper we would like to add to that literature by considering the experiences of 18 African countries. To this end, in Section 2 we review the literature related to Africa. We then introduce the models and methods in Section 3. Results supporting asymmetric effects of exchange rate changes on domestic investment are reported in Section 4 followed by a summary in Section 5. Finally, data definition and sources are cited in an Appendix.

2. THE AFRICAN LITERATURE

The literature related to Africa is very paltry and include a few studies that have addressed determinants of domestic investment in Africa. In a comprehensive study, Oshikoya (1994) identified macroeconomic determinants of domestic investment in Africa to be economic growth, the ratio of public sector investment to Gross Domestic Product (GDP), the change in credit to the private sector, the change in terms of trade, the real exchange rate, the lagged ratio of external debt service payments to exports of goods and services, the lagged ratio of private-sector investment. The model was estimated using pooled time-series data across several African countries and the results revealed that the real exchange rate carried significant positive coefficient in the model that included only middle-income countries in Africa but not in the model for low-income countries. The opposite was found by Ndikumana and Verick (2008), who analysed the impact of foreign direct investment (FDI) on domestic investment in Sub-Saharan Africa by estimating a panel model and concluded that indeed, FDI crowds in domestic investment and employment. The exchange rate was included in their model as a control variable and in line with theory, the results revealed that overvalued currencies in Africa hurt domestic investment.

Fahinde et al. (2015) also looked into the link between FDI and the exchange rate on domestic investment in West Africa Economic Monetary Union (WAEMU) and estimated a panel model. Contrary to the findings of Ndikumana and Verick (2008), their results supported crowding out argument that FDI hurts domestic investment. They also found that overvalued currencies are good in these countries and exchange rate

[1] Example of studies that show import and export prices and even domestic prices adjust to exchange rate changes asymmetrically include Delatte et al. (2012), Elbejaoui (2013), Cheung and Sengupta (2013), and Dhasmana, (2015).

appreciation leads to an increase in domestic investment. Positive impact of FDI on domestic investment is also discovered by Zhang and Ward (2015) and Adams et al. (2016) who also estimated a panel model. However, while the first study found that exchange rate changes have no significant impact on domestic investment, the second study did not include the exchange rate as a determinant of domestic investment.

The above studies have all used panel data to arrive at their conflicting conclusions. However, the results from panel models are subject to "aggregation bias" in that what is true for one cross-sectional unit, it may not be true for another unit. Therefore, to reduce the bias a time-series model has to be estimated for each country and time-series problems such as degree of integrations must be addressed. To this end, Bahmani-Oskooee and Hajilee (2010) engaged in the most comprehensive study by estimating an investment function for each of the 50 countries in their sample. Included among the 50 countries were 11 countries from Africa, i.e., Algeria, Cameroon, Egypt, Lesotho, Malawi, Morocco, Niger, Nigeria, Senegal, South Africa, and Tunisia. While in almost all 11 countries they found economic activity at home to be the significant contributing factor to domestic investment, currency depreciation had significantly positive and meaningful impact on domestic investment only in Cameroon and Niger and adverse impact in Morocco, Nigeria, and South Africa.[2]

A common feature of all studies reviewed above (Panel and Time-Series) is that they have all assumed the response of domestic investment to exchange rate changes to be symmetric. However, as discussed in previous section and demonstrated by Bahmani Oskooee et al. (2018), the response could be asymmetric. While Bahmani-Oskooee et al. (2018) demonstrated the asymmetric response of investment to exchange rate changes by using data from six emerging economies of Brazil, Hungary, Malaysia, Mexico, the Philippines, and South Africa, we address the same issue by using data from 18 African nations for which data on relevant papers were available. For this purpose, we outline the model and the estimation methods in next section.

3. THE MODEL AND METHODS

Bahmani-Oskooee et al. (2018) adopted an investment function in which the level of economic activity, the interest rate, and the real exchange rate were identified as three main determinants of domestic real investment. Here, we adopt the same procedure for each of the African countries in our sample. However, due to missing data on interest rate in most countries, we modified their model and followed Oshikoya (1994) and replaced the interest rate by the rate of inflation. Indeed, Bahmani-Oskooee (1996) have argued that since the interest rate in developing countries is not market determined and

[2] Note that a negative coefficient in Bahmani-Oskooee and Hajilee (Table 1, Panel B) for the real effective exchange rate (ER) variables implies that a real depreciation leads to an increase in domestic investment. Thus, a positive coefficient implies that a depreciation reduces domestic investment.

set by the government at a fixed level for a prolonged period of time, inflation rate serves as a better measure of opportunity cost of money. Therefore, we begin with the following specification:

$$\ln I_t = a + b\ln Y_t + c\pi_t + d\ln RX_t + \varepsilon_t, \quad (1)$$

where I is private real domestic investment that is assumed to depend on the level of economic activity denoted by Y, the inflation rate, denoted by π, and the real effective exchange rate, denoted by RX. Following the literature if increased economic activity is to stimulate domestic investment, an estimate of b should be positive and if increase in inflation rate is to hurt investment by raising the borrowing cost and cost of inputs, an estimate of c is expected to be negative. Finally, a real depreciation reflected in EX decline could have a negative or positive effect depending on whether firms in a given country are export or import oriented. Hence an estimate of d could be negative or positive.

Estimate of equation (1) by Ordinary Least Square (OLS) yields only the long-run effects. For these effects to be meaningful, however, cointegration among the variables must be established. According Engle and Granger (1987), if each variable in (1) is integrated of order d, $I(d)$, but the residuals are integrated at an order less than d, all variables are cointegrated in the long run. For example, if each variable is $I(1)$, and the residuals are $I(0)$, variables are cointegrated. In case the residuals are also $I(1)$, Banerjee et al. (1998) propose an alternative test, which is based on the error-correction specification of (1) as follows:

$$\Delta\ln I_t = \alpha_0 + \sum_{i=1}^{n1}\alpha_{1i}\,\Delta\ln I_{t-i} + \sum_{i=0}^{n2}\alpha_{2i}\,\Delta\ln Y_{t-i} + \sum_{i=0}^{n3}\alpha_{3i}\,\Delta\pi_{t-i} + \sum_{i=0}^{n4}\alpha_{4i}\,\Delta\ln RX_{t-i} + \lambda\varepsilon_{t-i} + \omega_t. \quad (2)$$

Banerjee et al. (1998) demonstrate that if estimate of λ is negative and significant, variables will converge toward their long-run equilibrium values. They also demonstrate that the t-test for judging the significant of $\hat{\lambda}$ has a new distribution for which they tabulated new critical values. This test is also known as the t-test for cointegration. Note that once (2) is estimated, estimate of coefficients attached to first-differenced variables represent short-run effects of exogenous variables on domestic investment.

What to do if some variables in (1) are $I(1)$, and some are $I(0)$?, Pesaran et al. (2001) offer another approach. They solve equation (1) for ε_t, and lag the solution by one period and substitute the results into (2) to arrive at:

$$\Delta\ln I_t = \alpha_0 + \sum_{i=1}^{n1}\alpha_{1i}\,\Delta\ln I_{t-i} + \sum_{i=0}^{n2}\alpha_{2i}\,\Delta\ln Y_{t-i} + \sum_{i=0}^{n3}\alpha_{3i}\,\Delta\pi_{t-i} + \sum_{i=0}^{n4}\alpha_{4i}\,\Delta\ln RX_{t-i} + \lambda\ln I_{t-1} + \lambda b\ln Y_{t-1} + \lambda c\pi_{t-1} + \lambda d\ln RX_{t-1} + \omega_t. \quad (3)$$

Specification (3) is an error-correction model and once it is estimated, the short-run effects, again, are reflected by the estimates of coefficients attached to first-differenced variables. The long-run effects are derived by normalizing estimates of λb, λc, and λd on the estimate of λ as follows:

$$\frac{\lambda b}{-\lambda} = b, \qquad \frac{\lambda c}{-\lambda} = c, \qquad \frac{\lambda d}{-\lambda} = d.$$

However, for the long-run effects to be valid, Pesaran et al. (2001) propose two tests. An F-test to establish joint significance of lagged level variables or the t-test to judge significance of λ attached to $\ln I_{t-1}$. In line with Banerjee et al. (1998), the estimate of λ must be negative. However, in this context where variables are combination of $I(0)$, and $I(0)$, both tests have new distribution for which Pesaran et al. (2001) tabulate new critical values that account for integrating properties of variables. Therefore, since almost all macro variables are either $I(0)$ or $I(1)$ there is no need for pre-unit root testing.[3]

The next step is to modify (3) so that we can assess asymmetric effects of exchange rate changes. Following Bahmani-Oskooee et al. (2018) and more specifically Shin et al. (2014), the real exchange rate series is decomposed into two separate series using partial sum concept. First $\Delta \ln RX$ is formed which includes positive changes reflecting appreciations and negative changes reflecting depreciation. Then the two new series are constructed as:

$$POS_t = \sum_{j=1}^{t} max(\Delta \ln RX_j, 0), \qquad NEG_t = \sum_{j=1}^{t} min(\Delta \ln RX_j, 0), \tag{4}$$

where POS_t is the partial sum of positive changes, representing appreciation and NEG_t, is the partial sum of negative changes, representing depreciation.

In the next step, we go back to (3) and replace the $\ln RX$ variable by POS and NEG variables to arrive at a new error-correction model as follows:

$$\begin{aligned} \Delta \ln I_t = \theta_0 &+ \sum_{i=1}^{n1} \theta_{1i} \Delta \ln I_{t-i} + \sum_{i=0}^{n2} \theta_{2i} \Delta \ln Y_{t-i} + \sum_{i=0}^{n3} \theta_{3i} \Delta \pi_{t-i} \\ &+ \sum_{i=0}^{n4} \theta_{4i} \Delta POS_{t-i} + \sum_{i=0}^{n5} \theta_{5i} \Delta NEG_{t-i} + \rho_0 \ln I_{t-1} + \rho_1 \ln Y_{t-1} \\ &+ \rho_2 \pi_{t-1} + \rho_3 POS_{t-1} + \rho_4 NEG_{t-1} + \mu_t. \end{aligned} \tag{5}$$

Since construction of the partial sum variables introduce nonlinearity into the adjustment process, models like (5) are commonly referred to as nonlinear ARDL models whereas, those like (3) are referred to as linear ARDL models.

Once (5) is estimated by OLS, again, short-run effects are reflected in the estimates of coefficients attached to the first-differenced variables and long-run effects are derived

[3] The critical values for the F test are in Pesaran et al. (2001, p. 300) and those for the t-test are in Pesaran et al. (2001, p. 303). It must be noted that Pesaran et al.'s critical values are for large samples. For small samples such as ours Narayan (2005) provides critical values for the F test and Banerjee et al. (1998) for the t-test (see the notes to tables).

by normalizing estimates of ρ_1-ρ_4 on ρ_0. However, for the long-run effects to be valid, the same F-test for joint significance of linear combination of lagged level variables and the same t-test for significance of $\hat{\rho}_0$ are recommended.[4] Once cointegration is established, long-run asymmetric effects of exchange rate changes will be established if we reject the null hypothesis of $\frac{\hat{\rho}_3}{-\hat{\rho}_0} = \frac{\hat{\rho}_4}{-\hat{\rho}_0}$ by applying the Wald test. As for short-run asymmetric effects, if n4 ≠ n5[5], i.e., ΔPOS takes a different lag order than ΔNEG, that will be evidence of adjustment asymmetry. Furthermore, at a given lag order i, if $\hat{\theta}_{4i}$ is different than $\hat{\theta}_{5i}$, that will support short-run asymmetric effects. However, if we reject the null of $\sum \hat{\theta}_{4i} = \sum \hat{\theta}_{5i}$ by the Wald test, short-run cumulative or impact asymmetric effects will be supported.[6]

4. THE RESULTS

Both the linear model (3) and the nonlinear model (5) are estimated for each of the 18 African countries for which annual data over the period 1971-2016 were available. Since data are annual, we impose four lags on each first-differenced variable and use Akaike's Information Criterion (AIC) to select an optimum model in each case. We then report the results of the linear models in Table 1 and those of the nonlinear model in Table 2. Furthermore, since there are different critical values for different tests, we collect them in the notes to each table and use them to identify significant estimates or diagnostic statistics. One * is used if an estimate is significant at the 10% level and two ** are used at the 5% level.

Let us first consider estimates of the linear models in Table 1. From the short-run coefficient estimates in Panel A we gather that the real effective exchange rate carries at least one significant coefficient in the results for Ethiopia, Senegal, and Togo. However, the level of economic activity and rate of inflation carry significant coefficients in most countries. It appears that in the short-run, the level of domestic investment is relatively more affected by the economic activity and rate of inflation than the exchange rate change. Numbers are somewhat different in the long run. The long-run estimates in Panel B reveal that a depreciation stimulates domestic investment in Ghana, Senegal, and Tanzania, but it depresses it in South Africa and Togo. In the case of first three countries, the real effective exchange rate, $\ln RX$, carries significantly negative coefficient but in the results for the last two countries the estimate is positive. In 11 countries, the level of economic activity seems to be the main determinant of domestic investment in the long run since $\ln Y$ carries a significant and positive coefficient.

[4] Note that in applying the F test, Shin et al. (2014, p. 291) recommend treating the two partial sum variables as a single variable so that the critical values of the F-test remain the same for both the linear and nonlinear model. However, this is not the case for the t-test.

[5] n4 and n5 are numbers of lags on ΔPOS and ΔNEG variables in the model.

[6] For some other application of these methods see Arize et al. (2017), Nusair (2017).

Inflation rate seems to have also adverse effect on investment in the long run, in at least five countries.

The long-run estimates are valid since cointegration is supported by the F-test or the t-test in almost all models in which there is at least one long-run significant estimate. These two tests are reported in Panel C along with some other diagnostic statistics. The Lagrange Multiplier (LM) statistic is reported to identify models that suffer from autocorrelation. It is significant only in two out of 18 models, supporting lack of serial correlation among the residuals in the remaining 16 models.[7] Ramsey's misspecification test (RESET) is significant in six cases (i.e. in Burundi, Cote D'ivoire, Ghana, Morocco, Senegal, and Tanzania), supporting correct specification of each optimum model in the remaining 12 countries. The results of the well-known CUSUM and CUSUMSQ stability tests reveal that all estimates are stable. The two tests are reported as QS and QS^2 where stable estimates are identified by "S" and unstable ones by "UNS". Finally, adjusted R^2 is reported to judge the goodness of fit. To sum up our findings from the linear model, changes in real effective exchange rates have short-run significant effects on the domestic investment of Ethiopia, Senegal and Togo, and long-run significant and meaningful effects on the domestic investment of Ghana, Senegal, South Africa, Tanzania, and Togo).[8] How do these results change if we consider the nonlinear adjustment of the exchange rate and results from the nonlinear models in Table 2?

From the short-run coefficient estimates in Panel A of Table 2 we gather that in 13 countries either the ΔPOS or ΔNEG or both carry at least one significant coefficient, supporting significant short-run effects of either currency appreciation or depreciation on domestic investment in these 13 countries. The exceptions are: Egypt, Morocco, Niger, Rwanda, and Sierra Leone. Thus, the increase from three countries to 13 countries must be clearly attributed to nonlinear adjustment of the real effective exchange rate. Short-run effects also reveal that at the same lag order, the coefficient obtained for ΔPOS is different than the one obtained for ΔNEG, supporting short-run asymmetric effects of exchange rate changes on domestic investment in all countries. However, cumulative or impact short-run asymmetric effects are supported only in the cases of 11 countries. The list includes Burkina Faso, Burundi, Cote D'ivoire, Ethiopia, Gabon, Ghana, Kenya, Mauritius, South Africa, Tanzania, and Togo. In these countries the Wald test reported as Wald-S in Panel C is significant, rejecting the null of equality of sum of the coefficients attached to ΔPOS and ΔNEG. In which countries, short-run asymmetric effects translate into the long run?

From the long-run estimates in Panel B we gather that either the POS or the NEG variable carry a significant and meaningful coefficient in the results for Burkina Faso, Cote D'ivoire, Gabon, Ghana, Mauritius, Seychelles, and Tanzania. Again, increase in number of countries from five in Table 1 to seven in Table 2 should be attributed to

[7] The two cases are Kenya and Rwanda.
[8] By meaningful we mean significant coefficients that are supported by one of the cointegration tests.

Table 1. Estimates of the Linear ARDL Model (3)

Linear ARDL	Burkina Faso	Burundi	Cote D'ivoire	Egypt	Ethiopia	Gabon
Panel A: Short-run						
$\ln RX_t$	-0.35(1.42)	0.03(0.17)	-0.09(0.47)	0.06(0.91)	0.38(2.79)**	0.14(0.91)
$\ln Y_t$	-0.42(2.22)**	-2.00(2.50)**	2.59(3.74)**	2.97(3.83)**	0.62(7.92)**	0.33(1.66)
$\Delta\ln Y_{t-1}$	-	1.72(2.15)**	-	-2.36(2.52)**	-	-
$\Delta\pi_t$	-0.43(1.21)	-0.85(1.65)	1.21(1.63)	-0.91(1.73)*	-0.99(3.71)**	-0.16(1.94)*
$\Delta\pi_{t-1}$	-	1.06(1.99)*	1.28(2.30)**	0.82(1.62)	-	-
Panel B: Long-run						
$\ln RX$	-0.58(1.41)	0.29(0.18)	-0.33(0.46)	0.25(0.85)	0.10(1.08)	0.33(1.00)
$\ln Y$	-0.70(2.35)**	-3.23(0.76)	0.98(0.87)	1.45(1.79)*	0.62(7.92)**	0.76(1.78)*
π	0.58(3.71)**	-0.17(0.26)	0.10(0.20)	-0.71(2.02)**	0.01(0.37)	-0.36(2.30)**
Constant	5.52(1.23)	27.99(0.67)	-13.04(1.08)	-13.20(2.04)**	-6.76(8.06)**	-9.68(1.65)
Panel C: Diagnostics						
F	5.67**	3.60	4.7*	3.86	9.01**	1.87
$\hat{\lambda}$ ($t-ratio$)	-070(4.99)**	-0.10(3.95)**	-0.30(4.51)**	-0.26(3.85)**	-0.84(6.24)**	-0.38(2.83)
LM	0.42	0.46	2.64	0.02	0.39	0.30
RESET	0.06	5.95**	3.00*	0.01	0.01	0.03
QS(S2)	S(S)	S(S)	S(S)	S(S)	S(S)	S(S)
Adjusted R^2	0.55	0.45	0.52	0.50	0.55	0.24

Linear ARDL	Ghana	Kenya	Mauritius	Morocco	Niger	Rwanda
Panel A: Short-run						
$\Delta\ln RX_t$	-0.20(1.13)	0.09(1.10)	0.07(0.63)	0.10(0.51)	-0.30(0.86)	-0.02(0.33)
$\Delta\ln Y_t$	-	-	-	-	0.55(1.49)	-
$\Delta\ln Y_{t-1}$	-02(0.99)	0.31(1.93)*	-0.39(0.95)	-0.59(1.70)*	0.72(2.17)**	1.12(7.37)**
$\Delta\pi_t$	-	0.42(2.65)**	0.68(2.28)**	-	-	-0.81(4.28)**
$\Delta\pi_{t-1}$	0.02(0.71)	-0.41(2.04)**	-0.53(1.36)	0.44(0.77)	0.88(1.75)*	0.04(1.70)*
Panel B: Long-run						
$\ln RX$	-0.73(5.68)**	0.09(1.01)	0.21(0.70)	0.18(0.51)	0.33(0.46)	-0.05(0.33)
$\ln Y$	-0.30(0.96)	0.12(1.29)	0.51(1.80)*	0.71(5.09)**	2.00(3.82)**	0.47(3.47)**
π	0.04(0.71)	0.02(0.57)	-0.34(1.60)	-0.27(1.77)*	-0.64(1.45)	0.10(1.70)*
Constant	3.20(1.60)	-3.39(3.42)**	-4.95(2.44)**	-7.20(3.72)**	-2.37(3.78)**	-6.68(5.29)**

Panel C: Diagnostics						
F	5.67**	7.02**	3.09	9.48**	3.27	5.88**
$\hat{\lambda}$ ($t-ratio$)	-0.61(4.88)**	-0.81(5.52)**	-0.32(3.67)*	-0.57(6.39)**	-0.37(3.11)	-0.44(5.05)**
LM	.70	6.58**	.26	2.10	1.07	8.32**
RESET	7.2**	.86	2.32	10.31**	0.44	2.49
QS(S2)	S(S)	S(S)	S(S)	S(S)	S(S)	S(S)
Adjusted R^2	0.55	0.37	0.48	.37	0.50	0.28
Linear ARDL	Senegal	Seychelles	Sierra Leone	South Africa	Tanzania	Togo
Panel A: Short-run						
$\Delta \ln RX_t$	-0.25(2.50)**	-0.22(1.19)	-0.09(0.63)	-0.08(1.24)	0.03(0.82)	-1.26(4.18)**
$\Delta \ln Y_t$	-0.12(0.84)	1.55(1.87)*	0.39(1.48)	0.53(1.76)*	0.21(0.75)	1.33(2.62)**
$\Delta \ln Y_{t-1}$	-	-	-	0.87(2.67)**	-0.70(2.47)**	1.95(3.54)**
$\Delta \pi_t$	0.17(0.61)	-0.17(0.86)	-0.48(2.16)**	0.04(1.14)	-0.07(3.20)**	0.10(0.84)
$\Delta \pi_{t-1}$	-0.50(2.15)**	-	-	0.14(1.50)	-	-
Panel B: Long-run						
$\ln RX$	-0.58(1.96)*	-0.36(1.33)	-0.21(0.62)	0.41(1.87)*	-0.65(5.23)**	7.17(2.23)**
$\ln Y$	-0.27(0.75)	0.544(1.44)	0.93(2.12)**	1.22(5.04)**	0.27(3.09)**	4.34(2.26)**
π	0.18(1.32)	-0.29(0.93)	-0.03(0.58)	-0.33(5.21)**	-0.14(4.28)**	-0.58(1.04)
Constant	3.26(0.67)	-1.04(0.79)	-11.62(2.20)**	-14.47(5.77)**	-1.11(0.95)	-73.39(2.47)**
Panel C: Diagnostics						
F	3.67	4.40*	2.58	4.81**	4.39*	4.57*
$\hat{\lambda}$ ($t-ratio$)	-0.47(3.98)**	-0.56(4.32)**	-0.46(3.33)	-0.31(4.60)**	-0.50(4.37)**	-0.18(4.45)**
LM	1.41	0.32	0.62	1.48	0 .21	2.61
RESET	9.29**	1.70	1.35	0.12	4.56 **	0.38
QS(S2)	S(S)	S(S)	S(S)	S(S)	S(S)	S(S)
Adjusted R^2	0.55	0.33	0.28	0.37	0.64	0.32

Notes:

a. Numbers inside the parenthesis are absolute values of the t-ratio and *(**) indicates significant at the 10% (5%) confidence level.

b. At the 10% (5%) significance level when there are three exogenous variables (k=3), the critical value of the F-test is 3.983 (4.733). These comes from Narayan (2005, p. 1988) for our sample size of 45 observations.

c. At the 10% (5%) significance level when there are three exogenous variables (k=3), the critical value of the t-test is -3.45 (-3.82). These come from Banerjee et al (1998, p. 276).

d. LM is Lagrange Multiplier test of residual serial correlation. It is distributed as χ^2 with one degree of freedom since we are testing for 1st order serial correlation. Its critical value at the 10% (5%) level is 2.71 (3.84).

e. RESET is for misspecification test. It is distributed as χ^2 with one degree of freedom. Its critical value at the 10% (5%) level is 2.71 (3.84).

Table 2. Coefficient Estimates of the Nonlinear ARDL Model (5)

Nonlinear ARDL	Burkina Faso	Burundi	Cote devoir	Egypt	Ethiopia	Gabon
Panel A: Short-run						
ΔPOS_t	-0.01(2.29)**	-1.47(1.99)*	-0.98(1.89)*	0.08(0.39)	0.78(1.96)*	-0.56(1.18)
ΔPOS_{t-1}	-	-	-	-	-	-1.03(2.05)**
ΔNEG_t	-0.48(0.70)	0.41(1.70)*	0.46(1.61)	-0.07(0.50)	0.05(0.51)	0.38(1.11)
ΔNEG_{t-1}	-	-	-	-	-	0.69(2.30)**
$\Delta \ln Y_t$	-0.85(1.28)	1.71(2.24)**	-3.09(4.58)**	-2.71(2.65)**	-0.49(3.92)**	-1.22(6.01)**
$\Delta \ln Y_{t-1}$	-1.63(2.55)**	-1.70(2.08)**		2.01(2.10)**	-	-
$\Delta \pi_t$	-0.38(0.95)	-0.25(0.44)	1.98(2.69)**	-0.16(0.92)	-1.13(3.07)**	-0.29(0.92)
$\Delta \pi_{t-1}$	-0.80(2.33)**	0.80(1.58)	1.51(2.77)**	-	-	-
Panel B: Long-run						
POS	-0.67(2.92)**	35.80(0.43)	-2.33(2.26)**	0.27(0.40)	-0.19(0.41)	-1.65(3.78)**
NEG	-0.41(0.69)	-10.10(0.39)	1.10(1.71)*	0.32(0.87)	-0.06(0.51)	0.36(2.56)**
$\ln Y$	0.60(2.21)**	0.34(0.04)	-1.08(1.60)	-1.14(1.75)*	-0.62(5.15)**	1.26(6.25)**
π	0.52(3.03)**	-15.44(0.42)	2.13(2.17)**	-0.54(0.(98)	0.16(0.58)	0.45(3.03)**
Constant	2.90(0.92)	9.66(0.13)	-9.51(3.21)**	-9.69(1.99)*	-6.49(9.61)**	-9.35(6.41)**
Panel C: Diagnostics						
F	5.96**	2.96	5.50**	2.16	5.96**	7.81**
$\hat{\rho}_0$ $(t-ratio)$	-0.83(5.75)**	0.04(4.01)**	-0.41(4.66)**	-0.29(3.44)	-0.79(5.76)**	-0.85(6.23)**
LM	0.25	0.92	3.98**	0.00	0.66	0.15
RESET	0.08	5.06**	0.98	0.02	0.08	0.36
QS(S^2)	S(S)	S(S)	S(S)	S(S)	S(S)	S(S)
Adjusted R^2	0.46	0.45	0.73	0.47	0.56	0.57
Wald Tests						
Wald-short	8.17**	3.40*	6.20**	1.59	4.27**	13.89**
Wald-long	3.53*	0.13	10.72**	0.33	0.25	15.09**

Nonlinear ARDL	Ghana	Kenya	Mauritius	Morocco	Niger	Rwanda
Panel A: Short-run						
ΔPOS_t	0.08(0.24)	0.46 (2.85)**	-0.71(2.83)**	-0.35(0.64)	0.39(0.94)	-0.06(0.47)
ΔPOS_{t-1}	-	0.52(3.32)**	-	-	-	-
ΔNEG_t	-0.54(3.32)**	-0.11(1.26) -0.07(1.66)	0.22(1.41)	0.32(0.79)	-0.52(1.03)	0.13(1.50)
ΔNEG_{t-1}	-	-	0.33(1.75)*	-	-	-
ΔlnY_t	0.34(1.15)	-0.22(2.79)**	0.22(0.59)	0.63(1.82)*	-0.92(1.72)*	-1.40(7.92)**
ΔlnY_{t-1}	-		-0.49(1.61)	-	-	0.54(2.42)**
$\Delta \pi_t$	-0.10(0.71)	-0.12(3.20)**	-0.17(0.46)	-0.16(1.12)	0.92(1.91)*	0.73(2.37)**
$\Delta \pi_{t-1}$	-	-	0.69(2.30)**	-	-	-
Panel B: Long-run						
POS	-1.04(3.97**)	0.13(1.58)	-2.29 (1.99)*	-0.61(0.68)	0.87(0.82)	-0.10(0.45)
NEG	-0.78(3.47)**	-0.11(1.26)	-0.57(1.14)	0.55(0.86)	1.02(1.94)*	0.21(1.46)
lnY	0.49(1.14)	-0.22(2.79)**	-0.93(2.71)**	-0.86(3.52)**	-2.09(2.97)**	-0.46(5.28)**
π	0.14(0.71)	-0.12(3.20)**	-0.11(0.46)	-0.28(1.02)	-0.35(0.76)	0.35(1.52)
Constant	1.37(0.43)	-3.83(5.37)**	-7.23(3.54)**	-6.98(2.96)**	-7.06(3.19)**	-7.34(9.32)**
Panel C: Diagnostic tests						
F	6.27**	10.45**	4.03*	7.34**	2.92	6.89**
$\hat{\rho}_0$ $(t-ratio)$	-0.62(5.34)**	-1.09(7.61)**	-0.31(4.79)**	-058(6.40)**	-0214(2.04)	-0.61 (6.19)**
LM	1.06	0.09	0.31	8.45**	0.81	6.17**
RESET	4.77**	0.16	3.77*	2.70	1.27	2.99*
QS(S^2)	S(S)	S(S)	S(S)	S(S)	S(S)	S(S)
Adjusted R^2	0.42	0.59	0.49	0.53	0.29	0.82
Wald Tests						
Wald-short	5.67**	7.28**	5.26**	2.22	0.32	1.57
Wald-long	13.66*	0.61	1.16	1.34	0.21	0.04
Nonlinear ARDL	Senegal	Seychelles	Sierra Leone	South Africa	Tanzania	Togo
Panel A: Short-run						
ΔPOS_t	-0.24(0.46)	-0.82(1.12)	0.07(0.28)	0.10(0.60)	-0.02(0.77)	-1.40(3.55)**
ΔPOS_{t-1}	-0.93(2.15)**	-	-	-0.31(2.24)**	-	-

ΔNEG_t	-0.07(0.55)	1.26(1.78)*	-0.20(1.06)	-0.11(1.10)	-0.48(6.11)**	-1.06(2.41)**
ΔNEG_{t-1}	-	-	-	0.15(1.42)	-	-
ΔlnY_t	-0.25(1.02)	-0.20(0.58)	-0.(0.58)	-0.83(2.39)**	0.10(0.35)	-1.35(2.60)**
ΔlnY_{t-1}	-	-	-	-1.27(3.39)**	1.04(3.72)**	-1.86(3.19)**
$\Delta \pi_t$	0.15(1.63)	-0.59(1.70)*	-0.62 (2.25)**	0.04(1.45)	-0.58(1.21)	0.25(0.93)
$\Delta \pi_{t-1}$	-	-	-	-	-0.98(2.23)**	-
Panel B: Long-run						
POS	-0.87(1.49)	0.22(0.31)	0.17(0.28)	1.67(1.30)	-0.04(0.76)	9.90(1.15)
NEG	-0.14(0.57)	-0.81(2.60)**	-0.48(0.99)	0.22(0.43)	-1.32(4.84)**	7.50(1.66)
lnY	-0.51(1.00)	-0.30(0.61)	-0.49(0.66)	0.10(0.07)	0.17(0.83)	-4.45(1.78)*
π	0.31(1.77)*	-0.86 (1.79)*	-0.32(0.89)	-0.65(2.27)**	-0.56(4.80)**	-1.81(0.67)
Constant	-7.77(1.48)	0.01(0.01)	-9.37(1.34)	0.21(0.02)	0.64(0.24)	-36.55(1.81)*
Panel C: Diagnostic tests						
F	2.04	4.40*	2.97	2.30	6.48**	3.60
$\hat{\rho}_0$ $(t-ratio)$	-0.31(2.33)	-o.68(4.32)**	-0.43(3.30)	-0.17(3.61)*	-0.38(6.03)**	0.15(4.48)**
LM	1.52	0.02	0.31	0.05	0.55	2.31
RESET	5.27*	0.30	0.48	0.34	0.25	0.54
QS(S^2)	S(S)	S(S)	S(S)	S(S)	S(S)	S(S)
Adjusted R^2	0.36	0.30	0.35	0.68	0.56	0.54
Wald Tests						
Wald-short	2.33	3.13	1.36	4.85**	12.87**	13.03*
Wald-long	0.301	3.41*	0.04	0.23	5.12**	0.04

Notes:

a. Numbers inside the parenthesis are absolute values of the t-ratio and *(**) indicates significant at the 10% (5%) confidence level.

b. At the 10% (5%) significance level when there are three exogenous variables (k=3), the critical value of the F-test is 3.983 (4.733). These comes from Narayan (2005, p. 1988) for our sample size of 45 observations.

c. At the 10% (5%) significance level when there are three exogenous variables (k=4), the critical value of the t-test is -3.64 (-4.03). These come from Banerjee et al (1998, p. 276).

d. LM is Lagrange Multiplier test of residual serial correlation. It is distributed as χ^2 with one degree of freedom since we are testing for 1st order serial correlation. Its critical value at the 10% (5%) level is 2.71 (3.84).

e. RESET is for misspecification test. It is distributed as χ^2 with one degree of freedom. Its critical value at the 10% (5%) level is 2.71 (3.84).

f. Both Wald Tests are distributed as χ^2 with one degree of freedom. Its critical value at the 10% (5%) level is 2.71 (3.84).

nonlinear adjustment of the real effective exchange rate. The long-run effects are asymmetric since the Wald test reported as Wald-L in Panel C rejects the equality of normalized long-run coefficients of the POS and NEG variables in almost all eight countries. Clearly, the results are country specific. For example, consider the first country. The real effective exchange rate had no significant short-run and long-run effects on domestic investment in Burkina Faso.

Like old studies, if we were to rely only on the symmetry assumption and the linear model, the process would have stopped and we would have concluded that in Burkina Faso exchange rate changes have no roles to play. However, when appreciations are separated from depreciations, the nonlinear model reveal that appreciations, indeed, hurt domestic investment but depreciations do not. All in all, it appears that in the long run, currency appreciation hurts domestic investment in Burkina Faso, Cote D'ivoire, Gabon, Ghana, and Mauritius. On the other hand, a depreciation hurts investment in the long run in Cote D'ivoire and Gabon and boosts investment in Ghana, Seychelles, and Tanzania.

5. SUMMARY

Although majority of studies in macroeconomics identify economic activity and interest rate to be main determinants of domestic real or direct investment, several other studies have added the exchange rate to that list. Since a depreciation has positive impact on export, it helps the economy to grow. That is, investors become more optimistic about the future course of the economy, they will invest more. On the other hand, inflationary effects of a depreciation raises cost of imported inputs and may reduce the profit margin, hurting domestic investment.

All previous studies that investigated the effects of exchange rate changes on domestic investment assumed that the effects are symmetric, meaning that if $x\%$ depreciation stimulates domestic investment by $y\%$, an $x\%$ appreciation discourages investment by $y\%$, a symmetric effects. However, recently Bahmani-Oskooee et al. (2018) argued that due to downward rigidity in traded goods prices as well as domestic prices, exchange rate changes could have asymmetric effects on domestic investment. They demonstrated their conjecture by using data from six emerging economies of Brazil, Hungary, Malaysia, Mexico, the Philippines, and South Africa.

In this paper we consider the experience of Africa, a region that is understudied. Once we review the literature, we realize that not only existing studies in Africa are not comprehensive, but none has addressed asymmetric response of domestic investment to changes in the exchange rate. To fill the gap, we consider the response of domestic investment to exchange rate changes in each of the 18 African countries for which annual data over 1971-2016 period were available for all variables. The list includes Burkina Faso, Burundi, Cote D'ivoire, Egept, Ethiopia, Gabon, Ghana, Kenya, Mauritius, Morocco, Niger, Rwanda, Senegal, Seychelles, Sierra Leone, South Africa, Tanzania, and Togo.

Our findings could be best summarized by stating that when we relied upon symmetry assumption and employed the linear ARDL approach of Pesaran et al. (2001) we found short-run effects of exchange rate changes on domestic investment in three countries (i.e., Ethiopia, Senegal and Togo) and long-run significant and meaningful effects on the domestic investment in five countries (i.e., Ghana, Senegal, South Africa, Tanzania, and Togo). However, when we separated currency appreciations from depreciations and engaged in asymmetry analysis by using the nonlinear ARDL approach of Shin et al. (2014), we found significant short-run effects of either appreciation or depreciation in 13 countries (i.e., Burkina Faso, Burundi, Cote D'ivoire, Ethiopia, Gabon, Ghana, Kenya, Mauritius, Senegal, Seychelles, South Africa, Tanzania, and Togo) and long-run significant and meaningful effects in seven countries (i.e. Burkina Faso, Cote D'ivoire, Gabon, Ghana, Mauritius, Seychelles, and Tanzania). The increase in number of countries in both the short run and long run must be attributed to nonlinear adjustment of the real effective exchange rate in these African countries. Both short-run and long-run effects were asymmetric in almost all countries.

Our findings are country specific and provide different policy implications for different countries. Specifically, concentrating on the long run, the findings that currency appreciation hurts domestic investment in Burkina Faso, Cote D'ivoire, Gabon, Ghana, and Mauritius prescribes to these countries to avoid overvalued currencies. On the other hand, the findings that a depreciation hurts investment in the long run in Cote D'ivoire and Gabon suggests that these two countries should avoid devaluations. Opposite was found to be the case for Ghana, Seychelles, and Tanzania.

All in all, while African countries may allow their currency to depreciate in real term to enjoy increased exports and eventually economic growth, depreciation seems to have limited positive impact on domestic investment of three countries only.

APPENDIX

A1. Variable Definition and Sources

All data are annually over the period 1971-A2016. The data come from the following sources:

a. International Financial Statistics of the IMF
b. Bahmani-Oskooee and Gelan (2007)

A2. Variables:

$I =$ Nominal Gross Fixed Capital Formation (GFCF) divided by nominal Gross Domestic Product (GDP). Data from source a.

$Y =$ Real GDP, based on GDP-deflator. Data from source a.

$\pi =$ Inflation rate defined as $\ln CPI_t - \ln CPI_{t-1}$ where CPI is the Consumer Price Index. Data come from source a.

$RX =$ Real Effective exchange rate, based on consumer price index. The data come from source b. However, we had to extend the period beyond 2005 by using exactly the same procedure in source b. Due to the method of construction, a decline reflects a depreciation of domestic currency.

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