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An Assessment of the Exchange Rate Pass-Through in Angola and Nigeria

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Abstract

This paper estimates the exchange rate pass-through to consumer price inflation in Angola and Nigeria, with particular emphasis on the changes of the pass-through over time. Even though the two countries share smilar dependence on oil exports, this paper reveals different results. For Angola, the long-run exchange rate pass-through to prices is high, though it has weakened in recent years reflecting the de-dollarization of the economy. In Nigeria, there is no stable long-run relationship between the exchange rate and prices, and changes in the exchange rate do not have a significant pass-through effect on inflation. However, the pass-through effect on core inflation is significant.

JEL Classification Numbers: E31, E52, F31, F42.

Keywords: Exchange rate path-through, monetary policy, inflation, Sub-Sahara Africa, oil-producing countries.

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I. INTRODUCTION

Angola and Nigeria are the two largest oil producers in Africa and oil exports are the main source of foreign exchange for both countries. Until recently, exchange rate stability was a key ingredient of the disinflation strategy in both Angola and Nigeria.[2] However, as international oil prices declined significantly and foreign exchange revenues became more limited, the Angolan kwanza and the Nigerian naira have faced depreciation pressures. In response, the National Bank of Angola and the Central Bank of Nigeria abandoned their exchange rate anchor and allowed their currencies to depreciate at least to some extent, together with a gradual drawdown of international reserves. Simultaneously, fiscal policies have been tightened. Despite these policy actions, depreciation pressures on both currencies continue.

Policy makers in both countries face a difficult policy choice. On one hand, letting the currency depreciate further would help rebalance the foreign exchange market and reduce the loss of international reserves. On the other hand, preventing the currency to weaken further would help contain inflation given exchange rate pass-through effects.[3] Thus, understanding better the relationship of exchange rate movements and inflation is very important for monetary policy decision-making in both Angola and Nigeria.

This paper estimates the exchange rate pass-through to inflation in Angola and Nigeria given their similar economic characteristics and similar policy reactions to the oil price shock until recently. The paper puts particular emphasis on the changes of the pass-through over time. As both countries experienced historically high pass-through effects, the paper investigates whether this is still the case. The paper then suggests possible policies that each country could adopt to contain inflation while preserving international reserves.

The same methodological steps are applied to both countries' data.[4] It is found that Angolan data series are cointegrated while Nigerian data series are not. For Angola, a cointegration analysis between domestic prices, the nominal effective exchange rate and trade-weighted import prices is conducted, controlling for international food and oil prices as well as local demand conditions. For Nigeria, since no cointegration relationship is found between the three main variables, VAR models of the monthly growth rates are implemented.

The rest of this paper is organized as follows. Section II summarizes the empirical literature on exchange-rate pass-through, with particular focus on African countries and, even more specifically, on Angola and Nigeria. Section III describes the data and methodology used in the empirical analysis. Section IV presents the empirical results for Angola and Nigeria. Section V concludes the paper and includes a few policy recommendations.

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[2] Although the Central Bank of Nigeria pays attention to exchange rate movements, it does not explicitly include the exchange rate in its reaction function.

[3] Oil prices have a direct effect on inflation (through the price of fuels) and an indirect effect through its impact on the exchange rate. However, direct effects depend on whether domestic fuel prices are liberalized or controlled.

[4] The range of possible econometric approaches has been seriously limited by data availability in both countries.

II. Related Literature

The empirical literature on exchange rate pass-through is vast and diverse both in terms of datasets and methodological approaches. The studies based on aggregate data have usually resorted to time series techniques. Both single equation and multivariate models have been considered and have addressed cointegration relationship when appropriate. More recently, asymmetries and non-linearity have also been studied through threshold, spline, STAR (Smooth Transition Autoregressive) and regime switching models. The time-varying nature of the pass-through has been examined via sample splitting, rolling regressions and means of state space models. With the development of more disaggregated datasets, the topic has been also approached using panel data regressions at the country, industry and firm/plant levels. However, most of these studies have focused on developed countries, where various data is available for longer periods.[5]

In line with the aforementioned diversity in the literature for developed countries, the literature on pass-through for Sub-Saharan Africa (SSA) has also proven to be very heterogeneous.[6] These papers mainly resorted to panel data regressions with fixed effects in all SSA countries and their findings are corresponding to SSA average countries. Meanwhile, Razafimahefa (2012) investigated exchange rate pass-through for all SSA countries using both panel regressions and time series techniques for individual countries. He found that the pass-through was incomplete, asymmetric (larger in the case of depreciations than appreciation), and relatively low on average, though with a lot of variability from country to country.[7] On the other hand, Nguyen et al (2015) also confirmed the relatively low importance of nominal exchange rate shocks in driving inflation. They used a Global Vector Autoregression model and concluded that inflation was mostly driven by domestic factors and especially by supply shocks. According to his paper, demand shocks only explain 15 percent of inflation fluctuations on average, of which 36 percent corresponds to exchange rate fluctuations. So, the overall impact of changes in the exchange rate on inflation is relatively limited. The remaining literature corresponds mostly to country level studies that vary in terms of methodologies and conclusions depending on data availability and on each country's circumstances.

For Angola, there are two specific studies that are related to ours. First, Carvalho et al. (2012), based on the quantitative theory of money à la Harberger-Hanson for the period between 2000 and 2011, estimated a long-run pass-through of approximately 0.2 - 0.3

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[5] Burstein and Gopinath (2014) provides a good summary of recent literatures on the topic for developed economies. Goldberg and Knetter (1997) and Menon (1995) provide a good survey of earlier literature.

[6] See Aron et al. (2014) for a survey on the most recent research on exchange rate pass-through for developing and emerging economies, including SSA countries.

[7] Razafimahefa (2012) only reports VAR model results, but does not report the VECM results as they are similar to those of the VAR. It could be the case that the short run behavior predicted by the VAR is similar to the one predicted by the VECM, but in the latter there is a long-run relationship that a VAR model does not capture. Whether to estimate a VAR or a VECM depends on the properties of the system (i.e. whether the series are cointegrated or not), and this point seems to be missing in Razafimahefa (2012).

depending on the specification considered. However, since they used a single equation approach, it did not take consideration of potential feedback effects between prices and the exchange rate, and potentially underestimated the overall pass-through effects. Second, Klein and Kyei (2009) estimated a long-run pass-through of 0.78 for the period between 1997 and 2007. The relatively high pass-through was caused probably by two factors. First, their period covers part of the civil war period, which was accompanied by high volatility in prices. The high volatility in prices is usually considered to be one of the factors behind high pass-through coefficients. Second, they did not cover the period of de-dollarization reform periods, which would be expected to reduce the pass-through effects. The other studies mostly analyze the periods of the civil war and the rigid fixed exchange period ("hard kwanza") immediately after the war was over. Therefore, our study intends to shed light on more recent aspects of Angolan pass-through effects, particularly after the de-dollarization process period, taking into consideration the feedback effects between prices and the exchange rate.

For Nigeria there are many more recent papers on exchange rate pass-through. Most of them implement either Vector Autoregressive (VAR) or Vector Error Correction (VEC) models. There is no consensus on the size of the exchange rate pass-through in Nigeria. Some papers found that it was incomplete, small and non-significant in the short-run, but increasing over the long-run to as much as 0.9 (Adeyemi and Samuel (2013), Essien (2005), Batini (2004)). Others, such as Zubair, Okorie and Sanusi (2013), found that the pass-through was small, of about 0.2 in the long-run. However, the period considered in this paper includes 2008-2009 when large depreciations driven by the international crisis were not reflected. If the impact of the crisis is not properly accounted in the model, the pass-through might be underestimated. Our study accounts for the most recent period after the financial crisis and the new exchange rate pressures observed in 2014 and 2015.

III. DATA AND METHODOLOGY

The main challenge of this paper has been to overcome the data limitations, which have substantially constrained the methodological options available for this empirical analysis. With consideration of those constraints, this study is based on monthly aggregate time series. The period we covered was between May 2005 and April 2015 for Angola to isolate the war and the immediate post-war effects, while it is between January 1999 and April 2015 for Nigeria. Nigeria's period corresponds to the reestablishment of democracy and coincides with the shift from a fixed exchange rate regime to a managed float.[8]

The key series used are the Consumer Price Index (CPI) and the exchange rate. The CPI was obtained from the National Bureau of Statistics of each country. The nominal effective exchange rate (NEER) was used as a measure of exchange rate, where an increase in NEER indicates an appreciation of the local currency against the weighted basket of currencies of its

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[8] The seasonal adjustment is performed on all series using the X12 procedure with multiplicative option and moving seasonality ratio as the seasonal filter.

trading partners.[9] For Angola, we used the NEER series published by the IMF, which are based on the official exchange rates for Angola and its trading partners' currencies. The Angolan official rate is considered to reflect the actual fluctuations in the foreign exchange market. The spread between the official and parallel market rates has stayed relatively small until very recently. However, for Nigeria the IMF's NEER is based on the official rates and may not fully reflect the actual fluctuations in the exchange rate.[10,11] Therefore, we adjusted the NEER series by replacing the official rate with the interbank foreign exchange market (IFEM) rate.

In addition to CPI and the exchange rate, we included control variables relevant for pricing following other empirical exchange rate pass-through studies. Specifically, we used three control variables: the production cost of imported goods, a measure of local demand conditions, and a measure of supply conditions.

- The production cost of imported goods (i.e. import prices) is measured as a weighted average of the export price indices in the top import origin countries.[12] The weights are the average shares of imports from these countries in total imports over the period 1992-2014. The export price indices are obtained from the International Financial Statistics produced by the IMF as well as from Haver Analytics. This measure accounts not only for the cost of producing imported goods but also for the cost of importing them, which tends to be large in developing economies and is appropriate to be included for examining the pass-through effects.

- Local demand conditions are unobservable. Therefore empirical studies normally proxy local demand conditions with the output gap, measured as the cyclical component of output.[13] However, as Nigeria and Angola do not have appropriate National Account statistics with

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[9] The nominal exchange rate against the US dollar was also used for the same analysis since firms make price decisions usually based on the nominal exchange rate. The results are broadly similar to the one of NEER.

[10] In Nigeria, there are three exchange rates against the US dollar: the rate used at the Dutch Auction System (DAS), which is considered the official rate; the one used at the Interbank Foreign Exchange Market (IFEM); and the one used at the Bureau de Change (BDC). In the existing system of managed floating, the DAS rate has remained fixed for long periods of time, and all the volatility in the foreign exchange market has come mostly from fluctuations in the IFEM rate.

[11] Currently almost 40 percent of Nigerian imports come either from China or from the US, with which transactions are mostly done in the US dollars. Therefore, using the correct rate against the US dollar when computing NEER is crucial to appropriately capture the developments in the foreign exchange market.

[12] For Angola, the top import origins, which represent 75 percent of total imports, are: Portugal (19 percent), United States (11 percent), South Africa (8 percent), China (7 percent), France (6 percent), Republic of Korea (6 percent), Brazil (6 percent), United Kingdom (6 percent), Spain (4 percent) and Netherlands (4 percent). For Nigeria, the top import origins, which represent 65 percent of total imports, are: United States (11 percent), China (11 percent), United Kingdom (9 percent), Germany (7 percent), Netherlands (7 percent), France (6 percent), Italy (4 percent), India (4 percent), Brazil (3 percent) and Japan (3 percent).

[13] The cyclical component of output may not be the most appropriate measure of output gap in oil-rich economies such as Angola or Nigeria. The best approach would be to quantify potential output, but this is not possible in this case given the limited data availability.

high frequency, we proxy the estimated output gap with a monthly economic activity index obtained from a latent factor model based on Aruoba, Diebold and Scotti (2009).[14] Details on the methodology and the estimated series are reported in Appendix B.[15]

- Supply conditions are also difficult to observe in Angola and Nigeria due to the lack of appropriate data. Therefore, a scarcity index of agricultural products is incorporated into the regressions as a proxy for this but only for Nigeria. While this is less important for Angola with low dependence on the agricultural sector, it is more relevant for Nigeria with the agricultural sector representing more than 20 percent of the economy. In order to gauge the scarcity of agricultural products in Nigeria, we first compute the cyclical component of the annual Crop Production Index, which is part of the World Development Indicators produced by the World Bank.[16] We then created a dummy variable at monthly frequency that takes the value one when the cyclical component of crop production falls below the trend, and takes the value of zero otherwise.

In terms of the methodology, the same general methodology was followed for both countries. First the data were inspected to identify features such as trends and structural breaks. Then, we determined the order of integration of the series by using standard unit root tests:

a. If the series are determined to be integrated of order 1, we applied the Johansen (1988) multivariate cointegration procedure to test the existence of a cointegrating vector among the non-stationary series. If the time series are found to be cointegrated, a Vector Error Correction Model (VECM) is estimated.[17] By using VECM, we can reconcile the long-run equilibrium with out-of-equilibrium behavior in the short-run and identify long-term and short-term relationship of the variables.

b. If the series are not found to be cointegrated, the pass-through coefficients are estimated by means of a VAR model following Burnstein and Gopinath (2014).[18]

While we adopt the same general econometric approach for both countries, we ended up using different econometric techniques in each country case. For Angola the series are

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[14] Angola's GDP statistics are only available for annual series. Nigeria's GDP statistics are available for quarterly series but only for a very short period starting from 2010. Therefore, we decided to construct monthly economic activity indicators, which follow the two countries' GDP statistics relatively well as shown in Appendix B.

[15] While the estimated index of economic activity seems to be satisfactory for Angola, it is less so for Nigeria given the lack of reliable statistics on the real sector of the economy. Also the constructed output gap does not capture the large informal activity in both countries.

[16] Obtained using the Hodrick-Prescott filter.

[17] ECM could be considered for this analysis. However, by considering VECM, we treated all variables as endogenous, which seems more plausible than the assumption that the exchange rate and import prices are exogenous variables.

[18] We could consider a structural VAR for this analysis. However, a VAR with Choleski decomposition is by itself a SVAR with constraints imposed on a lower triangular matrix. We could consider imposing different constraints but it would require to construct an appropriate model with deeper theoretical justification, which goes beyond the scope of this paper.

cointegrated, and VECM model was estimated. For Nigeria, the series were not found to be cointegrated, and VAR model was used to estimate the pass-through coefficients.

IV. EMPIRICAL ESTIMATES

A. Angola

Preliminary Data Inspection

Before running the model, we first inspected the general trends of the main variables (CPI, NEER and import prices) of Angola. The levels of the three variables–CPI, NEER and import prices – are depicted in Figure 1. Both CPI and import prices (Pm) exhibit a positive trend, while NEER is trended slightly downward. This is also reflected in the correlation coefficients of the variables in levels reported in Table 1. While there is a strong positive relationship between CPI and import prices, the relationship between CPI and NEER is negative. Meanwhile, the year-on-year growth rates of the three variables are presented in Figure 2. CPI and import prices show a similar trend while CPI and NEER exhibit somehow an opposite trend. These patterns are confirmed in Table 1, which shows correlation coefficients between the log-changes of CPI and NEER and those of CPI and import prices. Although the coefficients showed the expected signs, the absolute values appear relatively small.

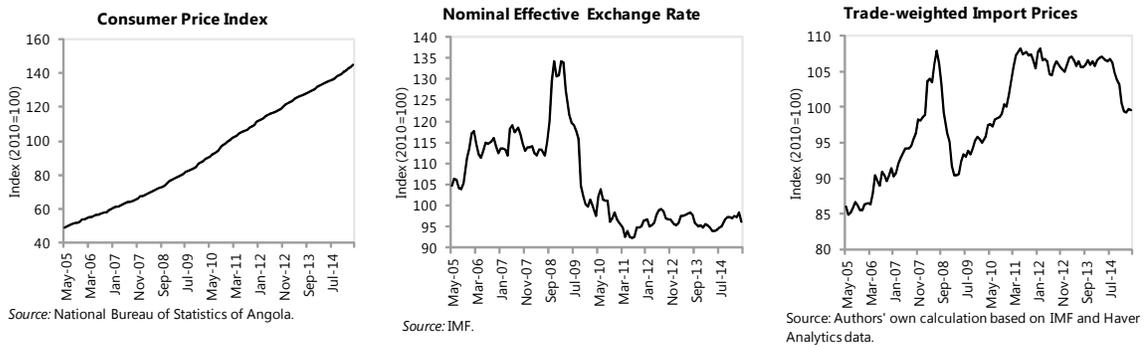Figure 1. Angola: CPI, NEER and Import Prices, Levels (2005-2015)

Source: National Bureau of Statistics of Angola.

Source: IMF.

Source: Authors' own calculation based on IMF and Haver Analytics data.

Figure 2. Angola: CPI, NEER and Import Prices, Annual Growth (2005-2015)

(In percent)

Then, we analyzed different sub-periods with the aim of identifying structural breaks in the relationship. We are particularly interested in the period of the global financial crisis (i.e. 2008 and 2009) and the de-dollarization reform period (2010 and onwards).[19] Table 1 shows that the negative relationship between CPI and NEER breaks in 2008-2009 (i.e. the global financial crisis period) with their correlation coefficients turning into positive in 2008-2009 and then returning negative after 2010. Meanwhile, the negative relationship between CPI and import prices became positive after 2010, when the authorities launched de-dollarization reforms. Those changes in the relationship strengthened our motivation to investigate the changes in the pass-through effects over time.

Order of Integration

Following the standard approach in time-series analysis, the order of integration of the series was determined by testing the existence of unit roots. Considering the low power of the available tests, both the Augmented Dickey-Fuller (ADF) and Dickey-Fuller GLS (DF-GLS) test statistics were used. The number of lagged differences used in the tests was the one suggested by the Schwarz information criteria if a maximum lag order of 12 was considered. The results of the tests are reported in Table 2. Since all the tests failed to reject the null hypothesis for the series in levels and rejected the null hypothesis for the series in first differences, we concluded that all the series are integrated of order 1. Therefore, cointegration tests are necessary before conducting the regression.

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[19] The Angolan central bank set de-dollarization as one of its goal at the end of 2009, and launched various policies to support the process. Consequently, the share of dollar-denominated loans and deposits in total loans and deposits declined from around 60 percent in 2009 to around 40 percent in 2014.

Cointegration Test and VECM

First, we evaluated the existence of a cointegrating relationship between CPI, NEER and import prices (Pm) by the Johansen test. A linear trend term was added to the test model due to the trending behavior observed in all the series. The number of lagged differences was determined based on model selection criteria applied to the VAR in levels.[20] The results of the test are shown in Table 3, pointing to the existence of a single cointegrating vector at the 5 percent level.

Second, we conducted a VECM on the three-dimensional system of interested variables (CPI, NEER, and Pm) with cointegrating rank 1 and 5 lagged differences based on the cointegration analysis results above. As discussed above, three exogenous variables (the output gap and the log-change of international food and oil prices) were incorporated to the model to control for the potential effect they may have on inflation in the short-run.[21] [22]

The long-run equilibrium relationship of the model is estimated to be

$$ec_t = cpi_t + 0.64 \times neer_t - 0.65 \times pm_t - 0.01 \times t - 4.04$$

where cpi_t stands for the log of CPI, $neer_t$ for the log of NEER, pm_t for the log of import prices, and t is a time trend. All the coefficients in the above expression are statistically significant at the 5 percent level.

The CPI in the long-run is associated negatively to NEER and positively to import prices. These results are in line with the purchasing power parity theory. The result shows that a 1 percent decline in NEER (i.e. a depreciation of the Angolan kwanza) generates an increase in CPI of 0.64 percent and a 1 percent increase in import prices generates an increase in CPI of 0.65 percent in the long-run. It shows that the exchange rate pass through to inflation is high and import prices have a significant impact on inflation in Angola (Figure 3).[23]

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[20] The model selection criteria applied to the VAR in levels, considering a maximum lag length of 12, suggest a lag length of 12 (LR), 5 (AIC, FPE, HQ) or 2 (SIC).

[21] We also considered a model including the measure of food scarcity as an additional control, but the results do not change substantially. This is not surprising given the low share of agriculture in Angola's GDP.

[22] After estimating the model by the Johansen maximum likelihood procedure and checking the residuals, the model seems to be satisfactory. The result was shown in Table 4.

[23] As shown in Figure 3, the error correction term rose substantially during the crisis. This means that there was a large deviation from the long-run relationship over this period. The fact that the error correction term varies over time reassures the need of addressing this problem using a VECM rather than a VAR.

Shifting attention to the short-run dynamics, the results of the ECM estimations are reported in Table 5. The error correction (ec) term is significant only for the NEER and import prices equations, which implies that following a shock only these two variables adjust endogenously to the long-run equilibrium. CPI lacks short-run adjustment and is mostly determined by its past changes. Meanwhile, changes in NEER only affect inflation with a delay of two months and the effect only lasts for one period.

Figure 3. Angola: Cointegrating vector,

Shaded area corresponds to the international crisis in 2008-2009.
Source: Authors' own calculations.

That is ΔNEER has no significant effect on inflation in the short-run. This result is somewhat puzzling given the relatively large pass-through effects in a long run. The possible explanation is that there exist many price setting schemes under administrative control in Angola. Therefore, price changes tend to occur only with substantial lags.

The Changes in the Pass-Through Effects Over Time

We now shift our focus on how the long-term relationship has evolved over time especially since the short-run relationship between inflation and changes in the exchange rate does not seem to be significant as discussed above. Therefore, we employed a Dynamic Ordinary Least Squares (DOLS) developed by Stock and Watson (1993) as an alternative because this methodology estimates cointegrating relationships but has flexibility to incorporate interaction terms together with other deterministic terms in the long run equation. As the preliminary data inspection suggested, we focused on the relationship breaks after the global financial crisis (2008 and 2009), and the de-dollarization reforms (2010 onwards). The results are shown in Table 6.

First, we incorporated an interaction term for the relationship break after the global financial crisis. The results show that the negative impact of the exchange rate on the price level declined to 0.49 in the period of 2008-2015 from 0.69 in the period before 2008. However, the period coincides with the global economic recovery following the global financial crisis, which was accompanied by lower volatility in oil and other commodity prices. The low volatility in commodity prices generally leads to the reduction in the exchange rate pass-through effects and so might exaggerate the decline.

Second, we incorporated an interaction term to take consideration of de-dollarization reforms (i.e. after 2010). The results show that the negative impact of NEER on CPI has weakened in
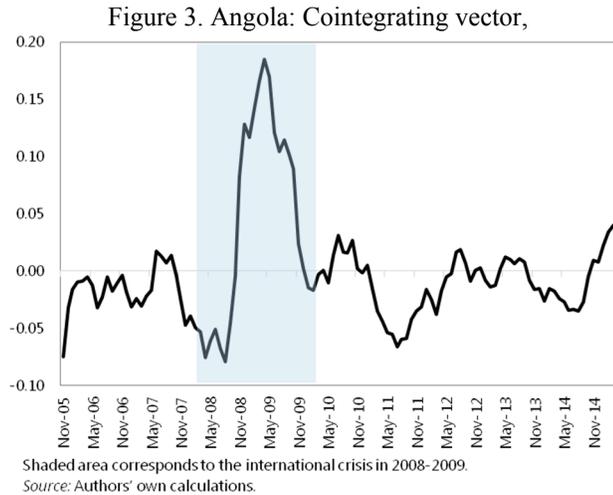
2010 and onwards, indicating that the de-dollarization reforms helped to reduce the pass-through effects. A 1 percent decline in NEER generates an increase in CPI of 0.34 percent in the period 2011-2015, substantially down from 0.63 for the period of 2005-2010.

Overall, this section showed that the long-run exchange rate pass-through to inflation in Angola is large, but it has weakened recently as a consequence of reforms aiming to de-dollarize the economy. The evidence also indicates that in the short-run the pass-through is not significantly different from zero.

B. Nigeria

Preliminary Data Analysis

The analysis for Nigeria covers the period January 1999- April 2015. This period corresponds to the reestablishment of democracy and the shift from a fixed exchange rate regime to a managed floating.

The levels and year-on-year growth rates of the three series under study – CPI, NEER and import prices– are depicted in Figure 4 and Figure 5. Regarding the levels, CPI and import prices exhibit a positive trend, while NEER's trend is downward sloping. This is also reflected in the correlation coefficients of the variables in levels reported in Table 7. During the period 2000-2015 the data displays a strong positive correlation between CPI and import prices and a strong negative correlation between CPI and NEER. This is in line with the predictions of the purchasing power parity theory. However, as will be shown in the cointegration analysis, this linear relationship among the (logs of the) three variables does not seem to be stable over the long-run.

Shifting attention to the growth rates, the contemporaneous correlation between inflation and the year-on-year log-change of NEER in the period 2000-2015 is very low (in absolute value) during the period under study. This lack of comovement in the growth rates is also evident from Figure 5. Additionally, by looking into the correlations for different sub-periods, it seems that the international financial crisis in 2008-2009 did not have a significant effect since, regardless of the period considered, the correlation between inflation and the year-on-year log-change in NEER is very close to zero. These preliminary observations will be confirmed with the results obtained from the estimation of the VAR reported in subsequent subsections.

The correlation between inflation and the year-on-year growth rate of import prices (Pm) is also close to zero for the whole sample, but it hides a change in the relationship over time. The correlation between inflation and the change in import prices has become relatively stronger, particularly in the aftermath of the international crisis. Nevertheless, the magnitude of the correlations in absolute value is still low.

Figure 4. Nigeria: CPI, NEER and Import Prices, Levels (1999-2015)

Source: National Bureau of Statistics of Nigeria.

Source: Authors' own calculations based on IMF data.

Source: Authors' own calculation based on IMF and Haver Analytics data.
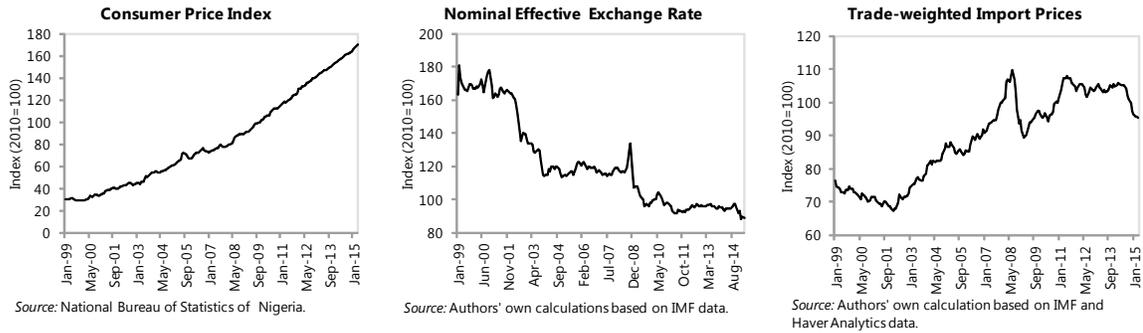
Figure 5. Nigeria: CPI, NEER and Import Prices, Annual Growth (2000-2015)
(In percent)
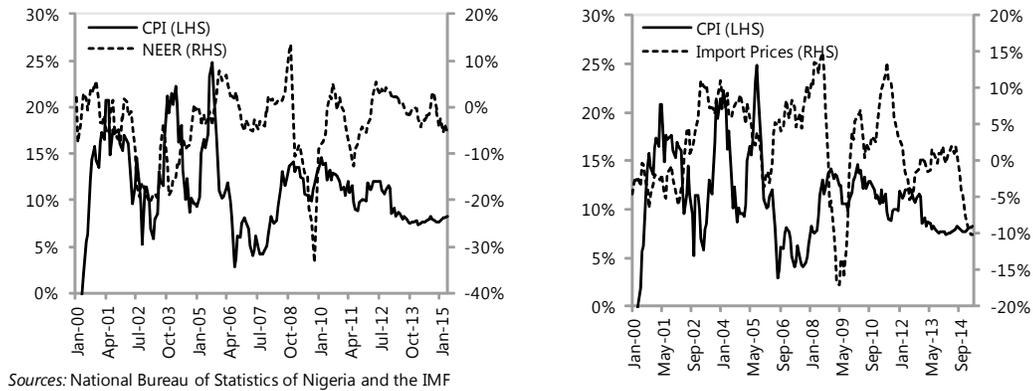
Sources: National Bureau of Statistics of Nigeria and the IMF

Order of Integration

Following the standard approach in time-series analysis, the order of integration of CPI, NEER and import prices is determined by testing the existence of unit roots. Considering the low power of the available tests, both the Augmented Dickey-Fuller (ADF) and Dickey-Fuller GLS (DF-GLS) test statistics are used. The number of lagged differences used in the tests is the one suggested by the Schwarz information criteria if a maximum lag order of 12 is considered. The results of the tests are reported in Table 8. Since all the tests fail to reject the null hypothesis for the series in levels and reject the null hypothesis for the series in first differences, it can be concluded that all the series considered are integrated of order 1. Therefore, cointegration tests are necessary before regression results can be considered.

Cointegration Test and VAR

The Johansen test is used to evaluate the existence of a cointegrating relationship between CPI, NEER and import prices (Pm). A linear trend term is added to the test model due to the trending behavior observed in all the series. The number of lagged differences is determined

based on model selection criteria applied to a VAR in levels.[24] The results of the test are reported in Table 9. The cointegration tests indicate no cointegration between these three variables at the 5 percent level of significance.

Given that the variables are not cointegrated, the exchange rate pass-through is quantified by estimating a VAR in first differences. Besides the variables considered so far (CPI, NEER, import prices), broad money (M2) is also incorporated to the model to account for the effect of monetary policy on inflation, which has been highlighted as an important channel in previous studies.[25] International oil and food prices are not considered since they are already captured by import prices (Figure 6).[26] Measures of output gap and food scarcity, as described in the data section, are also added to the model to control for local demand and supply conditions, respectively. Finally, we included dummies to control for exogenous policy changes as well as excessively large devaluations.[27] [28] The results do not change significantly if the dummies controlling for large devaluations are excluded, but their inclusion improves the fit of the model.

The lag length selection criteria, with a maximum lag length of 12, suggest a lag length of 3 (LR), 2 (AIC, FPE) or 1 (SIC, HQ). However, given the use of monthly data, such a small number of lags may not fully capture the dynamics of the system. Our rule of thumb is to include the minimum number of lags that guarantees multivariate normal white noise residuals, which in this case is 9. After estimating the model and checking the residuals, it satisfactorily represents the dynamics of the variables in the system.[29]

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[24] The model selection criteria applied to the VAR in levels, considering a maximum lag length of 12, suggest a lag length 2 (LR, AIC, FPE, HQ) or 1 (SIC).

[25] ADF tests reported in Table 8 indicate that broad money is I(1). According to the Johansen test on the augmented system ($CPI, NEER, PM, M2$) in Table 10, there seems to be no cointegrating relationship among these variables.

[26] The correlation of Pm with international oil and food prices is 0.96. The high co-movement is also observed in Figure 6.

[27] During the period under consideration three policy changes were made, which affected the variables included in the model. First, the introduction of DAS in July 2002. Second, the introduction of the Wholesale-DAS in February 2006 to foster exchange rate convergence between the DAS and the inter-bank market rates. Finally, the implementation of a new monetary policy framework by the Central Bank of Nigeria in December, 2006.

[28] The three largest devaluations occurred in December 2008 – January 2009, in November-December 2014 and in February-March 2015, as a consequence of the international crisis and the pressures generated by the decline in international oil prices. There was also another episode of substantial devaluation in October-November 2003. In this case, it was driven by demand pressures as a consequence of higher fiscal expenditure (related to one-off events such as All Africa Games in October and the Commonwealth Heads of Government Meeting in December), as well as factors such as the liberalization of the domestic retail petroleum products market and speculative pressures following a reduction in average daily sales in October (IMF, 2004).

[29] The model satisfies the non-autocorrelation and normality of the estimated errors. The only note of concern regards heteroscedasticity. The volatility of the first difference of CPI was larger before 2006 and declined afterwards. This might be a potential source of heteroscedasticity in the estimated errors. If that is the case, estimating a model that better accounts for this behavior, such as an ARCH/GARCH model, may be more appropriate to better represent inflation in Nigeria. This is left for future research.

Figure 6. Nigeria: Import Prices and Commodity Prices (1999-2015)

Sources: IMF and Haver Analytics.
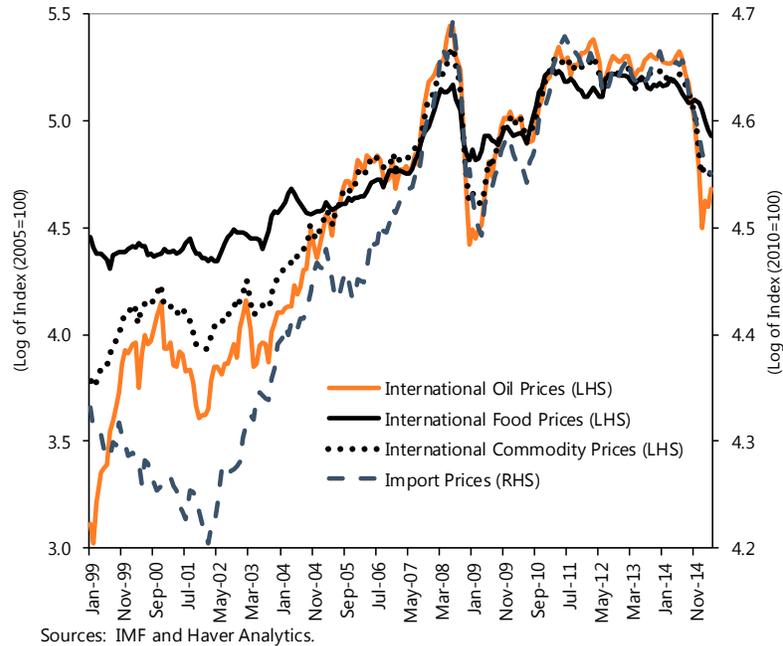
The dynamic behavior of the variables is assessed using impulse response functions (IRFs). Assuming that the system starts at its long-run equilibrium, the impulse response of inflation to a one-standard deviation shock to ΔNEER is obtained using a Cholesky decomposition with the following ordering: $\Delta pm \rightarrow \Delta neer \rightarrow \Delta cpi \rightarrow \Delta m2$.[30] The IRF obtained from the estimated VAR is displayed in Figure 7.[31] The results indicate that inflation is irresponsive to changes in NEER, since the IRF is not statistically significantly different from zero within a year following the shock. Dynamic pass-through elasticities are computed from the estimated VAR and reported in Table 11.[32] As expected, the point estimates for the pass-through are

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[30] This assumption is equivalent to the one in McCarthy (2007). McCarthy(2007)'s economic intuition is that foreign shocks (which could include oil price shock) are identified from the dynamics of import price inflation only; the exchange rate shocks are identified from the dynamics of exchange rate appreciation after taking into account the contemporaneous effects of the foreign shocks; then CPI inflation can be affected by both the exchange rate and import prices so that it comes after the exchange rate in order of exogeneity; then money supply comes last because monetary policy reacts to both exchange rate fluctuations and to domestic inflation. Other orderings were tried, in particular $\Delta pm \rightarrow \Delta m2 \rightarrow \Delta neer \rightarrow \Delta cpi$, and yielded similar impulse responses.

[31] The confidence intervals in Figure 8 correspond to +/- two standard deviations of the IRF point estimates. The residuals of the model were tested to make sure that the errors are distributed multivariate normal. Therefore, two standard deviations from the point estimate would correspond to approximately 95 percent confidence.

[32] The dynamic pass-through elasticity of inflation to a ΔNEER shock in period t is defined as the ratio of the accumulated impulse response of inflation in period t over the initial shock to ΔNEER (i.e. ΔNEER standard deviation).

very small, of less than 10 percent even 6 months after the shock occurs, which is in line with the fact that tradable goods represent a very small share of the CPI basket.

Figure 7. Nigeria: Impulse Response Functions of Headline Inflation to a 1 Standard Deviation Shock to ΔNEER
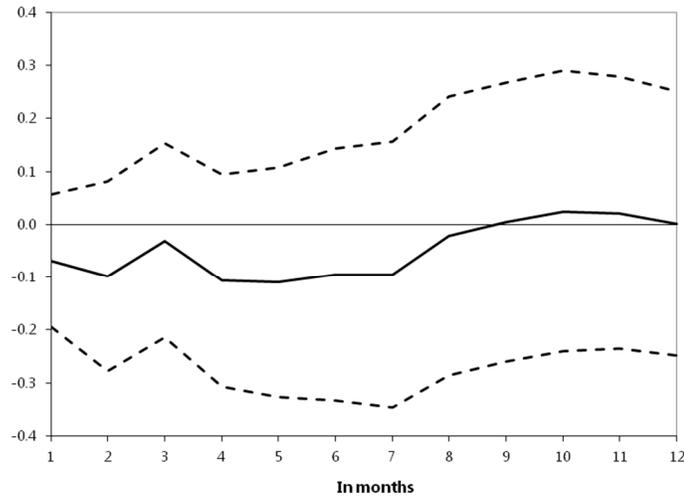
Source: Authors' calculation.
Note: The confidence intervals correspond to an approximately 95 percent confidence level.

To evaluate the stability over time of the regression relationship, which involves constancy of the estimated parameters and their corresponding variances, we resort to tests based on the cumulative sum and the cumulative sum of squares of recursive residuals. The results, reported in Figure 8, suggest that the estimated relationship has not changed over time. The values of the test statistics do not exceed the critical values for a 5 percent significance level test. This finding is not surprising since it is in line with the preliminary analysis of the correlations between the series, which were very close to zero regardless of the period considered.

We hypothesize that the main reason behind the low pass-through from exchange rate to headline inflation is the non-responsiveness of food prices to changes in NEER. To test this hypothesis we re-estimate the VAR but, rather than using headline inflation, we use core inflation, which excludes food. [33] The resulting impulse response function is shown in Figure 9 and the estimated dynamic pass-through elasticities are reported in Table 11. We find that the changes in NEER do not have a contemporaneous effect on core inflation. The impact becomes statistically significant 4 months after the shock occurs, but only lasts for 2 months, becoming statistically insignificant afterwards. The pass-through elasticity half a year after the shock occurs is of 32 percent.

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[33] We repeated all the cointegration tests using core inflation and found that there is no cointegration relationship. That is why we estimated a VAR rather than a VECM with core inflation.

Figure 8. Nigeria: Stability Analysis

Cumulative Sum

Source: Authors' calculation.
Note: The confidence intervals correspond to an approximately 95 percent confidence level.

Cumulative Sum of Squares of Recursive Residuals

Source: Authors' calculation.
Note: The confidence intervals correspond to an approximately 95 percent confidence level.
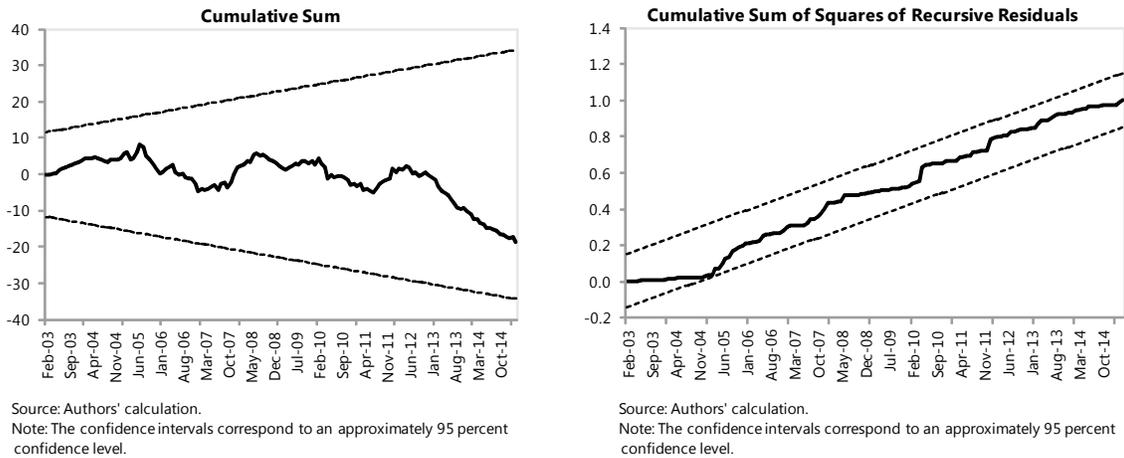
Figure 9. Nigeria: Impulse Response Function of Core Inflation to a 1 Standard Deviation Shock to ΔNEER

Source: Authors' calculation.
Note: The confidence intervals correspond to +/- two standard deviations from the IRF point estimates.
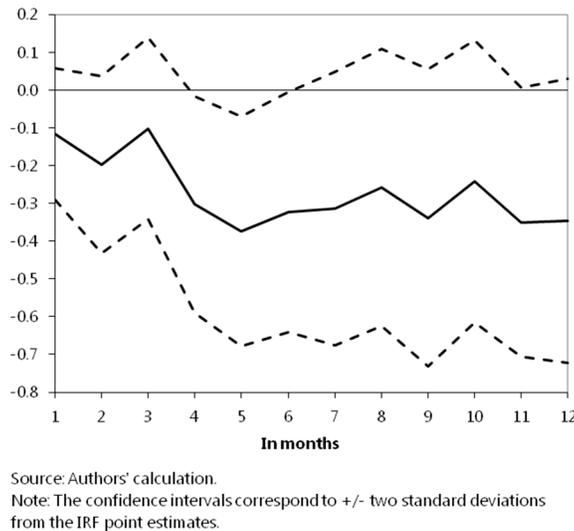
In summary, the results do not show a stable long-run relationship between CPI, NEER and import prices (Pm) for the period from January 2000 to April 2015. However, changes in the NEER have a significant, but short-lived, pass-through effect on core inflation.

In the short-run, headline inflation is not responsive to changes in NEER. Impulse response functions obtained from the estimation of a Vector Autoregressive model are not statistically significantly different from zero within a year following the shock. The point estimates for the pass-through are very small, of less than 10 percent even 6 months after the shock occurs. Evidence indicates that this relationship has not changed over time.

Core inflation displays a lagged and short-lived response to changes in NEER. Changes in NEER do not have a contemporaneous effect on core inflation. The impact becomes statistically significant 4 months after the shock occurs, but only lasts for 2 months, becoming statistically insignificant afterwards. The pass-through elasticity to core inflation half a year after the shock occurs is around 32 percent.

A key factor behind the low pass-through from exchange rate to headline inflation is that food prices are not affected by changes in NEER. The results indicate that devaluations of the naira only have a short-lived effect on non-food inflation. Food prices do not react to changes in the exchange rate because most of the food is locally produced. That is, food prices are to respond more strongly to local market supply and demand developments to foreign exchange market developments.

V. CONCLUSIONS AND POLICY RECOMMENDATIONS

This paper estimated the exchange rate pass-through to consumer price inflation in Angola and Nigeria with particular emphasis on the changes of the pass-through over time. While the same methodological steps were conducted for both countries, different econometric techniques were used for each country. For Angola, a cointegration analysis between domestic prices, nominal effective exchange rate and trade-weighted import prices was conducted, controlling for international food and oil prices as well as local demand conditions. For Nigeria, since no cointegration relationship was found between the three main variables, VAR models of their monthly growth rates were applied.

Angola's results show that the long-run exchange rate pass-through to inflation has been relatively high given the country's less diversified economic structure and, therefore, heavy reliance on imports. However, pass-through effects have weakened recently as a consequence of de-dollarization. The results indicate that pass-through effects in the short-run are not significantly different from zero, pointing to possible price distortions by administrative price setting schemes.

For Nigeria, the analysis shows that the exchange rate pass-through has short-lived effects on non-food (core) inflation. Food prices do not seem to react to changes in the exchange rate because most food items are locally produced. That is, changes in food prices respond more strongly to local developments in supply and demand than to developments in the foreign exchange market. Therefore, following a devaluation episode, the groups mostly affected would be the ones for which non-food consumption represents a larger share of their income. Conversely, maintaining a stable exchange rate would protect the consumption level of groups for which non-food items are relatively more important in their total spending.

The paper revealed that Angola and Nigeria show a different relationship between the exchange rate and prices, although the two countries share similar dependence on oil exports and until recently had adopted similar policy actions to the oil price shock. This reflects the different structure of their domestic economies. Among others, the depth of the domestic food production base appears to matter the most. Although food represents roughly a half of the CPI basket in both countries, most food items are imported in Angola but are locally produced in

Nigeria. As a consequence, the exchange rate pass-through to prices in Nigeria turned out to be smaller than in Angola, even though the pass-through in Angola has declined over time.

Based on these findings, the following policies could be considered for Angola:

- First, the authorities should consider another nominal anchor for the economy. When the pass-through effects were extremely high, the exchange rate was arguably the only possible monetary policy anchor. However, with now lower pass-through effects, the authorities could introduce alternative monetary policy anchors and allow additional exchange rate flexibility.

- Second, de-dollarization policies should be pursued further. Angola's dollarization levels declined substantially as a result of explicit de-dollarization policies, but it still remains somewhat high, with a share of dollar-denominated loans and deposits of around 30 percent in 2015. High dollarization constraints the central bank's monetary policy flexibility because it limits the effectiveness of monetary policies. Therefore, in order to restore full policy flexibility, the Angolan authorities should continue to actively pursue de-dollarization.

- Third, it is important to accelerate the pace of structural reforms in pursue of economic diversification. The still relatively high pass-through effects, especially compared to Nigeria, appear to stem from a less diversified economic structure and thus higher import dependence of the Angolan economy. If the Angolan economy becomes more diversified and less dependent on imports, the pass-through effects are expected to diminish further, providing additional policy flexibility in general to the Angolan authorities.

For Nigeria, the following policies could be considered:

- First, as the exchange rate pass-through to prices in Nigeria is limited, the monetary authorities should not be as concerned with the effect of a devaluation on inflation and should allow the exchange rate to adjust in line with underlying macroeconomic fundamentals.

- Second, adopting a regime that permits greater exchange rate flexibility would help mitigate the impact of an external shock and reduce the burden on other policies. Experience shows that, when shocks are largely external in nature, e.g. a shock to oil prices, a more flexible regime proves more resilient. In contrast, in a more fixed regime, fiscal policy typically has to carry the burden of adjustment to shocks. However, fiscal policy can have limited scope to be flexible when a tightening is required. Capital expenditures are often the buffer, but this could have adverse effects on long-run growth prospects.

- Third, the monetary authority's recent efforts to move toward greater flexibility in the exchange rate should be part of a consistent and credible package of sustainable policies. In particular, the need for employing an effective monetary policy framework that supports a flexible exchange rate regime and anchors inflation.

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APPENDIX A: TABLES

Table 1. Angola: Correlation Coefficients

CPI–NEER		
Levels	2005-2015	-0.730
Growth Rates (y-o-y)	2005-2015	-0.207
	2005-2007	-0.560
	2008-2009	0.068
	2010-2015	-0.597
CPI – Pm		
Levels	2005-2015	0.793
Growth Rates (y-o-y)	2005-2015	0.219
	2005-2007	-0.535
	2008-2009	-0.869
	2010-2015	0.794

Table 2. Angola: ADF and DF-GLS Unit Root Tests

Variable	Deterministic Terms	ADF			DF-GLS		
		Lags	Test Statistic	Critical Value	Lags	Test Statistic	Critical Value
CPI	c, t	1	1.2324	-3.4483	3	-0.6807	-3.0140
D(CPI)	c, t	0	-5.8990	-3.4483	0	-5.9323	-3.0120
NEER	c, t	1	-2.6710	-3.4483	1	-2.0584	-3.0120
D(NEER)	c	0	-6.9958	-2.8861	0	-6.8089	-1.9436
Pm	c, t	3	-2.5864	-3.4490	3	-2.3034	-3.0140
D(Pm)	c	2	-3.7041	-2.8865	2	-3.1125	-1.9436

Table 3. Angola: Johansen Cointegration Test for CPI, NEER and Pm

Test	Deterministic Terms	No. of Lagged Differences	Null Hypothesis	Test Statistic	Critical Values	Prob.
Trace	Constant linear trend	5	$r = 0$	66.75	42.92	0.0000
			$r \leq 1$	17.97	25.87	0.3457
			$r \leq 2$	0.99	12.52	0.9991
Maximum Eigenvalue	Constant linear trend	5	$r = 0$	48.78	25.82	0.0000
			$r \leq 1$	16.98	19.39	0.1081
			$r \leq 2$	0.99	12.52	0.9991

Table 4. Angola: Diagnostics for VECM for CPI, NEER and Pm

Test	Autocorrelation			Normality		Heteroskedasticity
	Q_{21}	$Adj.Q_{21}$	LM_4	JB_4^L	JB_4^{DH}	χ^2_{186}
Test Statistics	163.89	182.36	5.107	5.5125	5.7216	258.28
P-value	0.2071	0.0370	0.8249	0.4799	0.4551	0.6854

Table 5. Angola: Error Correction Model for CPI, NEER and Pm (2005 May – 2015 April)

	Δcpi_t	$\Delta neer_t$	Δpm_t
ec_{t-1}	-0.00029	-0.32262*	0.06515*
	(0.00559)	(0.04978)	(0.02775)
Δcpi_{t-1}	0.38815*	-0.79883	0.06919
	(0.07987)	(0.71135)	(0.39660)
Δcpi_{t-2}	0.02133	0.53451	-0.11445
	(0.08736)	(0.77808)	(0.43380)
Δcpi_{t-3}	0.08120	1.68332*	-1.17480*
	(0.08809)	(0.78461)	(0.43744)
Δcpi_{t-4}	0.05391	-0.64219	1.00440*
	(0.08422)	(0.75016)	(0.41823)
Δcpi_{t-5}	0.04961	0.88038	-0.04653
	(0.08004)	(0.71287)	(0.39744)
$\Delta neer_{t-1}$	-0.00505	0.17202*	0.02299
	(0.00850)	(0.07570)	(0.04220)
$\Delta neer_{t-2}$	-0.01652**	-0.09548	-0.08860*
	(0.00865)	(0.07705)	(0.04296)
$\Delta neer_{t-3}$	0.01191	-0.04775	0.02379
	(0.00890)	(0.07925)	(0.04418)
$\Delta neer_{t-4}$	-0.00299	-0.06196	0.06894
	(0.00878)	(0.07820)	(0.04360)
$\Delta neer_{t-5}$	-0.00919	-0.03012	-0.04627
	(0.00834)	(0.07431)	(0.04143)
Δpm_{t-1}	0.00964	-0.26437**	0.10580
	(0.01673)	(0.14901)	(0.08307)
Δpm_{t-2}	-0.00942	-0.22823	-0.13322**
	(0.01642)	(0.14627)	(0.08155)
Δpm_{t-3}	0.01009	-0.32087*	0.11970
	(0.01699)	(0.15133)	(0.08437)
Δpm_{t-4}	-0.01539	-0.47901*	0.42795*
	(0.01639)	(0.14600)	(0.08140)
Δpm_{t-5}	-0.01558	-0.42267*	0.03166
	(0.01792)	(0.15964)	(0.08900)
output gap	0.00018	0.00002	-0.00128**
	(0.00014)	(0.00121)	(0.00068)
Δp_{food}^*	-0.00261	-0.12907*	0.05953*
	(0.00514)	(0.04575)	(0.02551)
Δp_{oil}^*	-0.00209	-0.03941*	0.04623*
	(0.00221)	(0.01968)	(0.01097)
Trend	-0.00002*	-0.00011*	-0.00002
	(0.00001)	(0.00005)	(0.00003)
C	0.00472*	-0.00623	0.00400
	(0.00111)	(0.00991)	(0.00553)

Note: Standard deviations in parenthesis. The regression also included dummies to control for outliers.

* Significance at 5 percent level. ** significance at 10 percent level.

Table 6. Angola: Cointegrating Equation and the Impact of Monetary Policy Reforms

Dependent Variable: CPI

Method: DOLS

Variable	Coefficient	Prob.	Coefficient	Prob.
Pm	0.6741948	0.000	0.7882717	0.000
NEER	-0.6889709	0.000	-0.6308608	0.000
NEER*Reform08	0.1972947	0.030		
Reform08	-0.9077203	0.036		
NEER*Reform11			0.2922213	0.000
Reform11			-1.3389820	0.000
Linear Trend	0.0066681	0.000	0.0063050	0.000
Constant	4.1900840	0.000	3.4211020	0.000

Note: Reform08 is a shift dummy variable that takes the value one on 2008 and afterwards, and zero otherwise. Reform11 is a shift dummy variable that takes the value one on 2011 and afterwards, and zero otherwise. 12 leads and lags of the differenced explanatory variables were also added to the regression. The maximum number of lags considered for the autocorrelation structure is 3.

Table 7. Nigeria: Correlation Coefficients

CPI–NEER

Levels	2000-2015	-0.852
Growth Rates (y-o-y)	2000-2015	-0.118
	2000-2007	-0.132
	2008-2009	0.020
	2010-2015	0.019

CPI–Pm

Levels	2000-2015	0.866
Growth Rates (y-o-y)	2000-2015	-0.045
	2000-2007	-0.106
	2008-2009	-0.456
	2010-2015	0.334

Table 8. Nigeria: ADF and DF-GLS Unit Root Tests

Variable	Deterministic terms	ADF			DF-GLS		
		Lags	Test Statistic	Critical Value	Lags	Test Statistic	Critical Value
CPI	c, t	0	-1.7160	-3.4330	0	-1.7437	-2.9350
D(CPI)	c	0	-12.8675	-2.8763	0	-11.865	-1.9425
NEER	c, t	2	-2.0139	-3.4333	2	-1.4251	-2.9370
D(NEER)	c	1	-10.846	-2.8764	2	-6.2160	-1.9425
Pm	c, t	1	-1.2612	-3.4332	1	-1.4411	-2.9360
D(Pm)	c	0	-10.0493	-2.8763	3	-2.2142	-1.9425
M2	c, t	1	-1.2227	-3.4332	1	-0.8497	-2.9360
D(M2)	c	0	-18.5125	-2.8763	0	-17.5661	-1.9425

Table 9. Nigeria: Johansen Cointegration Test for CPI, NEER and Pm

Test	Deterministic Terms	No. of Lagged Differences	Null Hypothesis	Test Statistic	Critical Values	Prob.
Trace	Constant linear trend	1	$r = 0$	37.74	42.92	0.1496
			$r \leq 1$	12.20	25.87	0.7977
			$r \leq 2$	4.86	12.52	0.6168
Maximum Eigenvalue	Constant linear trend	1	$r = 0$	25.54	25.82	0.0545
			$r \leq 1$	7.35	19.39	0.8759
			$r \leq 2$	4.86	12.52	0.6168

Table 10. Nigeria: Johansen Cointegration Test for CPI, NEER, Pm and M2

Test	Deterministic Terms	No. of Lagged Differences	Null Hypothesis	Test Statistics	Critical Values	Prob.
Trace	Constant linear trend	1	$r = 0$	37.74	42.92	0.1496
			$r \leq 1$	12.20	25.87	0.7977
			$r \leq 2$	4.85	12.52	0.6168
Maximum Eigenvalue	Constant linear trend	1	$r = 0$	25.54	25.82	0.0545
			$r \leq 1$	7.35	19.39	0.8759
			$r \leq 2$	4.86	12.52	0.6168

Table 11. Nigeria: Dynamic Pass-through Elasticity of Inflation to a 1Standard Deviation Shock to ΔNEER

Period (months)	Headline Inflation	Core Inflation
1	-0.069	-0.115
3	-0.031	-0.101
6	-0.095	-0.322

APPENDIX B: INDEX OF ECONOMIC ACTIVITY

GDP data is available only at annual frequency in Angola, and at quarterly frequency starting in 2010 in Nigeria. In addition, the official statistics are released with some publication lag. This has made short-run economic analysis very challenging. To overcome this limitation, we build a monthly index of economic activity for Nigeria and Angola.

The construction of this high frequency measure follows the methodology proposed by Aruoba, Diebold and Scotti (2009). It is assumed that there is an unobserved monthly level of economic activity that is implied by the interaction and comovement of observed indicators at multiple frequencies. The latent state of the economy is derived from a dynamic factor model at monthly frequency, and using a state-space representation, it is extracted using a Kalman filter and smoother. The model is estimated by maximum likelihood.

The distinct feature of this framework is its flexibility, since the framework allows incorporating missing observations and mixed-frequency data. This is particularly relevant for economies such as Angola and Nigeria with less developed statistical systems. In these cases, the analysis is not based on the *best* data series but only on the *available* data series, which sometimes do not have the required length or frequency. But, given the flexibility of the methodology, information can also be extracted from low-frequency or short time series that, if other methodologies were applied, would have been ignored.

Regarding the choice of variables, this methodology usually uses composite coincident indexes, such as GDP, industrial production, electricity generation, labor market variables (payroll employment and initial jobless claims), manufacturing sales, retail sales and imports of intermediate goods.[34] The problem is that most of these variables are not available for Angola and Nigeria. Therefore the Angolan series incorporated money, private credit, exports, imports, and industrial production (starting in 2007) at monthly frequency for the period 2000-2015.[35] The Nigerian series incorporated money, private credit, exports of goods and imports of goods at monthly frequency; industrial production index (starting in 2006) and GDP (starting in 2010) at quarterly frequency; and, GDP and unemployment (starting in 2000) at annual frequency for the period 1992-2015. All variables are deflated by CPI, seasonally adjusted and de-trended prior to fitting the model.[36] [37]

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[34] For the application other than the US economy, see Kumar (2013) for Canada and Aruoba and Sarikaya (2012) for Turkey.

[35] We considered other series but they were excluded from the final estimation for different reasons. First, employment series in Angola are not reliable. Second, car purchases, as well as energy and cement production, only covers a short period of time (after 2010). Third, public investment can be adjusted at discretion of the government and may not reflect the evolution of the economy. Fourth, given that GDP series are only available at annual frequency, there are too many gaps in the data that affect the convergence of the model.

[36] The seasonal adjustment is performed using the X12 procedure with multiplicative option and moving seasonality ratio as the seasonal filter.

[37] As in Aruoba, Diebold and Scotti (2009) we assume a third-order polynomial trend and we de-trend the series prior to fitting the model in order to reduce the number of parameters to be estimated.

Appendix Figure 1 shows the extracted real activity indicators for Angola and Nigeria with the average value of the indexes at zero, since they represent deviations from the trend. Positive values indicate better-than-average conditions, whereas negative values indicate worse-than-average conditions. The indexes are able to capture the slowdown in economic activity between 2009 and 2011 as a consequence of falling international oil prices, and the subsequent recovery in 2012. They also capture the more recent deceleration in economic activity that has been taking place throughout 2015.

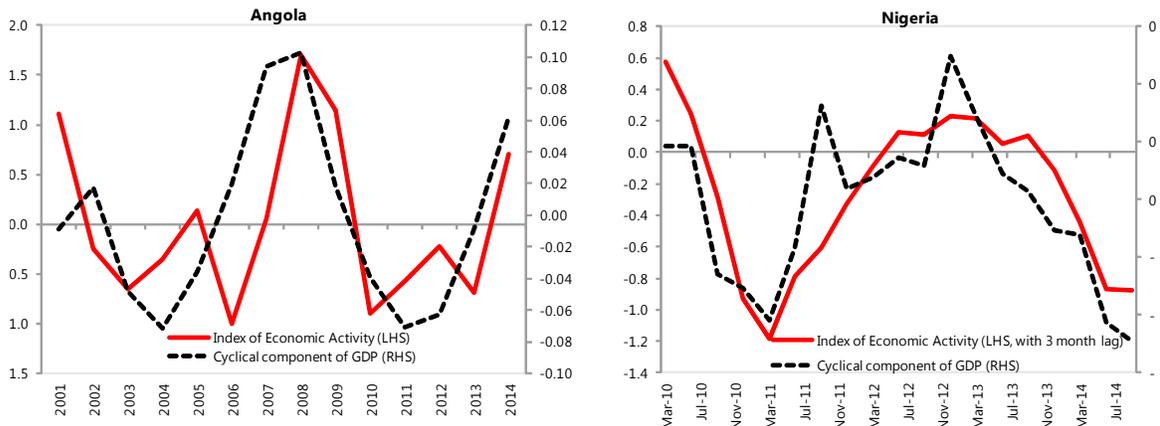Appendix Figure 1. Index of Economic Activity, Angola and Nigeria
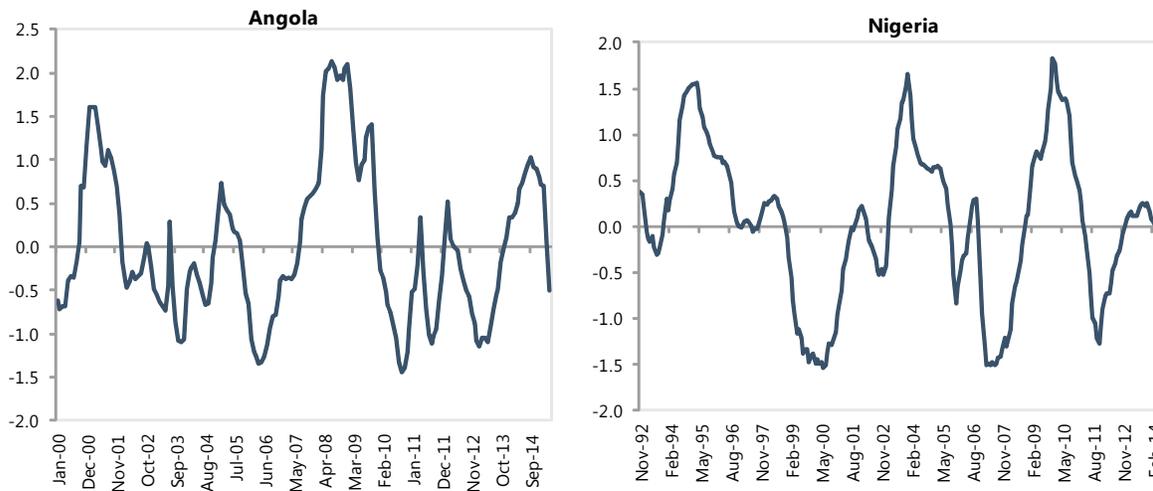
Source: Authrors' calculation.

Appendix Figure 2. shows how they compare to the cyclical component of GDP (obtained by applying the Hodrick-Prescott filter) for the years in which GDP data is available. In general, the indicators are consistent with the patterns observed for the Angolan and Nigerian business cycles. In the case of Angola, our index precisely tracks the cyclical component of GDP. In the case of Nigeria, our index seems to have some lagging behavior, since it seems to track the cyclical component of GDP with a 3 month delay. This might be a consequence of the inclusion of variables such as money or credit, which are normally thought to be lagging indicators more than coincident indicators.[38]

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[38] These indexes have a room for improvement – particularly in the case of Nigeria – by incorporating more coincident indicators to the estimation. Also, for simplicity we have only considered first-order dynamics in the model; the results might be improved by incorporating more flexible dynamics. Nevertheless, we determined that our economic activity indexes are able to represent the state of the economy well enough to make assessments of the developments in the real sector in a timely fashion.

Appendix Figure 2. Comparison of Index of Economic Activity with Cyclical Component of GDP

Source: Authors' calculation.