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Exploring the oil prices and exchange rates nexus in some African economies

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ABSTRACT

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JEL classification: F31, F41, Q43

Keywords: oil prices, exchange rates, African economies, VAR model.

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1. Introduction

Oil is one of the most important natural resources in the modern economy and also it is becoming more and more relevant for developing countries, which already account for more than a half of world total oil consumption. For example, in 2013 the total oil demand in the world increased by 1.4%, and more than a half of this growth is due to the non-OECD countries. According to Energy Information Administration (2013), most of the oil consumption growth is due to the demand in developing countries.[1]

In this paper we focus on some African economies. Accordingly to the World Bank Africa Overview (2014), it is crucially important the improvement of policymaking in order to assure the economic stability of the region.[2] In this sense, the main motivation of the paper is a deeper exploration of the nexus between exchange rates and oil prices in this continent, where so little has been done on policy improvement. The continent needs a better analysis of factors that may affect their economic stability, such as oil price shocks. The Economist (2013) gives us an insight of what perspectives may be waiting for African countries in the coming years. We may expect an African economic boom because a lot of improvements have taken place in the last decade: school enrolment is growing, new roads are being built, more democracies and civil activists have appeared in the continent and much fewer wars are now in course.

In sum, oil consumption has been growing in Africa during last five years, and it is expected to remain at the similar levels in next two decades, according to International Energy Outlook (2013). Oil consumption in sub-Saharan countries will continue growing, as well as sensitivity to oil price shocks. The novelty of this paper is precisely to study oil price shocks effect in these countries with a standard methodology widely applied for the study of developed and developing countries.

[1] See, International Energy Outlook (2013), US Energy Information Administration.
[2] See, the World Bank Africa Overview website at http://www.worldbank.org/en/region/afr/overview.

The present paper investigates the relationship between oil prices and exchange rates in three African countries (namely Botswana, Kenya and Tanzania).[3] We use a Vector AutoRegressive (VAR) model to evaluate the impact of oil prices on exchange rate, taking into account the role of interest rates. We do not only want to find a relationship between exchange rates and oil prices, but also with the interest rates of the country, in order to study in what way oil prices might affect or not the state of the economy through inflationary pressure (Bernanke *et al.*, 1997). We are aware that monetary policy can play a determining role in the exchange rate in the event of disturbances which may come through the trading balance, such as an oil price shock, and it is not only the case of giants such as China (Huang and Guo, 2007), but also of small countries as the case of Fiji islands, studied by Brahmasrene *et al.* (2014). We select daily data on exchange rate and short term interest rate for Botswana, Kenya and Tanzania, from 01/12/2003 to 02/07/2014. To our knowledge, our research is the first to analyze exclusively these three African countries using daily data, with a sample period which covers the recent oil price dynamics over the period 2003-2014. Coleman *et al.* (2011) also study a pool of thirteen African countries, but they use monthly real effective exchange rate and monthly interest rates and they only overlap with our study in the case of Kenya. The other interesting paper, following a similar methodology, is Hacihasanoglu *et al.* (2013). These authors study a set of emerging countries, but only select Nigeria and South Africa. The other difference with our work is that while we only select oil importing countries, their data set has a large presence of oil exporting countries, also starting in 2003 (01/03/2003), but ending in 06/02/2010.

The rest of the paper has a structure as follows. Section 2 reviews the literature on the nexus between oil prices and exchange rates. Section 3 describes the data set. Section 4

[3] Previous studies have documented the relationship between oil prices and macroeconomic and financial variables (Hamilton, 1983; Bollini, 2007; Jouini, 2013).

presents the methodology and the main empirical results obtained for the selected African economies. Finally, section 5 concludes and includes some policy implications.

2. Literature review on exchange rates and oil prices

The main literature that examines the relationship between oil prices and exchange rate is not new. In early 80's there were some works published that analyzed this relationship, exploring possible mechanisms of transmission. The simple intuition behind the relationship among exchange rates and oil prices is that oil prices will appreciate the dollar against oil importing countries, and depreciate it against oil exporting countries. The mechanism behind this is that, as the US is one of the largest consumers in the world, the oil price increase causes it to buy the oil at a higher price, injecting money into oil exporting economies and appreciating the value of their own currencies against US dollar. Oil importing countries have to pay more as the price of oil goes up; thus depreciating oil importing currencies against the dollar. This is the current balance mechanism broadly explained by Krugman (1980, 1983), Golub (1983) and others. The former explored a simple mechanism of the transmission based on wealth transfer due to the increase in price and the investment of petrodollars by oil exporting countries. Latter, Golub (1983), explored a similar mechanism, analyzing the relationship among US dollar and oil price increases. For this author, the important thing is the mechanism of wealth reallocation generated by oil price shocks. For example, a positive oil price shock produces a surplus in current balance for oil exporting countries, like OPEC, and deficit for oil importing countries. If the supply of dollars by OPEC is superior to the demand of dollars by oil-importing countries, then there will be an excess of dollar supply which leads to depreciation.

The issue of the connection between exchange rates and oil prices has been explored by many authors: see for example, Amano and Norden (1998), Brahmasrene *et al.* (2014), Paresh *et al.* (2008), Chen and Chen (2007), Zhang et al. (2008) and Reboredo (2012), amongst others. Some of these papers focus on real exchange rates (Amano and Norden, 1998, Huang and Guo, 2007) while others use nominal exchange rate (Reboredo, 2012). Alternative methodologies have been used previously to study the relationship between oil prices and exchange rates, for instance VAR (Coleman *et al.*, 2011, Bénassy-Quéré *et al.*, 2007), Structural Vector AutoRegression (SVAR) models (Huang and Guo, 2007) and EGARH model (Paresh *et al.,* 2008). Another interesting methodology is that used in Reboredo (2012), applying correlations and copulas to model the oil prices and exchange rates co-movements in G7 countries, with monthly data period from 01/1972 until 10/2005 on nominal exchange rates, consumer price indexes and various oil price benchmarks. The two main results of his work is that oil prices and exchange rate have a very weak dependence, although it increases significantly after a financial crisis, even if there is not big market dependence between those two variables.

Alternatively, Amano and Norden (1998) apply cointegration, causality and VECM techniques on monthly data of US real exchange rate and US real oil price. They state that oil shocks have been the main source of real exchange shocks in the post Breton-Woods period and that the causality goes from oil prices to exchange rates. Their ECM has significant power to predict the size and the sign of variations in exchange rates and they suggest including this variable while modeling the US dollar movement.

More recent findings in that sense suggest that there is a difference in short and long run. Brahmasrene *et al.* (2014) uses Granger causality test, variance decomposition and impulse-response function analysis on US imported oil prices. Their work is based on monthly data of US imported oil prices from Energy Information Administration and bilateral exchange rate. The sample period is from 01/1996 to 12/2009. They find that in short run the causality runs from exchange rates to oil prices, but in the long run it turns the other way around. However, it does not have to be like this, as Bénassy-Quéré *et al.* (2007) state. They cite the case of China, since this country has become a major player both in oil consumption and exchange rate markets. They use a monthly real exchange rate and real oil price from 01/1974 to 11/2004 for cointegration techniques and a VAR model. They conclude that the causality runs from oil prices to dollar, but it could be reversed due to the emergence of China in both markets and its pegged exchanged rate regime. The recent work of Basher *et al.* (2012) examines the relationship between oil prices, exchange rates and emerging market stock prices. His results show that, on the one hand, a positive oil price shock is negatively related with market stock prices, and also that a positive stock market shock is positively related with oil prices. This result is in line with the work of Bénassy-Quéré *et al.* (2007), which found that a rapidly growing demand can pressure oil prices. Some other interesting work in China is Huang and Guo (2007). They study this effect in the Chinese economy by using the four dimensional monthly SVAR with real oil price, real effective exchange rate, relative industrial production and relative consumer price index. Their results suggest that real price shocks have minor effects on exchange rates in long run because of the smaller dependence of China on oil that pegged countries in its RMB (Chinese renminbi) basket, and also because of China's rigorous regulation in domestic energy market

Nowadays, the study of emerging markets is becoming more relevant, for a number of reasons. First, GDP in emerging markets is increasing and, consequently, their oil consumption grows. Secondly, US oil consumption grows very slowly and Western Europe demand is even shrinking; in the meantime, the demand of oil by emerging countries is still growing. There are a number of significant works related to oil price-exchange rate nexus in emerging market. Some of them are country case studies such as Rautava (2004), which explores this nexus in the case of Russia, or Paresh *et al.* (2008), who do the same thing for

Fiji islands. The paper by Paresh *et al.* (2008), is particularly interesting for our research, because the country that they analyze is an oil importing country, just like the set of countries that we have chosen for our study. Paresh *et al.* (2008) study the link between the two variables for the Fiji islands using daily data from 2000 to 2006. They use an EGARCH model and conclude that oil price increases lead to the appreciation of the Fijian dollar against the US dollar. There are also some work with a multi-country approach, such as Hacihasanoglu *et al.* (2013). Those authors use the daily exchange rate and oil price data in a set of emerging countries. In the same way, Coleman *et al.* (2011) study the nexus between real effective exchange rate and oil price shocks for a pool of 13 African countries. They apply cointegration tests and VAR and determine that there is no general rule, because the effect on exchange rate is different for each country, due to their different economic structures; some of them are oil producers, while others are oil consumers.

The main contribution of the present paper is the special selection of some African countries. In fact, the selected countries represent a great percentage of African GDP, but there are is no literature regarding the link between oil prices and exchange rates. In this sense, our research is the first to analyze this link for those particular countries, using daily data in a VAR model.

3. Description of the data set

In this section we describe the data set used in our empirical analysis, considering the selected set of countries, the sample period, the variables and the sources from which we obtained the data. Table 1 offers the summary of the data set.

a. Selected African countries

Several factors were taking into account when selecting the countries for our study. The first and most important was data availability, because some countries started to report the data on the exchange rate and short term interest rate just some years ago. The second factor was the comparability of the selected countries in terms of oil production and oil consumption, because all three of the countries are net consumers and importers of oil. Botswana and Tanzania do not produce oil, while Kenya produces little more than 1 thousand barrels per day, but imports some 54,000 barrels. In sum, all three countries are net importers. These factors enable us to give a richer interpretation of empirical results if the effects of oil price are different across these countries.

b. Sample period

As we mentioned before, one of the most important issues with sub-Saharan countries is the availability of the data. In our data set, all variables start at 01/12/2003, except the interest rate of Botswana which starts at 16/11/2004. The sample period ends on 04/07/2014 for all the variables.

c. Selected variables

We selected the following variables in order to analyze their relationship between oil prices and exchange rates:

-*Exchange rates*: we defined exchange rates as the amount of local currency to 1 US dollar. As we worked with daily data, there was no need to deflate them by the local Consumer Price Index in order to convert to the real exchange rates. The data for each exchange rate was taken from local Central Banks. In some way, we are followed a similar methodology to that of Hacihasanoglu *et al.* (2013), who also used daily series of exchange rates. This variable is in logs.

-*Interest rates*: the rate at what the Central Bank of each country lends to commercial banks and this is the main instrument of influencing the interest rates in the rest of the economy. We used a daily short term repo rate as a proxy to the monetary policy of a central bank, in order to capture the increase or decrease of the benchmark interest rate of all countries (Bernanke *et al.*, 1997). This variable is in levels.

-*Oil prices:* we used the nominal price of UK Brent oil price. The Brent benchmark is one of the most accurate indicators of world oil prices because it is one of the most traded oils in the current global oil market, and due to this liquidity, it follows perfectly the evolution of the global oil prices, according to Wlazlowski *et al.* (2011). This variable is in logs.

d. Source of the data set

For this work we used official data from recognized financial institutions, which are explained below:

The sources of the data are the following:

-*Bank of Botswana*: is the Central Bank of the country and it is in charge of the monetary policy implementation. The daily data on exchange rate and 91 days Bank of Botswana Certificates is publicly available on its website.

-*Central Bank of Kenya*: publishes the daily data on exchange rate and Central Bank Rate (CBR). The CBR is the minimum interest rate at which the Central Bank injects money into the money market of the country.

-*Bank of Tanzania*: elaborates the data on exchange rates and Repurchase Agreement rate (which is the analogue of the short term rates of the rates mentioned above).

-*Federal Reserve of Bank of St. Louis*: releases data on many economic indicators. The daily data on Brent oil prices was taken from its website and it is publicly available.

<Insert Table 1 about here>

4. Empirical analysis with a VAR model

In this section we initially analyze unit root tests of the relevant variables. Then, we conduct structural break and cointegration tests respectively. Finally, we propose a VAR model that we estimate in the empirical analysis.

a. Unit root tests

In this section we present results of unit root tests for exchange rates, interest rates and oil prices for the selected African economies. Each variable is expressed in logs except interest rates. We use three alternative unit root tests: Augmented Dickey-Fuller (ADF, Dickey and Fuller, 1981) test, the Kwiatkowski - Phillips - Schmidt - Shin (KPSS, Kwiatkowski *et al*., 1992) test and the Dickey-Fuller Generalized Linear Square (DF-GLS, Elliot *et al.*, 1996) test.

The test was carried out in levels and in first differences. The results, included in Table 2, suggest that all series, exchange rates, nominal short term interest rates and Brent oil prices do not reject the null hypothesis, and hence are integrated at I(1). The ADF test is a classical unit root test that is widely used in the economic and financial literature, but has proven to be insufficient or ineffective when there is a large and negative Moving Average component, because it rejects the null hypothesis of I(1) more often, as Schwert (1987) points out. That is the reason why we also use the ADF-GLS unit root test proposed by Elliot *et al.* (1996), which follows a similar procedure, but with GLS detrended data. The test were carried out in levels and in first differences and the results, shown in Table 2, suggest that all series, exchange rates, nominal short term interest rates and Brent oil prices do not reject the null hypothesis, and hence are integrated at I(1). The configuration of KPSS is different from the ADF or ADF-GLS, because it is testing the opposite hypothesis where H_0 is that the series is I(0) integrated, and it rejects it in all cases.

In summary, the results show that all the three variables -exchange rates, interest rates and oil prices- are integrated of order one variables (*i.e*., stationary in first differences). There are some previous related studies that confirm the unit root in oil prices and exchange rates (Amano and Norden, 1998; Basher *et al*., 2012).

<Insert Table 2 about here>

b. Structural breaks

Structural break testing is a very important issue in time series analysis because if there are actually structural breaks, the series has to be de-trended in order to work with it.

In our work, we use the Least Squares with Breakpoints method of calculation following Bai and Perron (1998). We also used sequential testing suggested by Bai and Perron (2006), where they run an extensive Monte Carlo simulations and conclude that the widely used Bayesian Information Criteria often fail to detect breaks. The sequential testing does not require information criteria because, in fact, it works in a very intuitive way. First, it detects the first break, and then it tests for more breaks in subsamples.

The results of this estimation are outlined in Table 3, and we can clearly see that the number of breaks goes from two to four, with the exception of Tanzanian interest rate, where no structural breaks were detected. However, we did not take them into account because we found no common trend in those breaks and they did not capture the major oil price peak of the previous decade that occurred in July of 2008. This shock can be clearly seen in Figure 1.

Many related to our research do not include the studies of the series for structural breaks (Paresh *et al.*, 2008, Brahmasrene *et al.*, 2014, and Coleman *et al.*, 2011). There are some studies which include at least one structural break test, such in Basher *et al.* (2012), which uses a single test suggested by Harris *et al.* (2009). In Basher *et al.* (2012) a structural break is included in all series at the end of 90's and a dummy variable is included in their following estimation of VAR in order to have a control for this. In our work, only a single structural break was included, in order to have a control for the 2008 oil price shock In that we follow a similar logic to Hacihasanoglu *et al.* (2013), who also separate the whole data set in three subsamples, capturing even more movements in oil prices around the second half of 2008.

<Insert Figure 1 about here> **<Insert Table 3 about here>**

c. Cointegration tests

Once we proved that all the relevant variables contained a unit root, we tested for cointegration (Johansen and Juselius, 1990) using both the trace and the maximum eigenvalue tests. We followed the recent advanced techniques in time series analysis in series cointegration proposed by Johansen and Juselius (1990) and Johansen (1991, 1995) because this procedure enabled us to test for more than one series at the same time. The results reported in Table 4 show that no correlation was found for the cointegration test, with the exception of Kenya in a case without a linear trend. For the rest of countries the null hypothesis of no cointegration cannot be rejected at 5% significance level. This result suggests that no long run relationship was found between local exchange rates, short term interest rates and oil prices.

Cointegration tests are very common in the literature. However, the most used in the literature is the cointegration test proposed by Johansen and Juselius (1990). It is used in Bénassy-Quéré *et al*. (2007) rejecting the null hypothesis of no cointegration, however the same is used in Coleman *et al.* (2011) for a pool of African countries and it rejects the null hypothesis only for some countries, and not for the rest. The only country studied which is also in our data set is Kenya and their test rejects the null hypothesis, while our does not The difference in result probably is due to differences in selected variables, because they use monthly data on real effective exchange rates and monthly real oil prices, whereas we use move in a nominal daily framework.

<Insert Table 4 about here>

d. VAR model and results

The empirical model estimated in this paper has already been used in the context of oil prices and economic activity by Hamilton (1983), Mork (1989), Bernanke *et al.* (1997) and

Cunado and Perez de Gracia (2005) among many others, and it is based on the VAR methodology proposed by Sims (1980).

A VAR model of order p, where the order p represents the number of lags, that includes k variables, can be expressed as:

$$y_t = A_0 + \sum_{i=1}^{p} A_i y_{t-i} + u_t, \qquad (1)$$

where $y_t = [y_{1t} \ldots y_{kt}]'$ is a column vector of observation on the current values of all variables in the model (exchange rates, interest rates and oil prices); A_i is k x k matrix of unknown coefficients; A_0 is a column vector of deterministic constant terms; u_t is a column vector of errors with the following properties,

$$E(u_t) = 0 \quad \forall\, t,$$

$$E(u_s u'_t) = \Omega \quad if\ s = t,$$

$$E(u_s u'_t) = 0 \quad if\ s \neq t,$$

where u'_t is not serially correlated but may be contemporaneously correlated and Ω is the variance-covariance matrix with non-zero off-diagonal elements. Given a VAR(p) model of I(1) variables, there always exists an error correction representation of the form

$$\Delta y_t = \prod y_{t-1} + \mathrm{B}_0 + \sum_{i=1}^{p-1} \Delta B_i y_{t-i} + v_t, \qquad (2)$$

where Δ is the first difference operator; y_{t-i} is a vector of error correction terms; Π is the matrix denoting the speed of adjustment toward the equilibrium and rank (Π) = r, the number of cointegration vectors, which in our case, and based on the previous results, we assume it is equal to 1, B_0 is a column vector of deterministic constant terms and the column vector of errors, v_t, satisfy the same conditions as the u_t in equation (1).

Based on this model, we analyzed the impact of oil prices on exchange rates by examining impulse response functions. Figure 1 shows the impulse response functions of exchange rates to a one-standard deviation structural innovation in oil price to exchange rate and short term interbank interest rates. The red short-dashed lines indicate two-standard deviation confidence interval of the estimated impulse response function. The main goal of the present paper is to find a relationship between oil price shocks, exchange rate and short term interest rates in the three selected sub-Saharan countries, and some interesting results can be taken from the impulse response function. Our countries are net oil importers, because Botswana and Tanzania do not produce oil, and Kenya produces some, but the proportion of what it consumes to what it produces was nearly 40:1 in 2010, according to EIA.

We estimated the function for the whole sample period, and then we selected two subsamples which go from the beginning of the sample period (01/12/2003) until July of 2008 (30/06/2008), and from this date until the end of the whole sample period (02/04/2014). The reason for doing two subsamples in our paper is to have a control for the beginning of the global financial crisis and the huge drop of oil prices when Brent passed from almost $144 per barrel on July 2 to around $40 in December. The whole sample period offers a more general view of how the reaction of exchange rate and interbank rate was to a shock in oil prices. But the subsample level offers a better insight how things changed after the drop in oil prices and the global financial crisis

We obtain similar results as Coleman *et al.* (2011) where an oil price shock leads to different effects on the local currency of each African country. The effect of an oil price increase seem very tiny at the full sample level, but at the subsample level it can be seen that before the July 2008 the effect was very soft: the local currencies appreciated a little bit in the short run and then returned to more or less the same state. The currency of Kenya even shows a slight positive movement meaning the depreciation of Kenyan shilling against the US dollar.

After July 2008 movements are stronger. This is in line with Reboredo (2012) and Hacihasanoglu *et al.* (2013) who also note the increasing relationship between the two variables after the financial crisis. The Botswanan pula experienced much stronger appreciation in the second period that in the first one. The Kenyan shilling in the first period was even experiencing a slight depreciation, however the direction of the oil price shock effect changed completely in the second period causing the appreciation of the Kenyan currency against the US dollar in the second subsample. The Tanzanian shilling in the first period had a slight positive effect after an oil shock, however, the second subsample shows a different behavior because the it captured both appreciation and depreciation, staying finally a little more depreciated with respect to the US dollar.

The interest rates also show interesting behavior. In our results, the interbank interest rate displays different behavior before and after July 2008. The Botswanan interest rate does not react to an oil price shock, but Kenyan and Tanzanian interest rates in the event of oil price increase went down in the short run and remained more or less at the same level. However, after July 2008 the interest rates of the latter two countries change their behavior completely. The Kenyan interest rate in that period had much more dramatic increase, going a little bit down in a long run. The Tanzanian interbank interest rate also reacted differently from the other subsample, but it had much l weaker increase than the Kenyan interest rate. With respect to the interest rate, it cannot be treated as an exogenous variable because the Central Bank adjusts it depending on needs of the country, as Basher *et al.* (2012) points out. Also according to them, the monetary policy is much more active today than in 70's. Today it is very likely that a Central Bank would influence the economy through the open market operations responding to inflationary pressures produced by real shocks, such as an oil price shock. The reason behind the different response of Central

Banks in Kenya and Tanzania before and after July 2008 is still an open question and this work was not intended to explore them.

5. Concluding remarks and policy recommendations

In this paper, we focus on the relationship between oil prices and exchanges rates in selected African economies. In line with previous empirical papers such as Coleman *et al*. (2011), Basher *et al.* (2012), this research examines the impact of oil prices on the exchange rate and short term interbank interest rate of Botswana, Kenya and Tanzania. The main contribution of the paper is that it allows for direction of the value of the local currency with respect to US dollar after oil prices variation. Many authors agree that an oil prices increase the local currency tends to appreciate against the US dollar and our result is in line with Paresh *et al.* (2008), Hacihasanoglu *et al.* (2013), Basher *et al.* (2012), among many others. We also find different responses of Central Banks between the subsamples, with the exception of Botswana which seem to remain the same in the event of oil prices. But for Kenya and Tanzania in the first subsample the response was to lower interest rates, meanwhile in the second subsample it was moving in different direction. The short term interbank interest rate in Kenya also changed its direction and the intensity of this change was much stronger than in Tanzania. In the first subsample, the Kenyan interest rate was affected negatively by oil prices, but in the second subsample the effect was already positive and the curves of the change in the two subsamples have the similar shape but are opposite to each other. The Tanzanian interest rate in the first subsample had a negative shift, but then remained more or less in the same line, however in the second subsample it remained almost unaffected by the oil prices, increasing very slightly.

Our results suggest the similar behavior of local currencies in an event of oil price shock, appreciating in a short run against the US dollar. Despite some differences in the first subsample where the oil price shock had a slight positive effect for Botswanan and

Tanzanian currencies, but on Kenya the effect was the opposite, implying the slight depreciation of Kenyan shilling against the US dollar. However, in the second subsample an oil price shock had much positive effect for the Botswanan pula, a slight positive effect on Kenyan shilling and some undetermined effect on Tanzanian shilling which first depreciates and then appreciates and finally remains at the initial level.

The global result of the paper is in line with the literature, especially of those works that evaluate the oil price- exchange rate link in emerging countries, as Coleman *et al.* (2011).

We also leave for future research the issue of non-stationarity of interest rates and exchange rates for sub-Saharan countries and a deeper evaluation of the exchange rate and oil price link.

Previous empirical results from VAR model have several relevant policy implications for fiscal and monetary authorities, researchers and traders.

First, our results support that oil prices dynamics tend to affect exchanges rates in some African economies. The main message for those economies is that the fiscal and monetary authorities should take into account the role of oil price shocks as one main determinant of exchange rate dynamics. According to our results, the relevance of oil prices as explanatory variable increases after 2008 crisis.

Second, our findings also have implications for monetary authorities, central banks and traders. Specifically, our results support that the role for monetary policy in response to oil price shock should be more passive (a similar results is also found in Reboredo, 2012). In our sample countries, we only detect an active role of monetary authorities in the case of Kenya.

Finally, as we mentioned previously in the Introduction section, African economies should need a better understanding of the underlying factors that may affect their economic stability. Our findings pointed out that policy authorities needs a better understanding of the impact of crude oil price shocks on macroeconomic variables.

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Table 1. Variable description and sources

Variable	Sample period	State	Source
Oil price - Brent	01/12/2003 - 02/7/2014	Logs	Fed. Res. of Bank of St. Louis
Botswana - Exchange rate	01/12/2003 - 02/7/2014	Logs	Bank of Botswana
Botswana - Interest rate	16/11/2004 - 02/7/2014	Levels	Bank of Botswana
Kenya - Exchange rate	01/12/2003 - 02/7/2014	Logs	Central Bank of Kenya
Kenya - Interest rate	01/12/2003 - 02/7/2014	Levels	Central Bank of Kenya
Tanzania - Exchange rate	01/12/2003 - 02/7/2014	Logs	Bank of Tanzania
Tanzania - Interest rate	01/12/2003 - 02/7/2014	Levels	Bank of Tanzania

Table 2. Unit roots for the variables and its first differences

	ADF		KPSS		ADF-GLS	
	Constant	Constant and trend	Constant	Constant and trend	Constant	Constant and trend
			Original series			
Oil prices	-2.63*	-2.85**	4.60	0.32	-0.02	-1.27
Exchange rates						
Botswana	-0.69	-1.83	5.70	0.56	1.16	-1.41
Kenya	-1.14	-1.84	3.41	0.90	-0.89	-0.99
Tanzania	-0.78	-2.84	6.53	0.33	0.79	-2.80
Interest rates						
Botswana	0.37	-1.53	6.08	0.72	1.87	-1.41
Kenya	-3.48***	-3.54**	1.42	0.36	-2.69***	-3.27**
Tanzania	-4.20***	-4.38*	0.48*	0.25	-2.09**	-2.26
			First differences			
Oil prices	-48.95***	-48.96***	0.19***	0.03***	-3.23***	-3.98**
Exchange rates						
Botswana	-13.87***	-13.85***	0.07***	0.05***	-6.11***	-6.73***
Kenya	-35.44***	-35.44***	0.03***	0.03***	-3.16***	1.98
Tanzania	-23.01***	-23.01***	0.03***	0.02***	-0.79	-2.70**
Interest rates						
Botswana	-46.77***	-46.78***	0.23***	0.09***	-54.71***	-7.80***
Kenya	-10.71***	-10.71***	0.03***	0.01***	-10.19***	-3.75***
Tanzania	-56.68***	-56.67***	0.07***	0.02***	-54.42***	-12.37***

Notes: ***, **, * mean significant at 1%, 5% and 10% respectively.

Table 3. Structural break dates

	Break 1	Break 2	Break 3	Break 4
Oil prices	22/06/2005	17/05/2007	21/12/2010	
Exchange rates				
Botswana	11/08/2005	06/02/2008	17/05/2012	11/08/2005
Kenya	11/09/2006	22/09/2008	23/02/2011	
Tanzania	03/11/2005	21/10/2008	25/04/2010	18/10/2011
Interest rates				
Botswana	08/07/2009	07/12/2011		
Kenya	01/02/2005	29/05/2009	30/06/2011	03/09/2012
Tanzania				

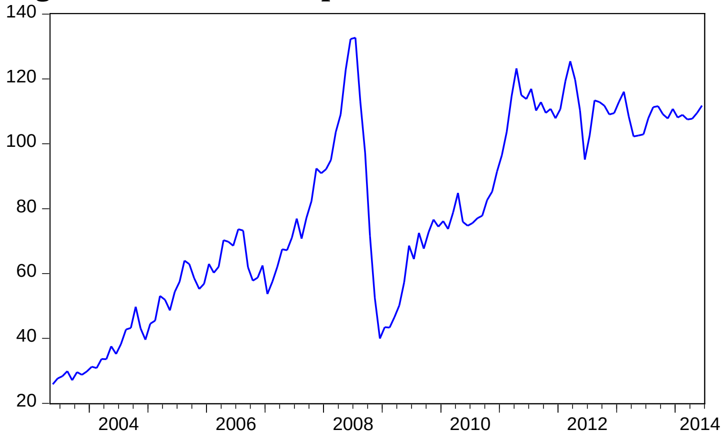
Notes: Breaks dates are calculated using the Least Squares with Breakpoints with sequential testing and coefficient covariance matrix by HAC (Newey-West) method with quadratic-spectral Kernel and Andrews automatic bandwidth method.

Table 4. The Johansen-Juselius cointegration test

		r = 0		r ≤ 1		r ≤ 2	
		(1)	(2)	(1)	(2)	(1)	(2)
Botswana	Trace Statistic	19.39	25.63	9.65	11.57	0.65	1.84
	Max-Eigen Stat	0.01	0.01	0.01	0.01	0.00	0.00
Kenya	Trace Statistic	37.25*	40.93	3.18	6.85	0.35	0.43
	Max-Eigen Stat	0.03	0.03	0.00	0.00	0.00	0.00
Tanzania	Trace Statistic	24.84	36.80	4.02	7.27	1.67	1.70
	Max-Eigen Stat	0.01	0.02	0.00	0.00	0.00	0.00

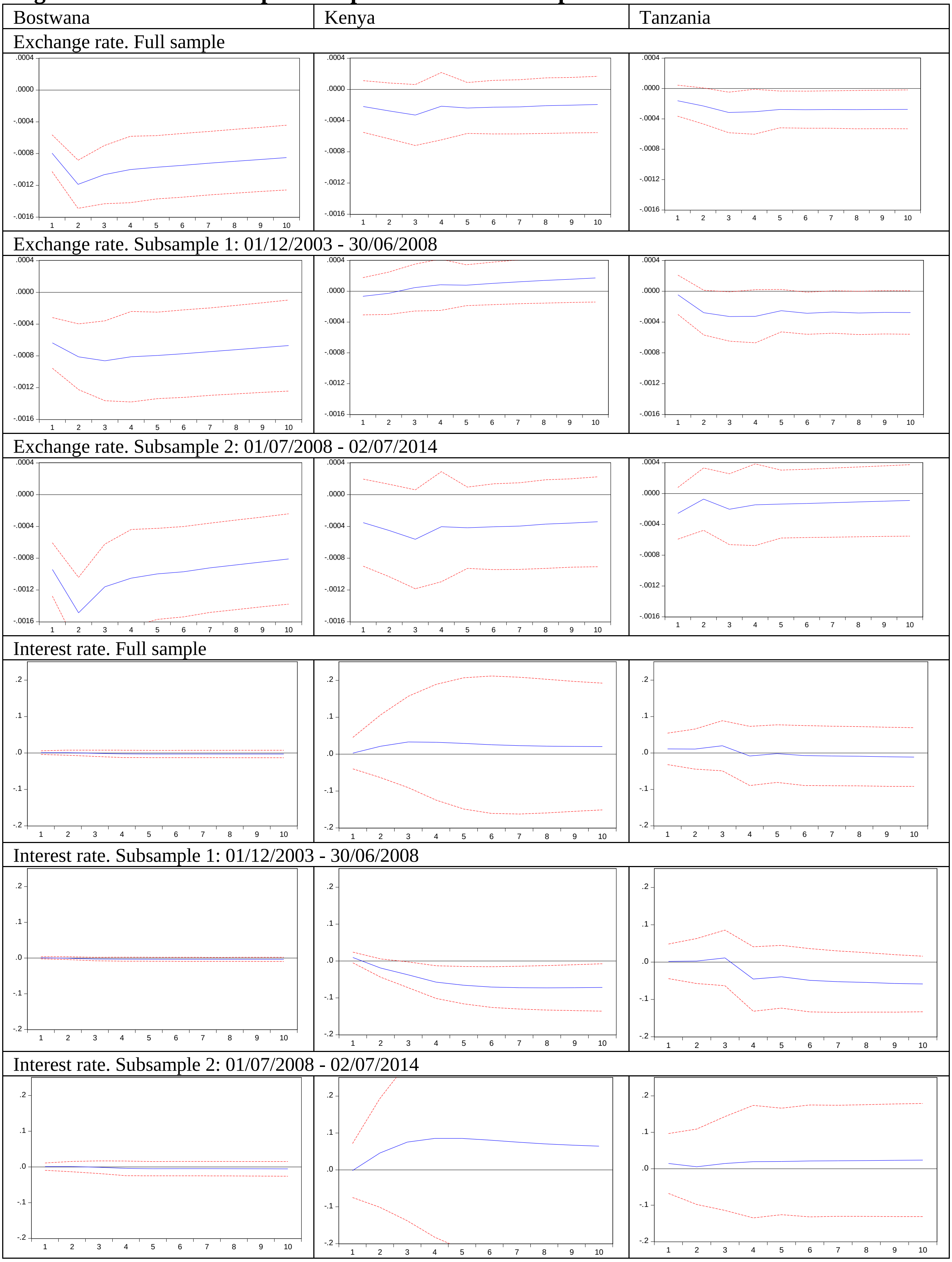
Notes: Selected variables are oil prices, exchange rates and interest rates. r: number of cointegrating vector. *, ** and *** denote rejection of the null hypothesis at the 10%, 5% and 1% levels of significance, respectively. In column 3 (r = 0) we test the null hypothesis of no cointegration against the alternative of cointegration. The Akaike Information Criterion (AIC) was used for the lag determination. (1) and (2) mean exclusion or inclusion of a linear trend in the test equation, respectively.

Figure 1. UK Brent oil prices



Note: prices are expressed in US dollars.

Figure 2. Generalized impulse-response function to oil price



Notes: Blue line: impulse response functions of exchange rates to a one-standard deviation structural innovation in oil price to exchange rate and short term interbank interest rates. Red line: indicate two-standard deviation confidence interval of the estimated impulse response function.