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THE CHOICE OF EXCHANGE RATE REGIMES IN OIL EXPORTING COUNTRIES: IS CCB A GOOD SOLUTION FOR SAUDI ARABIA?

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Abstract

This paper has threefold: first it aims to construct an index of exchange rate for Saudi Arabia as oil-rich country integrating foreign currencies and oil prices. Second we study movements of actual exchange rate taking the constructed currencies-oil exchange rate as benchmark and determine periods of overvaluation and devaluation for Saudi Riyal. Third we study the consequences of adopting currencies-oil exchange rate on internal and external balances. Effects on internal balance are studied through inflation and GDP growth, while those on external balance are analyzed through balance of payment. Using ARDL model and bound-cointegration tests of Pesaran et al. (2001), our results reveal short-run and log-run relationship between currencies-oil exchange rate and the retained macroeconomic variables. Moreover, adopting Toda-Yamamato non-sequential procedure we depict bidirectional Granger-causality relationship between currencies-oil exchange rate and balance of payment and unidirectional one running from currencies-oil exchange rate to growth and to inflation. These outcomes could help policymakers to design a new exchange regime and could have prominent implications and point recommendations in terms of monetary policy.

Keywords: Commodity-currency exchange rate, Oil prices volatility, ARDL, Bound-cointegration, Toda-Yamamato Granger-causality

INTRODUCTION

The choice of exchange rate regime has received no agreed “conventional wisdom” among economists especially for countries that are heavily dependent on exports of a single volatile commodity like oil. Oil exporters can differ from other advanced and emerging market countries along multiple dimensions. These countries are in general exposed to wider fluctuations in their external accounts, because their exports, by definition, are relatively undiversified and oil prices fluctuate more widely than the prices of other goods. Such volatility is directly reflected in the higher volatility of their terms of trade, current accounts as a percent of GDP, and income more generally.

In the literature we can find two propositions in opposite directions. The first is that small and open economies with high share of traded goods should adopt a fixed exchange rate in order to avoid costly volatility and to allow to monetary authorities to have a visible anchor for monetary policy (Frankel and Rose 2002). The second view suggests that countries with one dominant traded good such as oil exporters should let their currency float (Calvo and Mishkin (2003), Calvo (2001)). Under such a regime the currency will automatically appreciate when the world oil market is booming and automatically depreciate when the oil market declines. Empirical literature has shown that under floating regime, the currencies of commodity-exporting countries fluctuate together with prices of the commodity in question.

Krugman (1980) was the first to establish a correlation between a commodity exporting country and its currency, as he observed how oil prices affected different exchange rates. Cashin et al. (2004) find a long-run relationship between national real exchange rate and real commodity prices for about one-third of the commodity-exporting countries. Being dependent on movements in the real price of commodity exports, the long-run real exchange rate of these ‘commodity currencies’ is time varying. Bodart et al. (2012) find that the price of the dominant commodity has a significant long-run impact on the real exchange rate when the exports of the leading commodity have a share of at least 20 percent in the country's total exports of merchandises. Their results also show that the larger this share, the larger the size of the impact. Furthermore, a number of studies (Edwards and Levy-Yeyati (2005), Céspedes and Velasco (2012)) have confirmed empirically that in the presence of large terms of trade shocks, economic performance tends to be better in countries with floating exchange rates than in countries with conventionally fixed exchange rates. Work by Habib and Kalamova (2007) studies the relationship between real oil price and real exchange rates in the case of the three main oil exporting countries (Norway, Russia and Saudi Arabia). According to them, in oil exporting countries, the main driver of the terms of trade is the oil price. Gomes (2016) investigates to which extent dollar real exchange rate fluctuations explain the unexpected divergent movement between the real exchange rate of oil exporting countries and the price of oil in certain periods. Estimating a panel cointegration model for 11 OPEC and 5 major oil exporting countries over the 1980-2014 period, he finds evidence to support they have oil currencies in the long term. Gomes concluded that a 10% increase in the price of oil leads to a 2.1% appreciation of their real exchange rate.

The Gulf countries have opted for fixed exchange rates, either a peg to the dollar, as in the case of Saudi Arabia and the UAE, or a peg to a currency basket as in the case of Kuwait. The pegs have probably served the countries well in the past, especially in the 1980s and 1990s when oil prices were not quite so volatile. According to Alkhraief and Qualls (2016), in the special case of Saudi Arabia, the peg of the Saudi Riyal (SAR) to the USA dollar has successfully dampened inflation and allowed for acceptable growth, but it has created problems when the world price of oil exhibits big swings, up or down, as it has repeatedly since the beginning of the new millennium. This strategy is fruitful for their economies when oil prices are stable but can exacerbate the boom-bust cycle when prices are volatile. According to Frankel (2017), in order to reduce their vulnerability oil-exporters should adopt an exchange rate index integrating oil-prices.

One of the main purposes of this paper is the choice of exchange rate arrangements for an oil-exporting country that wishes to reduce its future vulnerability to fluctuations in the world price of oil. Our proposition is practical. Following Frankel (2017)and in order to determine an optimal exchange rate for Saudi Arabia, we intend to adopt the "Currency plus Commodity Basket" (CCB) methodology. The plan consists to add to a basket of major currencies, say the US dollar and Euro and Yen, a supplement unit, namely oil prices[1]. This strategy has two advantages. It allows benefiting from the stability, transparency and predictability of a peg, on one hand, with the sustainability and economic flexibility afforded by a floating exchange rate on the other hand. The construction of such index will allow to look at the path that the exchange rate of SAR would have followed under the CCB alternative and to check how historical periods of large over-evaluation or under-evaluation relative to that benchmark correspond to evidence of imbalances externally (large balance of payments deficits or surpluses) or internally (rising or dampening inflation and growth).

This paper will be organized as follows. Second section reviews the currency-commodity exchange rate literature. A particular attention will be paid to the currency-oil case. Section three will concentrate on Saudi Arabia as the first oil-economy in terms of production and exportation.

[1] In the future Saudi Authorities should think to add the Chinese currency (Yuan) to their basket. The integration of the Yuan could be justified by the fact that China is nowadays the first commercial partnership of Saudi Arabia and because IMF added the Chinese currency to the SDR basket since September 2016.

Section three is devoted to the construction and computation of a currency-oil nominal exchange rate for the Saudi Riyal. The calculated index will serve as a benchmark to evaluate the macroeconomic consequences of the non-adoption of such regime. In Section four we study macroeconomic effects of currencies-oil exchange rate. Section five develops the adopted methodology and analysis empirical results. Section six presents some policy recommendations and concludes the paper.

CURRENCY-COMMODITY EXCHANGE RATE: A SELECTIVE LITERATURE REVIEW

Firstly, it is worth mentioning that there is no precise definition of a commodity currency. Currently, the definition of a commodity currency is when a country's export is heavily dependent on one or more commodities. In other words, there is no set percentage of the country's export that has to consist of commodities for it to be defined as a commodity currency. Briefly speaking, commodity-currencies are currencies that respond significantly to the world prices of their corresponding country's commodity exports. The commodity-currencies are most common in developing countries, although they do also exist in developed nations. According to Chen and Lee (2014), about a third of the countries in the world rely on primary commodities such as mineral, agricultural, and energy products as a significant source of their export earnings. The wild fluctuations of global commodity prices thus account for a large share of these countries' terms of- trade shocks, which can have a major influence on the value of their currencies. Developing countries attempt to protect themselves from currency exchange rate volatility and Dutch disease by pegging their currency, usually to the U.S. dollar and/or the euro. But two of the world's biggest developed countries, Canada as a major oil exporter and Australia as the world's largest exporter of iron ore, also have commodity-currencies and they both have freely floating exchange rates.

Literature on commodity-to-currencies relationships is becoming tremendous the last few years. Three main models have usually been used to explain such a relationship: the sticky price monetary model (Dornbusch (1976), the portfolio balance model (Chen and Rogoff (2003); Chen and Rogoff and Rossi (2010) and the flexible price monetary model (Frankel (1976)).

The sticky price model states that commodity price increases lead to inflationary pressures on a commodity-exporting country's real wages, non traded goods prices, and exchange rate. However, wages and non traded goods prices are upwards sticky, leading only commodity price increases to impact the country's exchange rate. The efficient relative price between traded and non traded goods is then restored by the currency appreciation.

The portfolio balance model states that a commodity-exporting country's exchange rate is heavily dependent on foreign-determined asset supply and demand fluctuations. Thus, commodity price increases lead to a balance of payments surplus and an increase in foreign holdings of the country's currency. Both of these factors, in turn, lead to an increase in the relative demand for the country's currency, leading to positive currency returns (see Chen and Rogoff (2003); and Chen, Rogoff, and Rossi (2008) for further detailed discussions).

In commodity exporting countries, commodity-to-currency relationships is also explained by the fact that exogenous shocks in terms of trade are usually explained by commodity price changes (Cashin, Cespedes, and Sahay 2003; Chen and Rogoff2003). Terms-of-trade shocks then lead to a shift in the relative demand for an exporter's currency, which, in turn, leads to changes in that exporter's exchange rate (Chen, Rogoff, and Rossi 2008).

Chen and Rogoff (2003) studied the commodity currencies of three developed countries: Canada, Australia and New Zealand. The results showed that commodity prices had a strong influence on the real effective exchange rate (REER). However, the impact of the commodity was less for the Canadian dollar, as Canada's export was more diversified than the other two countries. Using panel data analysis for 63 countries for 1980-2010, Chen and Lee (2014) find that, in accordance with theory, the nation's export market structure, monetary policy choices and degree of trade and financial openness are the main determinants of the long-run cointegrating relationship between the real exchange rate and commodity export prices. They also show that the commodity price-exchange rate connection is much weaker in the short-run and for a group of oil-exporting countries.

Consequences of a commodity currency

Countries dependent on single commodity bear heavy risk. When the commodity experiences a decline in price, the income from exporting that commodity decreases along with the price. Canada and Saudi Arabia and their reliance on oil are great examples. In 2016, when oil prices dipped below 30 USD per barrel Canada has experienced 50 billion Canadian dollar cut to Canada's national income. During the last decade Saudi economy contracted remarkably in 2009 when GDP fell 2.1 percent after the global financial crisis sent oil prices crashing. In 2017 OPEC's biggest oil producer GDP shrank 0.5 percent due to a drop in crude production, as part of the 2016 Vienna production cut agreement, but mostly due to lower oil prices. Due to the drop-in oil revenues Saudi authorities estimate a budget deficit of $52 billion for 2018.

Another consequence of having a commodity currency could be the Dutch disease. In oil-based economy, exchange rate tends to track the global price of oil. When oil price rises, so does the exchange rate and this tends to attract inward investment and resources to the extractive industry. On another side, the high exchange rate rends other export sectors noncompetitive, a phenomenon known as “Dutch disease,” in which the economy becomes increasingly dependent on its extractive industries. When oil prices fall, the currency exchange rates of exporting countries fall in tandem.

CURRENCIES-OIL EXCHANGE RATE FOR SAUDI ARABIA

The construction of an exchange rate index for Saudi Arabia follows the methodology adopted by International Organization and several Central Banks (FED, Bank of Canada, European Central Bank…). Our contribution goes beyond and integrates oil prices (OP) together with bilateral exchange rates of Saudi Riyal (SAR) and the currencies of main commercial partnerships.

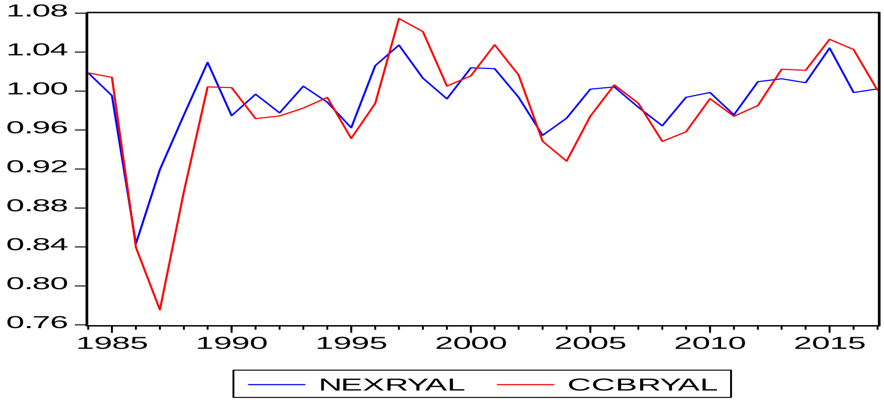
The nominal effective exchange rate index of the SAR at time t, I_t, can be written as follows:

$$I_t = I_{t-1} \times \prod_{i=1}^{n(t)} \left(\frac{e_{i,t}}{e_{i,t-1}}\right)^{w_{i,t}} \left(\frac{OP_t}{OP_{t-1}}\right)^{1-\Sigma w_{i,t}}$$

Where, I_{t-1} is the value of the index at time $(t - 1)$, $e_{i,t}$ and $e_{i,t-1}$ are the prices of the SAR in terms of foreign currency *i* at times t and $(t - 1)$, $n(t)$ is the number of foreigncurrencies in the index at time t and $w_{i,t}$ is the weight of currency i in the index at time t. The choice of the weighting system takes into account the commercial relationships of Saudi Arabia with its main partnership and is designed to reflect the importance of the respective economies for trade competition. Contrary to Frankel (2017) who adopted ad-hoc weights of currencies (US$ and Euro) and oil prices (OP) (1/3,1/3,1/3) we propose to calculate them endogenously. They are calculated as the share of Saudi imports plus exports of merchandises excluded oil with main partnerships (USA, Europe, and Japan). The weight of oil prices is the complement of the sum of trade weights to one.

Following the staff of bank of Canada we choose geometric rather than simple arithmetic averaging. It's argued that under geometric averaging, we can have the same numerical effect (though of opposite sign) on the index when the currency appreciates or depreciates in the same proportion. Figure 1 compares the evolution of the nominal effective exchange rate and the effective currencies-oil exchange rate. We depict that when introducing oil prices, exchange rate is more volatile. The volatility of oil prices can be transmitted to the Saudi economy through exchange rate and have effects on internal and external equilibrium. The effects on internal equilibrium can be elucidated through exchange rate-inflation and exchange rate-growth relationships while the effects on external equilibrium can be studied through the exchange rate-balance of payment relationship.

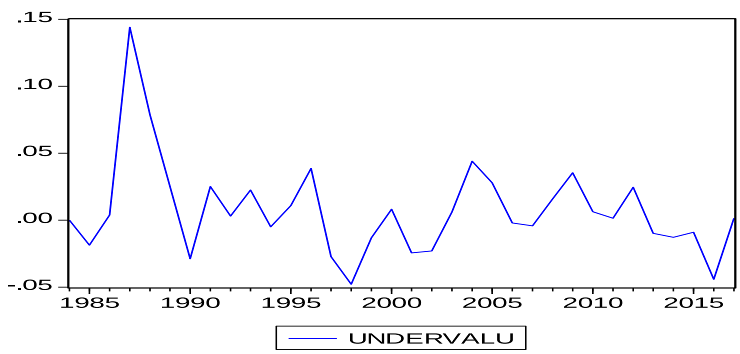
Figure 1: Nominal effective exchange rate (NEXRYAL) and commodity-currencies exchange rate (CCBRYAL) of Saudi Riyal.



In order to evaluate if the Saudi riyal has been undervalued or overvalued over the past periods we calculate the difference between effective nominal exchange rate (NEXRYAL) and the calculated CCB exchange rate (CCBRYAL) taken as benchmarking. We name this variable undervalu.

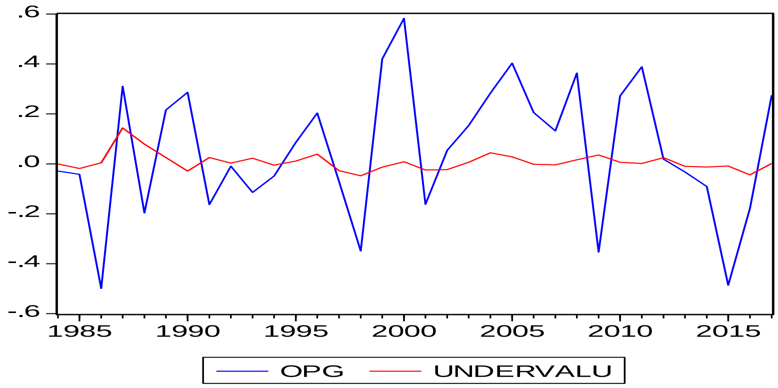
In the spirit of Rodrik (2008), we say that the riyal was undervalued if the difference is negative. When undervalu is positive, the riyal is overvalued. Figure 2 shows periods of undervaluation and overvaluation on the period 1984-2017.

Figure 2: Undervaluation and overvaluation of the Saudi riyal 1984-2017.



From graphic 3 we observe that movements in undervalu variable and those in oil prices are intimately related. Periods of high oil prices correspond to an overvaluation of Saudi Riyal while the opposite happens during periods of crises as since 2016 till nowadays. This means that when oil prices increase Saudi Riyal appreciates and when oil prices decrease Saudi Riyal depreciates.

Figure 3: Undervaluation-overvaluation of Saudi riyal and oil prices movements



EXCHANGE RATE AND MACROECONOMIC EQUILIBRIUM

In this section we study the effects of exchange rate on internal and external macroeconomic equilibrium when taking the currencies-oil exchange rate as benchmarking. Effects on internal equilibrium are apprehended through the link exchange rate-inflation and through exchange rate-growth nexus. Effects on external equilibrium are studied through exchange rate-balance of payments relationship.

Exchange rate regime and inflation

From a monetary policy perspective, understanding the role of exchange rates in shaping economic outcomes is important. In particular, monitoring and forecasting domestic inflation necessitates assessing the degree of pass-through of exchange rate movements to import or domestic prices. Since the seminal work of Dornbusch (1976) many contributions (Agenor and Montiel (1996), Svensson (2000) among others have been interested to the inflation-exchange rate relationship. Most of them recognize a set of mechanisms by which exchange rate affects inflation. The influence of exchange rate on inflation is both directly and indirectly. Direct effects of exchange rate are passed to consumer prices via their impact on the import prices of final consumer goods. When exchange rate depreciates, imported final consumer goods become more expensive (first stage pass-through), pushing up inflation. Indirect effects work via production costs and real channels and can take longer to trickle through the economy. When money depreciates, imported inputs become more expensive leading to higher production, and these feed through the different stages of domestic intermediate and final goods production (second stage pass-through). In this vein Calvo and Reinhart (2002) point out that the prospect of a strong and rapid transmission of exchange rate changes to domestic prices is one of the reasons why central banks reveal a real fear of floating and intervene in the foreign exchange market to avoid excessive exchange rate fluctuations. This is particularly the case for developing countries, where transmission seems more extensive than in developed countries.

Exchange rate regime and growth

Many previous works have tried to find whether different exchange rate regimes have different impacts on economic growth. Some studies recognize that the flexible exchange rate policy has positive impacts on growth (Sokolov et al. 2011), while others find that fixed exchange rate regime has negative impacts on growth (Levy-Yeyati and Sturzenegger, 2003). Ma and McCauley (2011) find that intermediate exchange rate regime is positively correlated with growth in emerging economies while floating exchange rate regimes do not show any significant impact on the advanced economies. Harms and Kretschmann (2009) find that various classifications of exchange rate regimes produce fairly similar results for industrial countries. These economies usually have a higher growth rate under the flexible exchange rate policy. While in developing countries and emerging markets, the announcement of a peg to the US currency and *de facto* stability in exchange rate normally have positive effects on growth. If a currency is pegged to USD only, it may hinder its economic development. As the higher the degree of dollarization, the more likely a negative effect on growth (Benhima, 2012). However, De Vita and Kyaw (2011) argue that the choice of exchange rate regime does not have direct effects on the long term growth in developing countries.

In particular, Rodrik (2008) evaluates this nexus on a database of 188 countries and 11 five-year periods ranging from 1950 to 2004. In order to measure undervaluation he adjusts real exchange rates for the Balassa-Samuelson effect. Rodrik finds that, an undervalued real exchange rate predicts stronger growth, at least for developing countries. The motivation for this finding is that tradable economic activities are special in developing countries as tradables suffer disproportionately from the institutional and market failures that keep countries poor.

Most empirical works tend to confirm a positive relation between weak real exchange rates and growth. Aguirre and Calderon (2005) find that large over- and under-valuation hurt growth, while modest undervaluation enhances growth, whereas Dollar (1992) shows that overvaluation harms growth. Similarly, Hausmann et al. (2005) argue that there exists correlation between rapid growth accelerations and real exchange rate depreciations. Rodrik

(2008) finds that the growth acceleration takes place, on average, after ten years of steady increase in undervaluation in developing countries. Using a panel dataset covering the period 1861-2011, Di Nino et al. (2011) also show that undervaluation and economic growth are positively correlated and that undervaluation supported growth by increasing exports, especially from high-productivity sectors.

Exchange rate regime and balance of payment

Balance of Payment (here after, BOP) records and summarizes international financial transaction of a country with the rest of the world at a specific period. These transactions include trade, financial transfers and capital movements. Theoretically, the BOP should be zero but in the practice this is rarely happened. The exchange rate is a key determinant of BOP and has an impact on each and every account such as current account, capital account and financial account. The general view supported by researchers is that if the exchange rate of a country is properly valued, it does not substantially affect the balance of payments and thus macro economic performance of that country. Exchange rate is commonly known as a measure of international competitiveness and the impact of exchange rate on balance of payment is explained theoretically by using J-Curve analysis.

A change in a country's BOP can cause fluctuations in the exchange rate. The reverse is also true when a fluctuation in relative currency strength can alter the BOP. This is true under a free or floating exchange rate regime. Under the flexible exchange rate regime, appreciation and depreciation bring some positive and negative impacts to the economy. When exchange rate appreciates, among other positive effects, it reduces the burden of public debt and budget deficit of the country. Conversely, a higher or stronger exchange rate could aggravate the trade deficit because imports become cheaper to domestic consumers and exports more expensive to foreigners. In this situation, trade deficit or current account deficit can exert contraction effects on economy. On the other hand, depreciation of the exchange rate would improve export competitiveness of the country as the depreciated exchange rate would lower the cost of exporters and makes imports more expensive. Moreover, depreciation increases the value of profit and income from abroad. The positive impact on current account, capital account and financial account leads to an improvement in the BOP situation.

In a fixed-rate system, the balance of payments does not impact the exchange rate because central banks adjust currency flows to offset the international exchange of funds. In a fixed exchange rate regime, fixing the rate at a level that is either too high or too low may not be compatible with other economic targets (for growth, inflation and unemployment) and may cause conflicts of policies.

Empirical studies on the impact of exchange rates on BOP are tremendous and have led to mixed results. Using ARDL and Granger causality in the case of Pakistan, Ahmed et al. (2014) conclude to the existence of a positive relationship between exchange rate and BOP. They argue that the stability of exchange rate creates positive environment and encourages investment which improves BOP. In the case of Nigeria, Odili (2014) found a positive significant relationship only in the long run. In the case of Iran, Lotfalipour and Bazargan (2014) investigated the impact of exchange rate volatility on trade balance of Iran by using the GARCH approach. The study found real effective exchange rate has no significant effect on the trade balance.

ECONOMETRIC METHODOLOGY

In order to evaluate what would have been the effects of exchange rate movements on internal and external equilibrium if Saudi Arabia has opted for an exchange rate regime integrating oil prices we study the effects of the constructed ccb-exchange rate on inflation, on GDP growth and on BOP. In order to adopt the adequate econometric methodology and avoid spurious regression we need to study in a first step the statistical proprieties of the used time series.

Data, variables and econometric methodology

Constrained by the availability of data our study consider the period 1984-2017. Two main sources have been used, World Bank and SAMA[2] statistics. In this study we use consumer price index to measure inflation. Economic growth is measured by GDP growth. The balance of payment position is measured by the current account balance which is the sum of net exports of goods and services, net primary income, and net secondary income. Table 2 presents descriptive statistics of the variables while table 3 presents correlations matrix. We observe that the nominal effective exchange rate (NEXRIYAL) is positively correlated with inflation and negatively correlated with economic growth while the constructed exchange rate integrating oil prices (CCBRIYAL) is positively correlated to both. As indicated by the literature, an overvalued exchange rate has a negative impact on growth. The introduction of oil prices in the calculation of the exchange rate can correct this bias. These intuitive results will be judiciously analyzed when performing ARDL-cointegration tests.

[2]Saudi Arabia Monetary Authority.

Table 1: Descriptive statistics

	CCBRIYAL	NEXRIYAL	GDPGR	INFLATION	BOP
Mean	1.018666	0.991261	3.672500	1.690625	3.356250
Median	0.989969	0.995037	2.840000	1.050000	0.350000
Maximum	1.457623	1.047304	17.01000	9.900000	27.40000
Minimum	0.598071	0.842687	-9.790000	-3.200000	-20.80000
Std. Dev.	0.209541	0.037680	6.185456	2.819444	14.21197
Skewness	-0.012607	-1.986302	0.301279	0.653609	0.276212
Kurtosis	2.680999	8.930316	2.976444	3.615590	1.812011
Jarque-Bera	0.136529	67.93366	0.484842	2.783697	2.288652
Probability	0.934013	0.000000	0.784726	0.248615	0.318438
Sum	32.59730	31.72035	117.5200	54.10000	107.4000
Sum Sq. Dev.	1.361131	0.044012	1186.056	246.4272	6261.379

From table 1 we observe that all variables are normally distributed (Jarque-Bera test is > 5%) and the currencies-commodity exchange rate is more volatile than the nominal exchange rate. The volatility of oil prices induces high volatility of macroeconomic variable (gdpgr, inflation, BOP).

Table 2: Correlation matrix

	CCBRIYAL	NEXRIYAL	INFLATION	GDPGR	BOP
CCBRIYAL	1.000000	0.336023	0.185485	0.156040	0.660550
NEXRIYAL	0.336023	1.000000	0.166428	-0.337568	0.166552
INFLATION	0.185485	0.166428	1.000000	0.218500	0.430729
GDPGR	0.156040	-0.337568	0.218500	1.000000	0.088994
BOP	0.660550	0.166552	0.430729	0.088994	1.000000

As mentioned before, the choice of the appropriate econometric method depends on the statistical proprieties of the time series in use. For this reason we perform in a first step unit roots tests.

Unit root tests

The determination of the nature and level of stationarity of variables is a crucial step for the rest of the analysis. For this reason we combine and compare results of three main unit root tests, Kwiatkowski-Phillips-Schmidt-Shin test (KPSS), Augmented Duckey-Fuller test (ADF), and Phillips-Perron test (PP)[3]. From results of Table 1 we depict that at 5% significance level, the ADF and PP tests accept the null hypothesis of non-stationarity of inflation rate and BOP while KPSS rejects it[4], they are I(1) variables. We also remark that the ADF and PP tests reject the

[3] Unit root tests usually differ from each other mainly in how they deal with serial correlation and heteroskedasticty in the errors. PP corrects the ADF test by the bias induced by omitted autocorrelation while KPSS is more appropriate when we test whether we have deterministic trend vs. stochastic trend.
[4] The null hypothesis is that the time series is I(1) for ADF and PP tests, while for the KPSS the null is I(0).

null hypothesis for the ccb-exchange rate (cccbriyal) and for nominal effective exchange rate (nexriyal) and for GDP growth rate (gdpgr) while the KPSS test accepts it, these three variable are I(0).

Table 3: Unit root tests

Variables	ADF	PP	KPSS	Result
ccbriyal	-4.31 (0.00)	-3.16 (0.031)	0.23	I(0)
Nexriyal	-3.93 (0.00)	-3.90 (0.00)	0.28	I(0)
Gdpgr	-6.70 (0.00)	-6.77 (0.00)	0.06	I(0)
Inflation	-2.36 (0.15)	-2.27 (0.18)	0.40	I(1)
BOP	-1.79 (0.37)	-1.74 (0.39)	0.52	I(1)
5% Critical value	-2.95	-2.95	0.46	

Based on results of table 3 we observe that there is heterogeneity in the level of integration of the different series. The appropriate econometric method that allows the use at the same time series with different level of integration (I(0) and I(1)) is ARDL model as developed by Pesaran et al. (2001).

A brief review of ARDL methodology

Traditional cointegration tests of Granger, Engle and Granger and Johansen and Juselius (1992) cannot be applied directly if variables of interest are of mixed order of integration. These methods require all the variables to be I(1). To remedy to this shortage, ARDL model is conceived to combine characteristics of Distributed Lag model (DL) and Autoregressive model (AR) (Pesaran and Shin 1999 and Pesaran et al. 2001). ARDL allows estimating short and long run dynamics for cointegrated time series or integrated distributed lag at different levels. It takes sufficient numbers of lags to capture the data generating process in a general-to-specific modeling framework. From ARDL we can derive a dynamic error correction model (ECM) integrating short-run dynamics with long-run equilibrium without losing long-run information and avoids spurious relationships resulting from non-stationary time series.

An explicit form of ARDL model can be illustrates as follows:

$$y_t = \varphi + \sum_{i=1}^{p} \alpha_i y_{t-i} + \sum_{j=0}^{q} \beta_j x_{t-j} + \varepsilon_t \qquad (1)$$

Where, ε_t is an error term $iid(0;\sigma^2)$.Lag length (p,q) are calculated using information criterion as AIC of Akaike and SIC of Schwarz. Short-run effect of x_t on y_t is reflected by β_0 while long-run effect is obtained from $\sum \beta_j / (1 - \sum \alpha_i)$.

Johansen and Juselius (1990) procedure is applied for vector error correction model when there exist multiple cointegration relationships and where variables are integrated at the same order. In the case of the existence of one cointegration vector with different order of integration of variables it's imperative to adopt ARDL-cointegration procedure or bounds test for cointegration proposed by Pesaran and Shin (1999) and Pesaran et al. (2001). The model serving for this test is:

$$\Delta y_t = \varphi + \sum_{i=1}^{p} \alpha_i \Delta y_{t-i} + \sum_{j=0}^{q-1} \beta_j \Delta x_{t-j} + \lambda_1 y_{t-1} + \lambda_2 x_{t-1} + \eta_t \qquad (2)$$

The bounds testing procedure is based on the F or Wald-statistics and is the first stage of the ARDL cointegration method. Accordingly, a joint significance test that implies no cointegration, (H_0: $\lambda_1 = \lambda_2 = 0$), should be performed for equation (2). The F test used for this procedure has a non-standard distribution. Thus, Pesaran et al. (2001) compute two sets of critical values for a given significance level. One set assumes that all variables are I(0) and the other set assumes they are all I(1). If the computed Fstatistic exceeds the upper critical bounds value, then $H_0$is rejectedand there is a cointegration relationship. If the F-statistic falls into the bounds then the test becomes inconclusive. Lastly, if the F-statistic is below the lower critical bounds value, it implies no cointegration.

From equation (2), if one cointegrating vector is identified, the ARDL model of the cointegrating vector is reparametrized into ECM. The error correction version of the ARDL model is given by:

$$\Delta y_t = \varphi + \sum_{i=1}^{p} \alpha_i \Delta y_{t-i} + \sum_{j=0}^{q-1} \beta_j \Delta x_{t-j} + \lambda ECT_{t-1} + \eta_t \qquad (3)$$

Where, $\lambda$is the speed of adjustment parameter and $ECT_{t-1}$is the residuals obtained from the estimated cointegration model of equation (1).

The ECM representation of ARDL model can be used to test the Granger causality following Toda and Yamamoto (1995). Conversely to the Granger their procedure is non-sequential one.

Toda-Yamamoto Granger Causality Test

Several critics have been addressed to traditional Granger causality test. In particular, they are applied only to stationary or cointegrated series. Yet, unit root test are less effective on small samples and are not always unbiased. Also, by differentiating series one can lose information about the level of series which is fruitful to explain the dynamics of the studied model. It follows that, on small samples, the Johansen cointegration test is sensitive to certain parameters choices that are likely to weaken it (risk of estimating a sub-parameterized VAR and risk of loss in degrees of freedom). These shortages can create bias that often leads to reject the hypothesis of absence of cointegration relationship while it is true. In order to surpass these anomalies, Toda and Yamamoto (1995) propose a non-sequential procedure consisting in estimating an over-parameterized VAR in level where probable cointegration relationships are not explicit. The Toda-Yamamoto Granger causality test follows the following steps:

- Determination of maximum order of integration of series (d_{max}),
- Determination of the optimal lag of the VAR in level (k) with information criterion (AIC, SIC),
- Estimation of the augmented VAR in level of order p=k+ d_{max}.

The number of lags in the estimation of the VAR in level depends of the order of integration of the series. If the series is stationary in level, we add no lag and if the series is stationary in difference, we add one lag, etc.

To illustrate the Toda-Yamamoto Granger causality test we consider the augmented following VAR in level:

$$x_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} x_{t-i} + \sum_{j=k+1}^{k+d_{max}} \alpha_{2i} x_{t-j} + \sum_{i=0}^{k} \beta_{1i} y_{t-i} + \sum_{j=k+1}^{k+d_{max}} \beta_{2j} y_{t-j} + \eta_{1t} \quad (5)$$

$$y_t = \alpha_0 + \sum_{i=1}^{k} \beta_{1i} y_{t-i} + \sum_{j=k+1}^{k+d_{max}} \beta_{2i} y_{t-j} + \sum_{i=0}^{k} \alpha_{1i} x_{t-i} + \sum_{j=k+1}^{k+d_{max}} \alpha_{2j} x_{t-j} + \eta_{2t} \quad (6)$$

The causality test is a Wald test which follows a $\chi^2_{(n)}$ andconsists on testing restrictions on the k first coefficients. The number of degree of freedom is equal to the number of restrictions. As mentioned by Toda and Yamamoto this test is independent of the order of integration of the series and of the cointegration relationships.

EMPIRICAL RESULTS

In order to test if the currencies-oil exchange rate has affected both internal equilibrium, through its effect on growth and inflation, and external equilibrium, through its effect on balance of payment (current account) we apply the developed methodology on Saudi Arabia data on the period 1980-2017. In our first step of analysis we have calculated unit root tests (see sub-section 5.1.1) and concluded that the used series have different level of integration. Then, the ARDL approach to testing for the existence of a long-run relationship between the variables in levels is applicable irrespective of whether the underlying regressors are purely I(0), purely I(1), or fractionally integrated.

Table 4 presents results of ARDL(1,1,1,1) estimation. As mentioned in the methodology section, optimal lags are obtained using the AIC and SIC criterion.

Table 4: ARDL(1,1,1,1) estimation

Dependent variable: ccbriyal				
Variables	coefficient	t-statistic	probability	
ccbriyal(-1)	0.579*	2.98	0.00	
gdpgr	0.043	1.02	0.31	
gdpgr (-1)	- 0.012*	2.08	0.16	
Inflation	0.057	0.35	0.72	
Inflation(-1)	- 0.001	0.10	0.91	
Bop	0.016*	4.53	0.00	
Bop(-1)	-0.012*	2.62	0.01	
Constant	0.375	1.85	0.07	
R-sq 0.633	F-statistic 6.89		Prob(F-statistic) 0.00	DW 1.77

Notes: * indicates significant at 5% level.

The second step consists on looking for cointegration relationships following the methodology of Pesaran et al. (2001).Results of bounds test to cointegration are presented in table 5.They confirm the existence of cointegration relationship between all variables. The calculated F-statistics are beyond the upper bounds.

Table 5: F-statistics for bounds test to cointegration

Variables	ARDL		Calculated F-statistics	
Ccbriyal, gdpgr, Inflation, BOP	ARDL(1,1,1,1)		11.36*	
Critical value bounds of F-statistic	10% level		5% level	
	Lower bound I(0)	Upper bound I(1)	Lower bound I(0)	Upper bound I(1)
	2.72	3.77	3.23	4.35

Note: Critical values are obtained from Table C1.iii (unrestricted intercept and no trend) In Pesaran*et al*. (2001).

* indicates the statistical significance at the 5 % level. The optimal lag length is 1.

Because a cointegration relationship is found among the variables, the next step is deriving the marginal impact of gdp growth rate, inflation rate, and balance of payment on currencies-oil exchange rate. Table 6 presents the results for both the long run and short run coefficients. We also calculated diagnostic tests for the goodness of fit of the retained ARDL (error autocorrelation, heteroscedasticity, normality and specification). The null hypothesis is accepted for all these tests. Hence, the outcome of the diagnostic tests indicates that the model has the desired econometric properties.

Then, ARDL(1,1,1,1), where the independent variables are GDP growth rate, inflation rate and balance of payment (current account), explains the dynamic of the currencies-oil exchange rate in Saudi Arabia.

Table 6: ARDL-VECM long-run and short-run coefficients

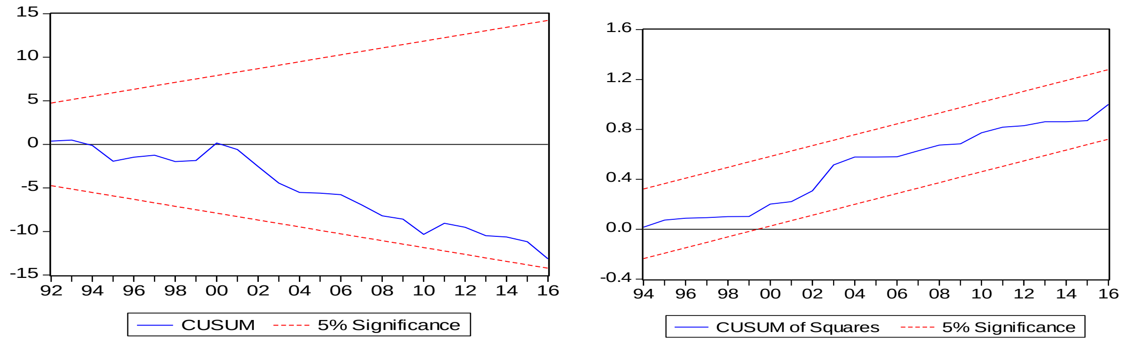
Dependent variable: Δccbriyal					
	Long-run		Short-run		
Variables	coefficient	sdt-dev	Variables	coefficients	std-dev
Gdpgr	0.032	0.023	Δgdpgr	0.006*	0.002
Inflation	0.123*	0.052	Δinflation	-0.075*	0.032
Bop	0.247*	0.085	Δbop	0.083*	0.038
Constant	0.521	0.283	ECM_{t-1}	-0.592*	0.182
R-sq : 0.763	F-statistic: 12.15*		Prob(F-statistic): 0.026		DW : 1.89
Diagnostic tests					
Autocorrelation	Heterosckedasticity		Normality	Specification	
Breusch-Godfrey	*Breusch-Pagan-Godfrey*		*Jarque-Bera*	*Ramsey*	
3.481	*0.213*		*8.462*	*4.893*	

Notes: * indicates significant at 5% level.

The term ECM_{t-1} as the speed of adjustment parameter or feedback effect is derived as the error term from the cointegration model. It shows how much of the disequilibrium is being corrected, that is, the extent to which any disequilibrium in the previous period is being adjusted in the dependent variable. A positive coefficient indicates a divergence, while a negative coefficient indicates convergence. According to results of table 6, the lagged error correction term exerts a negative sign at the 5% significance level, suggesting that the system has the ability to return to long-term equilibrium after a short-term shock. With a value of -0.592, about 60% disequilibria from the current year's shock can be adjusted in the next year. In other words, letting the exchange rate fluctuating with movements in oil prices could help the economy to converge after an external shock.

The existence of a cointegration derived from equation (2) does not necessarily imply that the estimated coefficients are stable as argued in Bahmani-Oskooee and Brooks (1999). Therefore, stability tests of Brown, which are also known as cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) tests based on the recursive regression residuals, may be employed to that end. These tests also incorporate the short-run dynamics to the long-run through residuals. The CUSUM and CUSUMSQ statistics are updated recursively and plotted against the break points of the model. Providing that the plot of these statistics fall inside the critical bounds of 5% significance, one assumes that the coefficients of a given regression are stable. These tests are usually implemented by means of graphical representation and shown in figure

Figure 4: CUSUM and CUSUM-squares stability tests of ARDL(1,1,1,1)



Both the CUSUM and the CUSUMSQ plots lie within the critical bounds at the 5% significance level, implying that all coefficients in the ECM are stable. Accordingly, ARDL(1,1,1,1) model has stability propriety.

Results of Toda-Yamamoto test are presented in table 7. As indicated before when variables have different degrees of integration, traditional Granger causality are inefficient. In this case we use Toda and Yamamoto (1995) causality test based on Wald statistic which follows a $\chi^2_{(n)}$ distribution where the degree of freedom n is equal to the number of restrictions on the k first coefficients of the VAR (ccbriyal, gdpgr, inflation, BOP).

Table 7: Toda-Yamamoto Granger causality

k	d_{max}	Variables	Ccbriyal	Gdpgr	Inflation	Bop
2	1	Ccbriyal	_	2.45	1.57	11.73*
		Gdpgr	6.48*	_	1.09	17.39*
		Inflation	8.29*	6.82*	_	8.39*
		Bop	12.45*	35.67*	6.72*	_
		All variables	25.34*	22.38*	10.28*	32.50*

Notes: in parenthesis are p-value; * indicates significance at 5%; k is optimal lag of the VAR in level andd_{max} is maximum integration order of variables.

We depict that there is bidirectional causality between currencies-oil exchange rate and balance of payment. This result is in line with theoretical and empirical literature. In fact movements in exchange rate affect the balance of payment especially through the value of imports and exports and conversely the balance of payment position affects the level of exchange rate. Adopting an exchange rate regime integrating oil-prices fluctuations is more realistic for oil-dependent economies in general and for Saudi Arabia in particular.

Also, we uncover a unidirectional causality from currencies-oil exchange rate to GDP growth rate. As mentioned by Hausmann et al. (2005) and Rodrik (2008), rapid growth accelerations are often correlated with real exchange rate depreciations. Moreover, Di Nino et al. (2011) show that undervaluation supported growth by increasing exports, especially from high-productivity sectors. On the other hand, Benhima (2012) argued that if a currency is pegged to USD only, the higher the degree of dollarization, the more likely a negative effect on growth. Saudi Arabia has adopted a fixed exchange rate and this would have probably hindered its growth.

Finally, we observe that there is unidirectional causality from currencies-oil exchange rate to inflation. This result confirms the exchange rate pass-through mechanism developed in the literature. In fact, Saudi Arabia is an open economy where most of consumer and capital goods are imported. When Saudi Riyal depreciates following a decrease in oil prices[5], inflation pressure could happen via consumer prices and production costs.

CONCLUSION AND POLICY RECOMMENDATIONS

Since 1986, Saudi Arabia has opted for a fixed exchange rate to the US dollar and the government has adopted a countercyclical fiscal policy to stabilize growth. During upswings in oil exports, the government runs a fiscal surplus. During downturns, the government utilizes its foreign exchange assets and boosts domestic spending by deficit spending. According to the Saudi Monetary authorities, linking the Saudi Riyal to the US dollar guarantees the stability of export earnings and protects them against exchange risks. Pegging firmly the Riyal to the dollar is also justified by authorities to strengthen monetary and financial stability and to not need to target inflation.

As it has been stressed by Alkhareifand Qualls (2016) and by Jeffrey (2017), the pegs have probably served the countries well in the past, when oil prices were not quite so volatilebut it has created problems when the world price of oil exhibits big swings, up or down. In order to reduce their vulnerability oil-exporters should adopt an exchange rate index integrating oil-prices in line with commodity-currencies exchange literature.

In this context, this work aimed at the construction of an exchange rate for the Saudi riyal integrating the currencies of the main trade partnerships (US dollar, Euro, and Yen) and oil

[5] Many empirical works (Zhoo 1995, Coudert el al. 2007) have shown that an increase in crude oil prices induces depreciation in the US dollar and this induces inflation in oil producer countries.

prices and deduce period of undervaluation and overvaluation of the riyal during 1984-2017. Our results show that periods of high (low) oil prices are accompanied by overvaluation (undervaluation)of the riyal. These movements have consequences on internal and external macroeconomic equilibrium. Effects of currencies-oil exchange rate on internal macroeconomic equilibrium have been apprehended through inflation and growth while effects on external macroeconomic equilibrium have been studied through balance of payment position. To attain this objective we have adopted an ARDL methodology taking into account the statistical proprieties of the used series. In particular, our series are of mixed level of integration and this leads to use bounds test to cointegration of Pesaran et al. (2001). Our results reveal a cointegration relationship between the currencies-oil exchange rate, GDP growth rate, inflation rate and balance of payment position. The estimation of short-run and long-run coefficients attests that there exist a stable long-run equilibrium of the model and that short-run shocks are rapidly absorbed. This could mean that adopting an exchange rate regime integrating oil prices fluctuations can help to protect the economy from external shocks. This is true because literature recognizes that fixed exchange rate regime where foreign exchange reserves play a major role in money supply fluctuations are conducive to the transmission of foreign disturbances into the domestic economy (Aleisa and Dibooglu (2002)).

Granger causality tests based on Toda-Yamamoto non-sequential procedure are conclusive. We have depicted bidirectional causality relationship between currencies-oil exchange rate and balance of payment position. In fact and conversely to the fixed exchange rate regime, where balance of payments does not impact the exchange rate because central bank adjusts currency flows to offset the international exchange of funds, in currencies-oil exchange rate regime, fluctuations of oil prices transmit to balance of payments and to the economy through exchange rate. Under such regime, appreciation or depreciation bring some positive and negative impacts that policymakers should evaluate and adopt the adequate exchange rate. According to the balance of payment approach the exchange rate is affected when inflow and outflow of foreign currency do not balance. If the price of an export commodity is increased it is assumed that the inflow of foreign currency raises and that leads to an appreciation of the domestic currency. If this holds, then an increase of the export commodity, in this case oil, leads to an appreciation of the export country’s exchange rate. In the specific case of Saudi Arabia we observe a positive relationship between currencies-oil exchange rate and balance of payments through ARDL coefficients and through correlation matrix.

Causality between currencies-oil exchange rate and internal macroeconomic equilibrium has been elucidated through inflation-exchange rate and through GDP growth rate-exchange rate nexus. The unidirectional causality from currencies-oil exchange rate to inflation is in concordance with theoretical and empirical literature. While fixed exchange rate protects domestic economy from inflation, currencies-oil exchange rate can influence domestic inflation both directly via the prices of imported final goods and indirectly via the prices of imported intermediate and capital goods. In this context monetary authorities have the role to avoid excessive exchange rate fluctuations.

Works on the exchange rate-economic growth nexus have supported a negative effect of exchange rate on growth especially in commodity-currency economy with fixed exchange rate. In addition, Benhima (2012) shows that pegging on USD only can hinder economic growth of the country and the higher the degree of dollarization, the more likely a negative effect on growth. Moreover, literature argues that high overvaluation or undervaluation of exchange rate hurt growth and that moderate depreciation enhances growth. In oil based-economies, oil revenue constitutes a high percentage of their income and their currency exchange rate tends to track fluctuations in oil prices. For these countries, pegging their money on oil and other currencies (USD, Euro) and keeping their exchange rate at appropriate levels and avoiding excess volatility can help them to exploit their capacity for growth and development. The causality relationship running from oil-currencies exchange rate to economic growth in the case of Saudi Arabia shown in table 7 can be interpreted and explained in this context.

In oil exporting countries in general and in Saudi Arabia in particular, the evolution of the price of oil is one, if not the most, important factor to be considered in economic policy decisions. These countries face costly and persistent macroeconomic instability when they fail to find optimal responses to oil price shocks. In modern economies, exchange rate is a strategic variable that determines their competitiveness and authorities should determine it optimally. During the past period, Saudi Arabian monetary authorities have chosen to peg firmly the riyal only to the USD. This choice is usually motivated by the advantage of importing stable monetary policy from a country with strong economic and political institutions. Nevertheless, this choice is not costless and should be evaluated. Model simulations elaborated by Habib and Strasky (2008) indicate that a currency basket is generally preferable to a single currency peg for oil-based economies, especially when some weight is placed by the policy maker on output stabilization. Pegging to a single currency becomes optimal only when inflation becomes the only policy objective.

This work was an attempt to contribute to this literature and to show that indexing exchange rate of oil-based economy on oil prices can help them to attain abrupt fluctuations and design sound macroeconomic policy. Further researches are needed to assess adequate currencies-commodity exchange rate regimes in resource-based economies in general and in oil-based economies in particular. In the case of Saudi Arabia, authorities should think to construct an exchange rate index integrating traditional currencies (US Dollar, Euro, Yen), oil prices and taking into account recent and future trends of trade especially with China.

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