External and Internal Real Exchange Rates and the Dutch Disease in Africa : Evidence from a Panel of Nine Oil-Exporting Countries

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Abstract

Despite a large number of empirical studies on Dutch disease in developing countries and the evidence that natural resources revenues tend to appreciate the real exchange rate, there remains little discussion about the definition of the real exchange rate. This article aims to fill this gap by using 4 different proxies of the real exchange rate, differentiating the internal from the external real exchange rates for agricultural and manufacturing sectors respectively. Using Pooled-Mean-Group and Mean-Group estimates on a panel of nine African countries, results show a clear appreciation of the RER except for the internal real exchange rate for manufacturing. This would imply that Dutch disease more clearly affect agricultural compared to manufacturing competitiveness in these African countries.

Keywords: Dutch disease, Oil revenues, Pooled-Mean-Group estimator, Equilibrium real exchange rate, Africa.

JEL classification: C23, F31, O13, 024, O55.

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Contents

1 Introduction

There is an important literature related to the role that natural resources, and especially oil, can play in explaining the absence of growth-producing structural transformations in several developing countries, and particularly in Africa (McMillan et al., 2014, [26] ; Rodrik, 2016, [33]...).). This question is even more prevalent today, due to the numerous discoveries in the 2010's all around the continent of new reserves of oil (Niger and the Mozambique Channel at the beginning of the 2010 decade, Senegal in the mid-2010's...) and gas (Egypt in the first half of the decade). One of the most common explanation for this phenomenon is the so-called Dutch disease effect, a widely known phenomenon that has been extensively discussed in the theoretical and empirical literature since the first models developed in the early 1980's (Buiter-Purvis, 1980, [6] ; Bruno and Sachs, 1982, [5] ; Corden and Neary, 1982, [12] ; van Wijnbergen, 1984, [36]....). This concept implies that natural resources tend to appreciate the RER through several channels which in return reduces the competitiveness of the non-resource tradable sector. Yet, there has been surprisingly little debate in the Dutch disease literature regarding the definition of the RER. Indeed, one can broadly distinguish between two types of measures: the "internal" RER from the model of Corden-Neary (Corden and Neary, 1982), defined as the ratio of price of non-tradable over tradable products, and the "external" RER, defined as the ratio of domestic over foreign prices. This distinction is important because those two indicators can be interpreted differently. The "internal" RER is a measure of the profitability differential between sectors, and hence explains structural transformations, whereas the "external" RER measures the external competitiveness of a country's production, explaining declining export revenues in the non-resource sectors. Thus, both may not show the same patterns over time, especially when a boom occurs, while most empirical studies use only the external definition of the RER, even when they directly refer to the Corden-Neary model as the core theoretical model. This can be explained by three reasons. First, the external exchange rate has now become the canonical definition of the exchange rate in the economic literature. Second, even though their definitions differ, there is a mathematical relationship between the two RER (see section 3). Finally, while several institutions (World Bank, IMF, UNCTAD...) provide measures of the external RER, reliable data for the internal RER are much more difficult to obtain. This remark is particularly true for developing countries, which have attracted most of the interest in the Dutch disease literature for the last two decades.

This paper intends to fill this gap by determining whether oil revenues have been associated in Africa with an appreciation of the external real exchange rate, with an appreciation of the internal real exchange rate, or both. Using a panel of nine African oil-exporting countries between 1995 and 2017, I investigate the long-run and short-run impacts of oil revenues on four different exchange rate indicators. These indicators correspond to the exchange rate computed for the main agricultural exports and for the main manufacturing exports for the internal and for the external exchange rates. The choice of using two indicators for each RER helps to strengthen the results and contributes to understand which export sector are the more likely to suffer from Dutch disease consequences. For this analysis, I apply the Pooled-Mean-Group estimator proposed by Pesaran et al. (1999, [31]) to the panel dataset, and tests its robustness by using the Mean-Group estimators. I use two different explanatory variables: oil revenues expressed in international USD per capita and the international price of oil. Finally, I account for potential cross-sectional dependence by applying the Cross-Sectionally Augmented Pooled-Mean-Group estimator and the original PMG with demeande values.

The panel data estimation strategies reveal a clear and significant appreciation effect of the two external real exchange rates caused by oil revenues in the countries of the sample. Regarding the internal measures of the real exchange rate, only the variable for agricultural products show a positive and significant correlation with oil revenues while the other variable leads to mixed results, implying that the Dutch disease could have more "de-agriculturalization" than "de-industrialization" effects for our nine African countries.

The contribution of this article to both the theoretical and the empirical literature is threefold. First, it is the only attempt to use four different RER so that to question the difference between internal and external ER and to investigate the different effects of DD on manufactured and agricultural competitiveness. Second, this study is new by its focus on a panel of nine main oil-exporting African countries, while empirical analyses of Dutch disease in Africa chose to focus on country-case studies or on specific areas (such as Northern Africa or the CFA Franc Zone). Finally, this study exploits brand new data provided by the FERDI[1] and completed by other sources. This last point is of special interest for the analysis of internal real exchange rate, due to the frequent lack of data in African countries.

In a first step, I briefly review the theoretical and empirical literature relative to the impact of natural resource revenues on the RER and link the Dutch disease models with the literature relative to the determinants of long-run equilibrium exchange rate (section 2. Then, I precisely define the two definitions of the RER given in this article and analyze the mathematical relationship between them (section 3. Third, I describe the source of the data and justify the variables used in this paper (section 4). Then, I detail the econometric specification and the results and present several tests of robustness (section 5). The last section concludes and comments on the main limitations of the analysis (section 6).

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[1] Fondation pour les Etudes et Recherches sur le Développement International

2 A Short Review of Theoretical and Empirical Literature

2.1 The Dutch Disease Models

The term "Dutch disease" has been applied for the first time by the journal The Economist to describe the appreciation of the real exchange rate and the subsequent decline in competitiveness of the manufacturing sector in the Netherlands caused by gas exports during the 1960's and 1970's. Following this, a large theoretical literature has emerged in the early 1980's to explain this phenomenon (Buiter-Purvis, 1980, [6] ; Bruno and Sachs, 1982, [5] ; Corden and Neary, 1982, [12] ; van Wijnbergen, 1984, [36] ; Corden, 1984, [11]...) with different assumptions, theoretical foundations and definitions.

Today, empirical studies almost always refer to the so-called model of Corden-Neary (Corden and Neary, 1982) and its extension (Corden, 1984) as the seminal theoretical model of Dutch disease. In that model, a boom in natural resources generates an exchange rate appreciation through two main channels : (i) by increasing public and private expenditures, it leads to a rise in the price of non-tradable goods while tradable goods prices are assumed exogenous (the Spending effect), (ii) by attracting labor into the resource sector it puts pressure on wages in the two other sectors, leading to a rise in wages and hence in prices in the non-tradable sector while the wages in the tradable non-resource sectors are also exogenous (the Resource-Movement Effect). In this model, the real exchange rate is defined as the ratio of domestic tradable and domestic non-tradable goods (called the internal real exchange rate or IRER in the rest of this paper). Yet, other definitions of the RER have been proposed in several models. For instance, Buiter and Purvis (1980) define the RER as the ratio of domestic and foreign prices, following the currently most common definition of the exchange rate (called the external real exchange rate or ERER in the rest of this paper), but describe only the Spending effect. In this paper, I specifically target the link between natural resources revenues and the different real exchange rates in order to compare the predictions of these different models of Dutch disease. Another major point relative to these models is that they often assume the existence of a perfectly non-tradable and a perfectly non-resource tradable sector, while imperfect tradability could exist in some sectors. On the contrary, Benjamin et al. (1989, [3]) assume imperfect substitutability between foreign and domestic goods in the tradable sectors in the Cameroonian case, considering this assumption to be more relevant when studying developing countries. This implies that a disease could have different effects on the different tradable sectors, depending on their level of substitutability in international markets. This question will also be investigated here thanks to the use of different proxies for agricultural and manufacturing exchange rates.

2.2 Equilibrium Exchange Rate and Fundamentals

We now turn to the theoretical and empirical studies relative to the determinants of the external real exchange rate, because it has produced a much more abundant literature than the internal real exchange rate. Since the first Purchasing Power Parity approach coming back from Cassel (1916a [7] and 1916b[8]), there has been a large emergence of new approaches aiming at capturing the concept of "equilibrium exchange rate" and of short-run misalignment. Among them, the two most popular approaches are the Fundamental Equilibrium Exchange Rate (FEER) associated with Williamson (1994 [37]) and the Behavioural Equilibrium Exchange Rate proposed by Clark and MacDonald (1999 [10])[2]. The FEER approach considers the equilibrium exchange rate as the exchange rate that simultaneously allows for external balance sustainability (exports equal imports) and for internal balance equilibrium (defined as the non-accelerating inflation rate of unemployment or NAIRU). On the contrary, the BEER approach focuses on a list of variables that are supposed to determine the long-run value of the real exchange rate. Since the paper from Clark and MacDonald, a large empirical literature has emerged, trying to estimate the main determinants of long-run real exchange rates. These fundamentals traditionally include GDP per capita or any other variable allowing to capture the Balassa-Samuelson effect, terms of trade, trade openness, public expenditures, investment, foreign capital inflows or net foreign assets... Consistent with the Dutch disease hypothesis, some studies also include causes for the DD in the fundamentals, such as international oil prices or resource revenues. This literature typically follows two steps. First, estimating the equilibrium exchange rate based on a set of fundamentals among the ones mentioned above. Then, computing the short-run misalignments defined as the difference between the equilibrium exchange rate estimated as the observed exchange rate.

In Africa, there has been an important literature relative to the understanding of exchange rate fundamentals. For instance, Roudet et al. (2007, [34]) estimate the impact of five fundamentals (terms of trade, government expenditures, openness, Balassa-Samuelson effect, and investment) on the exchange rate of WAEMU countries. For this, they first apply the Fully-Modified Ordinary Least Squares (FMOLS) and the Pooled-Mean-Group (PMG) to estimate the equilibrium RER for the complete panel and find similar results with both methodologies. Then, they apply the Hodrick-Prescott filter to evaluate short-run misalignments and conclude to the presence of an overvaluation of the RER before the

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[2] For a more detailed description of all different approaches, one can refer to Egert et al., 2006[17]

devaluation of the CFA Franc in 1994. Finally, they apply the Johansen maximum likelihood procedure and the ARDL approach to each country of the sample, allowing them to account for the heterogeneity in the panel. Similarly, Couharde et al. (2013, [14]) estimate the long-run relationship between the RER and a set of five fundamentals (terms of trade, Balassa-Samuelson, openness, public spending and NFA) in a panel of thirteen CFA area country members[3]) using Dynamic OLS estimation (DOLS). They also use VECM methodology to capture short-run dynamics for the variables. Nouira and Sekkat (2015, [28]) investigate the impact of five fundamentals (trade openness, net capital inflows, terms of trade, country debt service, government expenditures and Balassa-Samuelson effect) on the long-run equilibrium exchange rate using Dynamic OLS for a panel of 51 developing countries over 1980-2010. They also estimate short-run misalignments of this RER using the modified Hodrik-Prescott filter and find results that are overall consistent with the expectations.

2.3 Equilibrium Exchange Rates and Dutch Disease

In line with the DD model, an important strand of the literature tries to estimate the impact of resource revenues on exchange rates, either considering resource revenues as a fundamental similar to trade openness or productivity per capita, or focusing on short-run variations caused by natural resources discoveries or international price variations. For example, by focusing on international oil price increases and decreases in a panel of 32 developing oil-producing countries and by implementing both a first-difference and a system-GMM methodology, Arezki and Ismail (2013, [2]) observe that oil prices are positively correlated with government spending which in return has an appreciation effect on the RER. This supports the evidence of a Spending effect in their panel of oil-exporting countries. Coudert et al. (2015, [13]) also investigate the impact of international commodity prices for a panel of 68 commodity exporters (including 26 developing, 37 intermediate and 5 advanced countries). Using Dynamic OLS, and accounting for cross-sectional dependence, they estimate the impact of three variables on long-run equilibrium exchange rates and on short-run ER variations: workers productivity (i.e. the Balassa-Samuelson effect), Net Foreign Assets, and what they call commodity Terms of Trade which aim to capture the variations of commodity prices. They finally conclude to an appreciation effect caused by commodities exports, with a much stronger coefficient in low income countries. In a country-case perspective, Essien and Akipan investigate the impact of a set of key

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[3] Benin, Burkina Faso, Central African Republic, Chad, Cameroon, Congo, Cote d'Ivoire, Equatorial Guinea, Gabon, Mali, Niger, Senegal and Togo. Guinea-Bissau is excluded from the sample because it became a member of the WAEMU CFA Franc Zone only in 1997

fundamentals on the Nigerian equilibrium exchange rate (Essien and Akipan, 2016, [18]). They include the Balassa-Samuelson effect, the size of M2 in total economy, government expenditures, net foreign assets, trade openness and the international price of oil. In line with the DD, they conclude to a positive impact of oil prices on RER, with an average coefficient even higher than NFA, public expenditures and M2. It has also been argued in the empirical literature that Dutch disease could be driven by other channels than natural resources, such as international aid or migrant remittances. Regarding international aid, the seminal empirical investigation of Dutch disease in panel data comes from Rajan and Subramanian (2011, [32]). With a panel of 32 developing countries between 1980 and 2000, they estimate the impact of aid on several indicators, including a value for the excess appreciation of the RER based notably on the Balassa-Samuelson effect. Fielding and Gibson (2012, [19]) apply Vector Autoregressive (VAR) specifications to multiple time-series for 36 African countries between 1970 and 2009. By including the logarithm of international aid commitment, the logarithm of real GDP, the logarithm of the real effective exchange rate and a dummy for the 1994 nominal devaluation for CFA countries, they observe that foreign aid can contribute to RER appreciation but with a large heterogeneity across countries. Similarly, Nketiah et al. (2019, [27]) estimate the long-run impact of remittances on the Ghanaian RER based on a pooled OLS and including remittances, public expenditures, openness, capital inflows and terms of trade as fundamentals. Yet, their results are mixed, since the coefficient for remittances appears to be very low and mostly insignificant.
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This article follows this empirical literature by assessing the impact of oil revenues on exchange rates in a panel of nine oil-exporting African countries. However, the aim is here only to determine the relationship between oil revenues and ER variations in oil-exporting countries. Then, the methodology implemented allows to evaluate short-run and long-run impacts of oil revenues variations on the RER, but does not aim to estimate short-run misalignments from the equilibrium ER.

3 External and Internal Real Exchange Rates

The first question is the definition of the real exchange rate. This question may seem trivial but is not. Indeed, we can define two different exchange rates. First, the external real exchange rate is the most popular interpretation of the exchange rate and corresponds to the ratio of domestic over foreign prices. On the contrary, some studies sometimes use what will be called here an “internal” real exchange rate, defined as the ratio of domestic non-tradable over domestic tradables prices. Surprisingly, the seminal Corden-Neary model of Dutch disease never uses foreign prices but focuses only on the internal real exchange rate (Corden and Neary, 1982 ; Corden, 1984), yet a vast majority of empirical studies of Dutch disease adopt the most-common external real exchange rate, even when they directly refer to Corden and Neary as the core model of Dutch disease.

Here, I follow Hinkle and Montiel (1999, [23]) and define the internal real exchange rate (IRER) and the external real bilateral exchange rate (ERER)[4] as:

$$IRER_i = \frac{P_{i;N}}{P_{i;T}} \tag{1}$$

with $P_{i;N}$ and $P_{i;T}$ the index prices in non-tradable and tradable sectors respectively.

$$ERER_{i,j} = E_{i;j}\frac{P_i}{P_j} \tag{2}$$

with $E_{i;j}$ the nominal bilateral exchange rate between the two currencies, and P_i and P_j the price indexes in i and j respectively.

From equation 2, the external real effective exchange rate is then given by:

$$EREER_i = \prod_{j\in J}\left(E_{i;j}\frac{P_i}{P_j}\right)^{\gamma_j} \tag{3}$$

with γ_j a weight given to each partner country j. Usually, this weight corresponds to the share of trade between country i and country j in total trade of country i. However, these weights can be measured differently. Since this study focuses on the external competitiveness of oil-exporting countries, I prefer another weight whose construction will be detailed in next section and capturing competitors rather than partners shares.

Let's define λ_j as the share of tradables in total production of country j. It follows that:

$$\forall j, P_j = P_{j;T}^{\lambda_j} \times P_{j;N}^{1-\lambda_j}$$

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[4] For both the internal and the external exchange rates, there are always two different ways to define the ER and that depend on which price index is the numerator and which is the denominator. Here, I define them such that an increase in the ratio always means an appreciation of the exchange rate

Equation 3 becomes:

$$EREER_i = \prod_{j \neq i} \left(E_{i;j} \frac{P_{i;T}^{\lambda_i} P_{i;N}^{1-\lambda_i}}{P_{j;T}^{\lambda_j} P_{j;N}^{1-\lambda_j}} \right)^{\gamma_j} = \prod_{j \neq i} \left(E_{i;j} \frac{P_{i;T}}{P_{j;T}} \right)^{\gamma_j} \times \prod_{j \neq i} \left(\frac{P_{i;T}^{\lambda_i - 1} P_{i;N}^{1-\lambda_i}}{P_{j;T}^{\lambda_j - 1} P_{j;N}^{1-\lambda_j}} \right)^{\gamma_j}$$

$$= \prod_{j \neq i} \left(E_{i;j} \frac{P_{i;T}}{P_{j;T}} \right)^{\gamma_j} \times \prod_{j \neq i} \left(\frac{(\frac{P_{i;N}}{P_{i;T}})^{1-\lambda_i}}{(\frac{P_{j;N}}{P_{j;T}})^{1-\lambda_j}} \right)^{\gamma_j}$$

We finally get:

$$EREER_i = \prod_{j \neq i} \left(E_{i;j} \frac{P_{i;T}}{P_{j;T}} \right)^{\gamma_j} \times \prod_{j \neq i} \left(\frac{IRER_i^{1-\lambda_i}}{IRER_j^{1-\lambda_j}} \right)^{\gamma_j} \tag{4}$$

Under the Law of One Price ($E_{i;j} \frac{P_{i;T}}{P_{j;T}} = 1 \, \forall j$) and assuming that the internal exchange rates of foreign countries are exogenous, a change in the domestic internal real exchange rate corresponds to a similar change in the external real effective exchange rate. However, if these assumptions are not met, the internal and external exchange rates can have different patterns over time. The rest of this paper will therefore aim to estimate the impact of oil revenues on the internal and external exchange rates given by equations 1 and 3.

4 Data

I use data from several sources (FERDI-OCD, World Economic Outlook, World development Indicators and the UNCTAD) for nine main African oil exporting countries between 1995 and 2017 to investigate the long-run relationship between the external and internal exchange rates and the set of fundamentals. I selected the countries among the most oil-dependent countries in Africa according to the World Development Indicators. Since the empirical methodology applied here requires a variability in oil rent across time within each country, I included only countries which were producing oil over the whole 1995-2017 period. Due to a lack of data availability and to the political instability that could have led to poor quality of data, I excluded Libya, Sudan and South Sudan from the sample, keeping nine oil-dependent countries: Algeria, Angola, Cameroon, the Republic of Congo, Egypt, Equatorial Guinea, Gabon, Nigeria and Tunisia. Data sources are described in table 5. I detail in the following subsections the justification and definition of the variables used. Descriptive statistics and the matrix of correlation between all variables are displayed in the appendix.

4.1 The Dependent Variables

I use here four different dependent variables aiming at capturing the effects of oil revenues in oil-exporting countries. The dependent variables all come from the Sustainable Competitiveness Observatory (OCD) of the Foundation for Studies and Research on International Development (FERDI) and are:

- Two Internal Real Exchange Rates computed for agricultural and for manufacture products.
- Two External Real Exchange Rates computed for agricultural and for manufacture products.[5]

I now present the way these four proxies have been computed [6]. Regarding the internal real exchange rates, both indicators are defined as:

$$IRER_{OCD} = \frac{P}{P_X} \tag{5}$$

with P the consumer price index, and

$$P_X = \sum_{k=1}^{5} s_k p_k$$

with k the five main agricultural and the five main manufactured products exported by the country and s_k the share of each good k among these five exports (i.e. $\sum_{k=1}^{5} s_k = 1$). To avoid variations in the index that would not be caused by changes in prices but by changes in the share of each good among total exports, the weights s_k attributed to each good k are constant over time and based on the average composition of exports over the period 2008-2012. AAnother advantage of the use of such variables is that, by focusing only on the four main agricultural and manufacturing exports, they do not include oil, contrary to traditional measures of the real effective exchange rate which are often based on

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[5] Agricultural products include food products either transformed or not (such as cereals, vegetables, fish, meat or dairy) as well as primary goods produced for exports (such as coffee, rubber, tobacco or wood). Manufacturing products include transformed industrial goods. None of them include crud oil or oil products. For simplicity purpose, we will call them “agricultural” and “manufacturing” goods from now. The goods included in each exchange rate for each product is are detailed in the appendix (table 6)

[6] All variables used are described in OCD (2017, [1]) and can be found at `https://competitivite.ferdi.fr/`. The indexes are constructed by the FERDI based on data from the Centre d’études prospectives et d’informations internationales (CEPII) and International Financial Statistics (IFS). More details in the appendix

all price exports.

The internal real exchange rates of the OCD are t, contraru hus defined as the ratio of the price index over respectively agricultural exports prices and manufactured exports prices. This definition differs slightly from the internal real exchange rate as defined by Corden and Neary, but it is easily proved that they are linked with the following relationship[7]:

$$IRER_{OCD} = \frac{P_T}{P_X} \times IRER^{1-\lambda} \tag{6}$$

It is must be noted that the value in level for the exchange rates does not mean much in itself, the only condition required here is that changes in our proxy follow the same patterns as changes in the Corden-Neary internal real exchange rate.

We now move to the definitions of the external real effective exchange rates. Like the IRER, two indexes are constructed, both following the same equation:

$$EREER_{OCD} = \sum_{k=1}^{5} \left(\sum_{j=1}^{10} \left(E_{i;j} \frac{P_{k;i}}{P_{k;j}} \right)^{\gamma_j} \right)^{s_k} \tag{7}$$

with $P_{k;j}$ the price of good k in country j and $E_{i;j}$ the bilateral nominal exchange rate between countries i and j. Here, and contrary to the common definitions of the REER used by the World Bank or the IMF, the weights attributed to each foreign country γ_j correspond to the share of each country j among total exports of good k in the world for the ten main exporting countries of good k. Therefore, the weights are not based on the partner shares of each country, but on competition between i and j. It is an important distinction from traditional empirical studies, which often use an index based on partner shares, especially for countries that are specialized in primary products and that do not export products to or import them from the countries that are specialized in the same production. Since the aim is to analyze the impact of resource revenues on external competitiveness, it seems more relevant to focus on competitors rather than trade partners. Due to the difficulty to aggregate price data from a large sample of countries, and the high imprecision that may result from the lack of data availability in many African countries, the index is restricted to the ten main exporters for each good k. Finally, the two indexes are computed as the weighted average for the five main agricultural and the five main manufactured goods separately, with s_k the shares of each good k in exports of country i. Similarly to the IRER, the weights are constant over time and based on the shares calculated for the period

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[7] The demonstration as well as some comments relative to this equation can be found in the Appendix section 7.1

2008-2012. Simple correlations between variables reveal a strong and positive correlation between all four exchange rates, as expected, even though the internal real exchange rate for manufacturing products seem to diverge more from the three other variables (see table 7).

4.2 Explanatory Variable

4.2.1 Oil Revenues

In the Dutch disease literature, three different types of explanatory variables are used. The most straightforward variable is the share of resources (for instance oil revenues) in total GDP or in total exports. This variable presents the advantage of capturing directly the impact of resource revenues on the economy. However, it will also suffer from obvious endogeneity issues. First, for a given value of oil revenues, a poorer country will have a higher share of oil revenues in total GDP than a richer one. Reciprocally, one can assume that a more developed country will have more opportunities to develop a resource sector, or less incentives to do so, than a poor country. In both cases, the level of economic development (which is correlated with exchange rates) affects the variable used for oil revenues. Another difficulty arising from the use of this variable is the fact that the shares of all sectors among total GDP adds up to 100%, i.e. a sudden drop or boom in one sector generates a symmetric rise or fall in the share of resource revenues in GDP even without any change in the resource sector. This can create reverse causality issues in empirical studies investigating the impact of resources on structural changes but it can also generate a bias in the estimation of appreciation effects due to the direct impact of real exchange rates on different economic sectors. For instance, if an exogeneous appreciation occurs and harms more the tradable non-resource than the resource sector, the resource sector can decrease in value-added but increase when measured in % of total GDP, leading to estimate a positive relationship between oil revenues and the RER.

The second other most common strategy corresponds to the use of international prices (mainly oil prices such as the Brent, WTI or Dubai oil price). The clear advantage of this variable relies on its supposed exogeneity[8]. However, this proxy is also subject to some key limitations. First, resource revenues do not depend only on prices but also on other variables such as reserves discoveries or the political will to exploit natural resources. In

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[8] One might argue that for some large oil exporters, such as Saudi Arabia, the hypothesis of small economy is not verified and the international oil prices is not likely to be truly exogeneous. However, this assumption holds for most countries, and particularly for African countries that are mainly small producers at the world level

that case, resource revenues can be weakly correlated with prices, making it more difficult to detect Dutch disease effects. Then, the exogeneity assumption requires that domestic resource production does not react to international price variations. Yet, a country or a firm can reduce its production when prices are low and increase it when they are high. In that case, oil revenues will overreact to oil prices and the magnitude of the effect estimated might be overestimated. The third issue is specific to panel data analyses. Indeed, the use of international prices often implies to have a common variable to all countries and to assume an homogeneous effect of this variable on all countries. However, a given rise in oil prices will not have the same impact on a country in which the oil sector represents 5% of total GDP and on a country where the oil sector already represents more than 20% GDP while some econometric methodologies (especially those based on pooling) need to assume an homogeneous impact of the explanatory variable.

A final strand of the literature relies on the timing of resource discoveries to estimate the impact of booms in production on the RER (see for instance Arezki and Ismail, 2013, [2]). This methodology allows to implement different econometric strategies, such as difference-in-difference or synthetic control methods. I will not detail this literature here since, while it is helpful to estimate the impact of large booms, it is less useful when wanting to investigate the long-run relationships between resource revenues and exchange rates. This methodology also tends to require larger datasets than other strategies.

Due to the main issues mentioned for the use of international oil prices, I choose here to use both oil revenues and international crude oil prices. Oil revenues are expressed in two different ways. First, I use the traditional oil rent variable provided by the World Development Indicators, and expressed in percent of total GDP, and then I express this variable in international USD per capita. This variable therefore corresponds to oil revenues for domestic citizens and is less subject to short-term variations not caused by oil movements. These two variables have also different economic meanings, since the first one corresponds to the size of oil revenues in the economy, and is more likely to reveal the dependency towards oil resources, while the second indicates average oil revenues per capita and therefore helps at capturing spending effects. From now on, the first variable will be called "$OilRent$" and the second "$OilRevenues$". Regarding international oil prices, I exploit both the Brent and the West Texas Intermediate spot oil prices, which are the two main prices on international markets [9].

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[9] Remark: Even if other spot oil prices are available, they tend to differ in level but not in variations and the choice of one instead of another does not affect much the results. In addition, the Brent and the WTI prices are the more common indexes and the more likely to affect African oil prices to export.

4.2.2 Other Fundamentals

The control variables are the traditional fundamentals of the real effective exchange rate used in the literature on exchange rate misalignments, following the Behavioural Exchange Rate (BEER) approach. I select in particular:

- The degree of trade openness computed as the sum of total exports and total imports expressed in % of total GDP (from the UNCTAD). According to theoretical and empirical literature, this index is expected to be negatively associated with exchange rates. Indeed, from a theoretical point of view, higher trade barriers usually result in both lower trade openness and higher prices, hence implying a negative correlation between trade openness and real exchange rates (Egert et al., 2006, [17]). This argument is supported by the empirical studies for the external RER (Couharde et al., 2013, [14] ; Diop et al., 2018, [16] ...) Regarding our proxies for the internal RER, trade openness is expected to reduce domestic prices (the numerator) and thus the IRER.

- A proxy for the Balassa-Samuelson effect constructed by the FERDI-OCD as a ratio of non-oil GDP per capita against neighbouring countries non-oil GDP per capita. The use of non-oil GDP is important because (i) it captures more precisely productivity gains (which is the goal of a Balassa-Samuelson index) than total GDP and (ii) it does not include oil resource booms (which would lead to underestimate the impact of our oil revenues variable). Theoretically, the expected sign of this proxy should be positive: an increase in total productivity is associated with an appreciation of the exchange rate. The empirical evidence in the literature is quite mixed but suggests overall to expect a positive sign for this variable. For instance, Coudert et al. (2015, [13]) find for a large panel of countries that productivity implies appreciation in low income countries but not in richer countries.

- A variable for Net Foreign Assets expressed in % GDP (from the UNCTAD). The theoretical literature suggests a positive relationship between NFA and exchange rates. However, empirical evidence remain mixed. Egert et al. (2006, [17]) argue that NFA may be negatively correlated with capital inflows in the medium-run but positively in the long-run (if foreign capital inflows are invested in the export sector, they will increase competitiveness and boost exports in the long-run). If capital inflows tend to generate an appreciation effect, one will observe a negative correlation between NFA and RER in the medium-run and a positive one in the long-run. In that case, the heterogeneity in results depends mainly on the number of periods in the sample (i.e. the size of T). In this case, the expected sign of NFA can also depend on the nature of foreign capital inflows and on the sectors they are invested in, which depend themselves on the level of economic development. For instance, using a panel of countries with different levels of economic development, Coudert et al. (2015, [13]) observe a positive impact of NFA for developing countries (and to a lesser extent for advanced countries) but a negative coefficient for intermediate ones.

- Total investment (public and private) expressed in % of total GDP. There is no consensus neither in the theoretical nor in the empirical literature on the expected sign for this variable. For instance, Diop et al. (2018, [16]) find a positive impact of investment on the RER in Senegal based on a Johansen and an ARDL model while Saxegaard (2007, [35]) finds a negative impact for this country. One could expect that, in the short-run, investment plays a role in appreciating the exchange rate (like consumption) by increasing domestic prices. However, in the long-run, investment can help firms to become more productive and reduce prices, generating depreciation effects. This effect however depends on the nature of investment (public or private, external or domestic...) and can differ across sectors.

Except for Net Foreign Assets, all variables (including dependent and explanatory variables) are in logarithms. I do not include the terms of trade (which are also a common fundamental for the exchange rate in the empirical literature) since they could partly capture the appreciation effect of the Dutch disease.

5 Methodology and Results

5.1 Integration and Co-Integration Tests

I begin by testing for the presence of unit-roots in the selected variables. For this, I apply the Panel-data Fisher test based on Augmented Dickey Fuller and on Phillips-Perron for all variables, both in level and in difference. The Fisher test is chosen because it is proved to have better asymptotic properties than other tests, such as the Im-Pesaran-Shin test, in samples where N is finite. Since the Brent and the WTI oil prices are repeated time-series, I use the simple time-series Augmented-Dickey-Fuller and Phillips-Perron unit-root tests for these variables. Results are reported in table 8 in the appendix. All the main dependent and independent variables are integrated of order 1, except for the internal real exchange rate for Manufacture, oil revenues, Oil Rent and NFA for which the results are quite more mixed, since the Philipps-Perron based statistics indicate the variables are I(0) whereas the statistics based on Augmented-Dickey-Fuller suggest them to be I(1).

I test now for the presence of a co-integrating relationship among all variables. For this, I apply the test proposed by Kao (1999, [25] and the test of Pedroni (2004, [29]). Indeed, the Kao co-integration test tends to have more power in small samples than other tests such as the original test proposed by Pedroni or the Larsson et al.'s (2001) co-integration tests (Gutierrez, 2003, [21] ; Hurlin and Mignon, 2007, [24]). This test provides five statistics based on the Dickey-Fuller and Augmented Dickey-Fuller statistics, which are recognized to perform better in small-sample size panel than the Phillips-Perron based statistics (Davidson and MacKinnon, 2003, [15]). However, the Pedroni co-integration test has more power in sample with a fixed N and an increasing T and, compared to the previous tests, it also presents the advantage of overcoming the potential issue of more than one co-integration relationship between variables. This test provides seven different statistics, relying on different assumptions, and grouped into four Panel-Cointegration Statistics based on within-dimension and three Group-Mean Cointegration Statistics based on between-dimension. Results are reported in tables 9 and 11. Overall, all statistics indicate to strongly reject the null hypothesis of absence of co-integration for the two external RER and for the internal RER for manufacture. Regarding the IRER for agricultural products, four out of seven Pedroni statistics indicate to reject the null hypothesis for oil revenues and three for oil price. Yet, all five statistics from Kao strongly suggest rejecting the null hypothesis of no co-integration in both cases, which seems enough to accept the hypothesis of co-integration among variables in the regressions.

5.2 Estimation Results

Now, the aim is to estimate both the sign and the magnitude of the long-run relationships between each fundamental and the outcomes. The traditional empirical literature relative to the long-run determinants of real exchange rates in panel data has identified several econometric specifications to estimate such long-run relationships. These methods can be divided into two groups. In one side, pooling methods consist in using all data in the same regressions, and therefore require the assumption of homogeneity of effects across countries. On the contrary, "group-mean" specifications consist in (i) estimating the coefficients separately for each country and (ii) averaging them. These methods do not require the homogeneity assumption but have very low power due to the high number of coefficients to estimate. Therefore, I choose here to implement the intermediate strategy of the Pooled Mean Group Estimators developed by Pesaran et al. (1999, [31]), which presents a higher power than averaging methods but requires weaker assumption than pooling ones. Indeed, the PMG relies on the assumption that long-run coefficients are homogeneous but not short-run coefficients. It implies to estimate the following equation:

$$\Delta y_{it} = \phi_i y_{i;t-1} + \beta_i' x_{i;t} + \sum_{j=1}^{p-1}(\lambda_{i;j}^{*} \Delta y_{i;t-j}) + \sum_{j=0}^{q-1}(\delta_{i;j}^{*'} \Delta x_{i;t-j}) + \mu_i + \epsilon_{i;t} \tag{8}$$

where $y_{i;t}$ is for each country i at time t computed as the logarithm of the external RER for agricultural goods, of the external RER for manufactures, of the internal RER for agricultural goods and of the internal RER for manufactures (noted respectively $erer_{agriculture}$, $erer_{manufacture}$, $irer_{agriculture}$ and $irer_{manufacture}$)[10]. $x_{i;t}$ is a set of fundamentals that include our main explanatory variable and the four other control variables presented in section 4. The model also estimates the error-correction term, which indicates the speed of adjustment toward the long-run equilibrium and is expected to be between -1 and 0.

Regressions are run first with Oil Rent and the logarithm of Oil Revenues and second with the two international oil prices as the main explanatory variable. The number of lags (i.e. p and q) is selected using the Bayesian Information Criteria, as recommended by Pesaran et al. (1999), with a maximum lag length of 1. Both the AIC and the BIC indicate to prefer an ARDL(111111) for each variable, except for $erer_{manufacture}$ with oil revenues where an ARDL(101111) is preferred and for $irer_{manufacture}$ with oil prices where an ARDL(111101) is preferred[11]. The coefficients are then obtained through maximum likelihood estimation.

The PMG is preferred over the Mean-Group estimator for two reasons. First, due to the higher number of coefficients estimated in the MG specification, this strategy is very likely to provide imprecise and insignificant results, especially in a limited size sample like ours (207 observations). Second, according to Pesaran et al. (1999, [31]), PMG estimates also tend to be less sensitive to outliers than MG ones. The Mean-Group estimates are however also reported as robustness checks. Pesaran et al. (1999) recommend comparing the long-run coefficients provided by MG and PMG specifications to ensure the validity of the second methodology. Since the Hausman test tests the null hypothesis that the long-run coefficients are not systematically different, and under the assumption that MG estimates are unbiased, it results in testing the hypothesis that the long-run PMG coefficients are unbiased. If the coefficients are observed to be significantly different from each other at 5% (i.e. if the p-value < 0.05), the PMG estimators might be biased and Mean-Group

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[10] For simplicity purposes, all variables expressed in logarithms will be written in lower-case letters

[11] For comparison purposes, an ARDL(111111) is also computed in all three regressions. It provides similar results than the one displayed here, in terms of sign, magnitude and significance for $erer_{manufacture}$ with oil revenues, and similar sign but less significant results for $irer_{manufacture}$ with oil prices. Results are available on request.

procedures are more likely to provide consistent estimates. Otherwise, we are inclined to prefer the PMG over the MG estimators. It must be underlined that this test is not a formal econometric proof that the PMG is or is not unbiased but only an evidence to support the idea that the PMG results can be interpreted, since we are primarily interested in the average long-run effect of oil revenues on the four exchange rates. It can also be noted that it tests the joint difference in coefficients and not the difference for each explanatory variables used separately. Results for the PMG estimates and for the Hausman tests are displayed in tables 1 and 2.

We can first observe a positive correlation between both oil rent and oil revenues per capita and the external exchange rates, in the short- and in the long-run. The long-run coefficients for the two external RER are significant in all cases, implying that oil revenues negatively affect the external competitiveness of our countries. Regarding the internal exchange rate, the results are quite similar even though the long-run coefficients tend to be smaller and less significant, particularly for the index based on manufacturing products. Due to the limits of the proxy used, one must remain careful about such interpretations, and more analyses are required. However, the results overall seem to indicate that oil revenues are an important driver of RER fluctuations, even if the coefficient is lower trade openness and the Balassa-Samuelson effect, and to support the Dutch disease hypothesis for the external RER and, to a lesser extent, for the internal one.

Now, we turn to the impact of international oil prices. The results are very similar to the previous ones, with a positive and significant impact of the international Brent and the WTI oil prices on the ERERs and on the first IRER. Yet, the coefficient for manufacturing IRER, which was previously positive but insignificant, becomes here negative and significant at 1%. Two plausible explanations can be provided for this negative coefficient. First, one can assume that manufacture products are not perfectly tradable goods in our sample of countries, or that their degree of tradability is lower than the one of agricultural goods. In that case, the Dutch disease would be a concern for the agricultural sector rather than the manufacturing one. Second, oil can be used as an input for the domestic production of manufacturing goods, meaning that an exogeneous price increase in international markets will increase the production costs and the prices of these goods (even if the country is an oil-exporter since oil-producing firms sell their production at the international market price), counterbalancing the Dutch disease effects. However, Hausman tests provide low p-values for these two regressions, casting doubt upon the reliability of these coefficient.

Regarding the other fundamentals, the coefficients are mainly as expected. The variable for trade openness is always negative and significant, in line with both theoretical and empirical literature, whereas the Balassa-Samuelson proxy is always positive, except for the internal RER for manufacture, reinforcing the idea that agriculture and manufacture should be analyzed differently when estimating equilibrium exchange rates. Even if the coefficient for trade openness seems to be quite large when comparing it with other main determinants such as the Balassa-Samuelson effect or investment, its size remains reasonable. The only relatively surprising result is that Net Foreign Assets are indicated to generate depreciating effects while we were expecting an appreciation. Nevertheless, it is not in total contradiction with the literature since the evidence that NFA accumulation appreciates the ER is overall mixed in empirical analyses (see section 4). The variable for total investment is overall positive and strongly significant for the external exchange rates, but insignificant for internal exchange rates. One plausible explanation could be that investment tends to increase overall domestic prices (hence appreciating external exchange rates) but is not strongly biased toward one type of goods. Finally, the error-correction term is as expected negative and most of the time significant.

To check for robustness, all results for the Mean-Group estimators are displayed in tables 14 and 15 in the appendix, even when the Hausman test suggests to accept the PMG. As expected, the results are mostly insignificant even if the coefficients tend to support the results provided by the PMG since they are positive in every regression except for the $irer_{manufacture}$. The Hausman test however indicates to reject the null hypothesis of no systematic difference in the long-run coefficients only for $erer_{agriculture}$ with oil revenues. Yet, since the coefficient for $oilrevenues$ remains positive even with the MG, this does not seem to contradict our previous main conclusions.

5.3 Testing for Cross-Section Dependence

I test now the presence of potential cross-section dependence in the results by implementing the Breusch-Pagan Lagrange-Multiplier test (Breusch and Pagan, 1980, [4]). This test has indeed proved to be more efficient in panels with T larger than N than other tests, such as the CD test proposed by Pesaran, which is more efficient in panels with large N (Pesaran, 2015, [30]). Results are displayed in tableau 13 in the appendix and strongly suggest the presence of cross-section dependence in both models with $OilRent$ and with $oilrevenues$ as the main explanatory outcomes. To account for this issue, two different strategies are implemented. First, I apply the Cross-Sectionally Augmented Pooled-Mean-Group (CSPMG) used by Cavalcanti et al. (2012, [9]) and Grekou (2018, [20]). This

Table 1: Pooled-Mean-Group Results for Oil Revenues and Oil Rent

Variables	$erer_{agriculture}$		$erer_{manufacture}$		$irer_{agriculture}$		$irer_{manufacture}$	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Long-Run:								
$oilrevenues$	0.2285***		0.2225***		0.1028***		0.0559	
	(0.0282)		(0.0212)		(0.0338)		(0.0387)	
$OilRent$		0.02196***		0.0181***		0.0239***		0.0053**
		(0.0029)		(0.0020)		(0.0031)		(0.0025)
$openness$	-0.6187***	-1.0164***	-0.6942***	-0.8107***	-0.5514***	-0.6813***	-0.8519***	-0.6857***
	(0.0734)	(0.1142)	(0.0528)	(0.0862)	(0.1068)	(0.1064)	(0.1238)	(0.1270)
$balassa$	0.2945***	0.5204***	0.3252***	0.8088***	0.5113***	0.9813***	-0.2344**	-0.0028
	(0.0493)	(0.0885)	(0.0444)	(0.0660)	(0.1662)	(0.1116)	(0.1088)	(0.0669)
NFA	-0.0086***	-0.0039***	-0.0006	-0.0019***	-0.0035***	-0.0039***	-0.0088***	-0.0087***
	(0.0018)	(0.0011)	(0.0020)	(0.0006)	(0.0013)	(0.0010)	(0.0016)	(0.0012)
$investment$	0.3376***	0.3056***	0.3293***	0.1400**	-0.0104	0.1199**	0.1295*	0.1568**
	(0.1048)	(0.0977)	(0.0597)	(0.0665)	(0.0694)	(0.0589)	(0.0786)	(0.0777)
Short-Run:								
$\Delta oilrevenues$	0.0305				0.0421		0.1202**	
	(0.0363)				(0.0346)		(0.0516)	
$\Delta OilRent$		-0.0011		0.0005		-0.0050		0.0154
		(0.0040)		(0.0038)		(0.0045)		(0.0116)
$\Delta openness$	-0.1935*	-0.2054***	-0.1496	-0.2027***	-0.1022	-0.0323	-0.2109	-0.2386
	(0.1082)	(0.0679)	(0.0956)	(0.0713)	(0.1545)	(0.1804)	(0.2139)	(0.2290)
$\Delta balassa$	0.3923**	0.3880*	0.2611*	0.3599	0.6007***	0.49845***	0.9975***	1.0895***
	(0.1653)	(0.2279)	(0.1547)	(0.2320)	(0.1910)	(0.1825)	(0.3154)	(0.4113)
ΔNFA	-0.0057	-0.0044	-0.0044	-0.0037	-0.0036	-0.0032*	-0.0057	-0.0051*
	(0.0044)	(0.0034)	(0.0034)	(0.0033)	(0.0022)	(0.0016)	(0.0035)	(0.0028)
$\Delta investment$	-0.0386	-0.1209	-0.1031	-0.1250	0.1188	0.0076	0.0488	-0.0369
	(0.1143)	(0.1888)	(0.1432)	(0.1751)	(0.1204)	(0.1893)	(0.0860)	(0.1162)
ec	-0.1824*	-0.1491	-0.2029*	-0.2284**	-0.2364**	-0.2351**	-0.5382***	-0.5705***
	(0.1001)	(0.0993)	(0.1095)	(0.1071)	(0.0976)	(0.1022)	(0.0879)	(0.0943)
Constant	0.6514*	0.7961	0.7623*	0.8510**	0.9590**	0.5160**	4.8164***	4.1649***
	(0.3625)	(0.5401)	(0.4228)	(0.4133)	(0.4125)	(0.2509)	(0.8047)	(0.7105)
Hausman	0.0005	0.5462	0.8257	0.9496	0.9608	0.7995	0.3067	0.3927
Observations	207	207	207	207	207	207	207	207

Note: Hausman test reports the p-value for the Hausman test of PMG against MG. We prefer the Mean-Group over the Pooled-Mean-Group Estimator if $P < 0.05$. Variables in lower-case letters are expressed in logarithms, whereas $OilRent$ and NFA are in % GDP. The number of lags is selected using the Bayesian Information Criterion. Standard errors are in parentheses. * Significant at 10%. ** Significant at 5%. ***Significant at 1%

Table 2: Pooled-Mean-Group Results for Oil Prices

Variables	$erer_{agriculture}$ (1)	$erer_{agriculture}$ (2)	$erer_{manufacture}$ (1)	$erer_{manufacture}$ (2)	$irer_{agriculture}$ (1)	$irer_{agriculture}$ (2)	$irer_{manufacture}$ (1)	$irer_{manufacture}$ (2)
Long-Run:								
$oilprice$	0.0572***	0.1569***	0.4258***	0.4336***	0.0694***	0.0770***	-0.2221***	-0.2411***
	(0.0219)	(0.0358)	(0.0478)	(0.0496)	(0.0250)	(0.0290)	(0.0396)	(0.0489)
$openness$	-0.6383***	-0.3568***	-0.9645***	-0.9448***	-0.6580***	-0.6543***	-0.1843*	-0.1784*
	(0.0912)	(0.1039)	(0.0805)	(0.0773)	(0.0968)	(0.1000)	(0.0996)	(0.1080)
$balassa$	0.3034***	0.4532***	0.0432	0.0833	0.3819**	0.3875**	0.2705***	0.2636***
	(0.0825)	(0.0706)	(0.0867)	(0.0843)	(0.1730)	(0.1739)	(0.0413)	(0.0463)
NFA	-0.0024**	-0.0041***	0.0038	0.0061**	-0.0032**	-0.0029**	-0.0047***	-0.0046***
	(0.0011)	(0.0011)	(0.0030)	(0.0029)	(0.0013)	(0.0012)	(0.0011)	(0.0012)
$investment$	-0.0633	-0.0728	0.7755***	0.7091***	-0.0363	-0.0388	0.0135	0.0028
	(0.0966)	(0.0665)	(0.1036)	(0.0962)	(0.0684)	(0.0670)	(0.0692)	(0.0752)
Short-Run:								
$\Delta oilprice$	0.0316	0.0054	0.0995***	0.1148***	0.0408	0.0525	0.1324**	0.1009*
	(0.0451)	(0.0371)	(0.0314)	(0.0283)	(0.0604)	(0.0628)	(0.0637)	(0.0524)
$\Delta openness$	-0.2061***	-0.2178**	-0.2926***	-0.2883***	-0.1186	-0.1215	-0.3569*	-0.3380*
	(0.0665)	(0.0884)	(0.0990)	(0.1020)	(0.1420)	(0.1428)	(0.2169)	(0.2016)
$\Delta balassa$	0.4757**	0.3666**	0.4389***	0.4590***	0.6565***	0.6942***	0.9158***	0.8303***
	(0.2304)	(0.1701)	(0.1384)	(0.1292)	(0.1881)	(0.1860)	(0.2848)	(0.2767)
ΔNFA	-0.0046	-0.0044	-0.0062	-0.0062	-0.0024	-0.0026		
	(0.0037)	(0.0036)	(0.0045)	(0.0045)	(0.0019)	(0.0019)		
$\Delta investment$	-0.0384	-0.0302	-0.0896	-0.0939	0.0835	0.0750	-0.0944	-0.1002
	(0.1610)	(0.1556)	(0.1642)	(0.1616)	(0.1714)	(0.1749)	(0.1072)	(0.1156)
ec	-0.2524***	-0.2807***	-0.0670	-0.0781	-0.2282**	-0.2277**	-0.4364***	-0.4254***
	(0.0876)	(0.0894)	(0.0849)	(0.0889)	(0.0993)	(0.0992)	(0.1353)	(0.1296)
Constant	1.5272***	1.0728***	0.3016	0.3438	1.2467**	1.2281**	2.2907***	2.2818***
	(0.5373)	(0.3500)	(0.3922)	(0.4021)	(0.5551)	(0.5487)	(0.7391)	(0.7233)
Hausman	0.8254	0.8674	0.1360	0.0440	0.9906	0.9952	0.0943	0.0110
Observations	207	207	207	207	207	207	207	207

Note: Column (1) shows the results for the logarithm of the Brent oil price and column (2) for the logarithm of the WTI oil price. Hausman test reports the p-value for the Hausman test of PMG against MG. We prefer the Mean-Group over the Pooled-Mean-Group Estimator if $P < 0.05$. Variables in lower-case letters are expressed in logarithms, whereas NFA is in % GDP. The number of lags is selected using the Bayesian Information Criterion. Standard errors are in parentheses. * Significant at 10%. ** Significant at 5%. ***Significant at 1%

strategy consists in including the mean values of the variable of interest in the PMG[12]. Following de Cavalcanti et al. (2012), equation 8 thus becomes:

$$\begin{aligned}\Delta y_{it} = \phi_i y_{i;t-1} + \beta'_{i;t} x_i + \sum_{j=1}^{p-1}(\lambda^*_{i;j}\Delta y_{i;t-1}) + \sum_{j=0}^{q-1}(\delta^{*'}_{i;j}\Delta x_{i;t-j}) + \mu_i - c_i\overline{\mu} \\ +a^*_i\overline{y}_t + b^*_i\overline{oil}_t + \sum_{j=0}^{p-1}(c^*_{i;j}\Delta\overline{y}_{t-j}) + \sum_{j=0}^{q-1}(d^{*'}_{i;j}\Delta\overline{oil}_{t-j}) + \epsilon_{i;t}\end{aligned}$$

where $\overline{y_t} = \frac{1}{N}\sum_{i=1}^{N} y_{i;t}$ and $\overline{oil_t} = \frac{1}{N}\sum_{i=1}^{N} oil_{i;t}$ represent the cross-sectional average over all countries at time t for respectively the real exchange rate and both oil revenues per capita and oil rent. It can be noticed that oil is also included into $x_{i;t}$ (the set of fundamentals) but, because of limited sample size, a cross-sectional mean is added only to the variable of interest. Results are displayed in table 3.

Due to the low number of observations, I cannot include both the value and the cross-sectional mean for each explanatory variable in the sample. Hence, to account for potential cross-sectionality issues in the other fundamentals, I also implement the strategy proposed by Herzer (2020, [22]) and replace all variables by their demeaned value, defined as :

$$\widehat{x_{i;t}} = x_{i;t} - \frac{1}{N}\sum_{k=1}^{N} x_{k;t} = x_{i;t} - \overline{x_t}$$

.

Equation 8 is then estimated only on these demeaned values. Results are displayed in table 4.

In both empirical strategies, the results tend to confirm the previous analyses, except for the variable internal RER for manufacture, since all eight long-run coefficients for oil revenues are now positive and strongly significant, while six among the eight long-run coefficients for oil rent are positive and significant (the two other being positive but insignificant). All these results overall support the Dutch disease hypothesis, both for external and internal exchange rates.

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[12] Since the international price of oil is a repeated time-series and is the same for each country, we cannot apply cross-sectionally augmented empirical strategies to this variable and will restrict ourselves to $OilRent$ and $oilrevenues$ from now on

Table 3: CSPMG Results for Oil Revenues and Oil Rent

Variables	$erer_{agriculture}$ (1)	$erer_{agriculture}$ (2)	$erer_{manufacture}$ (1)	$erer_{manufacture}$ (2)	$irer_{agriculture}$ (1)	$irer_{agriculture}$ (2)	$irer_{manufacture}$ (1)	$irer_{manufacture}$ (2)
Long-Run:								
$oilrevenues$	0.2005***		0.6219***		0.2149***		0.3830***	
	(0.0428)		(0.0707)		(0.0474)		(0.1059)	
$OilRent$		0.0092***		0.0024		-0.0029		0.0067*
		(0.0023)		(0.0015)		(0.0021)		(0.0037)
$openness$	-0.4242***	-0.4284***	-0.6928***	-0.1851***	-0.3021***	-0.3201***	-0.5250***	-0.2699
	(0.0765)	(0.0958)	(0.0912)	(0.0588)	(0.0824)	(0.0726)	(0.1253)	(0.1704)
$balassa$	-0.0186	0.1551***	-0.3110***	0.1861***	0.0125	-0.0568	-0.3209***	-0.0803
	(0.0392)	(0.0250)	(0.0592)	(0.0298)	(0.0465)	(0.0613)	(0.1017)	(0.0768)
NFA	-0.0061***	-0.0086***	-0.0083***	0.0029**	-0.0053***	-0.0096***	0.0006	0.0034
	(0.0018)	(0.0017)	(0.0013)	(0.0012)	(0.0012)	(0.0018)	(0.0031)	(0.0033)
$investment$	0.1109**	0.0297	0.1056	0.0163	-0.0407	0.0143	0.1003	0.0168
	(0.0501)	(0.0497)	(0.0733)	(0.0183)	(0.0451)	(0.0349)	(0.0742)	(0.0647)
$\overline{rer}$	0.6918**	0.5729**	1.7863***	0.2670***	1.4980***	1.0914***	0.8773***	0.4089
	(0.2739)	(0.2243)	(0.2926)	(0.0743)	(0.2138)	(0.1485)	(0.2583)	(0.2745)
$\overline{oilrevenues}$	-0.1677***		-0.4921***		-0.1977***		-0.3872***	
	(0.0400)		(0.0978)		(0.0486)		(0.0936)	
$\overline{OilRent}$		-0.0011		0.0028**		0.0108***		-0.0105**
		(0.0030)		(0.0012)		(0.0019)		(0.0053)
Short-Run:								
$\Delta oilrevenues$	0.1162		0.0742		0.0449		0.1630	
	(0.0895)		(0.0752)		(0.0729)		(0.2451)	
$\Delta OilRent$		-0.0044		-0.0036		-0.0090***		-0.0041
		(0.0040)		(0.0040)		(0.0061)		(0.0104)
$\Delta openness$	-0.2061**	-0.1112	-0.1965**	-0.1202	-0.0476	0.0003	-0.2382	-0.2590
	(0.0919)	(0.1145)	(0.0858)	(0.1037)	(0.1441)	(0.1364)	(0.1994)	(0.2007)
$\Delta balassa$	0.1722	0.1661	0.2180	0.0594	0.5295**	0.3240	0.6938**	0.7487*
	(0.1387)	(0.1792)	(0.1444)	(0.1176)	(0.2702)	(0.2259)	(0.3375)	(0.4264)
ΔNFA	-0.0007	-0.0018	-0.0018	-0.0025	0.0006	0.0003	-0.0045	-0.0083**
	(0.0013)	(0.0021)	(0.0012)	(0.0020)	(0.0020)	(0.0024)	(0.0030)	(0.0036)
$\Delta investment$	0.0451	-0.0031	0.0333	-0.0709	0.2139**	0.1885**	0.0458	-0.1297
	(0.0485)	(0.0625)	(0.0543)	(0.0848)	(0.0929)	(0.0876)	(0.1369)	(0.1486)
$\Delta\overline{rer}$	0.5584	0.8295	0.5380	0.8854*	0.5239	0.7865	0.6156	0.7620*
	(0.3694)	(0.5958)	(0.3452)	(0.4916)	(0.3681)	(0.5113)	(0.3795)	(0.4282)
$\Delta\overline{oilrevenues}$	-0.0863		-0.0294		0.0253		-0.1311	
	(0.0904)		(0.0795)		(0.0960)		(0.2354)	
$\Delta\overline{OilRent}$		0.0064		0.0047		0.0092**		0.0089*
		(0.0056)		(0.0030)		(0.0040)		(0.0053)
ec	-0.2640***	-0.2877***	-0.1392	-0.3578**	-0.3859***	-0.3467***	-0.3589***	-0.4021***
	(0.0891)	(0.1015)	(0.0864)	(0.1551)	(0.0990)	(0.1309)	(0.0978)	(0.0901)
Constant	0.7385***	0.8629***	-0.0569	1.1162**	-0.4039***	0.3712***	1.4788***	1.7438***
	(0.2412)	(0.2993)	(0.0593)	(0.4760)	(0.1201)	(0.1316)	(0.4227)	(0.3974)
Observations	207	207	207	207	207	207	207	207

Note: In each regression, $\overline{rer}$ corresponds to the cross-country average value of the exchange rate variable used in this specific regression ($erer_{agriculture}$; $erer_{manufacture}$; $irer_{agriculture}$; and $irer_{manufacture}$). Variables in lower-case letters are expressed in logarithms, whereas $OilRent$ and NFA are in % GDP. Standard errors are in parentheses. * Significant at 10%. ** Significant at 5%. ***Significant at 1%

Table 4: PMG Results with demeaned variables for Oil Revenues and Oil Rent

Variables	$\widehat{erer_{agriculture}}$ (1)	$\widehat{erer_{agriculture}}$ (2)	$\widehat{erer_{manufacture}}$ (1)	$\widehat{erer_{manufacture}}$ (2)	$\widehat{irer_{agriculture}}$ (1)	$\widehat{irer_{agriculture}}$ (2)	$\widehat{irer_{manufacture}}$ (1)	$\widehat{irer_{manufacture}}$ (2)
Long-Run:								
$\widehat{oilrevenues}$	0.2184***		0.2352***		0.5187***		0.1886***	
	(0.0321)		(0.0432)		(0.1035)		(0.0440)	
$\widehat{OilRent}$		0.0128***		0.0685***		0.0123***		0.0075***
		(0.0023)		(0.0206)		(0.0042)		(0.0022)
$\widehat{openness}$	-0.5145***	-0.5006***	-0.6886***	0.0457	-0.9930***	-0.4947***	-1.0069***	-1.0625***
	(0.0817)	(0.1157)	(0.0772)	(0.2651)	(0.0722)	(0.1055)	(0.0805)	(0.0899)
$\widehat{balassa}$	-0.1479***	0.0371	-0.0407	0.0339	-0.7371***	0.2263***	-0.2359***	-0.1104**
	(0.0330)	(0.0346)	(0.0361)	(0.1535)	(0.1475)	(0.0814)	(0.0501)	(0.0479)
$\widehat{NFA}$	-0.0069***	-0.0063***	-0.0043***		-0.0124***	-0.0046***	-0.0106***	-0.0102***
	(0.0015)	(0.0020)	(0.0009)		(0.0017)	(0.0010)	(0.0011)	(0.0009)
$\widehat{investment}$	0.0434	-0.0610	0.1095**	-0.0111***	0.7484***	0.0696	0.2893***	0.2654***
	(0.0477)	(0.0601)	(0.0472)	(0.0036)	(0.1031)	(0.0611)	(0.0655)	(0.0658)
Short-Run:								
$\Delta\widehat{oilrevenues}$	0.1390		0.1481		0.0066		0.2865	
	(0.1198)		(0.0965)		(0.1338)		(0.2663)	
$\Delta\widehat{OilRent}$		-0.0033***		-0.0046*		-0.0024		0.0007
		(0.0015)		(0.0026)		(0.0034)		(0.0048)
$\Delta\widehat{openness}$	-0.2886***	-0.2752**	-0.2533**	-0.3597***	-0.2197	-0.1795	-0.1002	-0.0625
	(0.1102)	(0.1114)	(0.1039)	(0.1011)	(0.1549)	(0.1326)	(0.2185)	(0.1865)
$\Delta\widehat{balassa}$	0.2414*	0.1740	0.2433*	0.2424*	0.2205	0.1241	0.5195*	0.4544
	(0.1461)	(0.1307)	(0.1476)	(0.1384)	(0.2250)	(0.2051)	(0.3126)	(0.2903)
$\Delta\widehat{NFA}$	-0.0021	-0.0029	-0.0005	-0.0022	0.0001	-0.0017	0.0001	-0.0031
	(0.0018)	(0.0033)	(0.0021)	(0.0036)	(0.0025)	(0.0028)	(0.0025)	(0.0036)
$\Delta\widehat{investment}$	0.0417	-0.0731	0.0109	-0.0602	-0.0279	0.0306	-0.0717	-0.2158
	(0.0762)	(0.1445)	(0.0556)	(0.0999)	(0.0818)	(0.1611)	(0.0952)	(0.1619)
ec	-0.2617***	-0.2172***	-0.3176***	-0.0784	-0.2192**	-0.3004***	-0.5721***	-0.5614***
	(0.0871)	(0.0622)	(0.0884)	(0.0498)	(0.1099)	(0.0761)	(0.1216)	(0.0999)
Constant	-0.0067	0.0076	-0.0271	0.0213	0.0889	-0.0120	0.0267	0.0542
	(0.0333)	(0.0109)	(0.0401)	(0.0186)	(0.0835)	(0.0203)	(0.0536)	(0.0489)
Observations	207	207	207	207	207	207	207	207

Note: Variables in lower-case letters are expressed in logarithms, whereas $OilRent$ and NFA are in % GDP. Standard errors are in parentheses. * Significant at 10%. ** Significant at 5%. ***Significant at 1%

6 Conclusion

Based on brand-new data, I investigate in this paper the long-run relationship between oil revenues and four different variables for the real exchange rate in nine main African oil-exporting countries. The results clearly indicate that both the external interpretation of the Dutch disease (resource revenues weaken external competitiveness of other sectors and reduce non-resource exports) and the internal interpretation (resource revenues boost the development of non-tradable sectors at the expense of tradable ones and encourage structural transformations) are empirically confirmed in our panel of countries, supporting the seminal theoretical models of Dutch disease. Yet, results can differ across variables, highlighting the importance of considering the different definitions of exchange rates in both empirical and theoretical studies. Another finding relates to the difference between agricultural and manufacturing competitiveness. Indeed, the diversity of results for the internal real exchange rate for manufacture call for further analyses but overall seem to suggest that the decline in internal competitiveness affected more agriculture than manufacturing industries. This result is of major interest for African countries where agriculture often represents a higher share of the economy than manufacture, while empirical studies of Dutch disease focus more often on de-industrialization consequences.

However, these results should be carefully interpreted, due to obvious data limitations. In fact, the use of proxies for the internal exchange rates that do not perfectly correspond to the Corden-Neary definition of the RER, as well as the fact these proxies are based on a few products rather than on all exports by sectors, could have resulted in noise in the results. Therefore, more analyses are required to investigate the impact of natural resources on internal exchange rates, and to determine the differential impacts of Dutch disease effects on different tradable sectors. Finally, the empirical strategy implemented here does not allow to observe potential heterogeneity across countries. Further analyses relying on time-series could solve this issue and help to understand which countries in Africa are the most prone to Dutch disease.

7 Appendix

7.1 Mathematics

I investigate here the relationship between the OCD proxy for the two internal real exchange rates (called $IRER_{OCD}$ and the internal exchange rate as defined in Corden and Neary (1982). If we note α the share of the five main (agricultural and manufactured) exports in total domestic tradables and note P_H the index of prices for the tradable goods that are not among the five main exports such that $P_T = P_X^{\alpha} \times P_H^{1-\alpha}$[13], then:

$$IRER = \frac{P_N}{P_T} = \frac{P_N}{P_X^{\alpha}.P_H^{1-\alpha}} = \left(\frac{P_N}{P_X}\right)^{\alpha} \times \left(\frac{P_N}{P_H}\right)^{(1-\alpha)}$$

$$\begin{aligned} IRER_{OCD} = \frac{P}{P_X} = \frac{P_T^{\lambda}.P_N^{1-\lambda}}{P_X} &= \frac{P_X^{\alpha\lambda}.P_H^{(1-\alpha)\lambda}.P_N^{\alpha(1-\lambda)}.P_N^{(1-\alpha)(1-\lambda)}}{P_X^{\alpha\lambda}.P_X^{(1-\alpha)\lambda}.P_X^{\alpha(1-\lambda)}.P_X^{(1-\alpha)(1-\lambda)}} \\ &= \left(\frac{P_H^{1-\alpha}}{P_H^{(1-\alpha)(1-\lambda)}}\right) \times \frac{1}{P_X^{1-\alpha}} \times \left(\frac{P_N}{P_X}\right)^{\alpha(1-\lambda)} \times P_N^{(1-\alpha)(1-\lambda)} \\ &= \left(\frac{P_H}{P_X}\right)^{1-\alpha} \times \left(\frac{P_N}{P_X}\right)^{\alpha(1-\lambda)} \times \left(\frac{P_N}{P_H}\right)^{(1-\alpha)(1-\lambda)} \end{aligned}$$

Thus:

$$IRER_{OCD} = \left(\frac{P_H}{P_X}\right)^{(1-\alpha)} \times IRER^{1-\lambda}$$

Since $\left(\frac{P_H}{P_X}\right)^{(1-\alpha)} = P_H^{1-\alpha} \times \frac{P_X^{\alpha}}{P_X}$ and $P_T = P_X^{\alpha} \times P_H^{1-\alpha}$, we get:

$$IRER_{OCD} = \frac{P_T}{P_X} \times IRER^{1-\lambda}$$

Hence, there is a direct relationship between the internal real exchange rate and our proxy. Some main points must be noticed regarding this relationship:

- Since $\lambda < 1$, the greater the share of traded goods in total domestic production (i.e. the greater λ), the greater the divergence between the internal real exchange rate and OCD proxy.

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[13] Remark: P_H include both goods that are exported but not among the main exports and tradable but non exported goods.

- Due to possible changes in production structures, λ can change over time. Therefore, our proxy can change even when the internal exchange rate is constant (i.e. without changes in *prices*) if λ varies (i.e. with changes in the share of *tradables* among total production).

- Under the assumption that λ does not change, which is a plausible assumption in the short run, an increase in the IRER implies an increase in the proxy, but the relationship between them *is not linear*.

- The higher the share of our five main exports among total tradables (i.e. the higher α), the lower the divergence between our proxy and the theoretical Corden-Neary internal real exchange rate.

- The higher the divergence between P_H and P_X, the higher the divergence between our proxy and the true IRER. Since the exchange rates are always defined with a base 100 in a given year t, the comparisons in levels are not meaningful, yet the variations in the exchange rates are. In our case, it means that a general fall in the price of all tradables (i.e. an increase in the external competitiveness), will not only directly affect the prices of all tradable goods $p_{k;T}$ but also the relative shares of H and X among T (some previously tradable but not exported goods will start being exported), and therefore that the difference between P_T and P_X will decrease (making $IRER_{OCD}$ a better proxy for the IRER).

- The impact of a variation in P_H on $IRER_{OCD}$ is difficult to estimate: a rise in P_H will increase the ratio $\frac{P_H}{P_X}$ but is also likely to increase α (the non-ten best exports become less competitive hence the five best exports share in total exports rises) and reduce $1 - \alpha$.

7.2 Descriptive Statistics

Table 5: Descriptive Statistics

Variable	Observations	Mean	Std. Dev.	Min	Max	Source
TCERP	207	107.79	30.77	41	326	FERDI
TCERM	207	106.72	33.03	43	303	FERDI
TCRIP	207	100.15	32.73	31	309	FERDI
TCRIM	207	120.93	48.48	13	554	FERDI
Oil Rent	207	20.80	16.55	1.32	58.12	WDI
Oil Revenues	207	953.39	1621.31	11.30	10683.13	WDI and WEO
Brent	23	54.14	33.60	12.72	111.96	IMF
WTI	23	52.54	29.48	14.42	99.61	IMF
Openness	207	86.70	41.62	21.10	268.24	UNCTAD
Balassa	207	96.72	31.27	6.46	219.86	FERDI
NFA	207	16.25	21.46	-44.77	107.93	IFS and WEO
Investment	207	28.80	15.34	8.25	115.10	WEO

"Oil Revenues" is the product of "Oil Rent" in % GDP (World Development Indicators) and GDP per capita in Current USD (World Economic Outlook). Four observations are missing for Equatorial Guinea between 2001 and 2004. These data were reconstructed using country's oil production (BEAC Central Bank) before 2001 and after 2005 and assuming similar trends.

"Brent" and "WTI" are respectively the Brent and WTI crude oil price per barrel (IMF Commodity Statistics Database). They are repeated time-series and are expressed in international US Dollars.

"Trade Openness" is the sum of total exports and total imports expressed in % GDP (UNCTAD). Three observations are missing for Equatorial Guinea in 2017 and Gabon in 2016 and 2017. The data are reconstructed based on data for trade openness from the WDI and assuming similar trends.

"Balassa" is the ratio of domestic non-resource GDP per capita over foreign non-resource GDP per capita of the main partner countries (FERDI-OCD). It is in base 100 for the year 2010. Four observations are missing for Egypt between 1995 and 1998. They are reconstructed using FERDI-OCD data for the Balassa-Samuelson effect based on imports only and assuming similar trends.

"NFA" is the ratio of Net Foreign Assets held by the Central Bank (International Financial Statistics) over total GDP (World Economic Outlook). It is expressed in % GDP.

"Investment" is the value of total investment expressed in % GDP (World Economic Outlook).

Table 6: Products included in External and Internal Exchange Rates

Country	Agriculture	Manufacture
Angola	Fish, frozen Shellfish Coffee Animal flour Wood in the rough	Paper and Paperboard Diamonds Structures of Cast-iron, Iron and Steel Interchangeable tools for hand tools Electric generating sets and rotary converters
Cameroon	Bananas Cocoa beans Natural Rubber Wood in the rough Wood sawn	Soap Sheets for veneering Boxes, Sacks and Bags of paper Bottles, flasks, jars, pots, phials, and other containers Bars and rods of iron or steel, hot-rolled
Congo Rep.	Coffee Natural Rubber Fuel wood in logs Wood in the rough Wood sawn	Sheets for veneering Diamonds Tubes and Pipes seamless, of iron or steel Other Articles or Iron or Steel Tools for hydrography, oceanography, hydrology, meteorology or geophysics
Algeria	Other vegetables Dates, Figs, Pineapple, Avocado, Guava and Mango Wheat and meslin Sugar Water	Hydrogen and rare gases Ammonium Acyclic alcohols Motor cars and other motor vehicles
Egypt Rep.	Cheese Potatoes Citruses Rice Sugar	Nitrogen fertilizer Men's suits, coats, jackets, trousers and the like Women's suits, coats, jackets, dresses, skirts, trousers and the like Flat-rolled products of iron or steel, not further worked than hot-rolled Insulated wire, cable and other insulated electric conductors
Gabon	Other tobacco Rubber Wood in the rough Railway or tramway sleepers of wood Wood sawn	Sheets for veneering Plywood Hand-crafted garments Ferro-alloy Tools for hydrography, oceanography, hydrology, meteorology or geophysics
Equatorial Guinea	Frozen fish Cocoa beans Raw wood Railway or tramway sleepers of wood Wood sawn	Acyclic hydrocarbons Acyclic alcohols Sheets for veneering Tubes and Pipes seamless, of iron or steel
Nigeria	Milk Coconut, Cashew and Brazil nut Other nuts and Oleaginous fruits Cocoa beans Rubber	Ammonium Tanned or crust hides and skins of bovine Other leather, without hair on, and skins of other animals Leather further prepared after tanning or crusting of bovine Other Footwear of Rubber or Plastic
Tunisia	Shellfish Mollusks Dates, Figs, Pineapple, Avocado, Guava and Mango Olive oil Other vegetable oil	Men's suits, coats, jackets, trousers and the like Women's suits, coats, jackets, dresses, skirts, trousers and the like Footwear with outer soles Insulated wire, cable and other insulated electric conductors Electrical apparatus for switching or connecting electrical circuits

Table 7: Matrix of Correlations

	$ererp$	$ererm$	$irerp$	$irerm$	$oilrevenues$	$OilRent$	$openness$	$balassa$	NFA	$investment$	$brent$
$ererp$	1.0000										
$ererm$	0.9557 (0.0000)	1.0000									
$irerp$	0.8933 (0.0000)	0.8859 (0.0000)	1.0000								
$irerm$	0.6124 (0.0000)	0.5437 (0.0000)	0.5592 (0.0000)	1.0000							
$oilrevenues$	-0.0279 (0.6900)	0.0050 (0.9429)	-0.0531 (0.4474)	0.0327 (0.6402)	1.0000						
$OilRent$	-0.2707 (0.0001)	-0.2461 (0.0004)	-0.3406 (0.0000)	-0.2482 (0.0003)	0.7535 (0.0000)	1.0000					
$openness$	-0.4186 (0.0000)	-0.4428 (0.0000)	-0.4241 (0.0000	-0.4102 (0.0000)	0.4524 (0.0000)	0.6921 (0.0000)	1.0000				
$balassa$	0.2603 (0.0002)	0.3461 (0.0000)	0.3404 (0.0000)	0.2455 (0.0004)	-0.0152 (0.8279)	-0.3503 (0.0000)	-0.4151 (0.0000)	1.0000			
NFA	-0.0519 (0.4578)	0.0387 (0.5799)	0.0286 (0.6829)	-0.1021 (0.1432)	0.3669 (0.0000)	0.1819 (0.0087)	-0.0557 (0.4252)	0.1038 (0.1368)	1.0000		
$investment$	-0.4314 (0.0000)	-0.4376 (0.0000)	-0.4987 (0.0000)	-0.3904 (0.0000)	0.3655 (0.0000)	0.4704 (0.0000)	0.6101 (0.0000)	-0.4007 (0.0000)	0.2710 (0.0001)	1.0000	
$brent$	0.0397 (0.5701)	0.1201 (0.0849)	0.1637 (0.0184)	0.0611 (0.3814)	0.4418 (0.0000)	0.1018 (0.1445)	-0.1260 (0.0705)	0.1415 (0.0419)	0.4376 (0.0000)	-0.0266 (0.7031)	1.0000
wti	0.0350 (0.6162)	0.1169 (0.0934)	0.1623 (0.0195)	0.0553 (0.4288)	0.4471 (0.0000)	0.1149 (0.0993)	-0.1171 (0.0928)	0.1381 (0.0472)	0.4426 (0.0000)	-0.0283 (0.6852)	0.9974 (0.0000)

Note: The correlations between variables are estimated for the nine countries of the database. Variables in lower-case letters are expressed in logarithms, whereas $OilRent$ and NFA are in % GDP. Significance levels are in parentheses.

7.3 Integration and Co-Integration Tests

Table 8: Unit-Root Tests Results (Z Statistics)

Variables	Variables in Level I(0)		Variables in Difference I(1)	
	ADF	PP	ADF	PP
$erer_{agriculture}$	-1.4296*	-0.5231	-11.4063***	-9.6577***
	(0.0764)	(0.3004)	(0.0000)	(0.0000)
$erer_{manufacture}$	-0.4407	-0.0018	-9.8029***	-9.3793***
	(0.3297)	(0.4993)	(0.0000)	(0.0000)
$irer_{agriculture}$	-1.4936*	-1.5478*	-7.2429***	-10.6308***
	(0.0676)	(0.0608)	(0.0000)	(0.0000)
$irer_{manufacture}$	-0.9409	-2.4724***	-9.8820***	-15.2123***
	(0.1734)	(0.0067)	(0.0000)	(0.0000)
$oilrevenues$	-0.8660	-1.6676**	-8.6529***	-9.8043***
	(0.1932)	(0.0477)	(0.0000)	(0.0000)
$OilRent$	-2.0294**	-2.3926***	-10.3533***	-11.6564***
	(0.0212)	(0.0084)	(0.0000)	(0.0000)
$openness$	-0.2312	0.3298	-8.3465***	-11.1588***
	(0.4086)	(0.6292)	(0.0000)	(0.0000)
$balassa$	-0.9836	-1.0761	-9.0330***	-9.9721***
	(0.1627)	(0.1409)	(0.0000)	(0.0000)
NFA	-0.7396	-2.3420***	-3.5406***	-7.9147***
	(0.2298)	(0.0096)	(0.0002)	(0.0000)
$investment$	-1.4606*	-0.6744	-8.9471***	-12.1788***
	(0.0721)	(0.2500)	(0.0000)	(0.0000)
$brent$	-1.449	-1.447	-3.974***	-3.944***
	(0.5587)	(0.5593)	(0.0016)	(0.0017)
wti	-1.514	-1.501	-4.299***	-4.291***
	(0.5266)	(0.5333)	(0.0004)	(0.0005)

Note: We show the Z-statistic for the results of the Fisher-type panel unit-root test based on Augmented-Dickey-Fuller (ADF) and Phillips-Perron (PP) methodologies for the ten first variables. For the logarithm of the Brent and the WTI Crude Oil Prices, we show the simple ADF and PP time-series unit-root tests. P-values are in parentheses.

Table 9: Kao and Pedroni Co-Integration Tests Results for Oil Revenues per capita

		$erer_{agriculture}$	$erer_{manufacture}$	$irer_{agriculture}$	$irer_{manufacture}$
Kao Co-Integration Test	Modified DF	-4.3436***	-3.2975***	-2.8093***	-5.1223***
		(0.0000)	(0.0005)	(0.0025)	(0.0000)
	DF	-4.5002***	-3.8879***	-3.1574***	-6.0908***
		(0.0000)	(0.0001)	(0.0008)	(0.0000)
	Augmented DF	-4.5624***	-4.0220***	-3.3963***	-4.4445***
		(0.0000)	(0.0000)	(0.0003)	(0.0000)
	Unadjusted Modified DF	-4.7293***	-3.8131***	-3.0619***	-9.3087***
		(0.0000)	(0.0001)	(0.0011)	(0.0000)
	Unadjusted DF	-4.6009***	-4.0500***	-3.2456***	-7.2079***
		(0.0000)	(0.0000)	(0.0006)	(0.0000)
Pedroni Co-Integration Test	Panel v-statistic	-2.6570***	-2.7218***	-2.7345***	-3.1889***
		(0.0039)	(0.0032)	(0.0031)	(0.0007)
	Panel ρ-statistic	2.2789**	1.8707**	2.7341***	1.1110
		(0.0113)	(0.0307)	(0.0031)	(0.1333)
	Panel PP-statistic	-1.9519**	-3.5296***	-0.1656	-5.2830***
		(0.0255)	(0.0002)	(0.4343)	(0.0000)
	Panel ADF-statistic	−4.2806***	-5.1144***	-0.7388	-5.1315***
		(0.0000)	(0.0000)	(0.2300)	(0.0000)
	Group ρ-statistic	3.3955***	3.1564***	3.8514***	2.2967**
		(0.0003)	(0.0008)	(0.0001)	(0.0108)
	Group PP-statistic	-1.4517*	-2.9072***	0.3199	-6.0782***
		(0.0733)	(0.0018)	(0.3745)	(0.0000)
	Group ADF-statistic	-5.8274***	-5.3931***	-1.4717*	-4.8909***
		(0.0000)	(0.0000)	(0.0706)	(0.0000)

Note: We show the seven statistics provided by the Pedroni co-integration test for all specifications of interest. The four first statistics are the Panel-Cointegration statistics (based on within-dimension) and the last three are the Group-Mean Cointegration statistics (based on between-dimension). For each specification, the number of lags is chosen using the Bayesian Information Criterion. P-values are in parentheses.

Table 10: Kao and Pedroni Co-Integration Tests Results for Oil Rent (in % GDP)

		$erer_{agriculture}$	$erer_{manufacture}$	$irer_{agriculture}$	$irer_{manufacture}$
Kao Co-Integration Test	Modified DF	-0.1490	0.1755	-0.2690	-2.6917***
		(0.4408)	(0.4303)	(0.3940)	(0.0036)
	DF	-1.8072**	-1.4035*	-1.4444*	-4.3733***
		(0.0354)	(0.0802)	(0.0743)	(0.0000)
	Augmented DF	-1.9043**	-1.5949*	-1.9043**	-2.7548***
		(0.0284)	(0.0554)	(0.0284)	(0.0029)
	Unadjusted Modified DF	-4.2461***	-3.2547***	-2.4200***	-8?2877***
		(0.0000)	(0.0006)	(0.0078)	(0.0000)
	Unadjusted DF	-4.1974***	-3.5845***	-2.7165***	-6.4846***
		(0.0000)	(0.0002)	(0.0033)	(0.0000)
Pedroni Co-Integration Test	Panel v-statistic	-2.5416***	-2.5624***	-2.6446***	-3.1271***
		(0.0055)	(0.0052)	(0.0041)	(0.0009)
	Panel ρ-statistic	2.2667**	2.2032**	2.3594***	0.9384
		(0.0117)	(0.0138)	(0.0092)	(0.1740)
	Panel PP-statistic	-1.7984**	-2.0023**	-1.0749	-5.9536***
		(0.0361)	(0.0226)	(0.1412)	(0.0000)
	Panel ADF-statistic	-5.1371***	-2.6655***	-1.5881*	-5.7942***
		(0.0000)	(0.0038)	(0.0561)	(0.0000)
	Group ρ-statistic	3.3503***	3.4302***	3.5037***	2.1709**
		(0.0004)	(0.0003)	(0.0002)	(0.0150)
	Group PP-statistic	-1.3208*	-1.4232*	-0.5859	-6.0487***
		(0.0933)	(0.0773)	(0.2790)	(0.0000)
	Group ADF-statistic	-5.4647***	-2.4867***	-1.1079	-5.2256***
		(0.0000)	(0.0064)	(0.1340)	(0.0000)

Note: We show the seven statistics provided by the Pedroni co-integration test for all specifications of interest. The four first statistics are the Panel-Cointegration statistics (based on within-dimension) and the last three are the Group-Mean Cointegration statistics (based on between-dimension). For each specification, the number of lags is chosen using the Bayesian Information Criterion. P-values are in parentheses.

Table 11: Kao and Pedroni Co-Integration Tests Results for the Brent Oil Price

		$erer_{agriculture}$	$erer_{manufacture}$	$irer_{agriculture}$	$irer_{manufacture}$
Kao Co-Integration Test	Modified DF	-4.0486***	-2.8247***	-2.3663***	-4.6470***
		(0.0000)	(0.0024)	(0.0090)	(0.0000)
	DF	-4.3309***	-3.5124***	-2.8296***	-5.6513***
		(0.0000)	(0.0002)	(0.0023)	(0.0000)
	Augmented DF	-4.4094***	-3.7209***	-3.2548***	-4.0290***
		(0.0000)	(0.0001)	(0.0006)	(0.0000)
	Unadjusted Modified DF	-4.4784***	-3.3428***	-2.5866***	-8.6820***
		(0.0000)	(0.0004)	(0.0048)	(0.0000)
	Unadjusted DF	-4.4490***	-3.6908***	-2.9136***	-6.7922***
		(0.0000)	(0.0001)	(0.0018)	(0.0000)
Pedroni Co-Integration Test	Panel v-statistic	-2.5284***	-2.5045***	-2.5099***	-3.1563***
		(0.0057)	(0.0061)	(0.0060)	(0.0008)
	Panel ρ-statistic	2.3156**	1.9092**	2.7236***	1.1747
		(0.0103)	(0.0281)	(0.0032)	(0.1201)
	Panel PP-statistic	-1.6462**	-3.1087***	0.0514	-5.0391***
		(0.0499)	(0.0009)	(0.4795)	(0.0000)
	Panel ADF-statistic	-3.5833***	-5.0638***	-0.6076	-5.1489***
		(0.0002)	(0.0000)	(0.2717)	(0.0000)
	Group ρ-statistic	3.4133***	3.2143***	3.8250***	2.3818***
		(0.0003)	(0.0007)	(0.0001)	(0.0086)
	Group PP-statistic	-1.1583	-2.4658***	0.4734	-5.6755***
		(0.1234)	(0.0068)	(0.3180)	(0.0000)
	Group ADF-statistic	-3.5266***	-4.3722***	-0.2719	-4.7311***
		(0.0002)	(0.0000)	(0.3928)	(0.0000)

Note: We show the seven statistics provided by the Pedroni co-integration test for all specifications of interest. The four first statistics are the Panel-Cointegration statistics (based on within-dimension) and the last three are the Group-Mean Cointegration statistics (based on between-dimension). For each specification, the number of lags is chosen using the Bayesian Information Criterion. P-values are in parentheses.

Table 12: Kao and Pedroni Co-Integration Tests Results for the WTI Oil Price

		$erer_{agriculture}$	$erer_{manufacture}$	$irer_{agriculture}$	$irer_{manufacture}$
Kao Co-Integration Test	Modified DF	-4.0576***	-2.8246***	-2.3678***	-4.6789***
		(0.0000)	(0.0024)	(0.0089)	(0.0000)
	DF	-4.3292***	-3.5117***	-2.8296***	-5.6703***
		(0.0000)	(0.0002)	(0.0023)	(0.0000)
	Augmented DF	-4.4062***	-3.7239***	-3.2561***	-4.0451***
		(0.0000)	(0.0001)	(0.0006)	(0.0000)
	Unadjusted Modified DF	-4.4811***	-3.3392***	-2.5845***	-8.6892***
		(0.0000)	(0.0004)	(0.0049)	(0.0000)
	Unadjusted DF	-4.4454***	-3.6889***	-2.9122***	-6.7988***
		(0.0000)	(0.0001)	(0.0018)	(0.0000)
Pedroni Co-Integration Test	Panel v-statistic	-2.4968***	-2.4995***	-2.5234***	-3.1781***
		(0.0063)	(0.0062)	(0.0058)	(0.0007)
	Panel ρ-statistic	2.33641**	1.9639**	2.7144***	1.1965
		(0.0090)	(0.0248)	(0.0033)	(0.1157)
	Panel PP-statistic	-1.4810**	-3.1994***	-0.0059	-5.1567***
		(0.0693)	(0.0007)	(0.4977)	(0.0000)
	Panel ADF-statistic	-3.5403***	-5.4479***	-0.7302	-5.2837***
		(0.0002)	(0.0000)	(0.2326)	(0.0000)
	Group ρ-statistic	3.2423***	3.2143***	3.8056***	2.4373***
		(0.0001)	(0.0006)	(0.0001)	(0.0074)
	Group PP-statistic	-0.9714	-2.6633***	0.4705	-6.3148***
		(0.1657)	(0.0039)	(0.3190)	(0.0000)
	Group ADF-statistic	-3.4994***	-4.7778***	-0.3651	-4.8246***
		(0.0002)	(0.0000)	(0.3575)	(0.0000)

Note: We show the seven statistics provided by the Pedroni co-integration test for all specifications of interest. The four first statistics are the Panel-Cointegration statistics (based on within-dimension) and the last three are the Group-Mean Cointegration statistics (based on between-dimension). For each specification, the number of lags is chosen using the Bayesian Information Criterion. P-values are in parentheses.

7.4 Robustness Tests

Table 13: Breusch-Pagan Test for Cross-Sectional Dependence

		$erer_{agriculture}$	$erer_{manufacture}$	$irer_{agriculture}$	$irer_{manufacture}$
$oilrevenues$	Without trend	85.27***	113.9***	99.66***	68.59***
		(0.0000)	(0.0000)	(0.0000)	(0.0009)
	With trend	99.68***	106.4***	92.58***	67.80***
		(0.0000)	(0.0000)	(0.0000)	(0.0011)
$OilRent$	Without trend	86.20***	104.30***	96.69***	73.09***
		(0.0000)	(0.0000)	(0.0000)	(0.0003)
	With trend	98.89***	111.10***	85.74***	74.11***
		(0.0000)	(0.0000)	(0.0000)	(0.0002)

Note: We present the statistics for the Cross-sectional dependence test based on Lagrange-Multiplier and proposed by Breusch and Pagan (1980). A p-value lower than 0.05 indicates to strongly reject the hypothesis of error cross-section independence. P-values are in parentheses.

Table 14: Mean-Group Results for Oil Revenues and Oil Rent

Variables	$erer_{agriculture}$ (1)	$erer_{agriculture}$ (2)	$erer_{manufacture}$ (1)	$erer_{manufacture}$ (2)	$irer_{agriculture}$ (1)	$irer_{agriculture}$ (2)	$irer_{manufacture}$ (1)	$irer_{manufacture}$ (2)
Long-Run:								
$oilrevenues$	0.1304		0.2072**		0.0004		-0.0635	
	(0.1138)		(0.0999)		(0.2480)		(0.1580)	
$OilRent$		0.1317		0.2015		0.0440**		0.0158
		(0.1231)		(0.1979)		(0.0215)		(0.0391)
$openness$	-0.4554**	-1.9532	-0.4653*	-3.1262	-1.0600**	-0.8736***	-0.4023	-0.5160
	(0.1958)	(1.6344)	(0.2489)	(2.5948)	(0.4295)	(0.2690)	(0.3090)	(0.6400)
$balassa$	-0.5534	-2.6657	-0.5146	-4.4721	-0.1866	-0.2178	-0.9745	-1.3336
	(0.7238)	(2.9501)	(0.7277)	(4.6152)	(0.5992)	(0.5696)	(0.6926)	(0.8524)
NFA	-0.0104	-0.0817	-0.0086	-0.1258	-0.0084	-0.0225	0.0094	-0.0151
	(0.0116)	(0.0821)	(0.0110)	(0.1281)	(0.0124)	(0.0143)	(0.0212)	(0.0240)
$investment$	-0.0557	0.0124	-0.0747	0.5655	-0.1543	-0.1089	-0.0894	-0.4307
	(0.1496)	(0.0975)	(0.1711)	(0.4928)	(0.4553)	(0.4461)	(0.2856)	(0.3317)
Short-Run:								
$\Delta oilrevenues$	0.0341		0.0276		-0.0148		0.3929**	
	(0.0414)		(0.0278)		(0.0386)		(0.1942)	
$\Delta OilRent$		-0.0006		0.0024		-0.0064		0.0269***
		(0.0059)		(0.0054)		(0.0061)		(0.0099)
$\Delta openness$	-0.0897	-0.0865	-0.0843	-0.0132	0.0125	0.0771	-0.4717	-0.2930
	(0.1084)	(0.1063)	(0.1125)	(0.1086)	(0.1647)	(0.1936)	(0.5663)	(0.2562)
$\Delta balassa$	0.5282	0.6359	0.4640	0.6983	0.4633*	0.5955*	1.4509***	1.3703***
	(0.3291)	(0.4434)	(0.3248)	(0.4412)	(0.2441)	(0.3091)	(0.4308)	(0.4715)
ΔNFA	-0.0028**	-0.0032*	-0.0034**	-0.0022	0.0006	-0.0003	-0.0081***	-0.0048
	(0.0012)	(0.0018)	(0.0016)	(0.0021)	(0.0019)	(0.0016)	(0.0030)	(0.0039)
$\Delta investment$	0.0091	-0.0304	-0.0009	-0.0853	0.0553	0.0048	0.2902	0.2244*
	(0.1124)	(0.1360)	(0.0981)	(0.1318)	(0.1274)	(0.1271)	(0.2342)	(0.1203)
ec	-0.6626***	-0.6178***	-0.6870***	-0.6495***	-0.5259***	-0.5042***	-0.9195***	-0.9538***
	(0.0661)	(0.0902)	(0.1268)	(0.1132)	(0.0655)	(0.0592)	(0.1572)	(0.1531)
Constant	4.5730***	4.1744***	4.1592***	4.9278***	3.6104**	3.4271***	9.2669***	9.6706***
	(1.4696)	(1.3604)	(1.2902)	(1.1487)	(1.5923)	(1.3006)	(2.6412)	(2.6432)
Observations	207	207	207	207	207	207	207	207

Note: Variables in lower-case letters are expressed in logarithms, whereas $OilRent$ and NFA are in % GDP. Standard errors are in parentheses. * Significant at 10%. ** Significant at 5%. ***Significant at 1%

Table 15: Mean-Group Results for Oil Prices

Variables	$erer_{agriculture}$ (1)	$erer_{agriculture}$ (2)	$erer_{manufacture}$ (1)	$erer_{manufacture}$ (2)	$irer_{agriculture}$ (1)	$irer_{agriculture}$ (2)	$irer_{manufacture}$ (1)	$irer_{manufacture}$ (2)
Long-Run:								
$oilprice$	0.0726	0.0793	0.1086	0.1259*	0.1642*	0.1844*	-0.1271	-0.1381
	(0.0744)	(0.0716)	(0.0776)	(0.0697)	(0.0946)	(0.1004)	(0.1118)	(0.1254)
$openness$	-0.1931	-0.2044	-0.2949*	-0.3093**	-0.5375***	-0.5971***	-0.4518**	-0.3958*
	(0.1773)	(0.1601)	(0.1698)	(0.1508)	(0.2077)	(0.2051)	(0.2196)	(0.2311)
$balassa$	0.2267	0.2405	0.2710	0.2694	0.4154	0.4861	-0.2947	-0.2561
	(0.2003)	(0.2113)	(0.2563)	(0.2457)	(0.4042)	(0.4339)	(0.5562)	(0.5528)
NFA	0.0018	0.0017	0.0055**	0.0047***	-0.0059	-0.0064	0.0073	0.0070
	(0.0019)	(0.0016)	(0.0022)	(0.0018)	(0.0055)	(0.0057)	(0.0070)	(0.0076)
$investment$	-0.4213	-0.4393	-0.6459	-0.6164	-0.2572	-0.2962	-0.6828	-0.6622
	(0.5903)	(0.5699)	(0.7076)	(0.6591)	(0.5964)	(0.6054)	(0.6747)	(0.6491)
Short-Run:								
$\Delta oilprice$	0.0775	0.0641	0.1112**	0.0950**	0.0345	0.0202	0.1356	-0.0192
	(0.0503)	(0.0461)	(0.0480)	(0.0476)	(0.0487)	(0.0451)	(0.1283)	(0.2244)
$\Delta openness$	-0.2050**	-0.1960*	-0.1408	-0.1335	-0.0863	-0.0710	0.0776	0.1691
	(0.0959)	(0.1009)	(0.0963)	(0.1038)	(0.1611)	(0.1538)	(0.1189)	(0.1820)
$\Delta balassa$	0.4032	0.3639	0.3362	0.3045	0.4166**	0.4471***	1.1192**	0.7735**
	(0.2547)	(0.2253)	(0.2765)	(0.2428)	(0.2061)	(0.1740)	(0.4985)	(0.3315)
ΔNFA	-0.0064	-0.0062	-0.0071	-0.0067	-0.0022	-0.0021	-0.0082	-0.0075
	(0.0047)	(0.0045)	(0.0049)	(0.0047)	(0.0028)	(0.0028)	(0.0064)	(0.0066)
$\Delta investment$	0.0954	0.0952	0.0788	0.0820	0.1336	0.1266	0.0469	0.0006
	(0.0718)	(0.0701)	(0.0653)	(0.0654)	(0.1262)	(0.1112)	(0.0802)	(0.1049)
ec	-0.6387***	-0.6323***	-0.7274***	-0.7311***	-0.4935***	-0.4737***	-0.9739***	-0.9448***
	(0.1071)	(0.0893)	(0.1471)	(0.1431)	(0.0679)	(0.0606)	(0.1437)	(0.1370)
Constant	3.0732***	3.0003***	3.1082***	3.1357***	2.4045**	2.2858**	10.3418***	9.7628***
	(0.9734)	(0.9513)	(1.0201)	(0.8944)	(1.1329)	(1.1034)	(2.8951)	(2.4742)
Observations	207	207	207	207	207	207	207	207

Note: Column (1) shows the results for the logarithm of the Brent oil price and column (2) for the logarithm of the WTI oil price. Variables in lower-case letters are expressed in logarithms, whereas NFA is in % GDP. Standard errors are in parentheses. * Significant at 10%. ** Significant at 5%. ***Significant at 1%

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