Impact of Oil Price and Oil Production on Inflation in the CEMAC

Abstract

There are different channels through which variations in international crude oil prices translate into changes in net-oil exporting countries' domestic prices. This article identifies two of these causal mechanisms, namely the pass-through effect and the Dutch disease effect. It intends to disentangle these two effects in the five oil producers of the Central African Economic and Monetary Community: Cameroon, the Republic of Congo, Chad, Equatorial Guinea, and Gabon. It also investigates the heterogeneity across countries in the face of international oil price and domestic oil production shocks based on a multiple time-series strategy covering the period 1995-2019. Applying Dynamic Ordinary Least Squares and AutoRegressive Distributed Lag models, it concludes to the presence of a pass-through effect in Cameroon, Chad, and Congo and of a Dutch disease effect in Equatorial Guinea. This contributes to the understanding of the relationships between international commodity prices and domestic consumer price variations but can also help policymakers in the CEMAC by assessing the vulnerability of its members toward external shocks.

1. Introduction

Previous empirical works have supported evidence that natural resources booms can generate inflation and/or exchange rates appreciation in resource-rich countries by increasing revenues without productivity gains and reallocating productive factors. This effect is commonly known as the "Dutch disease” within the framework of the so-called Corden-Neary model (Corden and Neary, 1982). Since the early 1980s, this model has led to an extensive empirical literature, either focusing on real exchange rate appreciation or on the decline in non-resource tradable sectors considered as the main consequence of this appreciation (Goujon and Mien, 2021). However, the discussions based on this model have neglected some key dimensions, notably regarding the underlying assumptions.

This paper aims to question the classical assumption that natural resources are fully exported, hence that international resource prices affect domestic prices and real exchange rates through Dutch disease effects only. Indeed, even in developing countries, natural resources - particularly energy such as oil, gas or coal- can be domestically consumed by households or used as inputs in other goods' production. In addition, international energy prices can affect the price of international manufacturing or agricultural goods, impacting domestic consumer price indexes in countries that import these goods, even when they do not produce them. We call here "Pass-through" the fact that international oil prices directly influence domestic inflation through production costs or by entering the basket of goods and services used to estimate price indexes. Our goal is to disentangle the Dutch disease (DD) from the Pass-through (PT) price effects in five Central African oil-producing countries: Cameroon, Chad, Congo, Equatorial Guinea, and Gabon.

This selection of countries is motivated by several factors. First, crude petroleum oil represents a large share of their total exports (from 36% in Cameroon to 74% in Chad in 2019[1]) but none of them is a large exporter at the world level. Hence, we consider these countries as price takers and oil price changes as exogenous. Furthermore, they are developing countries with low levels of industrialization. Therefore, they seem at first sight to meet the traditional assumptions of DD models, where energy is assumed to be fully exported. Then, they belong (with the Central African Republic) to the Central African Economic and Monetary Community (CEMAC): they share a common currency (the XAF CFA Franc), monetary policy, and trade policy. This allows consistent comparisons across countries based on their divergence in oil production patterns. Finally, the CFA Franc being fixed to the Euro (to the French Franc before 1999), DD effects can occur only through domestic inflation and not through nominal exchange rate appreciation (nominal bilateral exchange rate changes against foreign currencies are exogeneous, being determined by variations of the Euro against these currencies). These characteristics allow us to estimate the impact of oil production and international oil prices on the consumer price index and to investigate for each country whether oil-driven CPI variations are caused by Dutch disease, pass-through, or a combination of both. Our results show clear evidence of a Pass-Through effect in Cameroon and Chad and mixed evidence of such an effect in the Republic of Congo and Equatorial Guinea. They also suggest a Dutch Disease effect in Equatorial Guinea and, to a lesser extent, in Chad. Results remain inconclusive for Gabon.

The paper is organized as follows. Section 2 presents the literature on PT and DD and briefly discusses their respective methodologies. Section 3 provides a theoretical framework to explain the two effects and describes the main assumptions of this study. Section 4 presents the empirical methodology and the results. Section 5 concludes.

[1] https://oec.world

2. Why Should International Oil Prices Translate into Domestic Inflation? Pass-Through and Dutch Disease Literature

This section details the arguments for both the pass-through and Dutch disease explanations of the impact of oil shocks on prices. It also presents and compares the empirical literature of these two fields of the literature.

2.1 The Pass-Through from Oil Prices to the Domestic Consumer Price Index

International price variations in natural resources such as hydrocarbons or mining resources can result in variations in domestic consumer price indexes (CPI) in exporting and importing resources countries for two reasons. First, if the basket of goods used to compute the aggregate CPI includes the resource, a change in the resource's price is expected to generate a change in the CPI proportional to the weight of this resource in the basket. Second, if the resource is used as an input in the production of other goods or services, an increase in its price will increase the product price or decrease its producer's profit (or more likely a combination of both). However, different effects can reduce this pass-through between international resource prices and domestic CPI. Indeed, it depends on the price elasticity of the goods and services that use this resource in their production function. Another explanation is that domestic policy can react to changes in international prices to avoid excessive inflation when resource prices increase through subsidies, price controls, or reduced import tariffs. Due to its central importance in international trade markets and production processes, it is not surprising that most empirical articles that have investigated such pass-through effect have focused on international crude oil price variations. We present here some empirical works regarding the existence of a pass-through effect between international oil prices and domestic inflation with a focus on oil-producing countries.

Based on quarterly data over 1996-2010, Caceres et al. (2012) investigate the impact of global energy and food prices on the consumer price index in four countries of the CEMAC area (Cameroon, the Central African Republic, the Republic of Congo, and Gabon). Applying a Vector Auto Regressive (VAR) methodology, Dynamic Ordinary Least Squares (DOLS) and Fully Modified Ordinary Least Squares (FMOLS), they conclude that energy prices have a positive and significant effect on inflation in Cameroon and Gabon, while the significance of the impact in the Central African Republic (CAR) and Congo highly depends on the econometric model (VAR, DOLS or FMOLS). On the contrary, the coefficients associated with food prices are mostly insignificant, except for Gabon with a VAR and for the CAR with DOLS. This underlines the impact of global prices, particularly of energy prices, on inflation in the CEMAC area and the heterogeneity that may exist across countries even within a monetary union. Sakashita and Yoshizaki (2016) investigate the impact of different international oil shocks (demand and supply shocks) on the consumer price index in the United States and five emerging economies (Brazil, Chile, India, Mexico, and Russia) between 1994 and 2016. Based on a structural VAR with two blocks of variables (a "global oil market block" and a "domestic aggregate economy block"), they conclude to the absence of solid impacts of oil supply shocks on domestic economies' CPI, and to significant but heterogeneous effects of oil demand shocks: an increase in oil demand generates inflation in the United States, Chile, and India but disinflation in Brazil, Mexico, and Russia. This highlights both the fact that oil-importing (such as India) and oil-exporting countries (such as Mexico or Russia) are vulnerable to exogenous shocks on international oil markets and that the effects of such shocks largely differ across countries. Husaini et al. (2019) estimate the impact of energy subsidy and the international Brent crude oil price on both the consumer price index and the production price index in Malaysia. Based on an Auto Regressive Distributed Lag (ARDL) empirical strategy, they conclude to a long-term positive and significant effect of international oil prices on CPI and PPI (with a larger effect for PPI), but also observe that energy subsidy can contribute to reducing this pass-through effect by cutting down inflation. Following a Phillips curve model augmented by supply-side commodity prices, Fasanya and Awodimila (2020) compare the impact of energy and non-energy commodity prices on inflation in Nigeria and South Africa. They also examine separately the impact of positive and negative changes in commodity prices to account for potential asymmetries in the effects. Even if commodity prices appear to be good predictors of inflation, they observe heterogeneity between the two countries since the best forecast for inflation is when the Phillips curve is augmented with energy prices for Nigeria but with non-energy prices for South Africa.

Among panel data studies, Crowley (2010) investigates the impact of a set of variables on inflation in 25 countries in the Middle East, North Africa and Central Asia (MENACA) over 1997-2008. The determinants of inflation used include notably the U.S. nominal effective exchange rate, the country's nominal effective exchange rate, local interest rate, GDP growth and (fuel and non-fuel) commodity prices. The author finally observes a positive impact of non-fuel commodity prices on inflation but surprisingly no significant impact of fuel prices, in contradiction with the expectations. However, this panel-based methodology does not account for potential heterogeneity across countries of the sample, which seems of particular interest here since the sample includes both net oil-importers (such as Jordan, Lebanon, or Tunisia) and net oil-exporters (such as Algeria, Kazakhstan, or Saudi Arabia). Bala and Chin (2018) investigate the impact of oil prices on inflation in a panel of four African OPEC members countries (Algeria, Angola, Libya, and Nigeria) between 1995 and 2014. Using Pooled-Mean-Group and Mean-Group approaches, they also account for potential asymmetric effects by including a variable for positive oil price shocks and one for negative oil price shocks in the regressions. They finally conclude to a clear long-run impact of oil price shocks on inflation with asymmetrical effects, and a significant effect only of positive shocks in the short-run.

2.2 The Dutch Disease impact of oil prices

However, there is another reason why international resource price increases can lead to domestic inflation in resource-exporting countries. This relates to the so-called "Dutch disease" hypothesis traditionally associated with the model of Corden-Neary (Corden and Neary, 1982). According to this model, a boom in the resource sector generates an increase in public and private expenditures, leading to inflation in the non-tradable sector (the spending effect), and causes a reallocation of workers across sectors that will eventually also lead to price increase in the non-tradable sector (the resource-movement effect). These two effects result in inflation in the aggregate CPI (due to inflation in the non-tradable sector) and an appreciation of the domestic real exchange rate (measured as the ratio of non-tradable to tradable prices). There has been a large empirical literature investigating the presence of a DD, particularly in oil-exporting countries, even if all types of natural resources can drive DD. It is noticeable that most empirical studies focus on the real effective exchange rate (defined as the product of nominal exchange rate and the ratio of domestic and foreign prices) as the main outcome to detect the presence of a DD. However, there might be justification for DD analyses looking at domestic prices rather than real exchange rates (RER). First, the RER reveals a relative evolution of country's prices compared to foreign prices and might be unable to detect DD effects if trading partners also suffer from DD (or from PT effects). Then, classical variables of RER suffer from endogeneity issues since the weights associated with each trading partner are re-estimated regularly (on a three-year basis for the IMF). However, the external competitiveness of a country and the types of products it exports or imports affect the share of each foreign country in its total trade, and therefore the way the RER is estimated. Finally, in a fixed nominal exchange rate regime, the appreciation of the RER can only occur through price increases.

Kablan and Loening (2014) estimate the impact of oil prices and oil production shocks separately on inflation (based on the GDP deflator) in Chad between 1985 and 2008, in line with the DD model. Based on a structural VAR model, they conclude to a positive and significant impact of oil prices and a less significant impact of oil production on inflation. This allows them to conclude to inflationary pressures caused by DD effects in the Chadian economy. Khinsamone (2017) applies a VAR model to investigate the relations between a set of key variables in the Lao economy between 1980 and 2014: mining and utility production, manufacturing-service ratio, investment-consumption ratio, inflation (based on the consumer price index), and real GDP per capita. Regarding the determinants of inflation, they observe that the value-added in the mining sector has a significant and positive effect on prices. This result is confirmed by the Granger causality test, which indicates to reject the null hypothesis that mining and utility production does not Granger cause inflation and is interpreted as evidence in favor of the DD hypothesis by the author. Mukhtarov et al. (2019) apply a Vector Error Correction Model (VECM) to annual data over 1995 and 2017 to determine the impact of oil prices and exchange rates on inflation in Azerbaijan. They find a positive impact of oil prices on inflation and conclude to the evidence of DD effects, even if the impact of exchange rates on prices appears to be stronger. Nasir et al. (2018) apply multiple Time-Varying Structural VAR models and estimate the impact of international oil prices on economic growth, domestic inflation, and trade balance in five emerging countries: Brazil, China, India, Russia, and South Africa. They notably distinguish between the two net-oil exporting countries (Russia and Brazil) for which oil prices are assumed to positively affect prices through both DD and production costs and the three net-oil importers (China, India, and South Africa) for which the two channels (production costs and trade) are supposed to have opposite effects on the CPI. However, they find that oil prices affect long-run inflation positively in Brazil (oil exporter) and India (oil importer) but negatively in Russia (oil exporter), China, and South Africa (oil importers). This does not seem to support either DD or PT but underlines the heterogeneity across countries in the vulnerability toward external shocks. Finally, we must underline the contribution of Beverelli et al. (2011) who investigate the possibility that oil could be used for domestic production. Based on a large panel of 132 countries, they conclude that oil discoveries generate lower DD effects in countries with higher shares of oil-intensive industries. However, due to their focus on large oil discoveries, instead of oil production or prices, they do not try to disentangle DD-caused price increases from other sources of oil-shocks driven inflation. In addition, they focus on the use of oil as an input for industrial production, while we focus here on consumer price indexes, considering that oil can enter the CPI as a final consumption good or as an input for other goods or services (such as transportation).

2.3 Dutch Disease or Pass-Through?

It is striking that both Dutch disease and Pass-through studies often use very similar methodologies (estimating the impact of international resource prices or revenues on the RER or the CPI) but with very different interpretations. Indeed, analyses of the pass-through effect often neglect the Dutch disease hypothesis even when they focus on resource-exporting countries, making the implicit assumption that the impact of resource prices on domestic inflation depends only on the relationship between international and domestic resource prices and on the importance of resource consumption (either as a final good or as an input) in the economy. For instance, Fasanya and Awodimila (2020) do not mention potential Dutch disease effects even after observing that energy prices have a stronger effect on domestic inflation in Nigeria (which is an oil-exporting country) than in South Africa (which is an oil-importing country). Similarly, Bala and Chin (2018) find a positive impact of oil prices on inflation in four oil-exporting countries but do not investigate the DD hypothesis to explain this result. Conversely, Dutch disease theoretical models and empirical analyses assume that resources are fully exported and never domestically consumed. It is particularly noticeable that, while the small-open economy (or price-taking country) assumption is almost always explicitly mentioned and often justified, this assumption of no domestic resource consumption is usually implicit and very rarely discussed. This is an issue when interpreting a positive relationship between international resource prices and domestic CPI inflation or RER appreciation as evidence of DD. We can also notice that even if the country does not consume this resource, it can import goods that have required it in their production, and therefore that PT effects can still occur.

Overall, it appears that while the PT effect is mainly driven by the price of refined oil imports and the DD by the price of crude oil exports, most studies use an international crude oil price (most often the Brent crude oil price) as a proxy. Indeed, international crude oil prices present the main advantage of being easily available (contrary to domestic import or export prices) and are more likely to be exogeneous for small open economies. However, the use of the same proxy in these two types of studies reinforces the issues arising from the attribution of domestic inflation to one or the other effect. Even if some DD studies use oil discoveries (as in Beverelli et al., 2011), oil production, oil rents (expressed in % of total GDP), or oil exports rather than international oil prices, the presence of a positive correlation between these variables and oil prices (which is very likely) might imply that PT effects can affect the interpretation of the results. Here, we intend to disentangle the inflation effect caused by energy PT from the inflation effect caused by DD effects in a set of crude oil-exporting countries within a monetary area with a fixed nominal exchange rate.

3. Analytical Framework

We propose in this section an overview of the three main effects that are investigated in this study: the pass-through effect (caused by international oil prices), the spending effect (caused by oil revenues), and the resource-movement effect (caused by oil production).

Our framework relies on some main assumptions in line with a modified version of the model proposed by Corden and Neary (1982). First, we assume a small open economy. The consequences of this assumption are twofold. First, it implies that the domestic production of energy does not affect international prices. This is very likely to hold in our situation since none of the CEMAC country members are large oil-exporters on international markets. Then, it also implies that the share of domestic energy production that is not consumed is always exported abroad (i.e., there is no overproduction). This is important because it implies that an increase in oil production (if prices are constant) increases revenues coming from the oil sector. The second central assumption is that the country produces and consumes oil. This differs from the traditional model of Corden-Neary which considers that energy is fully exported. More precisely, the country exports crude oil and consumes refined imported oil (the domestic refinement industries being negligible), but we consider international spot crude oil prices (denoted from now "oil price") as proxies for both the price of oil exports and of oil consumption. Finally, the nominal bilateral exchange rate is exogenous. This is an essential condition since nominal exchange rates affect revenues coming from oil exports. Here, this relates to our focus on the CEMAC area, where the nominal exchange rate is fixed with the Euro[2].

We note:

$$P = P_N^{\alpha} P_T^{\beta} P_E^{\gamma}$$

[2] Even if we use the expression "fixed nominal exchange rate", it is fixed only with the Euro but varies with other currencies such as the USD in which international oil prices are denominated. However, these variations can be considered as exogenous since they are determined by the Euro/USD international forex market.

With P the CPI, P_N the price of non-tradable products, P_T the price of tradable non-energy products, P_E the price of energy products and $\alpha + \beta + \gamma = 1$. We also note N the nominal bilateral exchange rate[3] and P_i^* the price of i ($i \in \{T; E\}$) on international markets. Under the assumption that the country is price taker on international markets and with free competition:

$$P_T = P_T^* * N$$

And

$$P_E = P_E^* * N$$

On the other side, $P_N = f(total\ income, factor\ of\ production\ costs)$ depends on the domestic supply-demand equilibrium. If energy is required to produce non-tradable goods, P_N depends positively on P_E. Similarly, P_T^* depends positively on energy prices (because at the world level, energy is an input for the production and transportation of tradables). We present here three different effects (see Figure 1):

- *Pass-Through Effect*: An increase in international oil prices leads to domestic inflation if oil (or an energy index based partly on oil) is included in the basket of goods and services used to estimate the consumer price index. In addition, it increases the production costs of goods using oil as an input, encouraging inflation.
- *Spending Effect*: An increase in international oil prices (for a given level of oil production) or an increase in oil production (for a given level of price) leads to an increase in the revenues collected from oil exports (under the assumption that domestic consumption remains constant). These revenues are then shared between private agents and public authorities depending on the institutional arrangements and the level of taxation, and each agent is assumed to spend a fraction of these revenues in non-tradable and tradable expenditures. This increasing demand for tradable is compensated either by increasing imports, or by increasing production in tradable goods, which prices are assumed to be exogenous because fixed on international markets. However, non-tradable goods and services cannot be imported, hence prices must rise in this sector, leading to increases in aggregate CPI and in the ratio between non-tradable and tradable prices. Even if this effect is often associated with public expenditures, which are assumed to be biased towards non-tradable goods, the original model of Corden-Neary considers that both public and private expenditures can lead to this price increase. Indeed, the spending effect does not require a bias toward non-tradable to be effective.

[3] Defined as the number of domestic currency units into one foreign currency unit: an increase in N means a currency depreciation.

- *Resource-Movement Effec*t: If labor (or any other factor of production) is mobile across sectors but immobile across countries, an oil boom causes movements of workers out of the two other sectors into the oil sector, reducing non-oil production. Since non-oil production is now below domestic demand, imports of non-oil tradables increase (financed by oil exports) while non-tradables' prices rise. This leads to new movements of workers out of the tradable non-oil sector into the non-tradable sector (which partially offsets the price increase). The final equilibrium depends on the elasticity of non-tradables: if consumption of non-tradables cannot decrease, there is no price increase but a double decline in tradable production; but if expenditures are partially redirected toward tradable goods, the decline in the tradable sector is limited at the expense of a price increase in the non-tradable sector. Empirical studies often neglect this resource-movement because it is assumed to have a lower impact than the spending effect.

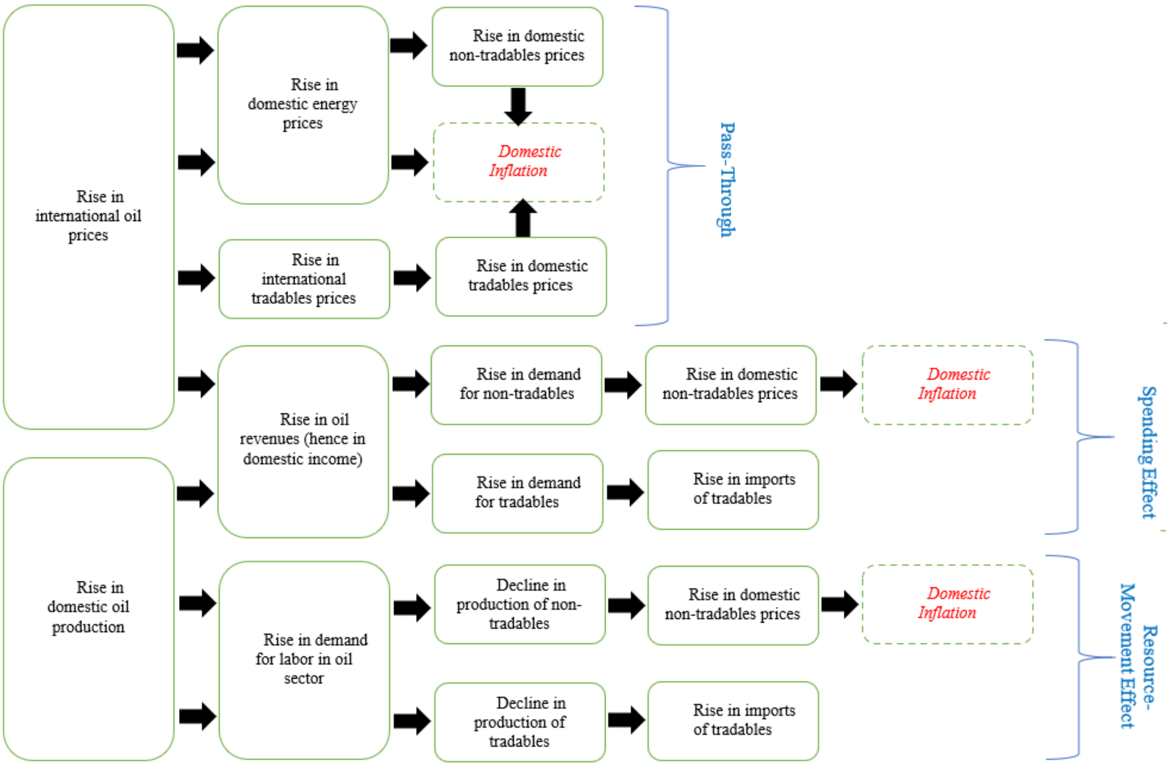
Hence, the pass-through effect depends directly on international prices, the spending effect on international revenues (determined by both prices and production), and the resource-movement effect by production only. The Dutch Disease is simply the combination of the spending and resource-movement effects. This leads us to two main assumptions:

Assumption 1: For a given level of oil prices, a rise in production leads only to Spending and Resource-Movement (hence Dutch disease) effects

Assumption 2: For a given level of oil production, a rise in international prices leads only to Pass-through and Spending effects

However, oil production and oil prices are likely to be correlated. Due to the small open economy assumption, international prices are exogenous and do not react to domestic oil production. However, oil production can adjust to oil price variations. In that case, prices only *indirectly* cause a resource-movement effect through increase in production. It must be noted that there might be a positive correlation between international crude oil prices and oil production (if the country or the exploiting firms decide to reduce oil production when prices are low to keep reserves for an expected price increase) but also a negative one (if oil revenues directly finance current public expenditures, a fall in international prices might be compensated by a rise in oil production to keep the financing of current spending constant). Finally, if an increase in oil production requires new investments in capital (for example to exploit a reserve that was already known but unexploited when prices were low), an increase in prices can lead to an increase in production but only after a few lags.

Figure 1: Presentation of the Pass-Through, Spending and Resource-Movement Effects



4. Empirical Analysis

4.1 Presentation of the Data

We use quarterly data for the period 1995q1-2019q4 from different sources. The consumer price index, the deposit interest rate, and the nominal bilateral exchange rate come from IMF International Financial Statistics Database. Oil price is the Brent spot crude oil price from IMF Commodity Prices Database. Finally, oil production is the number of barrels produced from U.S. Energy Information Administration. All variables are in logarithm, apart from the deposit interest rate. For Chad and Equatorial Guinea, the sample is restricted to the period when the country is a net-oil exporter (respectively 2004q2-2019q4 and 1997q3-2019q4). For Congo, the sample is restricted to 1999q1-2019q4 due to missing data for the CPI[4].

[4] A civil war occurred in Congo in 1997, hence data series begin in 1998 only. To avoid the reconstruction period, we start here at the beginning of 1999 (however, the inclusion of the year 1998 does not affect the results).

Table 1. Descriptive Statistics

		Cameroon	Chad	Congo	Equatorial Guinea	Gabon	Unit	Source
CPI	Mean	93	104	98	90	95	Base 2010 = 100	IMF
	Std. Dev.	16	13	17	25	14		
Brent	Mean	55	75	62	59	55	USD/barrel	IMF
	Std. Dev.	33	25	31	32	33		
Oil Production	Mean	83	130	258	242	261	Million barrels/day	EIA
	Std. Dev.	18	23	43	86	55		
Interest	Mean	3.97	3.31	3.73	3.81	3.97	Units	IMF
	Std. Dev.	1.11	0.86	1.05	1.06	1.11		
NBER	Mean	555	522	557	559	555	CFA/USD	IMF
	Std. Dev.	77	49	82	80	77		
Sample Period		1995q1-2019q4	2004q2-2019q4	1999q1-2019q4	1997q3-2019q4	1995q1-2019q4		

Note: The Brent oil price (*Brent*), deposit interest rate (*Interest*) and nominal bilateral exchange rate with the USD (*NBER*) are common to all countries. The variations across countries are due to differences in sample periods.

The evolutions of the brent crude oil price and of each country's oil production are provided in the appendix. They reveal a large heterogeneity in oil production patterns across countries and show that oil production does not directly follow international oil price variations.

4.2 Unit-Root Tests and Co-Integration Tests

Before proceeding to the econometric analyses, we need to investigate whether the variables are stationary or not. Indeed, Ordinary Least Square estimates are known to be inconsistent in time-series when the variables have a unit-root. For this, we implement the classical Augmented-Dickey-Fuller (ADF) and Philipps-Perron (PP) unit-root tests. Results are displayed in table 2 and indicate that all variables are I(1).

Table 2. Unit-Root Tests

Variable		Cameroon		Chad		Congo		Equatorial Guinea		Gabon	
		I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
cpi	ADF	-2.55	-7.64***	-3.36*	-4.66***	-2.75	-5.22***	-0.52	-9.27***	-2.06	-9.36***
	PP	-2.52	-9.01***	-3.03	-16.30***	-3.21*	-11.40***	-0.33	-9.24***	-2.08	-10.07***
oil production	ADF	-2.50	-9.35***	-2.22	-7.88***	-3.01	-9.04***	-3.09	-8.08***	-1.98	-10.23***
	PP	-1.87	-9.35***	-3.07	-6.09***	-2.40	-9.06***	-3.38*	-8.32***	-1.97	-10.29***
brent	ADF	-2.05	-7.16***	-2.80	-6.11***	-2.17	-7.02***	-1.97	-6.89***	-2.05	-7.16***
	PP	-1.50	-7.57***	-2.53	-6.08***	-2.23	-7.23***	-1.43	-7.27***	-1.50	-7.57***
interest	ADF	-2.00	-10.08***	-1.58	-7.62***	-2.00	-8.49***	-2.08	-8.88***	-2.00	-10.08***
	PP	-2.14	-10.08***	-1.64	-7.62***	-2.21	-8.49***	-2.25	-8.88***	-2.14	-10.08***
nber	ADF	-2.24	-7.23***	-2.26	-5.77***	-1.86	-6.42***	-1.88	-6.91***	-2.24	-7.23***
	PP	-1.71	-7.11***	-2.11	-5.75***	-1.52	-6.56***	-1.50	-6.73***	-1.71	-7.11***
5%	ADF/PP	-3.46		-3.48		-3.46		-3.46		-3.46	

Note: The number of lags is selected with the Akaike Information Criterion with a maximum of 4 lags. A constant and a time trend are included. Variables brent, interest and nber are common to all countries but the unit-root tests are run on the sub-samples of interest for Chad (63 observations), Congo (84 observations) and Equatorial Guinea (90 observations).

Since our variables are integrated of order 1, we want to determine whether there is a co-integrating relationship between them or not. We thus proceed to the Johansen co-integration tests for our combinations of five variables (the cpi and the four explanatory variables). Results are displayed in table 3. Overall, there seems to exist at least one cointegrating relationship among the variables in every country.

Table 3. Johansen Co-Integration Tests

	Cameroon	Chad	Chad (full sample)	Congo	Equatorial Guinea	Gabon
Trace Statistic	96.04*** (0.00)	108.08*** (0.00)	80.06** (0.03)	85.28** (0.01)	105.24*** (0.00)	81.83** (0.02)
Number of cointegrating relations (at 5%)	1	2	1	1	1	1

Note: Trace statistic indicates statistic from the unrestricted cointegration rank test (null hypothesis of at least one cointegrating equation). A constant is included. P-values are in parentheses. The number of cointegrating relations is decided when considering the rejection of the null hypothesis of at most n equations at the 5% level.

4.3 Regressions' Results

We now estimate the impact of our set of explanatory variables using two different approaches. First, we estimate the Dynamic Ordinary Least Square (DOLS) proposed by Stock and Watson (1993). This estimation strategy is justified by the existence of at least one relation of co-integration among the variables in all our time series. However, we also implement the AutoRegressive Distributed Lag (ARDL) Bounds Tests approach proposed by Pesaran et al. (2001). Indeed, this methodology presents the main advantage of providing consistent estimates of long-run regressors even with a combination of I(0) and I(1) variables (which is justified by the limitations of the traditional ADF and PP unit-root tests in small samples) or if some regressors are endogenous. We run regressions over the sample period described in table 1 for each country except Chad for which we separately estimate the coefficients for the sample period (when it is a net-oil exporter) and for the entire sample period.

Results for the DOLS estimators are provided in table 4. To check the robustness of the results, we also apply the Jarque-Bera test of normality on the residuals. For Cameroon and the Republic of Congo, the negative coefficients associated with oil production are unexpected and seem in opposition with the Dutch disease hypothesis. In contrast, the positive coefficients for the Brent oil price strongly support the PT hypothesis, in line with our second assumption. Regarding Congo, the Jarque-Bera normality test indicates to reject the null hypothesis of normality of the residuals at 10% but not at 5%, and encourages to remain cautious when interpreting these results but without invalidating them. For Chad, the coefficient for the Brent oil price is positive and significant in both regressions, whereas the coefficient associated with oil production is positive and significant at 10% only in full sample and insignificant in the restricted sample. One possible interpretation is that the sudden beginning in oil production had a positive impact on prices but without any strong relationship (or even a negative one as for Cameroon and Congo) between variations in oil production and variations in oil prices afterward. Equatorial Guinea is the only country of the sample for which both coefficients for oil prices and oil production are positive and significant (at respectively 5% and 1%). Since we expect a DD to lead to a positive impact of oil production (through spending and resource-movement effects according to assumption 1) and of oil prices (through spending effect only according to assumption 2) on domestic CPI, these two positive significant coefficients (the coefficient for oil production being even higher and more significant) strongly suggest a DD in Equatorial Guinea, with no firm evidence of a PT effect. Finally, the absence of any significant coefficient for Gabon seem to indicate that neither DD nor PT occurred in this country. However, we must remain cautious with such interpretations due to the potential measurement issues in the estimation of the CPI. Coefficients for the control variables are as expected: negative and significant in all regressions for the interest rate and positive for the bilateral exchange rate (yet not significant in Equatorial Guinea and Gabon). It is noticeable that the coefficient for domestic interest rate is particularly high in Chad (compared with other countries) and in Cameroon and Congo (compared with other variables).

Table 4. DOLS Results

	Cameroon	Chad	Chad (full sample)	Congo	Equatorial Guinea	Gabon
brent	0.0495^{***}	0.0773^{**}	0.0614^{**}	0.0882^{**}	0.0941^{**}	0.0006
	(0.0169)	(0.0308)	(0.0258)	(0.0370)	(0.0425)	(0.0252)
oil production	-0.0782^{**}	-0.1182	0.0149^{*}	-0.1697^{**}	0.1360^{***}	-0.0941
	(0.0335)	(0.0750)	(0.0076)	(0.0722)	(0.0370)	(0.0931)
interest	-0.1316^{***}	-0.0927^{***}	-0.1345^{***}	-0.1577^{***}	-0.2315^{***}	-0.1106^{***}
	(0.0053)	(0.0140)	(0.0122)	(0.0122)	(0.0180)	(0.0108)
nber	0.2206^{***}	0.5172^{***}	0.3059^{***}	0.2949^{**}	0.1874	0.0580
	(0.0385)	(0.1113)	(0.0835)	(0.1211)	(0.1197)	(0.1079)
constant	3.8070^{***}	1.9554^{***}	2.8255^{***}	3.8753^{***}	3.0792^{***}	5.1515^{***}
	(0.4174)	(0.8135)	(0.5921)	(0.9023)	(0.8596)	(1.1877)
Observations	100	63	100	84	90	100
R^2	0.99	0.94	0.96	0.99	0.98	0.98
Jarque-Bera Prob.	0.94	0.78	0.81	0.06^{*}	0.52	0.26

Note: The number of lags is selected with the Akaike Information Criterion with a maximum of 4 lags. Standard errors are in parentheses. Jarque-Bera indicates the p-value associated with the normality test of Jarque-Bera (null hypothesis of normality of the residuals).

We also apply the ARDL Bounds Test approach, as complementary results. The results for the F-Bound Tests (which investigate the presence of a long-run co-integration relationship among variables) are provided in table 5 and support the evidence of a relation of cointegration in Cameroon, Chad (in restricted sample), Equatorial Guinea and Gabon at 1%. For Chad in full sample and the Republic of Congo, the null hypothesis is rejected at 10% only, making the results harder to interpret. However, we still provide the long-run coefficients of the ARDL estimation regression for comparison purposes. Long-run coefficients for the variables of interest are reported in table 6 for each country, as well as different validity tests: the Jarque-Bera normality test, the LM-test of serial correlation and the Breusch-Pagan-Godfrey test for heteroskedasticity. ARDL estimates slightly moderate the previous results for Chad and Equatorial Guinea. Indeed, the coefficient for oil production is now negative and significant at 10% for Chad in restricted sample and insignificant in the full sample, while both coefficients for oil prices and oil production are now significant at 10% in Equatorial Guinea. Results remain insignificant for Gabon. Regarding Cameroon, the coefficient associated with the Brent oil price remains highly significant and positive, while the coefficient for oil production becomes positive and insignificant. Then, both coefficients become insignificant for Congo. The results for the different tests on the residuals support the validity of our results in all cases, except Cameroon (BP-test) and Equatorial Guinea (Jarque-Bera). Since the interpretations of our results for these two countries do not differ from the discussion of the DOLS estimates, this does not seem to invalidate our main conclusions. Finally, controls remain consistent with the expectations, except for Congo for which the nominal exchange rate becomes insignificant.

Table 5. F-Bound Tests

	Cameroon	Chad	Chad (full sample)	Congo	Equatorial Guinea	Gabon
F-Statistics	9.42***	7.65***	3.31*	3.64*	13.00***	5.57***
Finite Sample Size n=80	I(0)			I(1)		
	10%	5%	1%	10%	5%	1%
	2.30	2.67	3.60	3.22	3.70	4.79

Note: F-Statistic indicates the statistic from the F-Bounds Test (null hypothesis of no levels relationship).

Overall, there is strong evidence of a PT effect in Cameroon and Chad and weaker evidence of such effect in Congo and Equatorial Guinea, while there is strong evidence of a DD effect in Equatorial Guinea only. It must be noticed that this result is consistent with the fact that Equatorial Guinea is the most dependent country on oil revenues of our sample. In addition, the results for Cameroon and Congo are in line with Caceres et al. (2012) who find a positive impact of international energy prices with Dynamic OLS and Fully-Modified OLS estimates in these countries and interpret their results as evidence of a pass-through effect. Our results for Gabon are quite unexpected since neither the two variables of interest nor the bilateral exchange rate used as control are significant in any regression, in opposition with Caceres et al. (2012) who find a strongly positive impact of energy prices on inflation in this country. Finally, the results for Chad are also consistent with Kablan and Loening (2012) who find a positive and significant effect of oil price shocks on GDP deflator-based inflation and an insignificant effect of oil production shocks.

Table 6. ARDL Results

	Cameroon	Chad	Chad (full sample)	Congo	Equatorial Guinea	Gabon
brent	0.1326***	0.0821***	0.1463**	0.0545	0.1531*	0.0989
	(0.0431)	(0.0261)	(0.0603)	(0.0766)	(0.0861)	(0.0624)
oil production	0.0718	-0.1191*	0.0006	-0.0766	0.1545*	0.1795
	(0.0857)	(0.0626)	(0.0160)	(0.1324)	(0.0786)	(0.2281)
interest	-0.0884***	-0.0984***	-0.1017***	-0.1422***	-0.1719***	-0.1322***
	(0.0173)	(0.0120)	(0.0250)	(0.0290)	(0.0399)	(0.0280)
nber	0.2140**	0.4950***	0.4016**	-0.0615	0.4493*	0.3807
	(0.0973)	(0.0962)	(0.1748)	(0.2743)	(0.2687)	(0.2323)
constant	2.7859***	2.0924***	1.8479	5.7805***	1.0109	1.3532
	(1.0385)	(0.7095)	(1.2771)	(2.0759)	(1.9750)	(2.6968)
Observations	100	63	100	84	90	100
Selected Model	3, 2, 0, 0, 1	2, 0, 0, 0, 1	3, 0, 2, 3, 0	3, 1, 0, 0, 0	1, 0, 0, 0, 2	1, 0, 2, 0, 4
Jarque-Bera Prob.	0.60	0.83	0.95	0.84	0.00***	0.67
LM Prob	0.64	0.30	0.15	0.51	0.32	0.52
BP Prob	0.00***	0.44	0.32	0.10	0.20	0.54

Note: The number of lags is selected with the Akaike Information Criterion with a maximum of 4 lags. Standard errors are in parentheses. Jarque-Bera indicates the p-value associated with the normality test of Jarque-Bera (null hypothesis of normality of the residuals). LM indicates the p-value associated with the LM-Test for serial correlation (null hypothesis of no serial correlation). BP indicates the p-value associated with the Breusch-Pagan-Godfrey test for heteroskedasticity (null hypothesis of homoskedasticity).

4.4 Robustness Tests

Finally, we proceed to several robustness checks. All results are available in the appendix. First, we implement another empirical strategy, the Fully-Modified Ordinary Least Square, as a complement to DOLS estimates. FMOLS estimates are very close to DOLS ones, with only a positive and significant (at 5%) coefficient for oil production for Chad in full sample and a negative and significant one for oil production in Gabon.

Second, while the Brent crude oil price is the most common in both the DD and PT literature, it is mostly a reference for sweet light crude oil prices. On the opposite, the Dubai crude oil price is a reference for medium sour oil prices, and its tendency has slightly diverged from the Brent one around 2004-2005 and 2011-2014 due to changes in international demand. If our countries are mainly consumers of light oil products and since they tend to export a combination of light and medium crude oil, there is a possibility that the Brent oil price is more suited to capture PT than DD effects. Therefore, we proceed to the same empirical analyses with the Dubai instead of the Brent spot crude oil price. With DOLS, results slightly differ from the baseline analysis only for Chad in full sample where the coefficient for oil production becomes more significant and for Congo where coefficients for oil price and oil production both become less significant. For ARDL, results remain the same for all countries except Equatorial Guinea where only the coefficient for oil production remains significant (at 5%).

Finally, we investigate the possibility of seasonality in our variables that could drive the results. For this, we include seasonal dummies in the baseline regressions. This does not affect the magnitude or the significance of the coefficients. In addition, these dummies are never significant at 5% in any DOLS regression, and significant only for Chad (and to a lesser extent in Congo) for ARDL estimates. Overall, this suggests that seasonality is not a major concern in our sample.

5. Conclusion

There is strong evidence of a pass-through effect in Cameroon, Chad, and Congo and of a Dutch disease in Equatorial Guinea. If we exclude Gabon for which the results are impossible to analyze properly, this has different implications. It appears first that the classical models of DD relying on the assumption that natural resources are fully exported and do not affect domestic prices other than through DD effects is questionable even in low-income countries (particularly for energy products such as oil, gas, or coal) and could mislead DD analyses neglecting this dimension. Similarly, studies investigating the potential pass-through effect from international commodity prices to domestic consumer prices should consider Dutch disease models when focusing on commodity-exporting countries. Finally, even within a monetary area (here the CEMAC) with five net oil-exporting countries, there remains a large heterogeneity across countries in their price dynamics. This heterogeneity can depend on their level of resource production (Cameroon is the lowest oil-producer of the group) or on their history toward resource production (Chad began to produce oil after 2003), but also potentially on different macroeconomic policies (level of taxation, use of public oil revenues, international trade policies, industrialization strategies…). The coefficients for international oil prices and nominal exchange rates also indicate that some countries (particularly Chad and Congo) are highly vulnerable to external shocks and might reveal the obstacles to reaching an optimal monetary zone. This heterogeneity across countries is to be taken seriously by monetary authorities.

6. References

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7. Appendix

Figure A1. Evolution of Oil Production and Brent Oil Price by Country

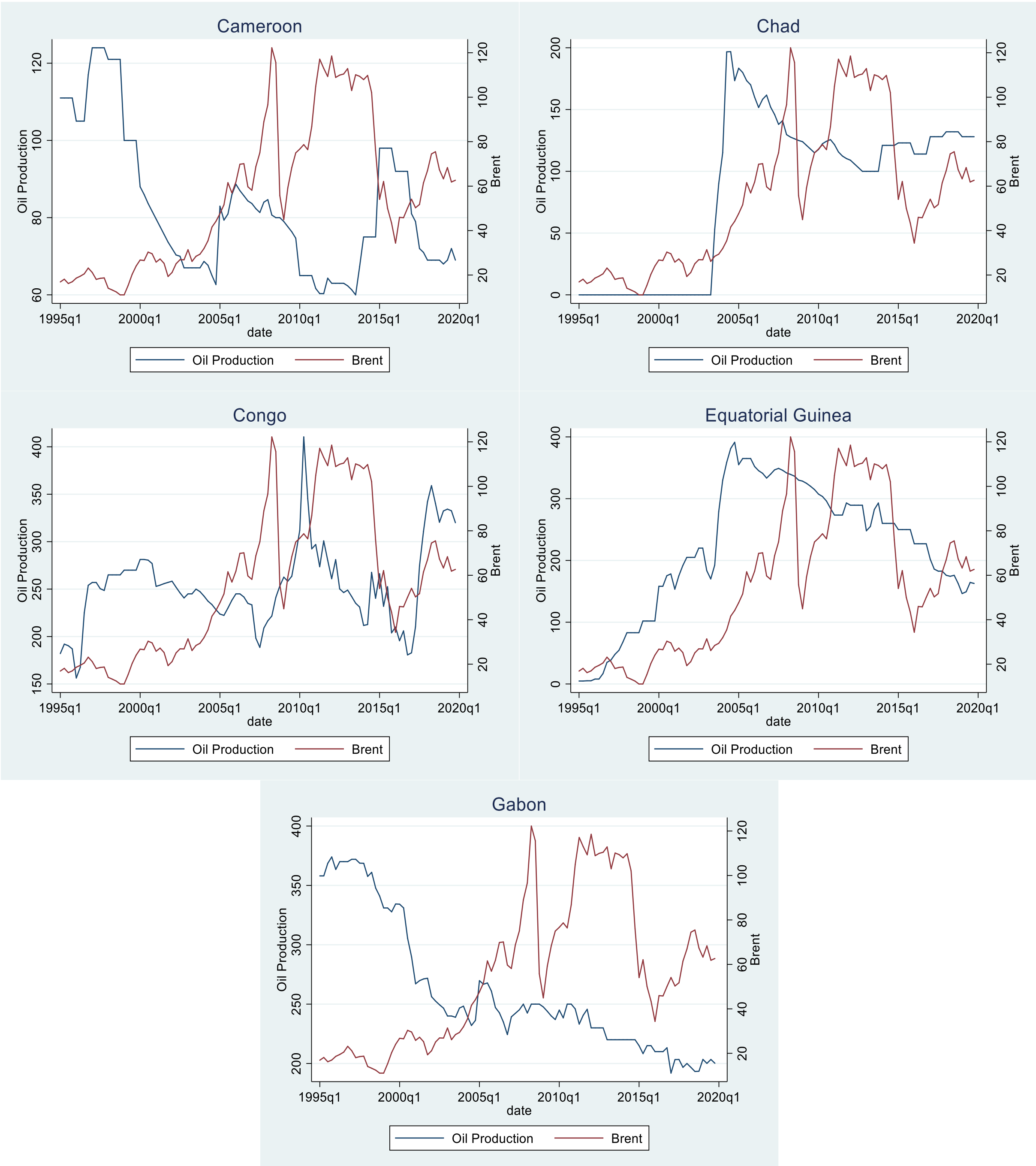

Table A1: FMOLS Results for the baseline specification

	Cameroon	Chad	Chad (full sample)	Congo	Equatorial Guinea	Gabon
brent	0.0469*	0.0815**	0.0648***	0.0479	0.0847**	-0.0291
	(0.0240)	(0.0313)	(0.0233)	(0.0347)	(0.0737)	(0.0312)
oil production	-0.0917*	-0.1270	0.0163**	-0.0750	0.1610**	-0.2168**
	(0.0488)	(0.0760)	(0.0068)	(0.0627)	(0.0711)	(0.1034)
interest	-0.1329***	-0.0917***	-0.1250***	-0.1693***	-0.2467***	-0.1039***
	(0.0091)	(0.0146)	(0.0110)	(0.0123)	(0.0284)	(0.0153)
nber	0.2241***	0.5593***	0.3401***	0.1663	0.3394	0.0169
	(0.0695)	(0.1150)	(0.0761)	(0.1164)	(0.2171)	(0.1035)
constant	3.8566***	1.7104**	2.5680***	4.3711***	2.0734	6.1695***
	(0.6560)	(0.8484)	(0.5406)	(0.8901)	(1.5829)	(1.1278)
Observations	100	63	100	84	90	100
R^2	0.96	0.92	0.93	0.95	0.94	0.94
Jarque-Bera Prob.	0.55	0.83	0.58	0.23	0.83	0.18

Note: The number of lags is selected with the Akaike Information Criterion with a maximum of 4 lags. Standard errors are in parentheses.

Table A2: Unit-Root Tests for the Dubai oil price

Variable		Cameroon		Chad		Congo		Equatorial Guinea		Gabon	
		I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
dubai	ADF	-1.60	-7.58***	-2.57	-6.17***	-2.54	-7.08***	-1.58	-7.28***	-1.60	-7.58***
	PP	-1.55	-7.92***	-2.63*	-6.20***	-2.55	-7.27***	-1.67	-7.58***	-1.55	-7.92***

Note: The number of lags is selected with the Akaike Information Criterion with a maximum of 4 lags.

Table A3. Johansen Co-Integration and F-Bound Tests with the Dubai oil price

	Cameroon		Chad		Chad (full sample)		Congo		Equatorial Guinea		Gabon	
	Trace	F	Trace	F	Trace	F	Trace	F	Trace	F	Trace	F
Statistics	95.35***	9.13***	109.31***	7.41***	79.27**	3.52*	81.97**	3.62*	104.33***	12.74***	80.87**	5.38***
Nb of relations	1		2		1		1		1		1	

Note: Trace indicates the statistic from the unrestricted cointegration rank test. A constant is included. The number of cointegrating relations is decided when considering the rejection of the null hypothesis of at most n equations at the 5% level, based on the Trace Statistics. F-Statistic indicates the statistic from the F-Bounds Test.

Table A4: DOLS Results with the Dubai oil price

	Cameroon	Chad	Chad (full sample)	Congo	Equatorial Guinea	Gabon
dubai	0.0460***	0.1215**	0.0585**	0.0558	0.0834*	0.0004
	(0.0170)	(0.0448)	(0.0263)	(0.0353)	(0.0428)	(0.0246)
oil production	-0.0858**	-0.1318	0.0155**	-0.1337*	0.1453***	-0.0923
	(0.0341)	(0.1247)	(0.0077)	(0.0720)	(0.0367)	(0.0898)
interest	-0.1319***	-0.0575***	-0.1344***	-0.1616***	-0.2337***	-0.1112***
	(0.0055)	(0.0201)	(0.0129)	(0.0123)	(0.0187)	(0.0107)
nber	0.2184***	0.8246***	0.3056***	0.1758	0.1764	0.0611
	(0.0397)	(0.1669)	(0.0872)	(0.1191)	(0.1233)	(0.1066)
constant	3.8707***	-0.2041***	2.8387***	4.5820***	3.1526***	5.1241***
	(0.4274)	(1.1340)	(0.6205)	(0.9049)	(0.8886)	(1.1560)
Observations	100	63	100	84	90	100
R^2	0.99	0.97	0.96	0.98	0.98	0.98
Jarque-Bera Prob.	0.99	0.99	0.82	0.34	0.50	0.33

Note: The number of lags is selected with the Akaike Information Criterion with a maximum of 4 lags. Standard errors are in parentheses.

Table A5: ARDL Results with the Dubai oil price

	Cameroon	Chad	Chad (full sample)	Congo	Equatorial Guinea	Gabon
dubai	0.1437**	0.0766***	0.1379***	0.0590	0.1366	0.0896
	(0.0573)	(0.0254)	(0.0508)	(0.0778)	(0.0888)	(0.0597)
oil production	0.0850	-0.1240*	0.0066	-0.0833	0.1722**	0.1442
	(0.1109)	(0.0627)	(0.0129)	(0.1328)	(0.0816)	(0.2176)
interest	-0.0785***	-0.0958***	-0.0904***	-0.1411***	-0.1717***	-0.1281***
	(0.0242)	(0.0121)	(0.0240)	(0.0301)	(0.0428)	(0.0272)
nber	0.2054*	0.4938***	0.3504**	-0.0484	0.4394	0.3502
	(0.1203)	(0.0980)	(0.1527)	(0.2664)	(0.2843)	(0.2240)
constant	2.7249**	2.1426***	2.1529*	5.7155***	1.0562	1.7655
	(1.3230)	(0.7196)	(1.1107)	(2.0098)	(2.0964)	(2.5703)
Observations	100	63	100	84	90	100
Selected Model	3, 2, 0, 0, 0	2, 0, 0, 0, 1	3, 3, 2, 4, 0	3, 1, 0, 0, 0	1, 0, 0, 0, 2	1, 0, 2, 0, 4
Jarque-Bera Prob.	0.75	0.77	0.97	0.84	0.00***	0.68
LM Prob	0.91	0.33	0.42	0.50	0.31	0.52
BP Prob	0.00***	0.32	0.40	0.12	0.21	0.55

Note: The number of lags is selected with the Akaike Information Criterion with a maximum of 4 lags. Standard errors are in parentheses.

Table A6: DOLS Results with seasonal dummies

	Cameroon	Chad	Chad (full sample)	Congo	Equatorial Guinea	Gabon
brent	0.0498***	0.1190**	0.0611**	0.0925**	0.0956**	-0.0087
	(0.0172)	(0.0455)	(0.0259)	(0.0425)	(0.0438)	(0.0340)
oil production	-0.0770**	-0.0835	0.0173**	-0.1968**	0.1362***	-0.1127
	(0.0341)	(0.1274)	(0.0077)	(0.0869)	(0.0378)	(0.1172)
interest	-0.1315***	-0.0621***	-0.1263***	-0.1599***	-0.2315***	-0.1082***
	(0.0054)	(0.0204)	(0.0125)	(0.0149)	(0.0184)	(0.0117)
nber	0.2213***	0.7358***	0.2895***	0.3287**	0.1934	0.0187
	(0.0393)	(0.1710)	(0.0846)	(0.1373)	(0.1242)	(0.1558)
constant	3.7975***	0.1424	2.8904***	3.8036***	3.0290***	5.5280***
	(0.4249)	(1.1126)	(0.6014)	(1.0404)	(0.8938)	(1.6692)
Q1	-0.0003	-0.0199	-0.0159	0.0007	0.0107	-0.0024
	(0.0068)	(0.0179)	(0.0198)	(0.0185)	(0.0272)	(0.0137)
Q2	-0.0042	-0.0002	0.0123	-0.0114	0.0075	-0.0035
	(0.0078)	(0.0202)	(0.0214)	(0.0202)	(0.0301)	(0.0151)
Q3	-0.0018	0.0328*	0.0318	-0.0095	0.0049	0.0013
	(0.0068)	(0.0186)	(0.0202)	(0.0200)	(0.0274)	(0.0131)
Observations	100	63	100	84	90	100
R^2	0.99	0.98	0.97	0.99	0.98	0.98
Jarque-Bera Prob.	0.91	0.64	0.52	0.08*	0.45	0.43

Note: The number of lags is selected with the Akaike Information Criterion with a maximum of 4 lags. Standard errors are in parentheses.

Table A7: ARDL Results with seasonal dummies

	Cameroon	Chad	Chad (full sample)	Congo	Equatorial Guinea	Gabon
brent	0.1338***	0.0678**	0.1047***	0.0669	0.1746*	0.0922
	(0.0460)	(0.0319)	(0.0389)	(0.0629)	(0.0885)	(0.0625)
oil production	0.0708	-0.1439*	0.0077	-0.0546	0.1420*	0.1643
	(0.0906)	(0.0770)	(0.0104)	(0.1076)	(0.0774)	(0.2317)
interest	-0.0853***	-0.0954***	-0.1164***	-0.1488***	-0.1661***	-0.1326***
	(0.0192)	(0.0148)	(0.0162)	(0.0216)	(0.0408)	(0.0290)
nber	0.2011*	0.4403***	0.3282***	0.0373	0.4853*	0.3607
	(0.1021)	(0.1169)	(0.1255)	(0.2010)	(0.2706)	(0.2346)
constant	2.8502**	2.5642***	2.3611**	5.0811***	0.7108	1.5664
	(1.0901)	(0.8619)	(0.9109)	(1.5398)	(1.9986)	(2.7283)
Q1	-0.0018	0.0163	0.0213**	-0.0080*	0.0087**	0.0001
	(0.0021)	(0.0111)	(0.0098)	(0.0046)	(0.0037)	(0.0031)
Q2	0.0019	0.0358***	0.0591***	-0.0228***	-0.0008	0.0050
	(0.0022)	(0.0107)	(0.0096)	(0.0046)	(0.0037)	(0.0031)
Q3	0.0029	0.0391***	0.0541***	-0.0075	0.0010	0.0044
	(0.0022)	(0.0097)	(0.0081)	(0.0046)	(0.0036)	(0.0031)
Observations	100	63	100	84	90	100
Selected Model	3, 2, 0, 0, 1	2, 0, 0, 0, 0	2, 0, 0, 4, 0	1, 0, 0, 0, 0	1, 0, 0, 0, 2	1, 0, 2, 0, 4
Jarque-Bera Prob.	0.33	0.45	0.81	0.85	0.00***	0.51
LM Prob	0.46	0.75	0.21	0.30	0.40	0.58
BP Prob	0.00***	0.36	0.12	0.35	0.53	0.71

Note: The number of lags is selected with the Akaike Information Criterion with a maximum of 4 lags. Standard errors are in parentheses.