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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 the Republic of 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 by 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, 2022). However, the discussions based on the model of Corden-Neary have neglected some key dimensions, notably regarding its 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, which is precisely the assumption we intend to discuss here. 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 exogenous, being determined by variations of the Euro against these other 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, Chad and the Republic Congo and mixed evidence of such an effect in Equatorial Guinea. They also suggest a Dutch Disease effect in Equatorial Guinea and, to a lesser extent, in Chad. Results remain inconclusive for Gabon. These results notably call for more interactions between two strands of the economic literature that are the DD and the PT literature, and which have very often neglected each other.

This article contributes to different strands of the economic literature on several points. First, it contributes to the empirical Dutch disease literature by questioning one key assumption of theoretical models (natural resources are fully exported). This point matters for the understanding of the Dutch disease effects since this assumption is rarely discussed in empirical

[1] https://oec.world

analyses. This article also contributes to the DD literature by focusing on inflation, and therefore on the impact of natural resources on households that do not directly benefit from these revenues, rather than on firms' competitiveness. Indeed, the DD is often perceived as being only negative for external competitiveness (due to real exchange rate appreciation caused either by nominal exchange rate appreciation or by domestic inflation), while the inflation effect caused by the increase in spending from agents benefiting from the resource boom might also have a negative impact on the real wages of agents that do not benefit from it. This article also contributes to the literature by linking the DD and the PT literature, two strands of economic research that rarely interact with each other. Finally, it provides a better understanding of the determinants of inflation in CEMAC countries, a region that has often been neglected in empirical studies. On this point, it is noticeable that, at the time of discussion about the suppression of the Western CFA Franc, the understanding of inflation dynamics in oil-exporting countries of the Central CFA Franc area can also be of major interest for recent or future oil-producers in the West African Economic and Monetary Union (WAEMU) such as Senegal.

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 describes the history and dynamics of the oil sector in the countries of interest. Section 5 presents the empirical methodology and the results. Section 6 concludes.

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 <u>The Pass-Through from Oil Prices to the Domestic Consumer Price Index</u>

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. This is notably relevant for energy products that can be used for cooking, lighting, heating or transportation. Second, if the resource is used as an input in the production of other goods or services, a price increase will raise the price of the final product or reduce its producer's profit (or more likely a combination of both). This includes energy products but also metals and minerals that can be used to produce manufactured goods or artificial fertilizers used in agriculture. 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.

The empirical literature on the pass-through from international commodity prices on domestic inflation in commodity consuming countries dates back at least 40 years, usually associated with Hamilton (1983). In this study, the author investigates the impact of international crude oil prices on different macroeconomic indicators in the United States, including notably inflation, economic growth or unemployment. Since then, various studies have tried to verify or falsify this PT effect in the USA or in other industrialized economies. However, due to a frequent lack of data availability, it is only recently that empirical studies have started to focus on developing and emerging economies. For instance, 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 Autoregressive 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 oil prices, Lacheheb and Sirag (2019) assess the effects of oil price changes on inflation in Algeria between 1970 and 2014. Using a nonlinear ARDL (NARDL) approach, they conclude to a significantly positive impact of positive oil price in inflation shocks but to an insignificant effect for negative shocks, and explain this heterogeneous impact by the existence of fuel subsidies. Similarly, Nusair (2019) apply multiple NARDL models to the six countries of the Gulf Cooperation Council (Bahrain, Saudi Arabia, Kuwait, Qatar, Oman and the United Arab Emirates) between the 1970s and 2016. They conclude to a long-run positive impact of oil price shocks on inflation in all countries, but to a positive and significant impact of negative shocks only in Oman. Finally, 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. Raheem et al. (2020) investigate the dynamics of inflation in a panel of 10 net oil exporting and 10 net oil importing countries between 1986 and 2017. They conclude to a positive correlation between international oil prices and domestic inflation but with heterogeneous impact between the two groups of countries. Overall, this empirical literature clearly suggests that PT effects occur both in exporting and in importing countries, even if such effects can be partly balanced by specific policy measures (such as price controls or energy subsidy).

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. We can also mention Lacheheb and Sirag (2019) or Nusair (2019) who do not mention the DD when observing an asymmetric effect of oil prices on inflation in oil exporting countries (asymmetric effect that could be attributed to an asymmetry in public or private spending) but prefer to explain this heterogeneity by domestic subsidies.

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 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 exogenous 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. Therefore, the lack of interaction between the DD literature that focuses on the demand side and the PT literature focusing on the supply side might lead researchers and policymakers to wrongly conclude to DD or to PT effects when observing a correlation between the dynamics in international markets and domestic inflation in countries that are both consumers and net-exporters of natural resources. In this article, we argue that any complete model should consider both interpretations. We therefore aim 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. Our focus on the oil sector is motivated by the fact hydrocarbons often provide large revenues in countries endowed with this resource and because petroleum products are often used by households or firms as a source of energy (contrary to luxury goods such as gold or diamonds for instance). Hence, it is likely to give birth to both DD and PT effects.

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:

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

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

$$P_E = P_E^* * N$$

[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.

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

On the other side, $P_N = f(total\ income, factors\ of\ production\ costs)$ 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.

- *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 hence depends on the capacity of non-tradable sectors to adjust their production to the rise in domestic demand: there is either a double decline in tradable outputs, no decline in non-tradable outputs and inflation if non-tradable sectors can perfectly adjust their production, or a simple decline in tradable outputs, a similar decline in non-tradable outputs and no inflationary pressure if non-tradable sectors cannot adjust their production. More likely, there will be a combination of a decline in non-tradable outputs and of inflation if non-tradable sectors can only imperfectly adjust their production. This situation will occur if for instance labor is imperfectly mobile across sectors due to different requirements in skills across sectors. On this point, we can highlight that non-resource sectors include very different types of activities (usually manufacture and export-oriented agriculture for tradables; services, construction and domestic-oriented agriculture for non-tradables) that may require different types of labor, justifying this assumption.

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:

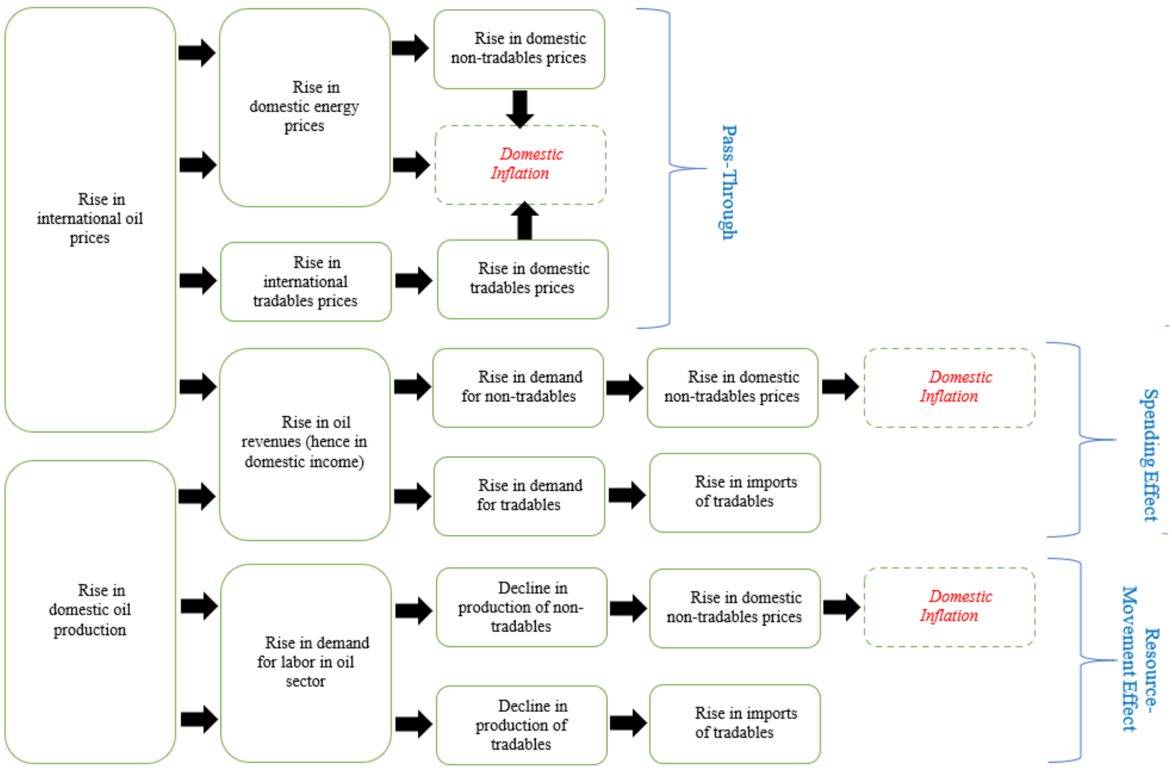
Assumption 1: For a given level of oil prices, a rise in production leads only to Spending and Resource-Movement (hence Dutch disease) effects

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

In addition to the small open economy assumption and the “full export of resources” assumption discussed in this paper, one must highlight that the resource-movement effect requires two other assumptions: mobility of labor across sectors (even if imperfect) and immobility of labor across countries. If the former assumption tends to hold in most cases, the latter one is more debatable. Indeed, one can suggest that international migrations from neighboring countries to resource-rich countries can contribute to increase production in resource and non-resource sectors and contribute to preventing price increase. This explains why empirical studies have often neglected the resource-movement effect. However, we consider that this effect should not be neglected for several reasons. First, the oil extraction sector tends to require skilled formal labor while migrants often work in informal sectors. Second, migrations as a response for the need to production adjustment are likely to occur in the medium- or long-run whereas our analysis relies on quarterly data. Finally, migrations can reduce the resource-movement effect, but they seem unlikely to perfectly negate it. Since we primarily focus on the opposition between DD and PT, and since DD can be caused by the spending effect alone, our analysis remains applicable even if resource-movement effects are reduced.

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



Source: Authors

4. Presentation of the Five CEMAC Oil-Exporting Countries

We apply the previous framework to the five net-oil exporting countries belonging to the Central African Economic and Monetary Community (CEMAC): Cameroon, Chad, the Republic of Congo, Equatorial Guinea, and Gabon. The CEMAC is a monetary and trade area between six countries (the five mentioned above and the Central African Republic which is excluded from this study, being not an oil producer). The six countries share a common currency -the XAF CFA Franc- pegged with the Euro at a level of 1 Euro = 655.957 CFA Francs, and a common Central Bank -the BEAC-. The only devaluation of the currency occurred in 1994, justifying the assumption that nominal exchange rate variations with the US Dollar are exogenous over the period 1995-2019. Since the countries are engaged in a monetary union with a common central bank, we can consider that monetary policies are homogeneous within the zone. Thus, heterogeneity in inflation dynamics can be attributed to differences in the oil sectors, in the use of oil revenues, in other macroeconomic indicators (economic structure, fiscal policy, trade policy…) or in the quality of institutions. In this section, we present the oil sector of the five countries of interest and provide an overview of their macroeconomic and institutional frameworks. Oil production trends for each country are also presented in Figure A1 in the Appendix.

4.1 Oil Production in the CEMAC

Oil production began in Cameroon in 1977, five years after the first oil discoveries in the Rio del Rey basin. To manage oil revenues, in 1980 was created the *Société Nationale des Hydrocarbures* (SNH), a publicly funded organization which primary goals are to monitor the activities of firms exploiting hydrocarbon fields and to sell on domestic and international markets the share of oil production reserved for the State. Oil revenues then increased until the peak of 1985 (when total oil production amounted to 186,000 barrels per day), and suddenly dropped after international prices fell, leading to ten years of negative economic growth. Since the middle of the 1990s, economic growth has progressively recovered but oil production has varied between 60,000 and 120,000 barrels per day with a long-run declining trend attributable to the exhaustion of known reserves and the progressive wear of infrastructures. Today, oil production is mainly offshore and regrouped around the Rio del Rey and the Douala and Kribi-

Campo areas. In 2019, oil rents represented less than 3% of GDP but around a third of the country's total exports[4] and more than 15% of government revenues. The only oil refinery is located in Limbe and is publicly managed (through the *Société Nationale de Raffinage* - SONARA) but appears to be largely under-exploited in comparison with Cameroon oil extraction capacities. Cameroon has joined the Extractive Industries Transparency Initiative (EITI) in 2007 and has been a member since then (for oil, gas and mining resources). According to a report from the Natural Resource Governance Institute (NRGI, 2019), Cameroon achieves the highest score in resource revenues management among 31 Sub-Saharan African countries assessed (based on budget transparency, fiscal rules, subnational revenue sharing mechanisms and sovereign wealth funds).

The presence of oil resources in Chad have been known since 1992. However, due to difficulties to access international sources of financing and to the necessity to negotiate with the neighboring Cameroon for the construction of a pipeline from Chadian oil fields to the harbor of Kribi, it is only in 2003 that oil extraction began in Komé, Miandoum and Bolobo. Oil production then sharply increased, reaching a peak of 200,000 barrels per day in 2004, representing one third of total GDP. Oil production then before progressively decreased and finally stabilized between 100,000 and 130,000 barrels during the 2010s. Oil resources are exploited by foreign firms and contribute to the Chadian government budget mainly through royalties and taxation. In 2019, oil revenues represented 18% of GDP but almost 75% of total exports, making the country highly vulnerable to international shocks on the oil market. Chad has joined the EITI in 2010 (for oil and mining).

The field of Pointe Indienne was the first oil field in the Republic of Congo, since its exploitation started in 1957. Oil production then rose during the following decades but experienced some turmoil, particularly during the 1990s due to several violent conflicts (notably in 1993, 1997 and 1999). It is only with the return of a relative political stability after 1999 that the economy started to recover. It is also at this period (in 1998) that the government created the *Société Nationale des Pétroles du Congo* (SNPC). The SNPC oversees the exploration of potential fields, of oil extraction (in joint-venture with private firms) and of oil refinery in the site of Pointe-Noire. Regarding oil production, it has varied between 200,000 and 400,000 barrels per day between 1999 and 2019 with a peak around 2010-2011 when oil revenues represented more than half of total GDP. Contrary to Cameroon, various oil reserves

[4] Oil rents in GDP data are from the World Development Indicators and oil exports are from the Observatory of Economic Complexity.

have been discovered in the last decades, compensating for the depletion of old fields. In 2019, oil rents represented 43% of total GDP and 60% of its exports, the Republic of Congo being the fifth largest crude petroleum oil exporter in Africa (after Nigeria, Angola, Libya and Algeria) and the first in Central Africa. Like Cameroon, the Republic of Congo has been a member of the EITI since 2007.

Oil exploitation began in the early 1990s in Equatorial Guinea with the discovery of an offshore field close to the island of Bioko. However, production remained below 20,000 barrels per day until 1996, and it is only during the second half of the 1990s that the oil sector really expanded, reaching a daily production of 200,000 barrels in 2001 and 400,000 in 2004. This sudden surge in oil production contributed to the country's high economic growth, and encouraged public authorities to implement a Sovereign Wealth Fund (the Fund for Future Generations) in 2002. However, this SWF has been criticized for a lack of transparency and for the poor quality of its governance, being ranked 31st among 33 SWF assessed in the world by the NRGI, with a score of 7/100 (NRGI, 2019). Oil production started to decrease after 2005 and stabilized around 160,000 barrels at the end of the 2010s. Even if oil production remains lower than in Gabon and approximately half than of Congo, the smaller size of Equatorial Guinea (less than 1.5 million inhabitants) makes it highly dependent towards oil revenues, which represent more than 20% of GDP and more than 70% of exports in 2019. Equatorial Guinea joined the EITI in 2008 but, contrary to the previous countries, it left the initiative in 2010 due to a lack of transparency in the information provided. Equatorial Guinea is ranked last in the zone and second last in Sub-Saharan Africa (just above Eritrea) for its resource revenues management (NRGI, 2019).

The history of oil is quite old in Gabon since the first fields were identified during the colonization era, while exploitation began in the 1950s and rapidly expanded until representing half of Gabonese GDP at the end of the 1970s. However, as in many neighboring countries, oil revenues have been highly volatile due to international oil price variations, which encouraged authorities to implement a Fund for Future Generations in 1998. Oil production has been following a clearly declining trend since the beginning of the 2000s, mostly attributable to the exhaustion of known reserves, from 340,000 barrels per day in 2000 to 200,000 at the end of 2010s. Yet, oil revenues still represent 20% of GDP and two thirds of exports. Gabon has also an oil refinery based in Port Gentil, but with much lower refining capacities than other countries of the zone (0.5 million of tons per year compared to 1Mt/year for Chad and Congo and more than 2Mt/year in Cameroon[5]). Gabon joined the EITI in 2007, but was delisted in 2013 and re-joined in 2021 (for oil, gas and mining).

4.2 *Fossil Fuel Subsidies in the CEMAC*

Subsidies are quite common in developing countries, and might explain why international price shocks do not translate into domestic inflation through a PT effect. On this point, accurate and reliable data are much more difficult to obtain, particularly for long periods. However, the OECD and the International Institute for Sustainable Development (IISD)[6] provide annual estimates for fossil fuel subsidies between 2010 and 2019. They indicate very low levels of subsidies on refined petroleum products for Cameroon, Chad and the Republic of Congo (below 1 USD per capita per year on average over this period) but much higher for Equatorial Guinea (14 USD per capita on average with a peak at 48 USD in 2018) and Gabon (35 USD per capita on average with a peak at 77 USD in 2014). Even if such data must be interpreted cautiously, they overall suggest that we are less likely to observe any PT effect in Gabon, and to a lesser extent in Equatorial Guinea, due to higher state intervention.

4.3 *Macroeconomic Indicators, Policy and Institutions*

In all countries, the non-resource economy is largely dominated by non-tradable activities, which is a crucial element since the resource-movement and spending effects tend to generate inflation through their impact on demand for non-tradable products. For instance, services represent on average for than half of non-mining outputs over the period in every country (from 50% in Chad to almost 75% in Gabon)[7]. On the contrary, manufacturing activities represent less than 15% of non-resource sectors, except in Equatorial Guinea where the manufacturing sector amounts at almost 30%, but is mainly dominated by hydrocarbon transformation activities (notably gas liquefaction), making it even more dependent on oil and gas markets. Finally, Chad is the country where agriculture represents the highest share of the economy (around one third on average over the period).

Fiscal policy can also play a role in preventing or encouraging DD. As presented in section 4, both public and private spending can generate DD effects. However, public

[5] https://www.euro-petrole.com/re_06_geolocalisation_sites_petroliers.php
[6] Data are available at https://fossilfuelsubsidytracker.org/
[7] Data are from the United Nations Statistics Division.

expenditures are often considered are biased towards non-tradable products (services or infrastructure) than private ones, making them more likely to have inflationary effects. Between 1995 and 2019, the share of government expenditures was lower in Cameroon and Chad (17% of GDP on average) than in Equatorial Guinea (23%), Gabon (24%) and Congo (28%)[8]. This can be explained by the lower size of oil revenues in Cameroon, and by the less effective fiscal capacity in Chad. These first numbers suggest that we are more likely to observe a DD in Congo, Equatorial Guinea and Gabon.

However, the quality and efficiency of public expenditures also matters, which depends on the institutional framework. On this point, all countries clearly underperform in comparison with the rest of the world. Indeed, the Polity IV index classifies all these countries among the category of "Closed Anocracies" (score between -5 and 0 on the scale ranging from -10 to 10), except Gabon (no data). Similarly, every country ranks for each year in the bottom half (and most of the time in the bottom quarter) in each of the six Worldwide Governance Indicator provided by the World Bank ("Control of Corruption", "Government Effectiveness", Political Stability and Absence of Violence/Terrorism", "Regulatory Quality", "Rule of Law" and "Voice and Accountability"), although Cameroon and Gabon tend to score slightly better than the three other countries. If we consider that mismanagement of oil revenues is likely to encourage the development of a DD, Equatorial Guinea appears as the most vulnerable country of the zone, while Cameroon is the least likely to suffer from such DD effects.

Finally, we can also give a look at trade statistics. Here, we can distinguish Cameroon where exports have been stable between 20 and 27% of domestic GDP; Chad where exports shifted from less than 15% of GDP before the beginning of oil production (in 2002) to a range comprised between 25% and 50% of GDP after 2003; and Congo, Equatorial Guinea and Gabon where total exports were not only higher but also much more volatile over time, ranging between 40% and 90% of their respective GDP over the period. In all countries however, exports have been largely dominated by crude oil, with a distinction between Cameroon (approximately one third of total exports) and the rest of the zone (between 60% and 80% of total exports). If exports can explain the presence of absence of a DD, the importance of imports might play a role in explaining the magnitude of PT effects. Indeed, we have seen in the previous subsection that both Equatorial Guinea and Gabon have implemented fossil fuel subsidies to limit inflation. However, such public subsidies might be insufficient to prevent

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[8] Data are from the World Economic Outlook of the IMF.

imported inflation caused by the increase in production costs of imported non-energy products. It is thus likely that a high reliance on imports might counterbalance the effect of fuel subsidies. Cameroon and Gabon appear to be less dependent than other countries on foreign markets, total imports fluctuating between 20% and 35% of domestic GDP in both countries over the period[9]. On the contrary, Chad and Equatorial Guinea are much more reliant on imports, ranging on average from 35% to 50% of GDP (apart from a peak above 100% of GDP in Chad in 2002 due to the need of investments for the beginning of oil production). Finally, imports represent more than 40% of Congolese GDP in each period, with large fluctuations and peaks above 80% in 2007 and 2016, making this country the less able to prevent imported inflation. Overall, it appears that Gabon is less exposed to PT effects than other countries, due to its large level of public subsidy and its lower vulnerability towards imported inflation. On the opposite, the Republic of Congo and Chad are more prone to PT effects due to their smaller level of fossil fuel subsidy and their large dependency towards imports.

5. Empirical Analysis

5.1 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 average number of barrels produced daily and comes from the 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[10].

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

[9] Data are from the World Development Indicators of the World Bank.

[10] 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).

	Std. Dev.	33	25	31	32	33		
Oil Production	Mean	83	130	258	242	261	Thousand 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 Figure A1 in the appendix. They reveal a large heterogeneity in oil production patterns across countries, motivating the use of multiple time-series rather than panel data. Figure A1 also suggests that oil production dynamics do not directly follow international price variations react mainly to oil fields discoveries and/or exhaustion of known reserves.

5.2 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.

5.3 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 than the coefficient for oil prices) 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. The absence of any significant impact of oil prices on inflation in Gabon is also in line with the fact that this country has the highest level of fossil fuels subsidies of the zone (at least at the end of the period of interest). 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).

5.4 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, which is a commonly used non-parametric alternative to DOLS estimates. FMOLS estimates are very close to DOLS ones, with only a positive significant (at 5%) coefficient for oil production for Chad in full sample and a negative 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 concern here.

6. Conclusion

There is 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 seem impossible to analyze properly, the implications of these results are threefold.

First, it appears that the classical assumption of DD models that natural resources are fully exported and do not affect domestic prices other than through spending or resource-movement effects is debatable even in low-income countries. This remark is particularly true for energy products such as oil, gas or coal. We argue here that the key underlying assumptions of theoretical models must be questioned before proceeding to empirical analyses and case-studies, which is rarely done in the DD literature.

Then, the results suggest that empirical analyses could wrongly conclude to DD effects when interpreting a positive correlation between international resource prices or resource revenues (that can be caused by either prices or production) and domestic inflation if they do not consider the simpler explanation of a PT effect. Reciprocally, studies investigating a potential PT from international commodity prices to domestic consumer prices should consider DD models when focusing on commodity-exporting countries. This is a crucial point for economic research but also, and perhaps more importantly, for policymakers in resource rich countries. Indeed, the understanding of the causes of inflation remains fundamental for policy trying to address this issue. Based on this observation, we therefore advocate for more interactions between these two strands of economic literature.

Finally, we observed that, even within a monetary area (here the CEMAC) with five net oil-exporting countries, the heterogeneity in inflation dynamics across countries remains large. 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 due to their economic structure and might reveal the obstacles to reaching an optimal monetary zone. This heterogeneity across countries is to be taken seriously by monetary authorities.

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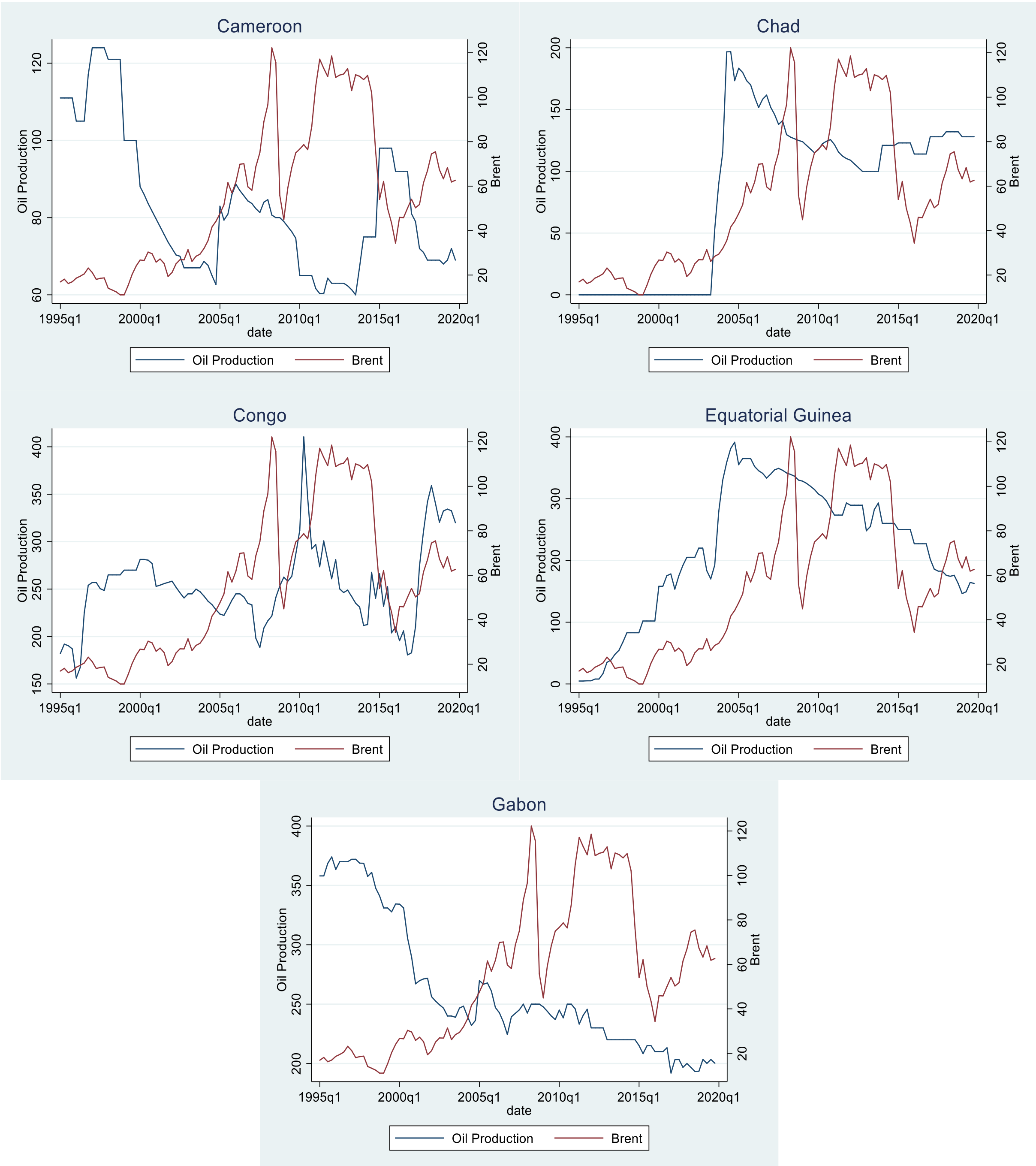
8. Appendix

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



Note: Oil Production is expressed in thousand barrels per day (source: EIA) and Brent crude oil price is expressed in international USD per barrel (source: IMF).

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.