THE DYNAMICS OF THE REAL PURCHASING POWER OF ALGERIA'S OIL REVENUES•

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Abstract

This paper seeks to evaluate the impact of Algeria's international trade structure, characterized by a strong asymmetry between exports denominated almost exclusively in US dollars and imports invoiced in alternative currencies, on the real purchasing power of this country's oil revenues.Using a 1970-2013 dataset, we construct, and adjust these revenues by means of, two indices. The first index captures the fluctuations in the value of the US dollar against a basket of currencies of Algeria's main import partners.The second accounts for changes in the inflation passed through imports from these partners. We find a persistent loss in the real purchasing power of Algeria's oil revenues, that however decreased, up to the late 1990s and then, thanks to a relatively stable imported inflation, turned into a gain after the year 2000. Besides allowing us to disentangle the effects of the US dollar fluctuations and the world inflation on the dynamics of the real purchasing power of Algeria's oil revenues, our analysis cast some light on the genuine role oil resources have played in the development of this country's economy over the last four decades.

Keywords: Algeria, Oil revenues, Real purchasing power, Dollar exchange rate, Importedinflation.
J**EL-codes:**O13, O55, Q32, Q43.

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Introduction

A distinctive feature of the structure of Algeria's foreign trade is that this country gets its revenuesmostly from oil exports and in USdollarswhereas it predominantly uses different currencies to import goods and services from various countries. As a result,Algeria's oil income may be affected by fluctuations in both the value of the US dollar against the currencies of its main non-dollar area import partners and in the prices of imported goods and services. This paper seeks to analyze Algeria's oil export revenues over the 1970-2013 period accounting for depreciation (appreciation) of the US dollar and imported inflation (deflation) for the purpose of tracking the dynamics of the "real" purchasing power of these revenues.

Historically, the US dollar has been the dominant currency used in international exchanges and the main currency reserve of governments. The Bretton Woods international monetary agreement of 1944 formalized the role of the US dollar by making nations set the official exchange rateof their currencies against the dollar and the United States commit to exchange dollars for gold at a fixed rate.With the expansion of capital flows denominated in US dollarsaround the worldduring the 1950s, gold backing of the dollar became increasingly unsustainable. By 1973, the Bretton Woods system collapsed and the US dollar began a long lasting depreciation.

Concerned with this depreciation of the US dollar that eroded the purchasing power of their oil revenues, Member Countries of the Organization of the PetroleumExporting Countries (OPEC) started in the 1970sto consider a shift from the dollar to a basket of currencies as the basis for determining the priceof crude oil.[1] The objective of this move by the OPEC countries was to protect their economies from the detrimental effects of an increasingly weak USdollar and a downward pressure on the oil price, which has been since steadily decreasing.

[1]The OPEC was established in Baghdad in 1960 by Iran, Iraq, Kuwait, Saudi Arabia, and Venezuela. Algeria joined this cartel in 1969. Today, OPEC comprises 12 members including, in addition to the above-cited countries, Angola, Ecuador, Libya, Nigeria, Qatar, and the United Arab Emirates.

In 1972, OPEC Member Countries agreed with the thenmajor international oil companies, the so-called"Seven Sisters,"to establish the *Geneva I*basket of currencies to be used in the calculation of an adjustment index of posted crude oil prices.[2] This index was based on the arithmetic average of the deviations of the exchange rates of the currencies of nine major OPEC countries' import partners against the US dollar.[3]In 1978, the *Geneva I* agreement was modified to incorporate an import-weighted average index that takes into account both exchange rates fluctuations and world inflation. Currently, the OPEC basket of currencies includes the US dollar, the Euro, the Japanese Yen, the UK Pound Sterling, and the Swiss Franc and uses the modified *Geneva I* methodology that, as mentioned, also accounts for world inflationpassed through imports.

When it comes to examining the impact of oil price fluctuations on the purchasing power of Algeria's oil revenues, two effects are at work. First, anincrease (decrease) of oil price obviously increases (decreases) these revenues in nominal terms. Second, this increase (decrease) in oil price clearly affects to some extent world inflation. Indeed, oil is widely considered as an important factor of production and, as such,an increase (a decrease) in its price should increase (decrease) the production cost of goods and services, in particular, ofthose imported by Algeria. Hence, in the same vein as the fluctuations of the US dollar exchange rate, world imported inflation (deflation)should affect the real purchasing power of Algeria's oil revenues.[4]

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[2] The Seven Sisters dominated the global petroleum industry from the mid-1940s to the 1970s controlling more than 85% of the world's oil reserves prior to the 1973 oil crisis. This group of companies comprised the Anglo-Persian Oil Company, nowBritish Petroleum, Gulf Oil, Standard Oil of California (SoCal), Texaco, now Chevron, Royal Dutch Shell, Standard Oil of New Jersey (Esso), and the Standard Oil Company of New York (Socony), now ExxonMobil. In recent decades, however, the dominance of these companies has declined following the increasing influence of the OPEC cartel and state-owned oil companies in emerging economies.

[3] The currencies included in the *Geneva I* agreementwere the Belgian, French, and Swiss Francs, the German Mark, the Italian Lira, the Japanese Yen, the Dutch Gulden, the Swedish Krone, and the UK Pound Sterling.

[4]Note that imported world inflation may also generate domestic inflation in oil-exporting countries and this local inflation should therefore be accounted for in an

Algeria is among the top three oil producers in Africa and the top ten net oil exporters in the world.[5]It began oil production in 1958 while still a French colony and joined the OPEC cartel in 1969 as an independent country. The oil sector is the backbone of its economy. In 2013, this sector represented the primary source of income accounting for about 35% of the Gross Domestic Product, more than 98% of export earnings, and about 60% of the total budget revenues.[6]Over the 1970-2013 period, European countries have been Algeria's main suppliers of consumption and investment goods (about 70%), followed by Asian and North American countries (about 13%).

A strong characteristic that shows in the trade pattern of Algeriais that while the largest part of this country's income stems from oil exports, and hence is denominated in US dollars, ano less large part of its imports comes from a non-dollar zone, most importantly from the Eurozone, which is, incidentally, also an intensive oil-importing zone. This suggests that exploring the dynamics of the real purchasing power of Algeria's oil revenues necessitates adjusting the nominal value of these revenues for both world inflation (deflation) and the dollar depreciation (appreciation).

This paper provides an exploratory study of the impact of thesharp asymmetry of the international trade structure of Algeria, namely, exportsdenominated almost exclusively in US dollars and imports in other currencies, essentially euros, on the real purchasing power of this country's oil revenues. By analyzing the dynamics of these revenues from 1970 up to 2013, this paper provides us with some indications on the genuine role that oil resources have played in the development of Algeria during the last four decades.

This paper is organized as follows. The next section describes the data analyzed and the procedure used to construct the currency basket of Algeria's main import partners. Section 3 gives an account of the empirical methodology for calculating the exchange rate and imported inflation indices used to assess the real purchasing power of Algeria's

examination of a more global purchasing power of oil exports revenues, an objective which is beyond the scope of this paper.

[5]See the website of the US Energy Information Administration the link of which is given in the references.

[6]International Monetary Fund (2013).

oil revenues. Section 4 reports our empiricalresults and section 5 concludes. The appendix contains some complementary material.

1. Data

The main challenge we faced in terms of data gathering was to locate a unique source that would allow us to circumvent data compatibility problems often faced by researchers seeking to build a comprehensive database. However, after a preliminary investigation, we realized thatwe had to rely on multiple sources to obtain raw data and then construct the variables we needed to perform our analysis. The 1970-2013 time series needed include revenues from Algeria's oil exports, nominal values of Algeria's imports from its main partners, exchange rates of the US dollar against these partners' currencies, and the levels of these partners' CPIs. In addition, some causality tests that we performed required data on oil prices and the US dollar effective exchange rate against the US main trade partners' currencies.

The bulk of the data were obtained from the Algerian Office National des Statistiques (ONS), the International Monetary Fund (IMF), the US Energy Information Administration (EIA), the Organization of Economic Cooperation and Development (OECD), Darvas (2014), and the United Nations (UN). More details on these sources of raw data and on the way we constructed our variables are given in the appendix. In the sequel of this section, we describe the procedure used to construct the basket of Algeria's main import partnersfrom which we build our exchange rate and imported inflation indices, and briefly point to some important properties of the data.

The currency basket used in the calculation of the indices is designed so as to account for the dynamics of Algeria's imports. Figure 1 below depicts the evolution of Algeria's total imports from 1970 to 2013. This figure clearly shows that Algeria's imports have experienced three distinct periods;a steady increase from the early 1970s to the early 1980s, a period of relative stabilization from the early 1980s up to the late 1990s, and a sharp increase thereafter.Indeed, during the 1970-1989 period, imports have increased at an average annual rate of 13.48% from 1.26 billion US dollars in 1970 to 9.19 billion US dollars in 1989. During the 1990-2000 period, imports increased annually by an average rate of 9.09%

whereas starting 2001 this rate jumped substantially reaching the peaks of 35.12% in 2004 and 42.86% in 2008.

This upward trend in imports over the four decades covered by our analysis may be explained by a growing domestic demand sustained by increasing public spending in infrastructure projects and a steadily declining domestic manufacturing sector since the 1980s despite the launching of a privatization process in the 1990s and a liberalization process accompanied by a series of reformsaimed at attracting foreign direct investment.[7]Moreover, the favorable conditions in world oil markets in recent years fostered the mono-export-multi-import structure of Algeria's trade. High oil prices have generated important income accumulation that directly served to strengthen public spending through vast national public investment programs and, therefore, increase domestic demand and by the same token the import bill.

Figure N°1**: Algeria's total import 1970-2013 (USD billions)**

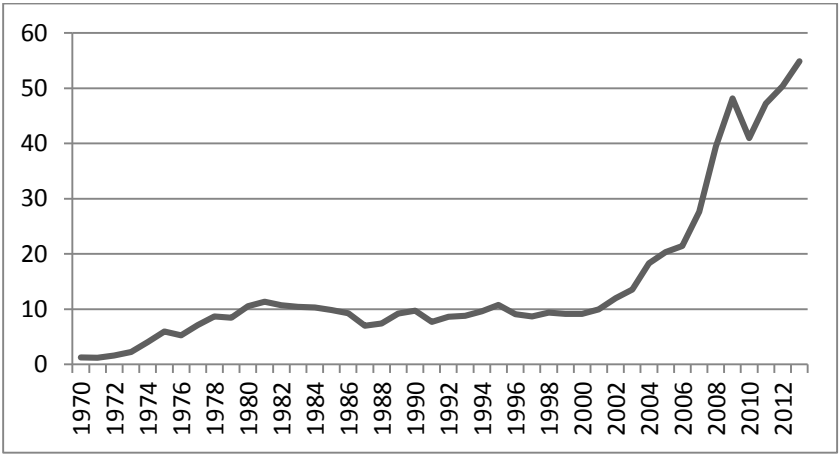


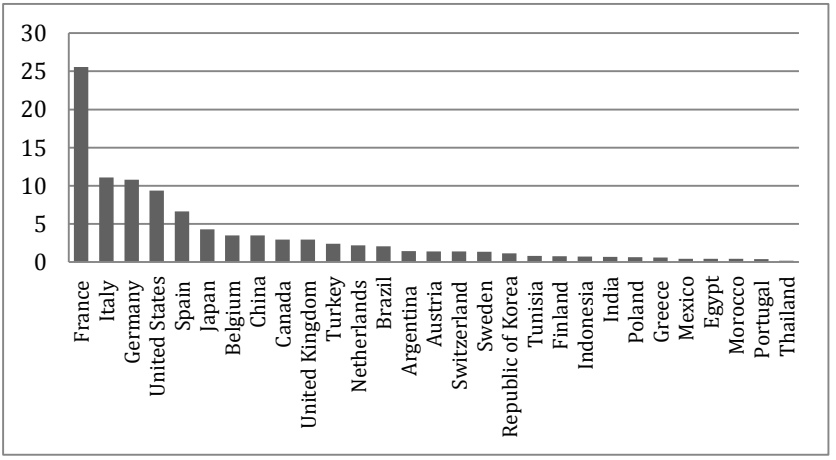
Figure 2 below shows the individual import shares of a large panel of 29 Algeria's import partners over the 1970-2013 periodwhose cumulated imports represent 90% of Algeria's total imports over that

[7] Indeed, the main products imported over the 1970-2013 period are machinery and transport equipment (40.43%), food products (21.08%), and manufactured goods (18.63%).

period.[8]It clearly appears that European countries are the prime suppliers of Algeria with a cumulated share of 69.32%. Asian countries come next with 12.93% then North American countries with 12.79%, Latin American countries with 3.50%, and North African countries with 1.64%.Important representative countries from these regions are France (25.56%), Italy (11.08%), Germany (10.80%), Spain (6.66%), Japan (4.29%), China (3.50%), Turkey (2.42%), USA (9.38%), and Canada (2.96%).

The data show that Algeria's volume of imports from the European countries, in particular those from the Eurozone, displays a relative stability.Some historical, geographical, cultural, and institutional factors may explain the fact that European countries keep on being the major import partners of Algeria since the 1970s.[9] Nevertheless, we see the emergence of new "distant" partners, particularlysome Asian countries such as China. Indeed, Algeria's import share from this country has significantly increased in recent years from 0.33% in 1999 to 14.56% in 2013. It is, however, worthwhile noting that, for the last decade or so, Algeria has been attempting to diversify its import partners.

Figure N°2: **Shares of Algeria's import partners 1970-2013 (%)**



[8] The remaining 10% imports come from a fringe of countries whose individual shares are too small to affect in any significant way our analysis and are thus neglected.

[9]The precise way these factors contribute to shaping the Algerian trade orientation is an interesting research question that is beyond the scope of this paper.

For the purpose of selecting a basket of countries to be used in our analysis of the dynamics of the real purchasing power of Algeria's oil revenues, and in view of the previous discussion, the list of 18 countries given in Table 1 that follows has been retained. Besides possessing the characteristics already discussed, the yearly average cumulated import share of Algeria from the countries that compose this group of 18 countries represents 94% of that of the set of 29 countries considered earlier.[10]Given the quantitative importance ofthis smaller basket of countries, it seemed to us that proceeding with the analysis by using it would substantially simplify the calculations without affecting the results in any significant way. Table 1 also exhibits theaverage share of each of these selected countries over the period 1970-2013.

Table N°1**: Algeria's imports from its main partners1970-2013**

Country	Average import share (%)
France	31.94
Italy	13.93
Germany	13.44
United States	11.74
Spain	8.40
Japan	5.36
China	4.53
Belgium	4.36
Canada	3.69
United Kingdom	3.66
Turkey	3.08
Netherlands	2.76
Brazil	2.58
Argentina	1.85
Austria	1.76
Switzerland	1.73
Sweden	1.70
Republic of Korea	1.48
	Total 100.00

Source: Authors' calculations.

[10] Hence, these 18 countries represent an annual average of 84.6% of Algeria's total imports.

2. Empirical methodology

Since the real purchasing power of oil revenues is subject to both the US dollar exchange rate fluctuations and world imported inflation, we need to compute animport-weighted index for each factor. The import-weighted US dollar exchange rate index, the *IWER*index hereafter, would provideus with a measure of the value of the US dollar relative to a range of currencies of interest. This index would then be used to assess the general dynamics of the US dollar, i.e., its fluctuations with respect to the other currencies. To be more specific, a key step in our empirical analysis is to calculate the *IWER*index of the US dollar against the currencies of the countries incorporated in the basket of Algeria's main import partners determined in the previous section.

We adopt the same formula as that used in Leahy (1998) known to have some attractive statistical properties.[11]This formula computes the index as the geometric mean of the bilateral exchange rates of the dollar against the currencies of the countries of the basket. The weight assigned to each currency isthe import share of each country in the basket and, to account for changes in the trade pattern, is updated annually.[12]A similar approach is used to compute animport-weighted index for imported inflation (*IWII*). Hence, we obtain the following formulae for respectively the*IWER* and *IWII* indices in year t:[13]

$$IWER_t = IWER_{t-1} \prod_{i=1}^{N} \left({e_t^i}/{e_{t-1}^i} \right)^{w_{it}} \quad (1)$$

$$IWII_t = IWII_{t-1} \prod_{i=1}^{N} \left({CPI_t^i}/{CPI_{t-1}^i} \right)^{w_{it}} \quad (2)$$

Where:

- $i = 1,2,\dots,N; t = 1,2,\dots,T$are respectively the indices designating the country in the basket and the year, $N = 18$is

[11] See also Mazraati (2005).

[12]Mazraati (2005) discusses with some level of detail the superiority of the geometric mean over the simple and the inverse means. In particular, he points to the need to make the weights vary and to avoid the possible bias stemming from the inclusion of a country with high inflation (deflation) and depreciation (appreciation) of its national currency.

[13] See the appendix for a full derivation of these formulae.

the number of countries in the basket, and $T = 44$ is the number of years considered in our analysis.

- e_t^i and CPI_t^i are respectively the bilateral exchange rate of the currency of Algeria's partner *i* in year *t* against the US dollar and the Consumer Price Index (*CPI*) of that partner in that year.
- $w_{it}$is the weight of Algeria's import partner *i* during year *t* which corresponds to the fraction of Algeria's total imports from the countries of the basket coming from this partner so that $\sum_{i=1}^{18} w_{it} = 1; t = 1,2, \dots ,44$.[14]

How are the indices reported in equations (1) and (2) to be interpreted? An increase (decrease) in the*IWER* index means a "global" appreciation (depreciation) of the US dollar against the basket of currencies, which increases (decreases) the dollar purchasing power. On the other hand, an increase (decrease) in the *IWII* index means a higher (lower) imported inflation, which translates into a lower (higher) purchasing power of the US dollar.

Consequently, to simultaneouslyaccount for these two effects of the changes in the *IWER* and *IWII* indices and find their combined effect on Algeria's oil revenues expressed in nominal terms, one merely multiplies these revenues by the product of the values of these two indices and divides them by a 10000. More explicitly,

$$ROR_t = \frac{NOR_t\left(\frac{IWER_t \times IWII_t}{100}\right)}{100} = \frac{NOR_t \times IWER_t \times IWII_t}{10000} \quad (3)$$

where ROR_t, NOR_t, $IWER_t$, and $IWII_t$are respectively Algeria's "real" oil revenues, Algeria's nominal oil revenues, the value of the import-weighted exchange rate index, and the value of the import-weighted imported inflation index in year t.

We next define, for each year $t = 1,2, \dots ,44$, the gapbetween the nominal and the real value of Algeria's oil revenues, GAP_t, and interpret it as a loss (gain) in these revenues' real purchasing power during that year if its sign is positive (negative). This gap is then

[14] Note that letting the weights vary with time allows us to capture any important changes in Algeria's trade pattern.

expressed as a percentage and interpreted accordingly. More specifically, we write:

$$GAP_t \equiv NOR_t - ROR_t \quad (4)$$

Then, compute the percentage:

$$L_t = \left(\frac{NOR_t - ROR_t}{NOR_t}\right) \times 100 \quad (5)$$

And finally,interpret this percentage as a loss (gain) if $GAP_t > 0$ (< 0).

Oil prices play a crucial role in today's world economy. It is the largest single internationally traded good, both in volume and value. As already alluded to, the prices of energy-intensive goods are strongly linked to prices of energy input consumption of which oil makes up the single most important share. Therefore, significant changes in oil prices have a wide range of consequences on the economies of both oil-producing and oil-consuming countries.

Given that Algeria's oil revenues are directly affected by oil prices and the value of the US dollar, some care should be taken in our analysis of the dynamics of the real purchasing power of these revenues about the possible existence of a significant relationship between this value and oil prices. If such a relationship exists, it should be controlled for in our computations in order to avoid some "simultaneously bias" of our results. We therefore investigate the existence of a causal relationship between the US dollar and oil prices fluctuations by means of pairwise Granger-causality tests.[15]

Prior to running these pairwise Granger-causality tests though, we have first to perform unit root tests to check whether the appropriate series are stationary and determine the required order of integration. Indeed, Granger causality tests require that the series be stationary in order to avoid spurious regressions results. So, we perform an Augmented Dickey-Fuller (ADF) testthat allows us to test the null hypothesis that there exists a unit root, i.e., that the series is not

[15] The relationship between oil prices and the US dollar has drawn much interest in the literature. See Breitenfellner and Cuaresma (2008) and Obadi (2012) among others.

stationary.Also, since the Granger-causality test is based on VAR-type regressions and is sensitive to the number of lags included in the regressions, we rely on both the Akaikeand Schwarz Information Criteria (AIC and SIC) to find the appropriate lag lengths. See the appendix for more details.

3. Results

This section discusses our empirical results.[16] We first present the outcome of the ADF test of the presence of a unit root in each of the four time series for which we seek to test the existence of a causal relationship, namely, US dollar nominal effective exchange rate (*neer*) and nominal oil prices (*nop*), on the one hand, US dollar real effective exchange rate (*reer*) and real oil prices (*rop*), on the other hand. Table 2below showsthe results of such a test.We see from this table that, in levels, all of these four variables are not stationary as we fail to reject the null hypothesis of the presence of a unit root for each of them. Thus, these variables were differenced once and the ADF test was performed again. The results of this second test are given in Table 3. We see from this table that the four variables are stationary in firstdifferences since we reject the null hypothesis of the presence of a unit root for each of them at a 1% level of significance.

Table N°2**:ADF test (Variables in levels)**

Variable	Number of observations	Value of the ADF statistic
neer	527	-1.114
reer	527	-2.151
nop	527	-0.615
rop	527	-1.629

Source: Authors' calculations.

[16] In the tables that present our econometric results, we indicate by "***"significance of a test at a 1% level.

Table N°3**: ADF test (Variables in first difference)**

Variable	Number of observations	Value of the ADF statistic
neer	526	-15.973***
reer	526	-17.109***
nop	526	-15.290***
rop	526	-16.320***

Source: Authors' calculations.

We next turn to the Ganger-causality tests. Based on the AIC and SIC criteria, the optimal lag length turned out to be equal to 1. Table 4 below reports the results of the pairwise Granger-causality tests between the variables *neer* and *nop*, on the one hand, and *reer* and *rop*, on the other hand. The results obtained clearly show the absence of any causal relationship between these variables. Changes in US dollar nominal effective exchange rate do not Granger-cause nominal oil prices, i.e., the past values of nominal effective exchange rate are not good predictors of the future values of nominal oil prices and vice-versa. The same conclusion applies to the US dollar real effective exchange rate and real oil prices variables. The empirical results suggest that there is no significant US dollar exchange rate-oil prices relationship to account for and hence we can carry out our calculations withouthaving to worry about any simultaneous bias.

Table N°4: **Pairwise Granger-causality tests***

Null hypothesis	Number of observations	F-statistic	Existence of causality
neer→nop	526	1.36	No
nop→neer	526	2.85	No
reer→rop	526	0.15	No
rop→reer	526	3.83	No

* $x \rightarrow y$ means"The variable $x$does not cause the variable y."

Source: Authors' calculations.

We now turn to our main objective, which is to study the evolution of the real purchasing power of Algeria's oil revenues from 1970 to 2013.This amounts to applying the two indices presented in the previous section, the *IWER* and *IWII* indices, to the series of Algeria's nominal oil revenues, a series which is shown in Figure 3 below. As can be seen from this figure, these revenues have had globally an increasing trend over the whole period moving from 0.7 billion US dollars in 1970 to 72.95 billionsof dollars in 2013. This sort of smooth pattern has been punctuated by some periods of abrupt variations though. Indeed, in the 1980s, following the oil shock of 1979, these revenues have plunged by about 50% from 15.37 billion US dollars in 1980 to 7.62 in 1986. Starting in 2002, these revenues have cruised up with an average annual growth rate of 21% from 18.09 billion US dollars to a peak of 77.36 in 2008 followed by a sharp drop of 43% to 44.13 in 2009 following the financial crisis that stroke the planet in 2007.

Figure N°3**: Algeria's nominal oil revenues 1970-2013 (USD billions)**

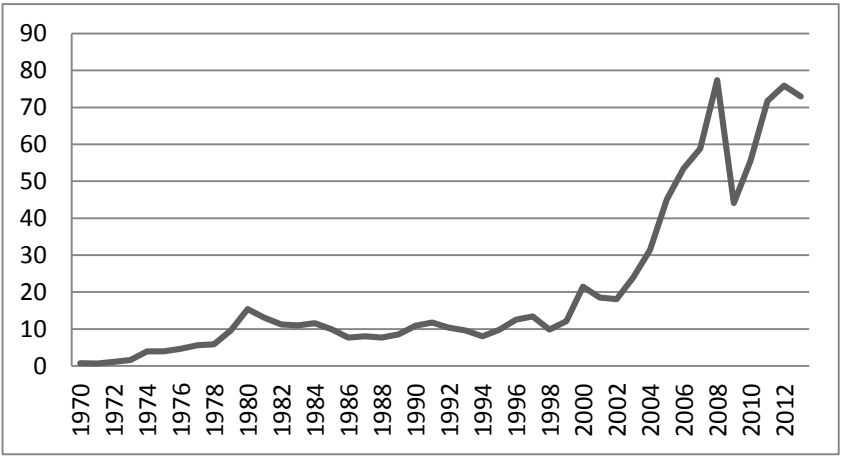


Table A1 in the appendix gives the values of the import-weighted exchange rate index, the import-weighted inflation index, the combined index, and their annual changes.[17] The annual changes in the US dollar exchange rate index indicate whether the US dollar has

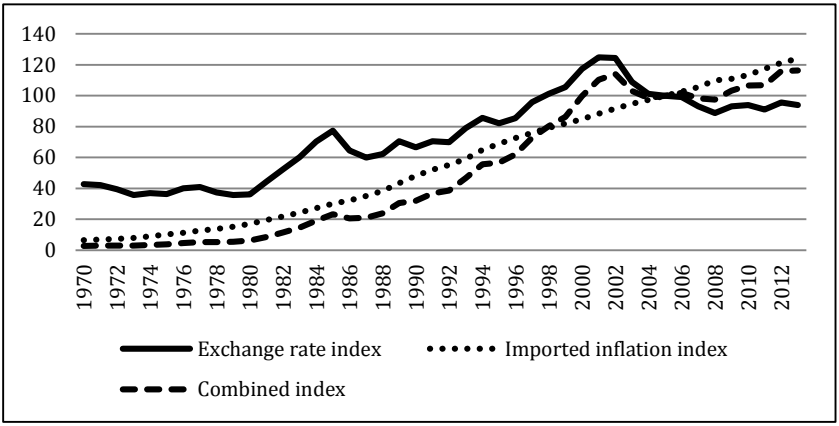
[17]The base year used for these calculations is 2005.

appreciated or depreciated relative to the basket of selected currencies while those of the imported inflation index indicate whether the inflation passed though Algeria's imports has improved or worsened. The annual changes of the combined index informus on the net effect of these two phenomena on Algeria's oil revenues. Figure 4below plots the values of these three indicesagainst time. We see from this table and Figure 4 that while the inflation index has been steadily increasing, both the exchange rate and the combined indices have experienced some decrease starting in the early 2000s. This leads us to further analyze the relative impact of exchange rate and inflation changes on Algeria's oil revenues in the neighborhood of year 2000.

Table A2 in the appendix gives, for each year, the nominal value of Algeria's oil revenues, these revenues adjusted only for the exchange rate fluctuations, these revenues adjusted only for imported inflation, the real value of these revenues (adjusted for both the exchange rate fluctuations and inflation), and the loss (gains) due to the three indices expressed in percentages. Figure 5 below plots these four time series.The results posted in Table A2 and Figure 5, which gives a broad and synthetic view of the dynamics of these results, convey some instructive quantitative information that we now discuss.

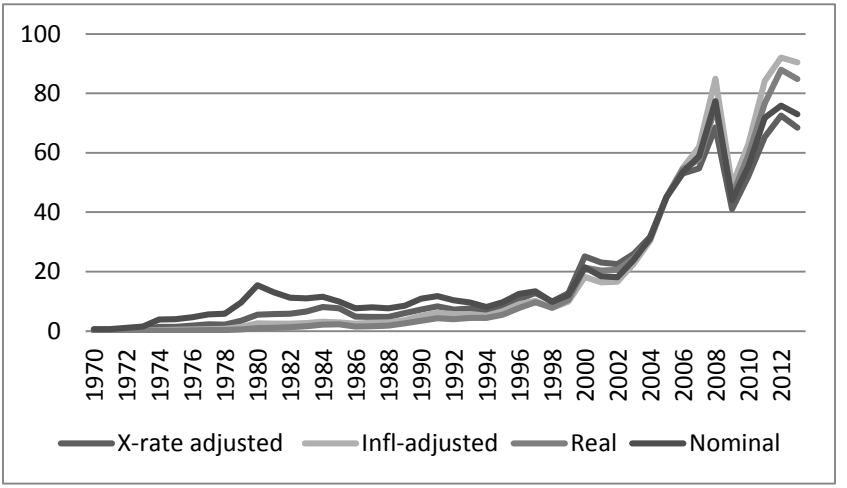
Some simple calculations using the results exhibited in Table A2 and the decomposition formulas given in the appendix allow us to conclude that, from 1970 to 2013, the real purchasing power of Algeria's oil revenues has, on average, annually decreased by about 14.5% due to fluctuations in the exchange rate of the US dollar against the currencies of Algeria's main import partners and world inflation. This represents an average annual loss of 3 billion US dollars of which about 90% (2.7 billion US dollars) are lost because of imported inflation and about 10% because of fluctuations of the US dollar relative to the currencies of Algeria's main import partners, mainly those of the European countries listed in Table 1.

Figure N°4: **Exchange rate, imported inflation, and combined indices**



Some interesting empirical factscome out of the results when one takes a closer look at the dynamics of the real purchasing power of Algeria's oil revenues over the period under study. Indeed, we see from Figure 5 that while the nominal value of these revenues and the real value, i.e., the nominal value adjusted for both US exchange rate and import prices fluctuations, have been steadily increasing, the curve of the latter has been consistently below that of the former with a diminishing gap, suggesting a persistent but decreasing loss in the purchasing power, up to the late 1990s. Starting from 2000, these curves cross and hence Algeria's oil revenues have gained in real purchasing power thereafter. Cross-examining the relative height of the four curves, however, allows us to conclude that the driving force behind this favorable evolution of the real purchasing power of Algeria's oil revenues posterior to the 2000s have been a relatively more stable inflation passed through imports.

Figure N°5: **Algeria's oil revenues adjusted for exchange rate fluctuations, for imported inflation, and for both (USD billions)**



4. Conclusion

The point of departure of the research issue that this paper has started exploring is a quite simple question. Can one precisely identify the role that oil resources have played in the Algerian economy over the last four decades? The answer to such a question is obviously complex because the question itself is complex in the first place. Indeed, despite various attempts to diversify it, the Algerian economy has been so strongly dominated by the oil sector that the implications of the latter for society go far beyond the pure economic sphere. The question is complex also because it goes beyond Algeria. In fact, the whole planet has relied so much on the "Black gold" to develop its economy for more than a century that the stakes cross the border of any single nation.

The aspect of this multi-facetted question that this paper has tackled is a measurement issue. In a nutshell, we have focused on the asymmetric structure of Algeria's international trade and its quantitative impact on this country' oil resource income. Algeria's oil revenues are constituted by exports denominated exclusively in US dollars while Algeria's imports are almost entirely invoiced in

alternative currencies. This distinctive feature of Algeria's interaction with the international markets has got to have a non-negligible impact on the real purchasing power of this country's oil income and measuring it and analyzing its dynamics is at the heart of the empirical study the results of which are reported in this paper.

We have constructed two indices that we have applied to the time series of Algeria's oil revenues from 1970 to 2013 in order to assess the evolution of their real purchasing power over this period.The first index is an import-exponentially-weighted index that captures the effect of changes in the value of US dollar against a basket of currencies of Algeria's main import partners. The second index, also based on the same weighting procedure as the first, accounts for inflation passed through imports from these partners to Algeria. These indices are then applied to the nominal value of the oil revenues to adjust them for these two factors. Our main finding is that from 1970 to the late 1990s Algeria's oil revenues have persistently lost purchasing power, although at a decreasing rate, but then, starting in the early 2000s, thanks to a relatively stable imported inflation, their purchasing power experienced some gains.

While our analysis has allowed us to measure, and disentangle, the effects of the US dollar fluctuations and the world inflation on the dynamics of the purchasing power of Algeria's oil revenues, it has only partially shed some light on the original question that motivated our research, namely to improve our understanding of the genuine role oil resources have played in the development of this country over the last four decades. Much more remains to be done. An obvious avenue for further research is to incorporate political economy and institutional factors in the analysis. One would hope that an important output of this future research would be some policy recommendations for improving the allocation of oil, this "extremely scarce" economic resource for Algeria.

Appendix

Raw data sources and variables construction

Data on Algeria's oil revenues can be found in the IMF database. However, they are only available from 1980 to 2013. Since our analysis starts from 1970, we relied on data from the retrospective report on mining and energy published by the ONS to construct our variables of interest.

This ONS report contains data on the value of oil exports since 1962 expressed in nominal terms in the national currency, i.e., the Algerian Dinar. We converted the value of oil export in current US dollars by using the bilateral exchange rate USD-DZD. The bilateral exchange rate data are collected from the IMF database. This allowed us to obtain annual values of oil exports in US dollars at current prices. This is the variable that we use as a proxy for Algeria's nominal annual oil revenues.

Data on annual Algeria's total imports were collected from the UN *Comtrade* database except for those concerning the year 1972 which were not available. We gathered the missing data from the retrospective report on foreign trade published by the ONS. The data cover the nine sections of the Standard International Trade Classification system (SITC Revision 3) and are expressed in current US dollars.

Data on annual bilateral exchange rates between the US dollar and the currencies of Algeria's main import partners were collected from the OECD main economic indicators database. This was also the case for annual data on the CPI for each import partner

In order to make our price of oil-US dollar effective exchange rate causality tests more accurate, we collected monthly data. Monthly data on nominal West Texas Intermediate oil prices are collected from the EIA database. Real or deflated oil price data were then obtained from the US CPI series by using 2005 as the base year. Monthly US dollar nominal and real effective exchange rates data were extracted from Darvas (2014). This author's database concerns 178 countries, spans the 1960-2014 period, and provides US dollar nominal and real effective exchange rates that reflect the US dollar fluctuations against a basket of currencies of 41 US trading partners.

Import-weighted exchange rate and imported inflation indices

Because they are denominated in US dollars and that they are mainly used for imports from Algeria's trade partners, Algeria's oil revenues are affected by inflation (deflation) imported from these partners, due to fluctuations of prices in these partners' economies, and depreciation (appreciation) of the US dollar relative to the currencies of these partners, due to variations in the exchange rates between the US dollar and these partners' currencies. Hence, one needs to account for these two effects when evaluating the real purchasing power of Algeria's oil revenues through two indices.

Let respectively $\mathcal{B}$and CPI_t^i be the basket of Algeria's N main import partners and the *CPI* of Algeria's partner *i* in year *t* (relative to a base year, 2005 say):

$$\mathcal{B} = \{1,2,\dots,N\} \quad \text{(A1)}$$

$$CPI_t^i, i = 1,2,\dots,N; t = 1,2,\dots,T \quad \text{(A2)}$$

Where T is the last period considered in the analysis.The bilateral exchange rate of the currency of partner *i* in year *t*against the US dollar is denoted by:

$$e_t^i, i = 1,2,\dots,N; t = 1,2,\dots,T \quad \text{(A3)}$$

Let M_{it} represent the nominal value of Algeria's imports from its partner *i* in year *t* :

$$M_{it}, i = 1,2,\dots,N; t = 1,2,\dots,T \quad \text{(A4)}$$

Then, the share of Algeria's imports from partner *i* during year *t* in its total imports from its *N* partners that year is given by:

$$w_{it} \equiv \frac{M_{it}}{\sum_{j=1}^{N} M_{jt}}, i = 1,2,\dots,N;\ t = 1,2,\dots,T \quad \text{(A5)}$$

Note that, for any year *t*, the weights add-up to one across partners. Indeed, for any $t = 1,2,\dots,T$, we have:

$$\sum_{i=1}^{N} w_{it} = \sum_{i=1}^{N} \frac{M_{it}}{\sum_{j=1}^{N} M_{jt}} = \frac{1}{\sum_{j=1}^{N} M_{jt}} \sum_{i=1}^{N} M_{it} = \frac{\sum_{i=1}^{N} M_{it}}{\sum_{j=1}^{N} M_{jt}} = 1 \qquad \text{(A6)}$$

The year $t = 1,2,\dots,T$, the import-weighted exchange rate and the import-weighted inflation indices, the *IWER* and the *IWII*, are then computed as the geometric means of the bilateral exchange rates and consumer price indices respectively:

$$IWER_t = IWER_{t-1} \prod_{i=1}^{N} \left(e_t^i \Big/ e_{t-1}^i \right)^{w_{it}} \qquad \text{(A7)}$$

$$IWII_t = IWII_{t-1} \prod_{i=1}^{N} \left(CPI_t^i \Big/ CPI_{t-1}^i \right)^{w_{it}} \qquad \text{(A8)}$$

Where Π is the product operator and these exponentially import-weighted indices are computed with respect to the base year 2005, i.e., $IWER_{2005} = IWII_{2005} \equiv 100$.

Granger-causality tests

To perform pairwise tests of the existence of a Granger-causality relationship between the US dollar nominal effective exchange rate and nominal oil prices, on the one hand, and the US dollar real effective exchange rate and real oil prices, on the other hand, we apply the following (standard) procedure:

Let $\{X\}_{t=1}^{T}$ and $\{Y\}_{t=1}^{T}$ be two stationary time-series. To test for the existence of a two-way causality relationship between these two series, we first regress the current values of each series on all its past values and the lagged values of the other. Hence, we estimate the following Vector Autoregressive (VAR) models:

$$Y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i Y_{t-i} + \sum_{i=1}^{q} \beta_i X_{t-i} + u_t \text{(A9)}$$

$$X_t = \gamma_0 + \sum_{i=1}^{k} \gamma_i X_{t-i} + \sum_{i=1}^{l} \delta_i Y_{t-i} + v_t \text{(A10)}$$

and perform "F tests" for the following null hypotheses:

$$H_0: \beta_1 = \beta_2 = \cdots = \beta_q = 0 \quad \text{(A11)}$$

$$H_0: \delta_1 = \delta_2 = \cdots = \delta_l = 0 \quad \text{(A12)}$$

Against the corresponding alternative hypotheses that respectively "Not all the β_s are equal to zero" and "Not all the δ_s are equal to zero."

A rejection of the null hypothesis (A11) would mean that X helps predict Y once the history of Yhas been controlled for, and hence that the hypothesis "X does not cause Y" is rejected. Similarly, a rejection of the null hypothesis (A12) would mean that Y helps predict X once the history of X has been controlled for, and hence that the hypothesis "Y does not cause X" is rejected. These tests are based on an *F-statistic* and a null hypothesis is rejected if the F-value exceeds a critical value at a given level of significance typically taken to be 10, 5, or 1%.

Combined effect decomposition

Let NORrepresent Algeria's oil revenues in a given year expressed in current dollars. The real counterpart of these revenues, ROR, is calculated as follows:

$$ROR = \frac{NOR\left(\frac{IWER \times IWII}{100}\right)}{100} = NOR\left(\frac{IWER}{100}\right)\left(\frac{IWII}{100}\right) \quad \text{(A13)}$$

where $IWER$ and $IWII$ are respectively the import-weighted exchange rate of the US dollar against Algeria's main trade partners and imported inflation indices. Then, using the properties of the natural logarithm function, we see that, due to the combined effect of these indices, the natural logarithm of the nominal revenues have varied by a percentageΔgiven by:

$$\Delta \equiv \left(\frac{\ln ROR - \ln NOR}{\ln NOR}\right) \times 100 = \left(\frac{\ln IWER'}{\ln NOR} + \frac{\ln IWII'}{\ln NOR}\right) \times 100 \quad \text{(A14)}$$

Where the "′" attached to the indices indicates that they have been normalized by dividing them by 100.[18] For small variations, this percentage may be approximated by:

$$\Delta = \left(\frac{d(\ln NOR)}{\ln NOR}\right) \times 100 \quad \text{(A15)}$$

[18] Note that for the base year 2005 both normalized indices are equal to 1 and hence $\Delta = 0$ for that year.

Dividing the numerator and the denominator of the fraction in the right-hand-side of (A15) by $dNOR$and rearranging terms yields:

$$\left(\frac{dNOR}{NOR}\right) \times 100 = \Delta \times \ln NOR \quad \text{(A16)}$$

Finally, using (A14), the following decomposition obtains:

$$\Phi_{Combined} = \Phi_{IWER} + \Phi_{IWII} \quad \text{(A17)}$$

Where$\Phi_{Combined}$ is the percentage variation of the nominal revenues NORdue to the combined index decomposed into its exchange rate and inflation components, $\Phi_{IWER}$and Φ_{IWII}, respectively given by:

$$\Phi_{IWER} = 100 \times \ln IWER' \quad \text{(A18)}$$

$$\Phi_{IWII} = 100 \times \ln IWII' \quad \text{(A19)}$$

Tables:

Table A1- Exchange rate, imported inflation, and combined indices

Year	Indices (2005=100)			Annual changes (%)		
	Exchange rate	Imported inflation	Combined	Exchange rate*	Imported Inflation**	Combined***
1970	42.70	6.49	2.77	-	-	-
1971	42.15	6.86	2.89	-1.29	5.66	4.30
1972	39.33	7.28	2.86	-6.70	6.14	-0.97
1973	35.67	7.88	2.81	-9.30	8.24	-1.83
1974	36.95	8.95	3.31	3.59	13.51	17.58
1975	36.33	10.17	3.69	-1.68	13.61	11.69
1976	39.95	11.30	4.51	9.96	11.12	22.19
1977	40.74	12.62	5.14	1.99	11.67	13.90
1978	37.40	13.73	5.14	-8.20	8.84	-0.08
1979	35.69	15.08	5.38	-4.59	9.81	4.77
1980	36.09	17.03	6.15	1.13	12.96	14.23
1981	44.30	19.42	8.60	22.74	14.01	39.93
1982	52.29	21.77	11.38	18.06	12.11	32.35
1983	60.05	24.15	14.50	14.82	10.94	27.38
1984	70.34	27.08	19.05	17.15	12.12	31.34
1985	77.23	30.00	23.17	9.79	10.81	21.65
1986	64.38	32.03	20.62	-16.64	6.76	-11.01
1987	59.88	34.99	20.95	-6.99	9.23	1.59
1988	62.24	38.42	23.91	3.95	9.81	14.15
1989	70.48	43.33	30.54	13.23	12.78	27.70
1990	66.57	48.06	31.99	-5.55	10.92	4.76
1991	70.52	52.12	36.76	5.93	8.46	14.89
1992	69.81	55.15	38.50	-1.00	5.81	4.75
1993	79.00	59.02	46.62	13.16	7.02	21.10
1994	85.62	64.98	55.64	8.39	10.10	19.33
1995	82.06	68.84	56.49	-4.16	5.94	1.54
1996	85.38	72.47	61.88	4.04	5.28	9.54
1997	95.85	75.81	72.66	12.26	4.61	17.43
1998	101.15	79.25	80.16	5.54	4.54	10.32
1999	105.47	81.81	86.29	4.27	3.24	7.64
2000	117.35	84.88	99.61	11.27	3.75	15.44
2001	124.75	88.40	110.28	6.30	4.15	10.71
2002	124.31	91.71	114.00	-0.35	3.74	3.38
2003	108.76	94.75	103.05	-12.51	3.32	-9.60
2004	101.20	97.28	98.45	-6.95	2.67	-4.47
2005	100.00	100.00	100.00	-1.18	2.79	1.58
2006	99.17	102.66	101.80	-0.83	2.66	1.80
2007	93.13	105.43	98.18	-6.09	2.70	-3.56
2008	88.66	109.78	97.33	-4.80	4.13	-0.87
2009	93.14	110.85	103.24	5.05	0.97	6.08
2010	93.96	113.34	106.49	0.88	2.24	3.15
2011	91.01	117.37	106.82	-3.14	3.56	0.31
2012	95.55	121.20	115.81	4.99	3.26	8.41
2013	93.86	123.90	116.29	-1.77	2.23	0.41

*A positive (negative) figure indicates an appreciation (depreciation) of the USD relative to the basket of currencies.

** A positive (negative) figure indicates an increase (decrease) of imported inflation.

* **A positive (negative) figure indicates a positive (negative) combined effect.

Source: Authors' calculation.

Table A2- Real purchasing power of Algeria's oil revenues (USD billions)

Year	Nominal revenues	X-rate adjusted	Infl-adjusted	Real	Loss/Gain* (X-rate)	Loss/Gain* (Infl)	Loss/Gain* (Combined)
1970	0.70	0.30	0.05	0.02	57.30	93.51	97.23
1971	0.64	0.27	0.04	0.02	57.85	93.14	97.11
1972	1.08	0.42	0.08	0.03	60.67	92.72	97.14
1973	1.57	0.56	0.12	0.04	64.33	92.12	97.19
1974	3.94	1.46	0.35	0.13	63.05	91.05	96.69
1975	3.97	1.44	0.40	0.15	63.67	89.83	96.31
1976	4.66	1.86	0.53	0.21	60.05	88.70	95.49
1977	5.57	2.27	0.70	0.29	59.26	87.38	94.86
1978	5.88	2.20	0.81	0.30	62.60	86.27	94.86
1979	9.65	3.44	1.45	0.52	64.31	84.92	94.62
1980	15.37	5.55	2.62	0.94	63.91	82.97	93.85
1981	13.02	5.77	2.53	1.12	55.70	80.58	91.40
1982	11.25	5.88	2.45	1.28	47.71	78.23	88.62
1983	11.00	6.60	2.66	1.59	39.95	75.85	85.50
1984	11.58	8.14	3.13	2.20	29.66	72.92	80.95
1985	9.89	7.64	2.97	2.29	22.77	70.00	76.83
1986	7.62	4.91	2.44	1.57	35.62	67.97	79.38
1987	8.02	4.80	2.81	1.68	40.12	65.01	79.05
1988	7.69	4.78	2.95	1.84	37.76	61.58	76.09
1989	8.57	6.04	3.71	2.62	29.52	56.67	69.46
1990	10.87	7.23	5.22	3.48	33.43	51.94	68.01
1991	11.73	8.27	6.11	4.31	29.48	47.88	63.24
1992	10.39	7.25	5.73	4.00	30.19	44.85	61.50
1993	9.61	7.59	5.67	4.48	21.00	40.98	53.38
1994	8.05	6.90	5.23	4.48	14.38	35.02	44.36
1995	9.73	7.99	6.70	5.50	17.94	31.16	43.51
1996	12.49	10.67	9.05	7.73	14.62	27.53	38.12
1997	13.38	12.82	10.14	9.72	4.15	24.19	27.34
1998	9.86	9.97	7.81	7.90	-1.15	20.75	19.84
1999	12.08	12.75	9.89	10.43	-5.47	18.19	13.71
2000	21.42	25.14	18.18	21.34	-17.35	15.12	0.39
2001	18.48	23.06	16.34	20.38	-24.75	11.60	-10.28
2002	18.09	22.49	16.59	20.62	-24.31	8.29	-14.00
2003	23.94	26.04	22.68	24.67	-8.76	5.25	-3.05
2004	31.30	31.68	30.45	30.82	-1.20	2.72	1.55
2005	45.09	45.09	45.09	45.09	0.00	0.00	0.00
2006	53.43	52.99	54.85	54.39	0.83	-2.66	-1.80
2007	58.83	54.79	62.02	57.76	6.87	-5.43	1.82
2008	77.36	68.59	84.93	75.30	11.34	-9.78	2.67

2009	44.13	41.10	48.92	45.56	6.86	-10.85	-3.24
2010	55.53	52.18	62.93	59.13	6.04	-13.34	-6.49
2011	71.76	65.31	84.22	76.65	8.99	-17.37	-6.82
2012	75.93	72.55	92.02	87.93	4.45	-21.20	-15.81
2013	72.95	68.47	90.39	84.83	6.14	-23.90	-16.29

[*] These figures are expressed in percentages. A positive (negative) figure indicates a loss (gain). *Source: Authors' calculation*.

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