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# Oil Price and the Dollar\*

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## Abstract

The aim of this paper is to test whether a stable long-term relationship exists between oil prices and the US effective exchange rate, expressed in real terms. To this end, we proceed to a cointegration and causality study between the two variables. Our results indicate that causality runs from oil prices to the exchange rate and that the relationship between the two variables is transmitted through the US net foreign asset position.

**Keywords:** oil prices, effective exchange rate, net foreign asset position, cointegration, causality, error correction model.

**JEL Classification:** C22, E32, Q43

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# 1 Introduction

Even after a decrease in the last 25 years, the role of oil in the global economy remains considerable. Oil represents the first source of primary energy and 95% of the transportation sector relies on it (Carnot & Hagege (2004)). The real oil price has been increasing since early 2002 after a strong increase in 1999 and 2000 followed by a decrease until early 2002. In October 2004, the real price of oil was close to the first oil shock level but still lower than the second oil shock price. What is the explanation of this recent increase ? On the supply side, many “small” shocks occurred that have limited the expansion of supply capacities and gave rise to concerns about provisioning capacities. Obviously, those fears of bottlenecks are also related to the situation in the Middle East (terrorism in Iraq and Saudi Arabia) and to the political troubles in Venezuela, a very important oil exporter for the United States. However, the main factor of this oil price increase is related to the demand side: with a strong – and not expected – increase in oil demand. This increase stems from the huge oil needs from China, that now ranks as the second world importer, but also from the United States because of its economic recovery. In sum, the tensions on supply and the increase in demand have lead to an almost complete saturation of the production capacities (Carnot & Hagege (2004)) and have contributed to the increase in oil prices since early 2002.

Meanwhile, dollar has been depreciating since mid-2001. Since the US currency plays a key role in the oil sector, it seems interesting to study the links between the two variables. Different authors have worked on the impact of oil prices on exchange rates movements. Among them, theoretical papers have been introduced by Krugman (1980, 1983), McGuirk (1983), Golub (1983) or Rogoff (1991). At an empirical level, one can mention the works by Throop (1993), Zhou (1995), Amano & van Norden (1995), Dibooglu (1995). Generally, they exhibit a relation between oil prices and exchange rates and this relation is positive, meaning that an increase in oil price is linked to a dollar appreciation. Therefore, the current period, when a dollar depreciation and an oil price increase simultaneously occur, is atypical compared to the relationships found in the previous papers. The direction of the causality is not a subject of investigation in these papers, with the exception of Amano & van Norden (1995). These latter show that oil prices are the main driving factor of the evolutions of long-term exchange rates changes in Germany, Japan and the United States.

In this paper, we propose an empirical study of the relationship between oil prices and the real effective exchange rate of the dollar between 1974 and 2004. We will particularly try to find a stable long-term relationship between these two variables and to identify the direction of the causality. Section 2 describes the main relationships that may exist between oil price and the dollar exchange rate, by studying the two possible causality directions and then by analyzing all the interactions developed in existing theoretical models. Section 3 consists in the econometric study of the relationship between the two variables. The last section concludes.

## 2 The interactions between the dollar exchange rate and oil price

The possible existence of a stable long-term relationship between oil prices and the dollar exchange rate implies a causality between the two variables. Previous studies generally show a causality direction from oil prices to the dollar. However, there are some arguments that also may justify the other direction of causality. We study the two types of causality and the resulting sign of the relationship.

### 2.1 Effect of the dollar exchange rate on oil demand, supply and price

The dollar exchange rate has an impact on the oil demand and supply since it affects the price perceived by consumers and producers. This effect depends on the currencies used in the different transactions linked to oil activities.

*Effects on demand.* Oil purchases are paid in dollars. However, demand depends on the domestic price for consumer countries which generally changes with the dollar fluctuations. Thus, the dollar depreciation reduces the oil price in domestic currencies for countries with a floating currency, like the euro zone or Japan. The effect is neutral for countries that have a currency pegged to the dollar, like China. On average, everything else being equal, the dollar depreciation generally tends to decrease the oil price in consumer countries. It results in an increase of their real income and an increase in their oil demand<sup>1</sup>. Therefore, the dollar depreciation has *a priori* a positive impact on oil demand and should contribute to raise the price.

*Effects on supply.* Oil companies use local currencies of producer countries to pay their employees, taxes and other costs. These currencies are often linked to the dollar, because of fixed-exchange rate regimes adopted by most producer countries (Frankel (2003)). Thus, dollar changes probably affect the price as perceived by the producers less than the one perceived by demanders.

Drilling activities are linked to oil prices: when this price increases, some hard-to-exploit wells, considered as non profitable so far, become profitable and the production capacity increases. Empirical studies have validated this positive link between the two variables in North America, Latin America and Middle East. However, this is not the case for the European and African countries: the number of wells has been diminishing for more than a year despite the oil price increase<sup>2</sup>. Noticeably, the relationship between oil price in dollars and drilling activities had changed since 1999 but it is difficult to determine whether this change is the outcome of the oil price drop of 1998 and early 1999, or the outcome of the introduction of

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<sup>1</sup>It is the same for the United States. The dollar depreciation cuts the purchasing power of American households but the income elasticity of oil demand is probably weak. Moreover, the dollar depreciation raises the external demand, generating a higher oil demand.

<sup>2</sup>The number of oil wells is negatively correlated with dollar-denominated oil prices but positively with euro-denominated oil prices.

the euro as a competitive currency in 1999.

The dollar depreciation can also generate inflation and decrease the purchasing power in oil producer countries with a currency linked to the dollar. All countries are not affected in the same way: OPEC that import a lot from the United States are less affected than countries that import more from Europe or Asia. The increase in inflation and the decrease in purchasing power reduce the real disposable income and therefore the income available for drilling, everything else equals. Overall, the dollar depreciation results in a reduction in oil supply.

*Effects on the short and long run.* On the short run, the supply is weakly elastic to price both upwards and downwards. The upward flexibility is weak because of the production capacities constraints. The downward flexibility is also small because the marginal production cost is generally rather low, inferior to the sale price, which urges producers to not limit their production when prices decrease. On the short run, the demand is also rather inelastic to prices. As rightly underlined by Carnot & Hagege (2004), this can be explained by the lack of substitutes to oil that could be quickly and easily exploited at a low cost. In sum, on the short run, supply and demand are quite inelastic.

But the effects of oil prices on supply and demand are mainly observable on the long run. At this horizon, the supply is flexible because it is possible to implement new investments to raise the production capacities. The demand also becomes more elastic because other sources of energy can be developed to replace oil. In sum, as underlined by Carnot & Hagege (2004), “everything happens as if expectations were self-fulfilling on the short run (the expectation of a price increase urges buyers to purchase, which increases spot prices) but counter-fulfilling in the long run: the expectation of durably higher prices can give rise to mechanisms that are able to reduce price on the long run. Thus, market mechanisms act as a driving force that generally prevents price from getting too far away for a range of possible equilibrium prices”.

*Consequences on the direction of the relationship.* Overall, the dollar depreciation causes an increase in oil demand and a reduction in supply, mainly on the long run, which maintain prices at a high level. The current situation is a good illustration of this mechanism. Thus, as underlined by Carnot & Hagege (2004), the increase of oil prices stems from two simultaneous factors. On one hand, the strong increase – badly anticipated – of oil demand, particularly in the United States and in China for more than two years, and, on the other hand, the cut in investments in the oil sector leading to a stagnation of production capacities and therefore to tensions on supply have provoked fears of provisioning breaks<sup>3</sup>.

However, if those demand and supply effects can correctly explain the current situation, they are unable to account for the relationship found in empirical studies since it goes in the opposite direction. Therefore, in order to explain this result, the opposite causality, from oil price to the dollar exchange rate, must be investigated.

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<sup>3</sup>Noticeably, the strong concentration of production capacities, mainly in Saudi Arabia, limits the market mechanisms, especially in times of strong tensions on capacities.

## 2.2 Effect of oil price on the dollar exchange rate

Most of the studies highlight a causality from oil prices to the exchange rate. In particular, Amano & van Norden (1993, 1995) show that oil prices are weakly exogenous, unlike the exchange rate. Thus, these authors show evidence of a long-term causality from oil prices to the exchange rate: on the long run, the real exchange rate causes oil prices. These results suggest that, even if oil prices are generally denominated in dollars, dollar changes have no significant impact on oil prices. In those empirical studies, the oil price is positively linked to the real effective exchange rate of the dollar. A frequently given explanation is the preference of exporter countries for financial investments in dollars.

Another explanation can be found in BEER (Behavioral Equilibrium Exchange Rate) models like Clark & MacDonald (1998). In this approach, two dependent variables are frequently used in reduced-form equations of exchange rate: the terms of trade and net foreign assets. Now, oil prices certainly have an influence on these two variables, which would therefore justify their impact on the exchange rate.

A first quick reasoning leads to a negative relationship between oil price and the dollar exchange rate. Indeed, the oil price increase should deteriorate the terms of trade and then depreciate the dollar. Moreover, that increase would have the same effect on the US current-account deficit, which should grow, leading to a reduction in the US net foreign assets (even if the incomes from oil are recycled in dollars). A dollar depreciation is then required to stabilize the US external position. However, the previous reasoning is not complete since it overlooks the multilateral nature of exchange rates. A more complete reasoning would allow to explain the positive relationship usually found in the literature by taking into account the relative effect of that price on the United States compared to its trade partners. If the United States is an important oil importer, an oil price increase can deteriorate its situation but if it imports less oil relatively to its European partners, its relative situation can improve relatively to its partners. Thus, an oil price increase would lead to a dollar appreciation relatively to the euro and the yen, and eventually, to a dollar appreciation in effective terms.

Another possible explanation could be the following: if the US demand for oil is very elastic on the long run, an oil price increase could generate an improvement of the trade balance and require an appreciation of the dollar exchange rate to restore the external balance<sup>4</sup>.

An interpretation can also be provided following the works by Krugman (1980, 1983) and Golub (1983). The authors consider a three-country world (Europe, the United States and OPEC). An oil price increase generates a wealth transfer from the United States and Europe to OPEC. If we assume that the share of the United States in the export markets of OPEC is low and that it is high in the import market of those same countries, then the wealth transfer from industrial countries to OPEC should contribute to the improvement of the US trade balance. This argument is more precisely described in the next section. It also enables to

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<sup>4</sup>Note that this interpretation holds only if the US oil demand is relatively more elastic than that of other industrial countries. This condition is probably met, if the United States is relatively less dependent on oil imports than the other countries.

understand why the oil price increase can generate a dollar appreciation.

### 2.3 Lessons from theoretical models

Krugman (1980) and Golub (1983) build models to describe the links between oil price and the dollar exchange rate. Golub (1983) assumes that the world is divided in three areas: OPEC, the United States and the Europe Union. His model studies the effects of wealth transfers that follow an oil price increase and their impact on portfolio equilibria<sup>5</sup>. Thus, an oil price increase will cause a dollar appreciation if OPEC propensity to hold dollars is high. Therefore, the impact on exchange rate depends on the wealth reallocation due to the change in oil price, resulting in an excess demand for dollars or not.

In a related approach, Krugman (1980) uses a dynamic partial equilibrium framework to model how producer countries use the revenue of their oil exports in dollars. By demanding more or less dollars, they will affect *in fine* the dollar exchange rate. The model also consists in three areas: the United States, Germany — standing for the whole European Union — and OPEC. The first two sell goods and services to themselves and to OPEC which only sell oil at a price that is assumed exogenously fixed in dollars. Then, OPEC distribute their purchases in the two other countries with a proportion  $\gamma$  which is a function of the dollar/mark parity:

$$X_G = \gamma(V)X \tag{1}$$

where  $X$  is the imports to OPEC. Those that are noted  $X_G$  come from Germany and  $V$  is the exchange rate between the US and the German currencies.

The crucial assumption made by Krugman is that OPEC spending adjusts only gradually to the level of their exports income:

$$\dot{X} = \lambda(P_O\bar{O} - X) \tag{2}$$

where  $\bar{O}$  represents the total exports made by OPEC,  $P_O$  being their price. In other words, if the oil price increases, OPEC will not immediately use all this new income in extra imports.

This model has only two assets: dollars and marks. OPEC share their wealth between the two, according to a proportion  $\alpha$ :

$$D_O = (1 - \alpha)W_O \tag{3}$$

where  $D_O$  represents the assets in dollars held by OPEC and  $W_O$  their total wealth.

The relationship between the exchange rate  $V$  and OPEC's spending in German and American goods depends both on  $\alpha$  and  $\gamma$ . The intuition is the following: an increase in OPEC's spending in German and American goods beyond their long-term levels will have two effects on the German balance of payments: the current account will benefit from the

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<sup>5</sup>Thus, this is a model of portfolio choice in which the currencies (the euro and the American dollar) are financial assets.

extra German exports but the capital account will suffer from the fact that OPEC will sell some of their marks to finance this new consumption. It is therefore very difficult to *a priori* determine a clear relationship between the OPEC spendings and the exchange rate change.

Krugman extends this analysis to an increase in oil price that triggers at least on the short run, an increase in income for OPEC. Then, a third parameter becomes essential,  $\sigma$ , that measures the German share in worldwide oil imports. The short-run impact depends on how large  $\alpha$  is compared to  $\sigma$  while the long-term effect depends on the comparison between  $\gamma$  and  $\sigma$ .

Let's use another intuitive description of these mechanisms: since OPEC spend their extra exports income only after a lag, an increase in oil price does not immediately lead to an increase in exports for industrial countries. This will deteriorate their current account but, conversely, their capital accounts will improve since OPEC invest their surpluses in dollars and marks. The sign of the effect on the dollar exchange rate is determined by the comparison between the proportion invested in dollars by OPEC and the share of the United States in the current account deficit of the industrialized world.

However, after a lag, OPEC will start to spend their surpluses in new imports and will therefore reduce their accumulation of foreign assets. The German and US balances of payments will no longer be mainly determined by the OPEC's preferences in financial investments but by their preferences in consumption goods. On the long run, only these latter will matter to know the final direction of exchange rate variations. Analytically, the equilibrium condition on the long run is described by:

$$\frac{\partial(\dot{V}/V)}{\partial P_O} = \frac{\bar{O}(\sigma - \alpha)}{M_{US}/V + \alpha(1 - \alpha)W_O + D_G} \quad (4)$$

where  $M_{US}$  represents the marks held by Americans and  $D_G$  the dollars held by Germans.

On the long run, the equilibrium becomes:

$$\frac{\partial V}{\partial P_O} = \frac{\bar{O}(\sigma - \gamma)}{\frac{\partial T}{\partial V} + X \frac{\partial \gamma}{\partial V}} \quad (5)$$

where  $T$  stands for the German trade balance, relatively to the US.

The interesting result of these conditions is that, in some configurations, the initial change in the exchange rate can be different from the long-term trend. For example, it will be the case if OPEC prefer American investments but German goods. Thus, depending on whether OPEC accumulate a lot of assets in the United States or import a lot of goods from Europe, the final outcome on the dollar exchange rate will be very different.

Such models show that one has to distinguish short-run impacts (where the financial approach is more relevant) and long-run impacts where the real approach is more appropriate. On the short run, the impact of an oil price increase depends on the US weight in the global oil imports compared to their weight in the assets held by OPEC. On the long run, the effect depends on the weight of oil in the US total imports compared to the US weight in the OPEC



imports. Empirically, it is possible that the two effects play in the opposite direction: on the short run, an oil price increase would tend to push the dollar up while, on the long run, a depreciation could happen.

### 3 Empirical study of the relation between the dollar real effective exchange rate and the real oil price

Our application concerns monthly data of oil prices and dollar exchange rates from January 1974 to November 2004. Data are extracted from the *Datastream* database. The oil price variable is expressed in real terms, i.e. deflated by the US consumer price index. The exchange rate is the dollar real effective exchange rate<sup>6</sup>.

#### 3.1 Preliminary study of variables

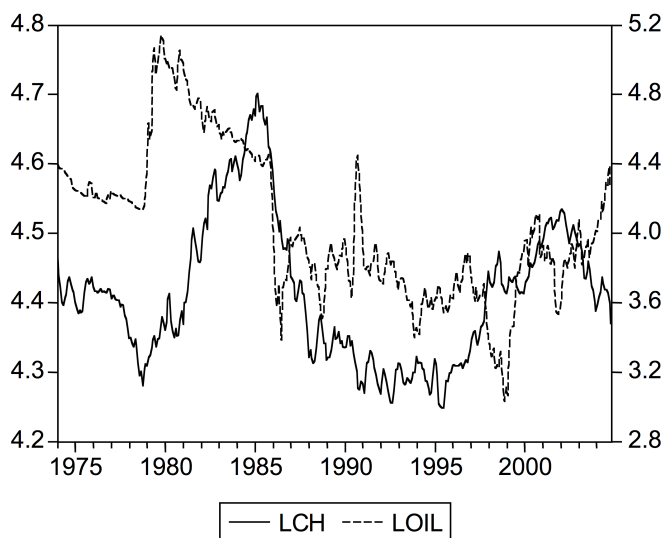


Figure 1: Real effective exchange rate of the dollar (left axis) and real oil price (right axis) in logarithm

Figure 1 reports the dollar effective exchange rate<sup>7</sup> and oil prices in real terms. Both series are taken in logarithms. Several observations can be made. First, it seems that both variables have similar evolutions when average fluctuations are low. For example, the 1986-1997 period appears to be characterized by a positive and relatively stable relation between

<sup>6</sup>The detail of this variable and its methodology are indicated in the OECD's Main Economic Indicators.

<sup>7</sup>An increase indicates an appreciation of the dollar.

the two variables. When exchange rates movements are more pronounced, the direction of the relation seems to be inverted. Thus, the early 1980s strong increase in the dollar was associated to a decrease in oil prices. The conclusions would be similar for the recent periods of dollar appreciation: 1997-1999 and early 2000s. The direction of the relationship between the two variables is not clear cut and seems to depend on the considered period<sup>8</sup>. Secondly, the oil variable seems to “lead” the exchange rate variable. In other words, if a causality between the two variables exists, it seems to come from the oil price to the exchange rate. Thus, the speculation on oil would lead to a speculation on the dollar, while the opposite does not seem to hold.

We try to check these intuitions through an empirical study. The first mandatory step is the study of the stationarity: the results are reported in table A1 in the appendix with Augmented-Dickey-Fuller (ADF) and Phillips-Perron (PP) tests applied to the two variables. It turns out that both series are integrated of order one. The descriptive statistics included in table A2 indicate that both series have a kurtosis excess, which is particularly strong for oil price, giving evidence of a high probability of extreme points. Besides, both series have an asymmetric distribution (skewed to the right for oil price changes and to the left for exchange rates changes).

### 3.2 Is there a stable equilibrium relation between the two series?

In order to evaluate a stable long-term relation between oil prices and the real effective exchange rate of the dollar, we study the cointegration between the two variables. A first approach is provided by the Engle & Granger (1987)’s procedure that consists in estimating a static long-term relationship between the two variables and then in testing the existence of a unit root in the residuals from this regression. The ADF test on these residuals yields a test statistic equal to -1.99, meaning that the null hypothesis of a unit root can not be rejected. In other words, oil prices and the effective exchange rate are not cointegrated. In order to check the validity of this result, we apply another more powerful procedure developed by Johansen (1988) and Johansen & Juselius (1990). The results of the trace test proposed by Johansen & Juselius (1990) are reported in table 1.

Table 1: Cointegration test

<b>Null hypothesis</b>	<b>Trace statistic</b>	<b>p-value</b>
No relation	15.98*	0.04
At most one relation	3.61	0.06

\*: rejection of the null hypothesis at the 5% significance level.

According to the trace test, the null hypothesis of no cointegration between the two

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<sup>8</sup>These remarks raise some questions about the more or less speculative nature of the times during which this positive relationship does not seem to hold. Figures A1 and A2 in the appendix report the volatilities of the two variables. The early 1980’s and the 1997-1999 period are indeed characterized by a strong exchange rate volatility but this is not true for the early 2000’s.

variables is rejected at the 5% significance level. Therefore, there is a long-term equilibrium relationship between oil prices and the dollar effective exchange rate. The estimation of this long-term relationship shows that an increase in oil price by 10% results, everything else being equal, in a dollar appreciation by around 4.5%. The test trace and the ADF test lead to opposite conclusions. Since we consider Johansen’s approach as more powerful, we infer from these tests that the two variables are cointegrated.

The cointegration between the two variables allows to estimate a vector error correction model (VECM) in order to describe the dynamic adjustment of the variables to the equilibrium given by the long-term relationship. The VECM estimation is reported in table 2.

Table 2: Error correction model estimation

	$\Delta LCH$	$\Delta LOIL$
$z_{t-1}$	-0.008874 [-2.25075]	0.054404 [ 2.15787]
$\Delta LCH_{t-1}$	0.265092 [ 5.07313]	-0.292383 [-0.87501]
$\Delta LCH_{t-2}$	-0.020041 [-0.38501]	0.699690 [ 2.10206]
$\Delta LOIL_{t-1}$	-0.007210 [-0.88532]	0.203523 [ 3.90787]
$\Delta LOIL_{t-2}$	-0.007081 [-0.87187]	0.002152 [ 0.04144]
Constant	-0.000152 [-0.21515]	0.001464 [ 0.32494]
<i>Tests on residuals</i>		
LB(4) = 0.1898 ; LB(8) = 0.7875 ; LB(12) = 0.1847		
JB = 0		

$z_{t-1}$  : residuals of the long-term relationship between LCH and LOIL in t-1. Between square brackets: t-statistics of estimated coefficients. LB(k) is the p-value of the Ljung-Box test of no autocorrelation for k lags. JB is the p-value of the normality test proposed by Jarque-Bera.

The results show that the error correction term is negative and significant in the equation of the exchange rate log variations. Therefore, there is a mean-reverting process of the exchange rate to its long-term target. However, the adjustment speed is very low (-0.0088), meaning that 10% of the adjustment to the equilibrium is made each year. It corresponds to a half-life of deviation of about six years and a half, which is quite long<sup>9</sup>. On the short run, exchange rate changes only depend on their one-period lagged changes; oil price changes depend on lagged (two periods) exchange rate changes and on one-period lagged oil price changes. The tests on residuals report no residual serial correlation. However, the residuals

<sup>9</sup>The studies on purchasing power parity usually have results of a half-life between three and five years (Rogoff (1996)).

do not have a normal distribution, which is common with financial variables.

### 3.3 Causality study

The existence of a cointegration relationship between the two variables means that at least one of the two variables Granger-causes the other. It is consequently relevant to study the direction of the causality and the nature (exogenous or not) of the considered variables.

We proceed in two steps. First, we test the existence of a long-term causality between the two variables with exogeneity tests. By doing so, we try to determine whether the exchange rate and/or oil price are weakly exogenous according to Engle, Hendry & Richard (1983). It implies to test whether the long-term relationship, captured by the residual, is significant or not in the equations of exchange rate log variations and oil price log variations. The results of the likelihood ratio test reported in table 3 show that the oil price is weakly exogenous while the exchange rate is not. In other words, the deviation from the long-term target significantly influences the exchange rate but does not affect oil prices.

Table 3: Results of the exogeneity tests (p-values)

Variable	p-value
Exchange rate	0.0245
Oil price	0.7756

In a second step, we study the Granger causality. To this end, we estimate a VAR model in level and we apply the Granger causality tests. The results are reported in table 4 for different lags,  $p$ , in the VAR process.

Table 4: Results of causality tests (p-values)

	VAR(1)	VAR(2)	VAR(3)	VAR(4)	VAR(6)	VAR(8)	VAR(10)	VAR(12)
O → C	0.0529*	0.1300	0.1800	0.1124	0.2035	0.2525	0.4485	0.4069
C → O	0.8473	0.9600	0.1704	0.2591	0.4653	0.5722	0.7687	0.1193

O → C is for the null hypothesis of no causality from oil prices to the exchange rate.

C → O is for the null hypothesis of no causality from the exchange rate to oil prices.

\* : rejection of the null hypothesis at the 10% significance level.

The null hypothesis is no causality. Table 4 clearly shows that the exchange rate does not cause oil prices. It means that even if oil prices are expressed in dollars, the changes of the dollar have no significant effect on oil prices. This result confirms the conclusion from the exogeneity tests. For the causality from oil prices to the exchange rate, the conclusion depends on the choice of the model; a causality can be observed, at the 10% level, only for one autoregressive lag.

### 3.4 Study for the 1980-2004 sub-period

In order to check that our results are not affected by the second oil shock in our sample, we do the same analysis for the January 1980 to November 2004 sub-period. We will not provide all the details of the estimations here but just sum up the main results<sup>10</sup>.

Overall, the results for this sub-period are very similar to those for the whole sample. Thus, while the Engle-Granger's approach does not reject the null hypothesis of no cointegration between real oil prices and the dollar real effective exchange rate, the trace test indicates that the two variables are cointegrated, at the 10% level. Everything else equals, a 10% increase in the real oil prices leads to a dollar appreciation by 4.2%, which is very close to the result on the whole period. The estimation of an error correction model with two lags also gives a significant driving force of the exchange rate to the long-term target. The adjustment speed remains low even if it is higher than for the whole period: it is equal to -0.0109, which means that 12.3% of the adjustment to the equilibrium is made every year, for a half-life of 5 years and three months. Finally, the results of the causality tests, obtained from a VAR(1) model in level, exhibit a causality from oil prices to the exchange rate at the 5% significance level. Like in the previous section, the null hypothesis of no causality from the exchange rate to oil prices was never rejected, for any lags in the VAR model estimation. Overall, the results for the 1980-2004 sub-period remain consistent with those on the whole period.

### 3.5 Which variable transmits the relationship between oil price and the exchange rate?

As previously underlined, the nature of the relationship between the real effective exchange rate and the real oil price is not clear cut. In this framework, it is important to determine which variable transmits the found positive relationship between the two series. Following a BEER model *à la* Clark & MacDonald (1998), we test whether the US net foreign assets or the terms of trade are or not the transmission variables in the relationship between the exchange rate and oil price. To this end, we first test the existence of a link between the exchange rate and each of the two other variables and then we study the impact of oil price on these same variables<sup>11</sup>.

Net foreign assets (LNFA) and terms of trade (LTOT) in logarithm being non stationary<sup>12</sup>, we test the existence of a cointegration relationship between the real effective exchange rate and each of the two other series. The results are reported in table 5.

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<sup>10</sup>Complete results are available upon request to the authors.

<sup>11</sup>The initial data are quarterly based. They were converted in monthly frequency in two different ways. A first method consists in assuming the same value for the three months of a quarter. In the second method, we resort to a linear interpolation. The results are identical with the two methods. We only report the results based on the first method of conversion. Figures A3 and A4 in the appendix depict the evolution of the net foreign assets and of the terms of trade.

<sup>12</sup>See table A3 in the appendix. The Dickey-Fuller and Phillips-Perron tests leading to opposite conclusions, we apply a third test: the KPSS test based on the null hypothesis of no unit root. The results (not reported here, but available upon request to the authors) indicate that such a hypothesis is rejected for both series: the net foreign assets and the terms of trade are integrated of order one.

Table 5: Cointegration test. Trace statistic

Null hypothesis	LCH and LNFA		LCH and LTOT	
	Trace stat.	p-value	Trace stat.	p-value
No relation	18.54*	0.01	9.36	0.33
At most one relation	2.40	0.12	3.41	0.06

\* : rejection of the null hypothesis at the 5% significance level.

These results show the existence of a cointegration relationship between the exchange rate and the US net foreign assets, whereas the terms of trade and the exchange rate are not cointegrated. So, on the long run, the net international position has an impact on the real effective exchange rate. The relationship between the two variables is positive, meaning an improvement in foreign assets position resulting in an appreciation of the exchange rate.

Therefore it appears that the long-term relationship between oil prices and the effective exchange rate is transmitted by net foreign position rather than by the terms of trade. In order to check this hypothesis, we test whether net foreign assets and oil prices are cointegrated or not. The results given by the trace test are reported in table 6. For more informations, we also supply the results from the cointegration test between oil prices and the terms of trade.

Table 6: Cointegration test. Trace statistic

Null hypothesis	LOIL and LNFA		LOIL and LTOT	
	Trace stat.	p-value	Trace stat.	p-value
No relation	22.94*	0	7.86	0.48
At most one relation	3.74	0.05	3.11	0.08

\*: rejection of the null hypothesis at the 5% significance level.

These results show that oil prices and the US net foreign position are cointegrated. Moreover, there is no cointegration relationship between oil prices and the terms of trade. So, according to these conclusions, the relationship between oil prices and the dollar real effective exchange rate is transmitted through the US net international position. In the estimation, a 10% oil price increase generates, everything else being equal, an improvement of the net international position by about 2%. Furthermore, the error correction model estimation (see table A4 in the appendix) shows that the error correction term is negative and significant in the equation of the changes of the US net international investment position. Finally, the adjustment speed is fairly high (the coefficient is equal to -0.2) and the variables do not seem to influence each other on the short run.

## 4 Conclusion

In this paper, we have tried to determine whether there was a link between the real price of oil and the US real effective exchange rate. Overall, our study has exhibited the quite

complex features of the relation between the two variables. More specifically, our results have shown that there exists a long-term relation (i.e. a cointegration relation) between the two series. The application of causality tests made it clear that the direction of the causality is from oil prices to the dollar exchange rate. This causality is unidirectional but turns out to be dependent on the parameters chosen for the VAR estimation and is only significant at the 10% level of confidence. The estimation of a vector error correction model has reported a very slow adjustment speed of the dollar real effective exchange rate to the long-term target (with a half life of deviations of about six years and a half for the 1974-2004 period). Finally, our results show that the relationship between the dollar real effective exchange rate and oil price seems to be transmitted through the US net international investment position. On the whole, as shown in previous studies, our results confirm that the increase in oil price is linked to a dollar appreciation in the long run. The 2003-2004 situation of a weakening dollar and an increasing oil price is therefore atypical, according to these results.

## A Appendix

Figures A1 and A2 report the volatility of the dollar real effective exchange rate and the volatility of oil prices. The volatility series are computed by the square of log-variations of the two variables. The horizontal line represents 1.96 times the standard error of the volatility series.

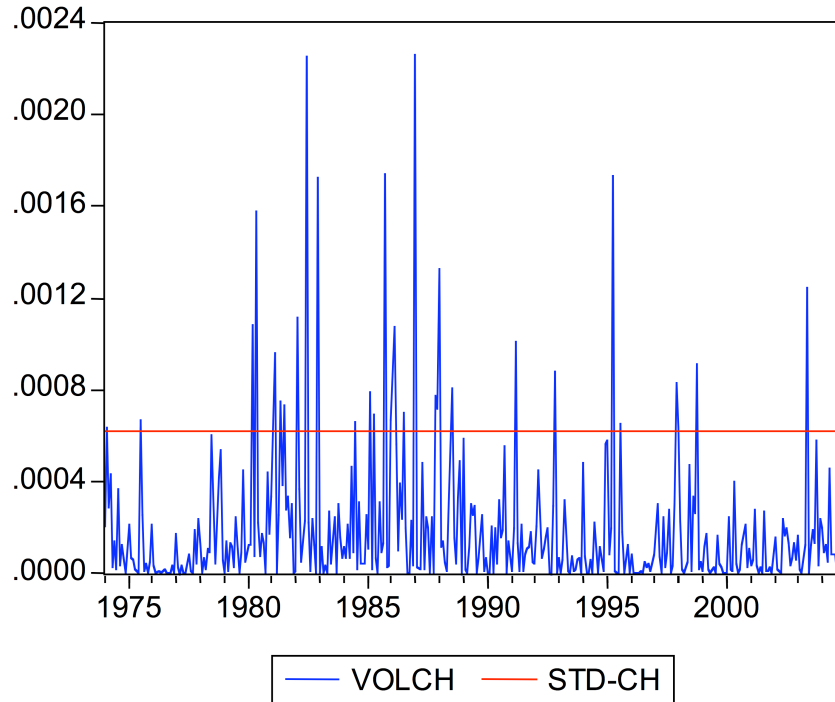


Figure A1: American real effective exchange rate volatility

The US net foreign assets variables (figure A3) was given by the Bureau of Economic Analysis. It is computed as the cumulative sum of the difference between row 40 (U.S.-owned assets abroad, net (increase/financial outflow (-)) and row 55 (Foreign-owned assets in the United States, net (increase/financial inflow (+)) of the American balance of payments. Data are in million dollars and are seasonally adjusted. Moreover, they were rescaled to accept the logarithmic transformation.



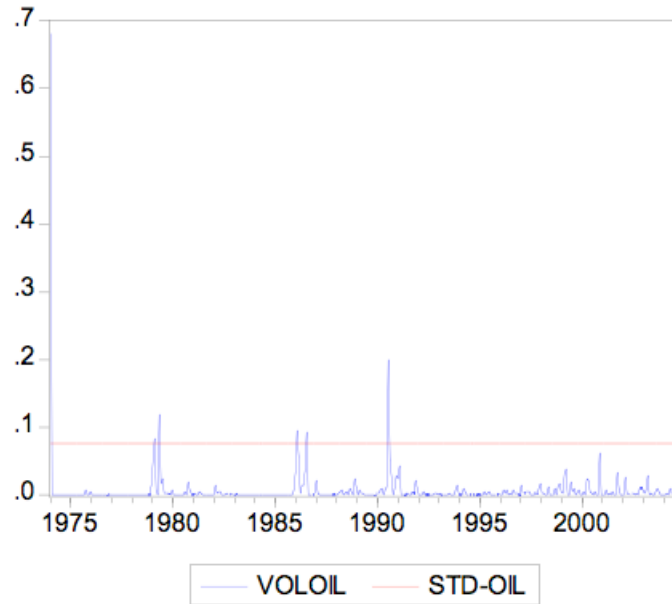


Figure A2: Real oil price volatility

Table A1: Unit root tests				
	American effective exchange rate (LCH)		Oil price (LOIL)	
	LCH	$\Delta$ LCH	LOIL	$\Delta$ LOIL
ADF test	-0.30 (1)	-14.55* (1)	0.07 (1)	-15.89* (1)
PP test	-0.29 (1)	-14.36* (1)	0.12 (1)	-15.68* (1)

\*: rejection of the null hypothesis of a unit root at the 5% significance level.

(1) model without constant nor trend.

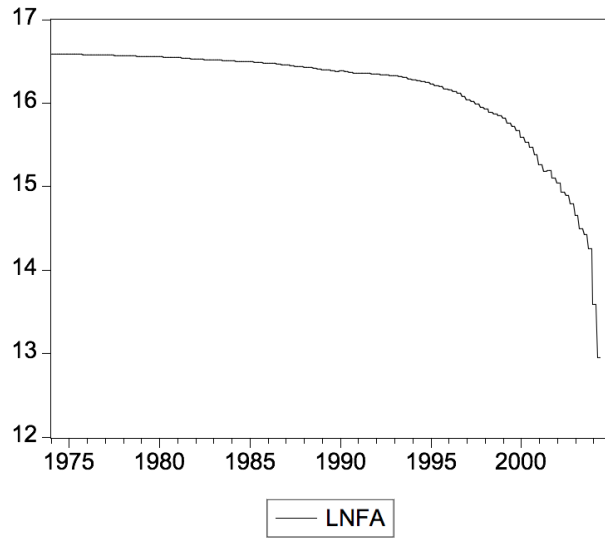


Figure A3: U.S. net foreign assets (in logarithms)

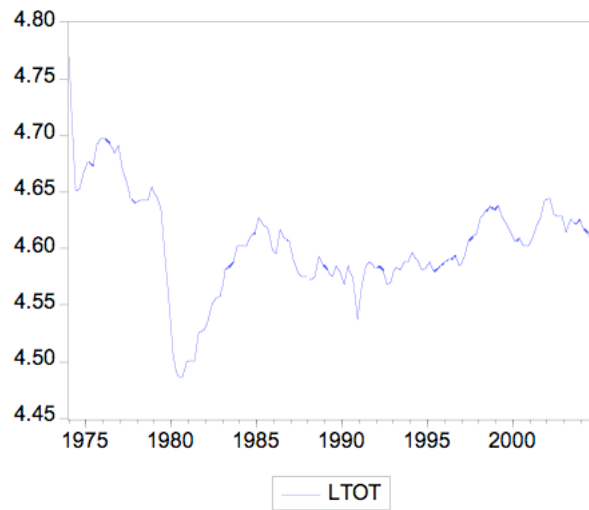


Figure A4: U.S. terms of trade (in logarithms)

Table A2: Descriptive statistics on first-differenced variables

	$\Delta$ LCH	$\Delta$ LOIL
Number of obs.	371	371
Mean	-0.0002	0.0019
Standard error	0.0141	0.0887
Skewness	-0.1828	2.5493
Kurtosis	3.5739	25.0536
Jarque-Bera	7.1585 (0.02)	7920.196 (0)

Between brackets: p-value for the Jarque and Bera's normality test statistic.

Table A3: Unit root tests for NFA and TOT in logarithms

	Net foreign assets (LNFA)		Terms of trade (LTOT)	
	LNFA	$\Delta$ LNFA	LTOT	$\Delta$ LTOT
ADF test	1.59 (1)	6.15 (1)	-0.14 (1)	-9.48* (1)
PP test	9.97 (3)	-21.15* (1)	-2.92* (2)	-19.42* (1)

(1) model without constant nor trend.

\*: rejection of the null hypothesis at the 5% significance level.

Table A4: VECM estimation between the net foreign assets and oil prices

	$\Delta$ LNFA	$\Delta$ LOIL
$\varepsilon_{t-1}$	-0.006418 [-4.06998]	-0.002055 [-0.48926]
$\Delta$ LOIL $_{t-1}$	-0.010288 [-0.51668]	0.326812 [ 6.16202]
$\Delta$ LLOIL $_{t-2}$	0.010442 [ 0.50510]	-0.176634 [-3.20752]
$\Delta$ LLOIL $_{t-3}$	-0.015932 [-0.79853]	0.104094 [ 1.95874]
$\Delta$ LNFA $_{t-1}$	-0.106648 [-2.83732]	-0.123388 [-1.23239]
$\Delta$ LNFA $_{t-2}$	-0.108272 [-2.87270]	0.003294 [ 0.03281]
$\Delta$ LNFA $_{t-3}$	0.976906 [ 21.7057]	-0.044169 [-0.36843]
Constant	-0.004129 [-2.40437]	-0.002143 [-0.46856]

Between square brackets :  $t$ -statistics of estimates.

$\varepsilon_{t-1}$ : residuals of the long-term relation between LNFA and LOIL in  $t - 1$ .

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