



**CEPII**

CENTRE  
D'ÉTUDES PROSPECTIVES  
ET D'INFORMATIONS  
INTERNATIONALES

No 2013 – 28  
Septembre

DOCUMENT DE TRAVAIL

## Energy prices and the real exchange rate of commodity-exporting countries

---

Magali Dauvin

**TABLE OF CONTENTS**

Highlights and Abstract . . . . .	3
Points clefs et résumé. . . . .	4
1. Introduction . . . . .	5
2. The terms-of-trade - RER <i>nexus</i> . . . . .	7
2.1. Theoretical models . . . . .	7
2.2. Empirical studies . . . . .	11
3. Empirical analysis . . . . .	14
3.1. Evolution of energy prices. . . . .	14
3.2. Econometric framework and data . . . . .	15
4. Are there energy-currencies? . . . . .	17
4.1. Panel unit root analysis and cointegration tests. . . . .	18
4.2. Results . . . . .	18
5. Do oil prices have a nonlinear impact on the real exchange rate? . . . . .	20
5.1. PSTR methodology . . . . .	21
5.2. Results . . . . .	22
6. Conclusion . . . . .	24
7. References . . . . .	25
8. Appendix . . . . .	30



## ENERGY PRICES AND THE REAL EXCHANGE RATE OF COMMODITY-EXPORTING COUNTRIES

Magali Dauvin

### HIGHLIGHTS

- We investigate the relationship between energy prices and exchange rates on a sample of 33 commodity-exporting countries.
- We rely upon the estimation of panel cointegrating vectors and smooth transition regression models over the 1980-2010 period.
- Energy prices have great explanatory power on the currency of energy-exporting countries.
- The effect of terms-of-trade on the real exchange rate is nonlinear and depends on the volatility of oil prices.

### ABSTRACT

This paper investigates the relationship between energy prices and the real effective exchange rate of commodity-exporting countries. We consider two sets of countries: 10 energy-exporting and 23 commodity-exporting countries over the period 1980-2011. Estimating a panel cointegrating relationship between the real exchange rate and its fundamentals, we provide evidence for the existence of "energy currencies". Relying on the estimation of panel smooth transition regression (PSTR) models, we show that there exists a certain threshold beyond which the real effective exchange rate of both energy and commodity exporters reacts to oil prices, through the terms-of-trade. More specifically, when oil price variations are low, the real effective exchange rates are not determined by terms-of-trade but by other usual fundamentals. Nevertheless, when the oil market is highly volatile, currencies follow an "oil currency" regime, terms-of-trade becoming an important driver of the real exchange rate.

*JEL Classification:* C33, F31, O13, Q43

*Keywords:* energy prices, terms-of-trade, exchange rate, commodity-exporting countries, panel cointegration, nonlinear model, PSTR



## ENERGY PRICES AND THE REAL EXCHANGE RATE OF COMMODITY-EXPORTING COUNTRIES

Magali Dauvin

### POINTS CLEFS

- Nous examinons la relation entre prix de l'énergie et taux de change sur un échantillon de 33 pays exportateurs de matières premières.
- Nous recourons à l'estimation de vecteurs de cointégration et de modèles de régression à transition lisse en panel sur la période 1980-2010.
- Les prix de l'énergie ont un fort pouvoir explicatif sur l'évolution du taux de change des pays exportateurs d'énergie.
- L'effet des termes de l'échange sur le taux de change réel est non-linéaire et dépend de la volatilité du prix du pétrole.

### RÉSUMÉ

Cet article étudie la relation entre les prix de l'énergie et le taux de change effectif réel des pays exportateurs de matières premières. Nous considérons deux groupes de pays : 10 exportateurs d'énergie et 23 pays exportateurs de matières premières, au cours de la période 1980-2011. Au moyen de méthodes de cointégration en panel, nous montrons que les dix pays producteurs d'énergie (charbon, gaz naturel, pétrole) considérés dans notre étude ont des "energy currency", ces dernières s'appréciant de 3% lorsque les prix de l'énergie augmentent de 10%. En recourant à l'estimation de modèles de régression à transition lisse en panel, nous montrons qu'il existe un certain seuil à partir duquel le taux de change réel des pays exportateurs de matières premières énergétiques et non énergétiques réagit au prix du pétrole. Plus précisément, lorsque les variations du prix de pétrole sont faibles, les termes de l'échange ne permettent pas d'expliquer l'évolution du taux de change à court terme. Toutefois, lorsque le marché pétrolier devient fortement volatile, les monnaies de ces pays suivent un régime "oil currency", les termes de l'échange devenant un important déterminant du taux de change.

*Classification JEL* : C33, F31, 013, Q43

*Mots clés* : prix de l'énergie, termes de l'échange, taux de change, matières premières, cointégration en panel, modèle non linéaire, PSTR

## ENERGY PRICES AND THE REAL EXCHANGE RATE OF COMMODITY-EXPORTING COUNTRIES<sup>1</sup>

Magali Dauvin\*

### 1. INTRODUCTION

The real exchange rate is a key economic variable that allows to assess the price competitiveness of a country, and constitutes a crucial stake in economies wherein revenues are derived from exports' activity. While the real exchange rate is difficult to forecast because of its high volatility (Meese and Rogoff, 1983; Obstfeld and Rogoff, 2000), it does not fluctuate erratically. Indeed, variables such as the net foreign asset position, productivity differentials, trade openness, public expenditure, *etc.* have been found to be key determinants of its dynamics (Gagnon, 1996; Clark and MacDonald, 1999; Lane and Milesi-Ferretti, 2002, 2007).

The literature also identified the terms-of-trade, defined as the ratio of the prices of a country's exports to the prices of its imports, as being a major determinant of real exchange rate movements (Dornbush, 1980; De Gregorio and Wolf, 1994; Edwards, 1994; Frenkel *et al.*, 1996). Terms-of-trade changes also impact macroeconomic flows, such as incomes, investments, savings, current accounts (Razin and Svensson, 1983; Mendoza, 1995; Baxter and Kouparitsas, 2000; Bems and de Carvalho Filho, 2008). Terms-of-trade fluctuations are usually twice as large in developing countries as in developed countries (Baxter and Kouparitsas, 2000), accounting for roughly one-third to half of the output volatility of these economies (Mendoza, 1995; Broda and Tille, 2003). Analyzing terms-of-trade's impact on the real exchange rate is highly relevant for developing countries since their wealth largely depends on commodity exports.

In the early 2000's, commodity prices experienced a surge which has sparked interest on the link between the real exchange rate and terms-of-trade of countries whose exports are mainly composed of commodities. The literature evidenced a positive link between the two variables, leading to the denomination "commodity currencies" (Chen and Rogoff, 2003; Cashin *et al.*, 2004), that applies to both developed (Amano and van Norden, 1995; Chen and Rogoff, 2003) and developing countries (Cashin *et al.*, 2004; Coudert *et al.*, 2011; Bodart *et al.*, 2012).

---

<sup>1</sup>For very helpful comments and suggestions, I wish to thank Gunther Capelle-Blancard, David Guerreiro, Sébastien Jean and Valérie Mignon.

\*EconomiX-CNRS, Université Paris Ouest Nanterre - la Défense, France ([magali.dauvin@u-paris10.fr](mailto:magali.dauvin@u-paris10.fr))

Regarding the link between energy prices and real exchange rates, research has essentially been focusing on two topics: the impact of oil prices on the U.S. dollar (Amano and van Norden, 1998; Coudert *et al.*, 2008) and its adverse effect on non-oil sectors, known as the "Dutch Disease" or the "resource curse". From the 1980's to the late 2000's, the dollar was found to co-move with the price of oil, resulting from a large counterpart in re-investments in American assets from oil-exporting countries (Krugman, 1980, 1983a, 1983b; Golub, 1983). During the same period, Corden and Neary (1982) investigated the reasons justifying the decline in the manufacturing sector of the Netherlands following a sharp appreciation of the Dutch guilder.<sup>2</sup> More recently, "oil currencies" were observed (Habib and Kalamova, 2007; Korhonen and Jurikkala, 2009; Coudert *et al.*, 2011), defined as currencies that appreciate when the price of oil goes up.

In this paper, we aim at filling the gap in the literature by exploring the link between energy prices and the real effective exchange rate over the period 1980-2010, focusing on two sets of economies: energy-exporting countries and commodity-exporting countries.

Our contribution is twofold. First, we provide global insights on the existence of "energy currencies". As previously mentioned, pre-existing studies have demonstrated that there were currencies that respond positively to oil terms-of-trade shocks. However, few attention has been paid in the existing literature to co-movements between energy prices other than oil and the real exchange rate of energy-dependent countries.<sup>3</sup> We explore the pattern followed by the real effective exchange rate of coal, gas and oil-exporting countries, allowing us to gather the currencies of countries whose exports are mainly composed of non-renewable energies, and whose currencies appreciate when energy prices go up. From a methodological viewpoint, we rely on panel techniques to increase the statistical power of our empirical analysis by combining information from both time and cross-section dimensions. Second, given (i) that oil is internationally and largely used as an intermediate input in the production process and (ii) the variability of its price, we raise the question of whether oil price changes have an asymmetric effect on the real exchange rate of both sets of countries.<sup>4</sup> To our best knowledge, our analysis is the first aiming

---

<sup>2</sup>The Dutch Disease was first stated in the magazine "The Economist" in 1977. In the 1960's, natural gas was discovered in the North sea. Its extraction accelerated gas exports, leading to windfall revenues which in turn seriously damaged the other sectors because of a high currency appreciation. The underlying mechanism will be detailed in Section 2.1.

<sup>3</sup>Yet, crude oil petroleum, natural gas and coal respectively represent 33%, 21% and 27% of the demand for primary energy worldwide. Although demand for energy products has decreased in developed regions (Europe and North America), due notably to government policies on fuel efficiency (IEA, 2013), the worldwide demand for fossil fuels has been steadily growing, mostly driven by Asian consumption. Source: *Institut Français du Pétrole et des Energies Nouvelles* (IFPEN).

<sup>4</sup>Changes in oil prices might have had significant impact on both energy-dependent countries and non-fuel commodity-exporting countries, *via* intermediate input costs (Backus and Crucini, 2000; Nazlioglu, 2011; Nazlioglu and Soytas, 2012).

at exploring the impact of energy prices on the real exchange rate through the terms-of-trade channel. We investigate whether we can evidence a sign effect and/or a magnitude effect. To this end, we rely on a panel nonlinear, smooth transition regression model (PSTR) proposed by González *et al.* (2005).

The rest of the paper is organized as follows. Section 2 reviews the literature on the terms-of-trade - real exchange rate *nexus*. Section 3 describes the econometric methodology and the data. Section 4 provides insights on the existence of "energy currencies". Section 5 reports the PSTR estimation results and Section 6 concludes.

## 2. THE TERMS-OF-TRADE - RER *nexus*

### 2.1. Theoretical models

We present two categories of theoretical models that are able to describe the mechanisms linking the real exchange rate and terms-of-trade of commodity-exporting countries. In this first set of models, the mechanisms described can be applied to all commodity exporters. Then, a second model is introduced which is of particular interest in the case of energy-exporting countries since it emphasizes the income effect<sup>5</sup> which can have adverse effects on the whole economy (so-called "Dutch disease"). All the models depicted here adopt the simplifying assumption that the commodity is entirely exported; hence its price is internationally determined, allowing us to focus only on the supply side (De Gregorio and Wolf, 1994).

### A general framework

Cashin, Céspedes and Sahay (2004) consider a small open home economy wherein two goods are produced: a good intended to be exported ( $X$ ), the primary commodity; and a non-tradable good ( $N$ ). Production is carried out by a constant returns to scale technology with labor as the only input.<sup>6</sup> It is assumed that labor can move freely across the economy in such a way that nominal wages ( $w$ ) are the same across sectors. Hence, at equilibrium, the marginal productivity must equal the real wage in each sector:

$$a_N = \frac{w}{P_N} \quad \text{and} \quad a_X = \frac{w}{P_X} \quad (1)$$

where  $a_N$  (resp.  $a_X$ ) is the productivity in the non-tradable good sector (resp. the exportable sector),  $P_N$  and  $P_X$  are the corresponding prices. The exportable good is traded on the international market and is not consumed locally (as in De Gregorio and Wolf, 1994), therefore its

<sup>5</sup>The terminology used by Corden and Neary (1982) is the "spending effect".

<sup>6</sup>It is assumed to be supplied inelastically to the different sectors.

price is determined by world demand and supply. The non-tradable good is not subject to international competition, its price depends solely on domestic demand and supply. Equation (2) replicates the well-known Balassa-Samuelson result which states that the relative price of the non-tradable good with respect to the primary commodity price is determined by technological factors, *i.e.* supply conditions:

$$P_N = \frac{a_X}{a_N} P_X \quad (2)$$

All things being equal, (2) shows that an improvement in the terms-of-trade will increase wages in sector  $X$ , leading to an upward shift of the non-traded good price, since nominal wage variations spread across the economy. In addition, domestic agents consume an imported good produced by foreign firms. The law of one price is assumed to hold for the latter, hence  $P_T = P_T^*/E$ , with  $E$  being the nominal exchange rate defined as the amount of foreign currency per local currency, and  $P_T$  (resp.  $P_T^*$ ) being the price in local (resp. foreign) currency of one unit of the tradable good.

The foreign economy consists in three sectors: the first two produce a non-tradable good ( $N^*$ ), an intermediate one ( $I^*$ ), and a final good ( $T^*$ ) that requires the primary commodity  $X$  and an intermediate input denoted  $I$  produced by the rest of the world.  $T^*$  is exported and consumed by domestic agents, among others. Labor is also assumed to move freely across sectors, hence prices can be expressed in the same fashion as in the domestic economy:

$$P_N^* = \frac{a_I^*}{a_N^*} P_I^* \quad (3)$$

The real exchange rate is defined as the foreign price of the domestic basket of consumption ( $EP$ ) relative to the foreign price of a foreign basket consumption ( $P^*$ ) (Cashin *et al.*, 2004, pp. 30):

$$RER = \frac{EP}{P^*} \quad (4)$$

Here, an increase of  $E$  means a real appreciation of the real exchange rate. The domestic consumer price index is given by:<sup>7</sup>

$$P = (P_N)^\gamma (P_T)^{1-\gamma}, \quad (5)$$

$\gamma$  is the share of non-tradables in the consumer's basket. The real exchange rate can be written as a function of the terms-of-trade :

$$RER = \left( \underbrace{\frac{a_X a_N^*}{a_I^* a_N}}_{BS} \underbrace{\frac{P_X^*}{P_I^*}}_{TOT} \right)^\gamma \quad (6)$$

<sup>7</sup>The foreign consumer price index is defined in the same way.

*TOT* refers to the terms-of-trade measured in foreign prices, *BS* embodies the Balassa-Samuelson effect: an increase in productivity in the exposed sector will tend to raise wages, which in turn will translate into higher non-traded goods prices. As the price of the primary commodity is exogenously determined, the final effect will be an appreciation of the real exchange rate. Overall, equation (6) illustrates that any change in the terms-of-trade yields a one-to-one variation of the real exchange rate.

Conversely, Chen and Rogoff (2003) offer a somewhat different model from Cashin *et al.* (2004) since they assume that the open sector requires capital input, in addition to labor. It allows the pass-through of an exogenous shock on the terms-of-trade to differ from unity, which is more likely to be verified in empirical studies. The model depicted in De Gregorio and Wolf (1994) offers the same implications. However, the authors acknowledge that the former results rely on strong assumptions such as the law of one price, perfect competition, perfect domestic mobility of factors, constant returns to scale, *etc.*

As all models that offer the advantage of simplicity, the main issue is that it can lead to rather limited results due to omitted mechanisms, as pointed out by Tokarick (2008). Indeed, none of the models discussed until now address the question of the income effect. In fact, an increase in the terms-of-trade generates greater wealth for the producers, which gives rise to two effects: (i) a substitution effect and (ii) an income effect that shifts the demand for non-traded good upwards. Consequently, the price of the non-traded good is pushed up, leading to an appreciation of the real exchange rate (Neary, 1988). This brings us to the models that describe the mechanisms that can lead to what is generally referred to as a "Dutch disease" that we discuss now.

### **The case of energy-exporting countries**

In the seventies, the Netherlands experienced a boom in its energy sector after the discovery of a large natural gas field in the North Sea (together with a surge in energy prices) while the manufacturing sector declined sharply because of the appreciation of the Dutch guilder relative to its trading partners' currency.<sup>8</sup> As previously mentioned, resource-exporting countries have had windfall revenues due to higher prices, resource discoveries or simply technological progress in the booming sector (Kutan and Wyzan, 2005). Accounting for a potential income effect is therefore essential.

Corden and Neary (1982) and Corden (1984) propose a theoretical framework considering a small open economy. Unlike the models mentioned in the previous section, the economy produces three goods, energy products and manufactured or agricultural products, all aimed at

---

<sup>8</sup>Subsequent to the boosted exports.

exports, plus a non-tradable good.<sup>9</sup> The production process requires labor for all three outputs and a specific factor to each industry (mobility is restricted to the country). For simplification purposes, there are no monetary considerations<sup>10</sup> and trade is assumed to be overall balanced. Real wages are perfectly flexible such that full employment is maintained at all times, and the boom in the energy sector raises automatically national welfare, *ceteris paribus*. The authors analyze the impact of boosted energy exports on the manufactured sector by enabling a technology progress which can be taken as a price increase in the exposed sector. We present the main implications of a terms-of-trade's improvement, highlighting the *resource-movement* and the *spending effects*.

Consider the price of energy goes up, increasing the profitability of the energy sector. The producers thus have greater incentives to produce. Demand for labor increases and consequently, so does the real wage. Since labor can move freely within the economy, it moves out from both the manufacturing and services sectors to the energy sector. This *resource-movement effect* gives rise to direct de-industrialization. Neary (1988) argues that results depend on whether the resource-sector is greatly integrated or not with the rest of the economy. In our case for instance, it can be neglectible since energy-sector usually employs few people (Corden, 1984).

The *spending effect* is a direct consequence of higher wages and profits in the energy sector. The sign of this effect differs with respect to the assumptions that are made. It depends on whether the country is a net exporter or a net importer of these energy products. A raise in energy prices when the country exports a large part of its energy output means an improvement in its terms-of-trade. Assuming the income-elasticity of demand for services is not zero,<sup>11</sup> the service industry faces greater demand and a contraction of its supply. The price of services must rise in order to eliminate the excess of demand, contributing to the appreciation of the real exchange rate (the price of the non tradable good increases relative to the others), which in turn provokes an indirect de-industrialization. It is important to note that in this type of model, it is the *income effect* that triggers the appreciation of the real exchange rate. Moreover, the *spending effect* can be magnified if services and energy are net substitutes. There can be a *substitution effect* that resorbs the excess supply on the non traded goods market, contributing to an even greater appreciation (and a more damaged manufacturing sector afterwards) of the real exchange rate (Neary, 1988).

---

<sup>9</sup>Tradable goods are sold at exogenously given world prices and the price of services is determined by domestic market clearing.

<sup>10</sup>Prices are expressed in terms of the prices of traded goods.

<sup>11</sup>Regardless of whether the generated surplus revenues are appropriated by the public or private sector.

## 2.2. Empirical studies

There has been a growing literature studying the empirical link between terms-of-trade and the real effective exchange rate (REER hereafter) of commodity and oil-exporting countries. In general, a positive link is found between those two variables. The currencies that follow this pattern are called either "commodity currencies" or "oil currencies". The long-run elasticities are somewhat larger for commodity-exporting countries than for oil-exporting countries. Being around 0.5 for commodity exporters (Coudert *et al.*, 2011; Bodart *et al.*, 2012), a 10% increase in oil terms-of-trade yields an appreciation of the REER of approximately 3% for oil-exporting countries (Habib and Kalamova, 2007; Jahan-Parvar and Mohammadi, 2011).

### Commodity-exporting countries

Chen and Rogoff (2003) focus on three developed commodity-exporting countries, namely Australia, Canada and New-Zealand, in order to investigate the determinants of their real exchange rate. Terms-of-trade are calculated as real commodity prices since they are more able to reflect exogenous terms-of-trade shocks than the usual export-to-import ratio (Backus and Crucini, 2000; Baxter and Kouparitsas, 2000). For Australia and New Zealand, they find evidence of a strong and stable correlation between the US dollar price of commodities and the REER, the long-run elasticity ranging from 0.73 to 1.01 for Australia and New-Zealand respectively. It is in line with Gruen and Wilkinson (1994) and Gruen and Kortian (1996) whose analyses point out the power of predictability of the terms-of-trade on the Australian currency over the period 1969-1994.

Cashin *et al.* (2004) expand the analysis to a set of 58 developed and developing countries over the period 1980-2002. The terms-of-trade are calculated as a weighted average of the three main exported commodities of each country, deflated by the manufactured unit value.<sup>12</sup> They find that 19 countries out of 58 have commodity currencies. For 10 countries out of the 19, there is a mean-reverting process of the real effective exchange rate to its equilibrium value, and causality runs from commodity prices to the REER. Moreover, Cashin *et al.* (2004) estimate a half-life of 10 months, which means that it takes about ten months for half of the commodity-exporting countries' REER deviations to fade away.

Coudert *et al.* (2011) look into the impact of terms-of-trade on the real exchange rate of 52 commodity-exporters over the period 1980-2008. They rely on a Behavioural Equilibrium Exchange Rate (BEER hereafter) approach proposed by Faruquee (1995) and Clark and MacDonald (1998). It consists in estimating a long-run relationship between the real exchange rate and its well-known fundamentals such as the net foreign asset position, the productivity differentials and the terms-of-trade.<sup>13</sup> The latter are calculated in the same way as in Cashin *et al.* (2004). A 10% rise in terms-of-trade is found to appreciate their currency by 4-6.5%.

<sup>12</sup>This index is commonly used in the commodity-price literature. See Cashin *et al.* (2000) among others.

<sup>13</sup>There are other key determinants of the real effective exchange rate, *e.g.* trade openness, public expenditure,

Contrary to the previous literature, Bodart *et al.* (2012) do not use a constructed price index to measure the terms-of-trade. They examine the role played by the price of one leading commodity in the determination of the real exchange rate of countries with one dominant exportable commodity. Using monthly data covering the period 1988-2008 for 14 commodity-country pairs, they find that the price of the leading-commodity is a long-run determinant of the real exchange rate of countries where the main commodity accounts for at least 20% of the total merchandise exports of the country considered. The long-run elasticity differs with respect to the estimation method chosen, ranging from 0.15 to 0.30. In addition, the authors show that the higher the specialization, the higher the elasticity.

### Oil-exporting countries

In addition to analyzing the link between commodity terms-of-trade and exchange rates in Canada, Chen and Rogoff (2003) include the real oil price in their regression. Unlike commodity prices, they obtain a significant negative impact on the Canadian dollar.<sup>14</sup> This result is consistent with the findings of Issa *et al.* (2006), showing that the sign of the elasticity differs with respect to whether Canada is net importer or net exporter of energy products. Indeed, prior to 1993, Canada's demand exceeded domestic supply of energy products and higher prices put a downward pressure on the real exchange rate. However, from 1993 onwards, energy prices have had the opposite effect, *i.e.* higher prices have made the currency stronger (see also Lizardo and Mollick, 2010).

Zalduendo (2006) looks into the impact of oil price on the Venezuelan currency over the period 1950-2004, using two measures of the real effective exchange rate: (i) a CPI-based REER, (ii) a parallel exchange rate. Both are affected by movements in oil prices although the long-run elasticities are almost three times higher when considering official rates (1.04 to 1.30) instead of parallel rates (0.44).<sup>15</sup> The Algerian currency seems to respond less to oil price since a 10% increase in oil prices leads to a 2% appreciation (Koranchelian, 2005). Habib and Kalamova (2007) investigate the existence of "oil-currencies" in three oil-exporting countries: Saudi Arabia, Norway and Russia on a country-basis. They find that oil prices and the Russian rouble follow a common stochastic trend.<sup>16</sup> As for the Saudi Arabian and the Norwegian currencies, there seems to be no long-run relationship between the RER and the price of oil. Korhonen and

---

foreign aid, *etc.* (Elbadawi and Soto, 1997).

<sup>14</sup>Similar results were drawn before in Amano and Van Norden (1995). Using monthly data from 1972 to 1992 for the Canada-US bilateral exchange rate, the estimated long-run elasticity associated with energy prices is negative and significantly different from zero. A 10% increase in oil prices led to a 2.2% depreciation of the Canadian dollar relative to the USD.

<sup>15</sup>The currency is usually more depreciated on the parallel market than on the official market. Therefore, growing oil prices (or terms-of-trade improvement) were less able to explain the evolution of the parallel-based exchange rate. I am grateful to Jean-Pierre Allegret who pointed out this stylized fact.

<sup>16</sup>There are other studies confirming the rouble as being an oil-currency, see for instance Spatafora and Stavrer (2003) and Kalcheva and Oomes (2007).

Juurikkala (2007) focus on how the real price of oil affects the real equilibrium exchange rate of twelve countries that rely heavily on exports of oil products: nine OPEC countries and three CIS (Commonwealth Independent States) over 1975-2005 and 1993-2005, respectively. To ensure robust results, they explore whether the effect of oil prices is the same with respect to different exchange rate measures (two bilateral real exchange rates: CPI-based and GDP deflator-based; and a REER). Their econometric strategy is based on a BEER approach.<sup>17</sup> The cointegrating vectors are obtained using the Pooled Mean Group (PMG) estimator proposed by Pesaran *et al.* (1999) whose advantage is that while long-run coefficients are restricted to be the same across cross-sections, the short-run responses can be different. The results confirm the existence of "oil currencies", regardless of the exchange rate measure chosen. This conclusion is supported by Coudert *et al.* (2011) whose findings suggest that for 16 oil-exporting countries, higher oil prices lead to a strengthening of their currency.<sup>18</sup>

As for the existence of a "resource curse" in both developed and developing countries, views upon results have been quite mixed. Indeed, the decline in the manufactured sector can be a long-term desindustrialization process as in Canada (Spilimbergo, 1998). The side effect described in the "Dutch Disease" model does not seem to be reflected in several OPEC members as one can notice in Figure 5. Regardless of the 2008 turmoil, from the early 2000's onwards, the real exchange rate of Algeria, Saudi Arabia, and the Republic of Iran remained quite stable although the price of oil has been following an upward trend since. One of the many possible reasons is that some of those currencies are pegged to the U.S. dollar, whose value has been declining since 2002.<sup>19</sup> The effects of terms-of-trade shocks can be dampened in several other ways. First and foremost, international reserves can play a buffer role on the REER's appreciation if the bank increases its stock of foreign reserves, pushing towards a nominal depreciation of the domestic currency, thereby cushioning the impact of the terms-of-trade shock. In the case of countries that operate under a fixed exchange rate regime (as several oil producers), the mechanism is quite the same, though there is no nominal depreciation *per se*, *e.g.*, reserve policies can be pursued in prediction of terms-of-trade shocks.<sup>20</sup> To a greater extent, it can be attributed to active management of international reserves through the creation of Sovereign Wealth Funds,<sup>21</sup> that can help the RER to be more resilient to external shocks by sterilizing the windfall revenues. An analogy can be drawn with Neary's (1988) model, the existence of SWFs could nullify the *spending effect*, and eventually, limit the currency's response.

<sup>17</sup>They do not include the stock of net foreign assets in the regression though.

<sup>18</sup>Note that Aziz and AbuBakar (2011) do not evidence such a relationship for Canada, Denmark (although it is self-sufficient in energy products) and Malaysia (natural gas constitutes 7% of its total exports). This is most certainly due to the fact that oil does not constitute the main export in 2 countries out of 3.

<sup>19</sup>For instance, Coudert *et al.* (2011) find an undervaluation of the cited countries' currencies ranging from -40.32 to -32.19.

<sup>20</sup>In this regard, the paper of Aizenman *et al.* (2012) suggests that the REER movements of commodity-exporting countries were smoothed by active reserve policies.

<sup>21</sup>According to the IMF, the overall size of global SWFs has reached and exceeded US\$ trillion. Also, a country's foreign exchange reserves does not take into account international reserves handled by the SWFs (IMF statistical scope, 2008).

### 3. EMPIRICAL ANALYSIS

As previously mentioned, our aim in this empirical analysis is twofold. First, we provide insights on the link between energy prices and real exchange rates in countries that export fossil fuel products (such as coal, natural gas and crude oil) in order to determine the existence of "energy currencies". Second, we analyze whether oil prices exert a non linear impact on the real exchange rate of energy-exporting countries as well as commodity-exporting countries. Prior to that, we present the data, the variables and the methodology used to conduct the study.

#### 3.1. Evolution of energy prices

Figures 1 and 2 in the Appendix depict the evolution of energy prices over the period 1980-2012. Globally, they have been following an upward trend from the early 2000's onwards, reaching a peak in 2008 before turning back to their 2007 level. Energy prices depend on a range of different supply and demand conditions, including the geopolitical situation (Hamilton, 2005), environmental protection costs, *etc.* First of all, global energy demand has been steadily increasing, mostly driven by Asia consumption as an input. For example, coal world consumption grew by +37% between 2000 and 2008,<sup>22</sup> coal being involved in 80% (resp. 68%) of China (resp. India)'s electricity production (source: IEA, 2012).

The surge in energy prices as well as in commodity prices highlighted that global supply has had difficulty keeping pace with the growth in demand. Indeed, the stagnation of the nineties (leaving to one side the Gulf War episode), discouraged producers from investing in capacity expansions. Once demand picked up in 2003, they were not able to answer it right away, pushing the prices up. Turning back to coal prices, as pointed out by the International Energy Agency (IEA), their trend has been reflecting the producers' anticipations on production costs that shift upwards because of growing extraction difficulties. Also, China was a net coal exporter until 2009 producing more than 50% of world coal production. According to the IEA (2012), China produced 3471 million tonnes (Mt) of hard coal out of the 6185 Mt produced worldwide. Knowing that only 15% is traded in average each year, the Chinese supply absorbed by domestic consumption accounted for a large reduction of the global supply, exerting an upward pressure on the price of coal.

As for natural gas prices, although both prices of gas have been following the same long-run pattern (albeit fluctuations of the American natural gas price that can be perceived as well as the 2008 economic downturn), the European and the American gas prices have been moving in the opposite direction for a couple of years. The fall in the American price can be attributed to abundant domestic supply, in part due to extraction in inexpensive areas, increased development

---

<sup>22</sup>It has been the fastest-growing global energy source with an average annual growth rate of 4.8%.

of shale gas resources<sup>23</sup> as well as gas storage capacity (Annual Energy Outlook 2013, IAE). On the other hand, the intensification of the European price is, *inter alia*, a consequence of the European Union's stricter environmental policies that promote the use of energies with low CO<sub>2</sub> emissions, encouraging the consumption of gas rather than oil and coal.

### 3.2. Econometric framework and data

In order to analyze the link between energy prices and real exchange rates, our econometric specification is based on the stock-flow approach to the equilibrium exchange rate proposed by Alberola *et al.* (1999, 2001). According to this approach, which is a refined version of the BEER methodology, a set of variables<sup>24</sup> such as the net foreign asset position, the Balassa-Samuelson effect and the terms-of-trade, are long-term drivers of the real exchange rate. It is a cointegration-based view of equilibrium exchange rates, such that:

$$lreer_{it} = \mu_i + \beta'X_{it} + \varepsilon_{it} \quad (7)$$

where  $lreer_{it}$  is the real effective exchange rate of country  $i$ ,  $X_{it}$  is a matrix containing its explanatory variables:  $lbs_{it}$ , the Balassa-Samuelson effect proxied by the country  $i$ 's PPP GDP per capita relative to other countries,  $nfa_{it}$  its net foreign asset position in percentage of GDP and finally  $ltot_{it}$ , its terms-of-trade.  $\mu_i$  accounts for unobserved heterogeneity between the countries of our sample. Finally,  $\varepsilon_{it}$  is an error term. All variables are expressed in logarithms, except the stock of net foreign asset position which is in percentage points of GDP.

### Sample

We consider yearly data spanning from 1980 to 2011 for two sets of countries:<sup>25</sup>

- 10 energy-exporting countries: Algeria, Australia, Canada, Colombia, the Republic of Iran, Nigeria, Norway, Saudi Arabia, South Africa and Venezuela. This sample includes 5 OPEC countries, 3 coal exporters and 2 gas-oil-exporting countries.
- 23 commodity-exporting countries: Bolivia, Brazil, Burundi, Cameroon, Central African Republic, Chile, Costa Rica, Côte d'Ivoire, Ghana, Iceland, Malawi, Malaysia, Morocco, New Zealand, Pakistan, Papua New Guinea, Paraguay, Philippines, Togo, Tunisia, Uganda, Uruguay and Zambia.

<sup>23</sup>The U.S. Energy Information Administration predicts that its share in total production will increase from 34 percent in 2011 to 50 percent in 2040.

<sup>24</sup>Data sources are given below.

<sup>25</sup>The choice is motivated by the fact that (i) the retained countries are the top exporters of these products and (ii) the considered commodity or energy is among the first three exported products of the country.

## Variables

**The real exchange rate** (*reer*) is provided by the International Monetary Fund's International Financial Statistics (IFS) database. It is calculated as a weighted average of real bilateral exchange rates against each partner and adjusted for relative movements in national price indicators of the home country and the selected countries. In other words, our exchange rates are expressed in effective and real terms (CPI-based, given as an index based on 2005=100). An increase in the real effective exchange rate thus means an appreciation.

**The net foreign asset position** (*nfa*) is extracted from the updated and extended version of dataset constructed by Lane and Milesi-Ferretti (2007) for the period 1980-2007.<sup>26</sup> Our sample covering the period 1980 to 2011, the database was completed by cumulating the current account in USD to the previous NFA position. The current account data was taken from the IMF World Economic Outlook (WEO, October 2012) database. We expect a positive correlation between the net foreign asset position and the real effective exchange rate. A country that faces growing extern liabilities (through a shortfall in the current account) needs to run large trade surpluses in order to face its dues. One way to achieve it is to have a depreciated exchange rate.

**The Balassa-Samuelson effect** (*BS*) is proxied by the PPP GDP per capita relative to the trading partners. The weights ( $w_j$ ) correspond to the shares in the world GDP calculated on average over the period 1980-2011,<sup>27</sup> using the GDP in current USD from the IMF's WEO database:

$$BS_{it} = \frac{\text{PPP GDP cap}_{i,t}}{\prod_{j=1, j \neq i}^{131} \text{PPP GDP cap}_{j,t}^{(w_j)}} \quad (8)$$

This Balassa-Samuelson effect states that in a country wherein the productivity in tradable goods relative to non-tradable goods increases (*versus* foreign countries), it induces a higher relative wage, thus increasing the relative price of non-tradable goods (the internal exchange rates appreciates). Consequently, the real exchange rate has to appreciate.

**The energy terms-of-trade** ( $tot^{en}$ ) are calculated as the price of energy deflated by the Manufactured Unit Value (MUV). This has been done for the oil-exporting countries and the coal

<sup>26</sup> Available at : [www.imf.org/external/pubs/ft/wp/2006/data/update/wp0669.zip](http://www.imf.org/external/pubs/ft/wp/2006/data/update/wp0669.zip). See Lane and Milesi-Ferretti (2007).

<sup>27</sup>  $w_j = \text{GDP}_j / \sum_{k=1}^{132} \text{GDP}_k$  and  $\sum_{j=1}^{132} w_j = 1$ . They are available upon request to the author.

exporting ones. Oil producers are often also gas producers since the extraction process is the same, it is the case of Norway and Canada.<sup>28</sup> Thus, for those two countries wherein oil and gas are both significant exports, export prices are expressed as a weighted average ( $\alpha$  and  $\beta$  displayed in Table 3) of both natural gas and crude oil prices. More specifically:

$$tot_{it}^{en} = \begin{cases} \frac{coal\ price_{it}}{MUV_t}, & (\text{Australia, Colombia and South Africa}) \\ \frac{oil\ price_t}{MUV_t}, & (\text{Algeria, Iran, Nigeria, Saudi Arabia and Venezuela}) \\ \frac{(oil\ price_t)^\alpha \times (gas\ price_{it})^\beta}{MUV_t}, & (\text{Canada and Norway}) \end{cases}$$

The price of oil does not vary with respect to the country. It is due to the fact that the oil price index is a simple average of US dollar prices in three major markets: Brent, Dubai, and West Texas and it is provided by the IFS database. For Norway, it seemed more relevant to use the wholesale price of natural gas in Europe rather than the U.S. price which accounts for the price of natural gas in Canada.

**The commodity terms-of-trade ( $tot^{com}$ )** are a weighted average price of the three main commodities exported by country  $i$ , deflated by MUV:

$$tot_{it}^{com} = \sum_{k=1}^3 share_i^k \cdot p_t^k / MUV_t \quad (9)$$

They are calculated in the same way as in Cashin *et al.* (2004) that provide the share ( $share_i^k$ ) of commodity  $k$  among the three main commodity exports of country  $i$ . They are displayed in Table 3.

#### 4. ARE THERE ENERGY-CURRENCIES?

Figures 3 to 5 depict the evolution of terms-of-trade and real effective exchange rates for our 10 energy-dependent countries over the period 1980-2011. Generally, the terms-of-trade experienced a downward trend until the late nineties before picking up. For coal-exporting countries, the real effective exchange rate is fairly co-moving with the terms-of-trade; a fact that is especially striking for Australia. Concerning the countries that export natural gas as well as oil, the pattern is less clear-cut at the beginning of the period. One important thing to be reminded is that Canada was until 1993 a net importer of energy products. The real effective exchange rates

<sup>28</sup>We acknowledge Algeria, Nigeria and the Republic of Iran as gas producers too. However, due to the impossibility of determining the weights of gas and oil exports in the export structure, we consider crude oil prices only.

of our oil-exporting countries have remained quite stable since the early 2000s, not following the same path than oil prices. It is especially apparent for Algeria and Saudi Arabia. As said earlier, it can be due to the constitution of SWF which has helped buffer the impact of the oil price surge. We now check these visual intuitions through an econometric analysis.

#### 4.1. Panel unit root analysis and cointegration tests

The first mandatory step in our analysis is to investigate the order of integration of our variables. To that end, we perform various panel unit root tests which differ with respect to the restrictions on the autoregressive process across cross-sections. The results are displayed in Table 4 in the Appendix. The Levin-Lin-Chu (2002, LLC), and Hadri (2000) tests assume that cross-sectional units share a common unit root. The alternative hypothesis being quite restrictive, we consider two other tests: the Im-Pesaran-Shin (1997, 2003, IPS) and the Maddala and Wu (1999, MW) tests that allow for heterogeneity in the value of the autoregressive coefficient under the alternative hypothesis. Hence, under the alternative hypothesis, while some series may be characterised by a unit root, some others can be stationary. Overall, our findings show that the series contain at least one unit root at a reasonable level of confidence.

Equation (7) is a long-term relationship which means that given the series' properties, there has to be some linear combination of these series that has time-invariant linear properties. We test the presence of a long-run relationship between the real effective exchange rate and its fundamentals considering two categories of tests based on the null hypothesis of no cointegration: the seven tests provided by Pedroni (1999, 2004) and the one proposed by Kao (1999). Within the seven tests proposed by Pedroni, four are within-dimension residual-based tests and the second class of statistics is based on the between-dimension. The between-statistics are less restrictive in that they allow the slope coefficients  $\beta_i$  to vary across individuals, so that the cointegrating vectors may not be the same among the members of the panel. The seven statistics are then constructed differently with respect to the way residuals are pooled.<sup>29</sup> As reported in Table 5 (Appendix), 6 out of the 8 tests applied suggest that the REER and its considered drivers are cointegrated at conventional confidence levels.

#### 4.2. Results

Our series being I(1) and cointegrated, we now proceed to the estimation of the cointegrating relationship. We estimate the long-run relationships with the panel DOLS procedure proposed by Kao and Chiang (2000) and Mark and Sul (2003).<sup>30</sup> It consists in augmenting the cointegrating regression with lead and lagged values of differences of the regressors to alleviate a potential endogenous feedback effect.

<sup>29</sup>See Pedroni (2004) and Hurlin and Mignon (2006).

<sup>30</sup>Unlike OLS estimates, DOLS estimators are not asymptotically biased and are independent of nuisance parameters (Pedroni, 2000; Kao and Chiang, 2000). In addition, the DOLS procedure presents lower size distortion than the Fully Modified OLS method.

The estimated cointegrating relationship is given by:<sup>31</sup>

$$lreer_{it}^{en} = \mu_i + \underset{(1.92)}{0.0002} nfa_{it} + \underset{(4.18)}{0.006} lbs_{it} + \underset{(3.75)}{0.287} ltot_{it}^{en} \quad (10)$$

As expected, all variables have a positive impact on the real effective exchange rate. The net foreign asset position is significant at the 10% confidence level and its improvement leads to an exchange rate appreciation. The productivity differential is significantly positive as expected, though its impact is quite low. The currencies of our energy-dependent countries can be considered as "energy currencies" since the long-run elasticity of the real effective exchange rate to the terms-of-trade is significant and positive. The real exchange rate of fossil-energy exporting countries should increase by roughly 2.8 % following a 10% increase in the international price of coal, gas and oil. Our results are somewhat consistent with studies analyzing the existence of "oil currencies" which indicate a long-run elasticity revolving around 0.3 which is close from our results (Habib and Kalamova, 2007; Coudert *et al.*, 2011).

Another interesting issue here is to check -as the theoretical models would predict- whether the terms-of-trade are exogenous or not. More particularly, we have interest in assessing the direction of causality, *i.e.* if energy prices influence the real exchange rate or if it is the other way round. Many studies have found that commodity terms-of-trade are weakly exogenous in the sense of Engle, Hendry and Richards (1983), meaning that it is the real exchange rate that adjusts towards its equilibrium value (Amano and van Norden, 1995; Cashin *et al.*, 2004; Coudert *et al.*, 2011). This result is rather straightforward to understand since many commodity-producers are small countries, they have very little influence over the price of their exports (Broda, 2003), they are price-takers on the world commodity market.<sup>32</sup> As for oil-producing countries, not many studies have carried out causality tests. We can however mention Habib and Kalamova (2007) that evidence causality running from oil prices to the real exchange rate for Russia, while in Coudert *et al.* (2011), the terms-of-trade and the real exchange rate affect each other (the causality being bi-directional). Prior to examining the direction of causality, one has to check which variables are weakly exogenous. The latter can be done by applying a panel non-causality Granger test on a vector autoregressive error correction model (with  $z_{t-1}$  the residuals of the cointegrating relationship (10)). The test proposed by Holtz-Eakin, Newey

<sup>31</sup> $t$ -stats are reported in parentheses.

<sup>32</sup>Although this view has been recently challenged by empirical evidence of spillovers across foreign exchange and commodity markets (Chen *et al.*, 2010). Clements and Fry (2008) challenge the original view by defining "currency commodities" as commodities whose prices are substantially affected by currency fluctuations. They study the case of well-known countries with commodity-currencies: Australia, Canada and New-Zealand and find that there is less evidence that currencies are affected by commodities than commodities affected by the commodity currencies (spillovers). However, they do not rely on a long-term analysis but on a multivariate latent model factor which focuses on the volatility while we rely on panel cointegration techniques. The reason explaining this spillover phenomenon arises from a two-step process: (i) first, the country's currency whose commodity export prices increase substantially will strengthen, as predicted by Cashin *et al.* (2004); (ii) the latter squeezing the volume of exports which can further put an upward pressure on the world commodity price.

and Rosen (1988) is based on the non-causality assumption against causality, and the results are displayed in Table 1.<sup>33</sup>

**Table 1 – Pairwise Granger Panel causality tests**

X/Y	$\Delta lreer$	$\Delta nfa$	$\Delta lbs$	$\Delta ltot$	$z_{t-1}^{en}$
$\Delta lreer$	-	0.11	0.53	0.41	0.00
$\Delta nfa$	0.24	-	0.07	0.25	0.62
$\Delta lbs$	0.01	0.02	-	0.00	0.12
$\Delta ltot$	0.05	0.13	0.00	-	0.73
$z_{t-1}^{en}$	0.00	0.83	0.55	0.64	-

Notes: the probabilities of incorrectly rejecting the null of no causality from  $X$  (columns) to  $Y$  (rows) are reported above. A VARECM is estimated with the number of lags  $p$  chosen as to minimize the SIC ( $p = 3$ ).

The terms-of-trade are weakly exogenous since they are not Granger-caused by the residuals  $z_{t-1}$ . The null of no causality running from the productivity differential variable to the terms-of-trade is rejected, indicating that the latter are not strongly exogenous. The  $p$ -value associated to the deviations (in the first column) indicates that it is the real exchange rate that adjusts to restore the long-run equilibrium. Also, the results illustrate a causality running from the energy terms-of-trade to the real exchange rate.

## 5. DO OIL PRICES HAVE A NONLINEAR IMPACT ON THE REAL EXCHANGE RATE?

Conversely to any type of commodity, fossil energies are widely used in the production and transportation of (agricultural) goods, but also in private consumption and energy production. As the engine of economic activities, many studies have examined the impact of oil prices on different macroeconomic variables. For instance, Hamilton (1983) and Mork (1989) find a negative link between oil price shocks and output, the latter being found as responsible, *inter alia*, for economic recessions particularly in the U.S. Oil price shocks also affect monetary and financial variables (Basher and Sadorsky, 2006; Du *et al.*, 2010, among others). In line with the development of nonlinear econometric techniques, there has been evidence of asymmetric effects of oil price shocks on economic variables (Mork, 1989; Huang *et al.* 2005, among others). As it has been evidenced in the former section, energy prices have a great explanatory power on the real exchange rate's evolution of energy-exporting countries, but one can possibly believe that energy prices also influence in a nonlinear fashion the real exchange rate. Akram (2004) explores the existence of a nonlinear relationship between oil prices and the nominal exchange

<sup>33</sup>The test of non-causality proposed by Dumitrescu and Hurlin (2012) was also applied, however we do not report the results as they are highly dependent on the number of lags chosen.

rate of the Krone over the period 1986-1998. The main findings show that there is a negative relationship between oil prices and the Norwegian exchange rate, relatively strong when oil prices are below 14 dollars and when experiencing a downward trend. It is the closest study to ours in the sense that we investigate whether oil prices impact in a nonlinear fashion the exchange rate. Nonetheless, we go further in our analysis by searching the channel through which it occurs, paying a particular attention to the-terms-of-trade. With respect to our problematic, we consider a panel smooth transition error correction model (PSTEEM).

### 5.1. PSTR methodology

Panel smooth transition models (hereafter PSTR) proposed by González *et al.* (2005) are a generalization of the panel threshold regression (PTR) model developed by Hansen (1999). In the latter, individuals are divided into several regimes (usually 2) depending on the value of one variable, the shift from one regime to the other occurring abruptly. The main feature of PSTR models is that they rely on a smooth transition. Our nonlinear specification can be written as follows, for both energy-dependent and commodity-exporting countries:

$$\begin{aligned} \Delta lreer_{it} = & \mu_{it} + \alpha_0 \Delta nfa_{it} + \alpha_1 \Delta lbs_{it} \\ & + \alpha_3 \underbrace{(lreer_{i,t-1} - \beta_{i0} - \beta_1 nfa_{i,t-1} - \beta_2 lbs_{i,t-1} - \beta_3 ltot_{i,t-1})}_{z_{i,t-1}} \\ & + \alpha_4 \Delta ltot_{it} + \alpha'_4 \Delta ltot_{it} \times G(S_t, \gamma, c) \\ & + \varepsilon_{it} \end{aligned} \quad (11)$$

for  $i = 1, \dots, N$  countries over  $t = 1, \dots, T$  periods. In this nonlinear ECM specification, the lagged residuals of the cointegrating vector  $z_{i,t-1}$  are included to account for the long-term dynamics of the real effective exchange rate,<sup>34</sup>  $\varepsilon_{it}$  an error term and  $\mu_{it}$  is an unobservable time-invariant regressor (fixed effects).  $G(\cdot)$  is a continuous transition function which is usually bounded by zero and one and takes the form of a logistic function (Granger and Teräsvirta, 1993; Teräsvirta, 1994):

$$G(S_t, \gamma, c) = [1 + \exp(-\gamma(S_t - c))]^{-1} \quad (13)$$

Specification (13) depends on three parameters: the speed of adjustment  $\gamma$  ( $\gamma > 0$ ) that determines the smoothness of the shift from one regime to the other,  $c$  the threshold at which the

<sup>34</sup>We evidenced that the 23 commodity-exporters have "commodity currencies". More precisely, the estimated cointegrating relationship is given by ( $t$ -stats reported in parentheses):

$$lreer_{it}^{com} = \mu_i + \underset{(1.24)}{0.0001} nfa_{it}^{com} + \underset{(5.29)}{0.002} lbs_{it}^{com} + \underset{(7.63)}{0.42} ltot_{it}^{com} \quad (12)$$

A 10% increase in commodity terms-of-trade yields an appreciation of the REER of approximately 4.2% for commodity-exporting countries. Although our aim in this paper is not to assess whether there exist "commodity currencies", we are able now to account for the long-run dynamics of the commodity-exporters' real exchange rate in the nonlinear specification by including the long-run residuals denoted  $z_{i,t-1}^{com}$ .

transition occurs, and finally  $S_t$  the variable that triggers the shift. The transition variable  $S_t$  (here, the variation of the price of oil expressed in real terms,  $\Delta lroil_{it}$ <sup>35</sup>) determines the value of  $G(\cdot)$ , thus the regression coefficients  $\alpha_4$  and  $\alpha'_4$  in (11). We allowed nonlinearity to affect one variable only, the terms-of-trade. It is very convenient in our case since we aim at examining whether the situation on the energy market has a differentiated effect on the terms-of-trade, and consequently on the real exchange rate. When there are two regimes and  $\gamma \rightarrow \infty$ ,  $G(\cdot)$  becomes an indicator function  $\mathbf{1}\{s_{it} > 0\}$ , we end up with the initial threshold model (Hansen, 1999) with a brutal transition from one regime to another.

We follow the three-step strategy proposed by González *et al.* (2005). Given the aim our paper, we start by applying linearity tests considering two transition variables:  $\Delta lroil$  and  $|\Delta lroil|$ , the latter being a proxy of oil price volatility. The results are reported in Table 6 in the Appendix. For commodity-exporting countries, all tests strongly reject the null of linearity for both choices of the transition variable, although the  $p$ -values associated to the volatility of oil prices are smaller. As for fossil fuels-exporting countries, homogeneity is rejected only with  $|\Delta lroil_{it}|$  at the 10% confidence level. Thus we proceed by estimating the PSTR<sup>36</sup>, the results being displayed in Table 2.

## 5.2. Results

All explanatory variables of the REER's variations -when significant- are correctly signed. Indeed, an increase in the productivity differentials has a positive impact on the REER, as expected. The net foreign asset position does not help explaining exchange rates' variations, as it is frequently obtained in the literature (Korhonen and Juurikkala, 2007; Coudert *et al.*, 2011). Also, for each set of countries, the lagged error-correction term is significant and negative, which allows to ascertain that the real effective exchange rate follows a mean reverting process. The speed of adjustment towards equilibrium is somewhat higher in commodity-exporting countries (-0.21) than in energy-exporting countries (-0.16). It can be attributed to some extent to the windfall revenues received in exchange of energy products that tend to push the real effective exchange rate farther away from its long-term target.

Let us consider the model with the growth rate of oil prices as the transition variable. When oil prices decrease more than 16%, a 10% rise in the terms-of-trade variations leads to a 3.8% increase in the REER of commodity-exporting countries. The first intuition is that when the price of oil follows a downward trend, production as well as transportation costs are reduced for

<sup>35</sup>The oil price measure is the same one used to calculate the oil terms-of-trade in Section 3. It is a simple weighted average of the three main market oil prices (UK Brent, Dubai and WTI).

<sup>36</sup>The PSTECM was estimated on the software RATS using the program provided by Gilbert Colletaz whom we are grateful for having made it available on: [www.univ-orleans.fr/deg/masters/ESA/GC/sources/gtvd\\_doc.pdf](http://www.univ-orleans.fr/deg/masters/ESA/GC/sources/gtvd_doc.pdf)

Table 2 – Estimation of PSTR models

Countries $S_t$	Commodity exporters				Energy exporters	
	$\Delta lroil$		$ \Delta lroil $		$ \Delta lroil $	
	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2
$\Delta nfa$	$6.14e^{-07}$ (0.33)		$6.38e^{-07}$ (0.31)		$-1.41e^{-07}$ (0.77)	
$\Delta lbs$	$8.73e^{-03}$ (0.00)		$8.27e^{-03}$ (0.00)		$9.38e^{-03}$ (0.00)	
$z_{t-1}$	-0.209 (0.00)		-0.21 (0.00)		-0.159 (0.00)	
$\Delta ltot$	0.38 (0.00)	-0.32 (0.00)	0.04 (0.15)	0.39 (0.00)	-0.127 (0.12)	0.207 (0.00)
$\hat{\gamma}$	299.99		300.01		4449.35	
$\hat{c}$	-0.168		0.365		0.251	

Notes:  $p$ -values are reported in parentheses.

commodity-producers, and might emphasize the positive effect of a terms-of-trade's improvement. Nevertheless, when taking a closer look at the data, there are only 4 observations out of 29 that belong to the first regime. They correspond to sharp decreases in oil prices (namely in 1986, 1988, 1998 and 2009) which were coupled with falls in prices of export commodities.<sup>37</sup> Moreover, the high correlation between  $\Delta ltot$  and  $\Delta lreer$  (0.38) is due to the fact that the deterioration in the terms-of-trade was accompanied by the depreciation of the commodity-exporters' currency (for 16 countries out of the 23 in our sample). However, when oil price variation reaches and exceeds -0.16, the overall effect is quite low, though positively significant. Most of the time, terms-of-trade have little impact on the REER in the short-run. One possible explanation is that the variations of the terms-of-trade are not able to reproduce the volatility of the real effective exchange rate. On the other hand, Bernanke *et al.* (1997) argue that the asymmetric effects of oil price shocks are due to contractionary monetary policy. Indeed, following an oil price increase, oil prices pass through core (imported) inflation, interest rates are raised which in turn attracts foreign investors since investments offer higher yieldings. Consequently, the real exchange rate has to appreciate. The real exchange rate would not be driven by the terms-of-trade in the short-run, but by other variables such as interest rates.

Turning to oil price variations in absolute terms as the switching variable, the results reinforce the previous findings. Indeed, the use of this transition variable enables us to determine whether there exists a certain threshold at which the real exchange rate reacts differently to

<sup>37</sup>Commodity prices were reduced by 12% on average in 1998 and 2009 and 3% in 1986. Source: *Author's calculation.*

the terms-of-trade with respect to the situation on the crude oil market in terms of volatility. When the situation on the oil market is quite stable, the coefficient associated to the variation of the terms-of-trade is very small but not significant for commodity-exporting countries and it is even negative (though not significant) for energy-exporting countries. However, beyond a certain value of  $\hat{c}$ , 0.36 and 0.25 for commodity and energy-exporting countries, respectively, the currencies follow an "oil-currency" regime. For the 23 countries that export commodities, extreme movements in oil prices -that is a variation of oil prices exceeding 36%- impact the terms-of-trade, either through the price of imports or the price of exports, that is the commodity prices. Although terms-of-trade are taken to be exogenous, perhaps high movements in oil prices affect producers worldwide, therefore the world price *in fine*. It is consistent with the findings of Backus and Crucini (2000) suggesting that a large part of the variability of the terms-of-trade can be attributed to extreme movements in oil prices. In line with the co-surge of both energy and commodity prices, the literature has been focusing on the oil price-commodity prices *nexus*. Nazlioglu (2011) performs a nonlinear causality analysis indicating that there are nonlinear feedback effects between oil and three agricultural prices (corn, soybeans and wheat). Moreover, there is a persistent unidirectional causality running from oil prices to the corn and the soybeans price, partly due to increasing demand for alternative fuels. Using monthly data from January 1980 to February 2010, the panel cointegration framework considered by Nazlioglu and Soytaş (2012) provides strong evidence regarding the impact of world oil prices on agricultural commodity prices.

Given that coal, natural gas as well as oil industries are energy-intensive sectors, they also require oil as an input, if not more than commodity-exporting countries. Hence, extreme movements in oil prices are very likely to increase the terms-of-trade impact on the real effective exchange. The fact that they do not need to import it<sup>38</sup> might be the reason why the terms-of-trade impact is lower in the case of energy-exporting countries than commodity-exporting countries.

## 6. CONCLUSION

This paper has studied the impact of energy prices on the real effective exchange rate of both energy-exporting and commodity-exporting countries. Using annual data over the period 1980-2011, we evidence a positive long-term relationship between energy terms-of-trade and the real effective exchange rate of energy-exporting countries: a 10% increase in energy price led to a 2.5% appreciation of their currency. The currencies that follow this pattern are called "energy currencies". The estimation of panel nonlinear, smooth transition regression models shows that there exists a certain threshold beyond which the real effective exchange rate of both sets of countries react to oil prices, through the terms-of-trade. More specifically, when the petroleum

<sup>38</sup>Then again, it does not apply to Australia, Colombia and South Africa which are coal-dependent countries. Nevertheless, in our sample, 7 out of 10 energy-dependent countries are crude oil producers.

market is calm, the real effective exchange rates of both energy and commodity-exporting countries are not determined by their terms-of-trade but by other usual fundamentals. Low oil price variations might not be transmitted to the real exchange rate through the terms-of-trade channel in the short-run but by financial ones (*e.g.* portfolio arbitrage, Krugman (1983)). Nevertheless, when the market is highly volatile, the currencies follow an "oil currency" regime, terms-of-trade becoming an important driver of the real exchange rate. This can be linked to the recent financialization of commodity and energy markets, high speculation enhancing great movements in the prices of the latter products (Cifarelli and Paladino, 2010; Creti *et al.*, 2012).

Given the recent co-surge in energy and commodity prices, our results have important implications for developing as well as emerging economies whose revenues heavily rely on exports. Indeed, a terms-of-trade improvement leads to an appreciation of the real effective exchange rate. In order to prevent energy prices fluctuations from enhancing great macroeconomic instability, exporting countries should find a way to buffer the impact of high variability of fuel/non-fuel commodity prices either by the constitution of Sovereign Wealth Funds or nominal exchange rate adjustments. Also, a greater monitoring of speculative activities would be helpful. With respect to our problematic, further research aiming at better understanding the underlying mechanisms linking extreme oil price changes and real exchange rate fluctuations through the terms-of-trade channel should enable us to provide suggestions on how to reduce the dependence to commodity and energy prices since oil prices affect both export and import prices.

## 7. REFERENCES

- Akram, Q.F., 2004. "Oil prices and exchange rates: Norwegian evidence." *The Econometrics Journal*, 7(2), pp. 476-504
- Mendoza, E., and H. Lopez, 2001. "Internal and external exchange rate equilibrium in a cointegrating framework. An application to the Spanish Peseta", *Spanish Economic Review*, Springer, 3(1), pp. 23-40
- Amano, R., and S. van Norden, 1995. "Terms of trade and real exchange rates: the Canadian evidence", *Journal of International Money and Finance*, 14(1), pp. 83-104
- , and S. Van Norden, 1998. "Oil prices and the rise and fall of the US real exchange rate." *Journal of international Money and finance*, 17(2), pp. 299-316
- Backus, D.K., and M.J. Crucini, 2000. "Oil prices and the terms of trade", *Journal of International Economics*, 50(1), pp. 185-213
- Bai, J., C. Kao, and S. Ng, 2009. "Panel cointegration with global stochastic trends." *Journal of Econometrics*, 149(1), pp. 82-99
- Balke, N.S., and T.B. Fomby, 1997. "Threshold cointegration." *International Economic Review*, pp. 627-645
- Basher, S.A., and P. Sadorsky, 2006. "Oil price risk and emerging stock markets." *Global*

- Finance Journal*, 17(2), pp. 224-251
- Baxter, M., and M.A. Kouparitsas, 2006. "What Can Account for Fluctuations in the Terms of Trade?", *International Finance*, Wiley Blackwell, 9(1), pp. 63-86
- Bems, R., and I. Evangelista de Carvalho Filho, 2011. "The current account and precautionary savings for exporters of exhaustible resources", *Journal of International Economics*, 84(1), pp. 48-64
- Bernanke, B.S., and F. S. Mishkin, 1997. "Inflation targeting: a new framework for monetary policy?" *NBER Working Paper*, 5893, National Bureau of Economic Research
- Bodart, V., B. Candelon, and J.-F. Carpentier, 2012. "Real exchanges rates in commodity producing countries: A reappraisal", *Journal of International Money and Finance*, 31(6), pp. 1482-1502
- Broda, C., and C. Tille, 2003. "Coping with terms-of-trade shocks in developing countries." *Current issues in Economics and Finance*, 9(11)
- , 2004. Terms of trade and exchange rate regimes in developing countries. *Journal of International Economics*, 63(1), pp. 31-58
- Cashin, P., L. Céspedes, and R. Sahay, 2004. "Commodity Currencies and the Real Exchange Rate", *Journal of Development Economics*, 75, pp. 239-268
- Chen, Y.-C. and K. Rogoff, 2003. "Commodity currencies", *Journal of International Economics*, 60, pp. 130-160
- , K. Rogoff, and B. Rossi, 2010. "Can exchange rates forecast commodity prices?", *Quarterly Journal of Economics*, 125(3), pp. 1145-1194
- Clark, P., and R. MacDonald, 1998. "Exchange rates and economic fundamentals: a methodological comparison of BEERs and FEERs", *IMF Working Paper*, 66
- Clements, K.W., and R. Fry, 2008. "Commodity currencies and currency commodity", *Resources Policy*, 33(2), pp. 55-73
- Corden, W.M., 1984. "Booming Sector and Dutch Disease Economics: Survey and Consolidation", *Oxford Economic Papers*, New Series, 36(3), November
- , and J.P. Neary, 1982. "Booming sector and de-industrialisation in a small open economy", *Economic Journal*, 92(368), pp. 825-848
- Coudert, V., C. Couharde and V. Mignon, 2011. "Does Euro or Dollar pegging impact the real exchange rate? The case of oil and commodity currencies", *World Economy*, 34(9), pp. 1557-1592
- , V. Mignon, and A. Penot, 2008. "Oil price and the dollar." *Energy Studies Review*, 15(2)
- Creti, A., M. Joëts and V. Mignon, 2013. "On the links between stock and commodity markets' volatility", *Energy Economics* 37, pp. 16-28
- De Gregorio, J., and H.C. Wolf, 1994. "Terms of trade, productivity and the real exchange rate", *NBER Working Paper*, 4807, National Bureau of Economic Research, Cambridge,

MA

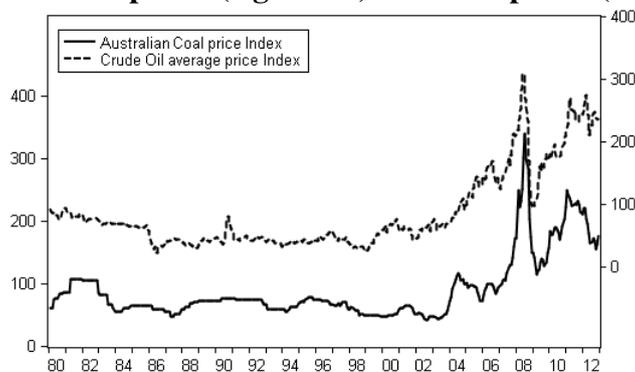
- Dornbusch, R., 1980. *Open economy macroeconomics*, New York: Basic Books
- Du, X., C.L. Yu, and D.J. Hayes, 2011. "Speculation and volatility spillover in the crude oil and agricultural commodity markets: A Bayesian analysis." *Energy Economics*, 33(3), pp. 497-503
- Edwards, S., 1994. "Real and monetary determinants of real exchange rate behavior: Theory and evidence from developing countries." *Estimating equilibrium exchange rates*, pp. 61-91
- Elbadawi, I.A., and R. Soto, 1997. "Real exchange rates and macroeconomic adjustment in Sub-Saharan Africa and other developing countries." *Journal of African Economies*, 6(3), pp. 74-12
- Engle, R.F., D.F. Hendry, and J.-F. Richard, 1983. "Exogeneity", *Econometrica: Journal of the Econometric Society*, 51(2), pp. 277-304
- Golub, S.S., 1983. "Oil prices and Exchange rates". *Economic Journal*, 93(371), pp. 576-593
- Gagnon J., 1996. "Net foreign assets and equilibrium exchange rates: panel evidence", *Board of Governors of the Federal Reserve System International Finance Discussion Paper*, 574, December
- González, A., T. Teräsvirta, and D. van Dijk, 2005. "Panel Smooth Transition Models", *Research Paper Series*, 165, Quantitative Finance Research Centre, University of Technology, Sydney
- Granger, C.W.J., 1980, "Testing for causality: a personal viewpoint." *Journal of Economic Dynamics and control*, 2, pp. 329-352
- Gruen, D.W.R., and J. Wilkinson, 1994. Australia's real exchange rate -Is it explained by the terms of trade or by real interest differentials? *Economic Record*, 70(209), pp. 204-219
- , and T. Kortian, 1996. Why does the Australian dollar move so closely with the terms of trade?, *Reserve Bank of Australia*
- Habib, M.M., and M.M. Kalamova, 2007. "Are there oil currencies? The real exchange rate of oil exporting countries", *European Central Bank Working Paper*, 839, December
- Hadri, K., 2000. "Testing unit roots in heterogenous panel data", *Econometrics Journal*, 3, pp. 148-161
- Hamilton, J.D., 1983. "Oil and the macroeconomy since World War II." *The Journal of Political Economy*, pp. 228-248
- , 2005. "Oil and the Macroeconomy", *The New Palgrave Dictionary of Economics*, MacMillan
- Holtz-Eakin, D., W. Newey, and H.S. Rosen, 1988. Estimating Vector Autoregressions with Panel Data. *Econometrica: Journal of the Econometric Society*, 56(6), pp. 1371-1395
- Huang, B.-N., M. J. Hwang, and H.P. Peng, 2005. "The asymmetry of the impact of oil price shocks on economic activities: An application of the multivariate threshold model." *Energy Economics*, 27(3), pp. 455-476

- Hurlin, C., and V. Mignon, 2005. "Une synthèse des tests de racine unitaire sur données de panel", *Economie & Prévision*, 3, pp. 253-294
- , and V. Mignon, 2008. "Une synthèse des tests de cointégration sur données de panel", *Economie & Prévision*, 4, pp. 241-265
- , and E. Dumitrescu, 2012. "Testing for Granger non-causality in heterogeneous panels", *Economic Modelling*, 29(4), pp. 1450-1460
- Im, K.S., M.H. Pesaran, and Y. Shin, 2003. "Testing for unit roots in heterogeneous panels", *Journal of Econometrics*, 115, pp. 53-74
- Issa, R., R. Lafrance and J. Murray, 2006. "The turning black tide: energy prices and the Canadian dollar", *Bank of Canada, Working Paper*, 29
- Kalcheva, K., and N. Oomes, 2007. "Diagnosing Dutch disease: does Russia have the symptoms?" *IMF Working Paper*, 07(102), International Monetary Fund, Washington DC
- Kao, C., 1999. "Spurious regression and residual-based tests for cointegration in panel data", *Journal of Econometrics*, 90(1), pp. 1-44
- Kilian, L., 2008. "The economic effects of energy price shocks", *Journal of Economic Literature*, 46(4), pp. 871-909
- Koranchelian, T., 2005. "The equilibrium real exchange rate in a commodity exporting country: Algerian experience", *IMF Working Paper*, 135, July
- Korhonen I., and T. Juurikkala, 2009. "Equilibrium exchange rates in oil-exporting countries", *Journal of Economics & Finance*, 33, pp. 71-79
- Krugman, P., 1983. Oil and the Dollar. *NBER Working Papers*, 0554, National Bureau of Economic Research, Cambridge, MA
- Kutan, A.M., and M.L. Wyzan, 2005. "Explaining the real exchange rate in Kazakhstan, 1996-2003: Is Kazakhstan vulnerable to the Dutch disease?." *Economic Systems*, 29(2), pp. 242-255
- Lane, P.R., and G.M. Milesi-Ferretti, 2002. "Long-term capital movements." *NBER Macroeconomics Annual 2001*, 16, pp. 73-136, MIT Press
- , and G.M. Milesi-Ferretti, 2007. "The external wealth of nations mark II: Revised and extended estimates of foreign assets and liabilities, 1970-2004", *Journal of International Economics*, 73, November, pp. 223-250
- Levin, A.T., C.-F. Lin, and C. Chu, 2002. "Unit root tests in panel data: asymptotic and finite-sample properties", *Journal of Econometrics*, 108, pp. 1-24
- Lizardo, R.A., and A.V. Mollick, 2010. "Oil price fluctuations and US dollar exchange rates", *Energy Economics*, 32(2), pp. 399-408
- Maddala, G.S., and S. Wu, 1999. "A comparative study of unit root tests with panel data and a new simple test." *Oxford Bulletin of Economics and statistics*, 61(S1), pp. 631-652
- Mark, N., and D. Sul, 2003. "Cointegration vector estimation by panel DOLS and long-run money demand", *Oxford Bulletin of Economics and Statistics*, Department of Economics,

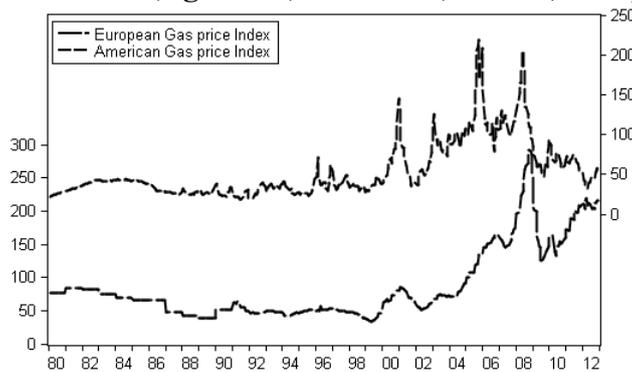
- University of Oxford, 65(5), pp. 655-680, December
- Meese, R.A., and K. Rogoff, 1983. "Empirical exchange rate models of the seventies: do they fit out of sample?" *Journal of international economics*, 14(1), pp. 3-24
- Mendoza, E.G, 1995. "The terms of trade, the real exchange rate, and economic fluctuations", *International Economic Review*, pp. 101-137
- Mork, K.A., 1989. "Oil and the macroeconomy when prices go up and down: an extension of Hamilton's results." *The Journal of Political Economy*, 97(3), pp. 740-744
- Neary, P., 1988. "Determinants of the equilibrium real exchange rate", *American Economic Review*, 78, pp. 210-215
- Nazlioglu, S., 2011. "World oil and agricultural commodity prices: evidence from nonlinear causality", *Energy Policy*, 39(5), pp. 2935-2943
- , and U. Soytaş, 2012. "Oil price, agricultural commodity prices, and the dollar: A panel cointegration and causality analysis", *Energy Economics*, 34(4), pp. 1098-1104
- Obstfeld, M., and K. Rogoff, 2001. "The six major puzzles in international macroeconomics: is there a common cause?." *NBER Macroeconomics Annual 2000*, 15, pp. 339-412, MIT press
- Pedroni, P., 1999. "Critical values for cointegration tests in heterogeneous panels with multiple regressors." *Oxford Bulletin of Economics and statistics*, 61(S1), pp. 653-670
- Pesaran, M.H., Y. Shin, and R.P. Smith, 1999. "Pooled mean group estimation of dynamic heterogeneous panels", *Journal of the American Statistical Association*, 94(446), pp. 621-634
- Razin, A., and L.E.O. Svensson, 1983. "Trade taxes and the current account." *Economics Letters*, 13(1), pp. 55-57
- Ramos, S.B., and H. Veiga, 2013. "Oil price asymmetric effects: Answering the puzzle in international stock markets." *Energy Economics*, 39, pp. 136-145
- Romer, C.D., and D.H. Romer, 1989. "Does monetary policy matter? A new test in the spirit of Friedman and Schwartz." *NBER Macroeconomics Annual 1989*, 4, pp. 121-184, MIT Press
- Sachs, J.D., and A.M. Warner, 2001. "The curse of natural resources." *European Economic Review*, (45)4, pp. 827-838
- Spilimbergo, A., 1998. "De-industrialization and Trade", *Review of International Economics*, (29), January
- Tokarick, S., 2008. "Commodity currencies and the real exchange rate", *Economics Letters*, 101, pp. 60-62, March
- Zaldueño, J., 2006. "Determinants of Venezuela's equilibrium real exchange rate", *IMF Working Paper*, 74, Washington D.C.

## 8. APPENDIX

**Figure 1 – Evolution of Oil prices (right axis) and Coal prices (left axis): 1980-2012**

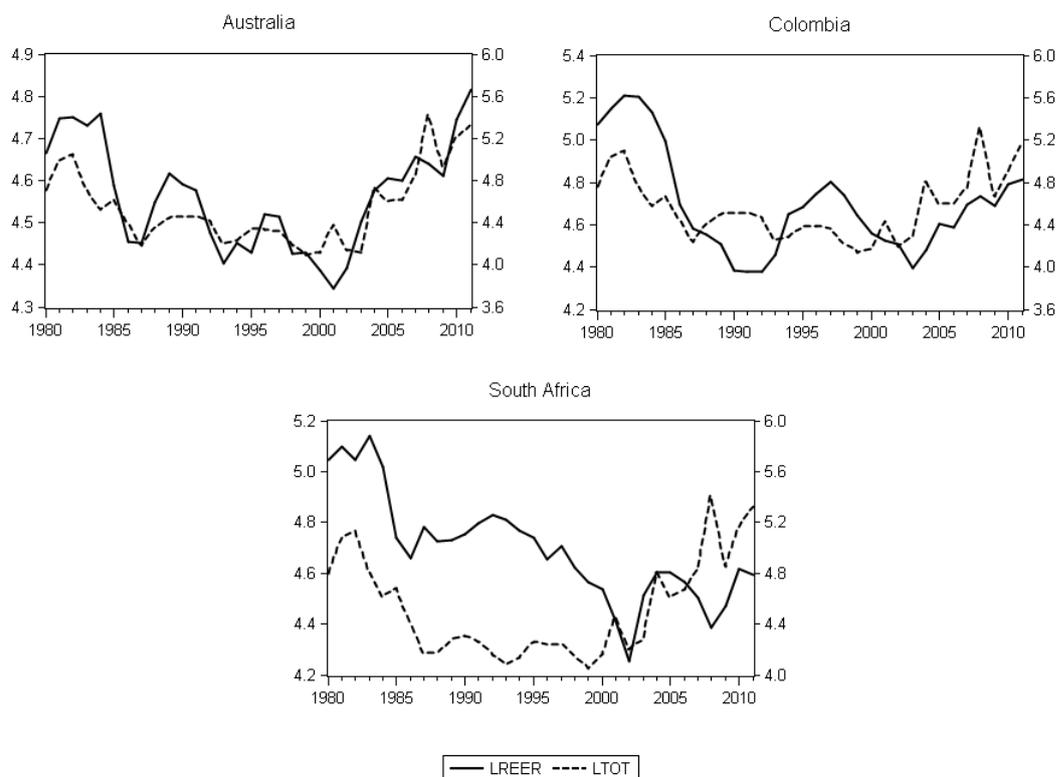


**Figure 2 – Evolution of U.S. (right axis) and E.U. (left axis) Gas prices: 1980-2012**



Notes: monthly price indexes base 2005M01=100. Source: *World DataBank database*

**Figure 3 – Real exchange rates (left axis) and terms-of-trade (right axis): coal-exporting countries**

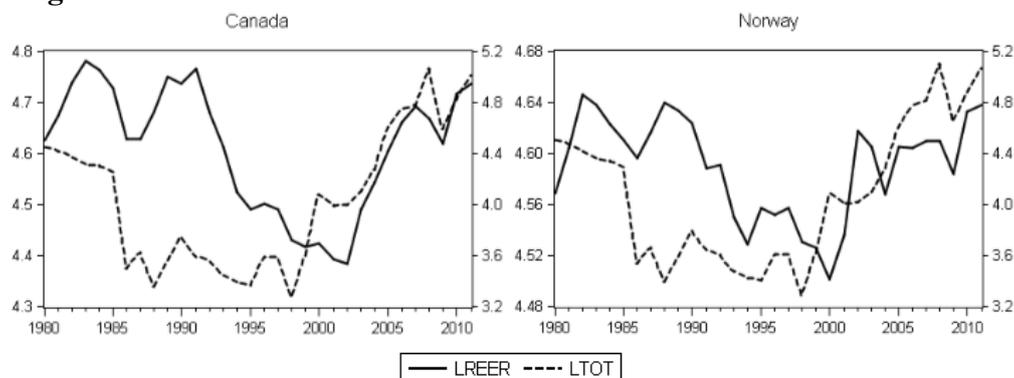


Notes: annual indexes base 2005=100. Source: energy prices were taken from the *World DataBank database* and real effective exchange rates were provided by the IMF's International Financial Statistics. Coal price data was available from 2000 and 1984 only, for Colombia and South Africa, respectively. The retroplation was made by using the Australian coal price series. The first step was to check that during the period 2000-2011, coal prices varied in similar proportion and direction among the three country-producers. Once the latter was verified, the Australian coal price's growth rate was applied to get backcasted data.

**Table 3 – Commodities exported by the 25 out of 33 exporting countries**

Country	Main exports			Share in commodity exports in %		
	1	2	3	1	2	3
<b>Non-fuel commodity-exporting countries</b>						
Bolivia	Zinc	Tin	Gold	27	18	13
Brazil	Iron	Coffee	Aluminum	21	15	10
Burundi	Coffee	Gold	Tea	59	35	2
Cameroon	Cocoa	Hardwood logs	Aluminum	23	22	14
Central African Rep.	Cotton	Coffee	Softwood logs	82	9	5
Chile	Copper	Fish	Fishmeal	70	9	6
Costa Rica	Bananas	Coffee	Fish	43	33	5
Côte d'Ivoire	Cocoa	Coffee	Cotton	65	14	6
Ghana	Cocoa	Gold	Aluminum	61	24	7
Iceland	Fish	Aluminum	Shrimp	73	20	7
Malawi	Tobacco	Tea	Sugar	78	8	7
Malaysia	Palm oil	Natural rubber	Hardwood logs	44	15	15
Morocco	Phosphate rock	Fish	Lead	55	14	7
New Zealand	Lamb	Beef	Wool	20	17	14
Pakistan	Rice	Cotton	Sugar	46	28	13
Papua New G.	Copper	Gold	Palm oil	23	23	20
Paraguay	Soybeans	Cotton	Soy meal	44	26	9
Philippines	Coconut oil	Copper	Bananas	29	21	12
Togo	Phosphate rock	Cotton	Coffee	44	40	9
Tunisia	Tobacco	Phosphate rock	Shrimp	23	21	20
Uganda	Coffee	Fish	Gold	71	8	4
Uruguay	Beef	Rice	Fish	36	27	13
Zambia	Copper	Sugar	Rien	97	2	0
<b>Fuel commodity-exporting countries</b>						
Canada*	Oil	Gas		62.3	29.9	
Norway	Oil	Gas	Fish	67	13	8

Notes. Weights are calculated for the period 1991-1999. Source: *Cashin et al. (2004), Tab. 1, pp. 246-247*. As for Canada, marked with a \*, the weights are taken from *Chen and Rogoff (2003), Tab. A3, page 158*, and are calculated over the period 1972q1-2001q2.

**Figure 4 – Real exchange rates (left axis) and terms-of-trade (right axis): gasoil-exporting countries**

Notes: annual indexes base 2005=100. Source: energy prices were taken from the *World DataBank database* and real effective exchange rates were provided by the IMF's International Financial Statistics.

**Table 4 – Panel unit root tests**

Series	LLC	Hadri	IPS	MW (ADF)
<i>lreer</i>	-0.19 (0.42)	5.97 (0.15)	0.80 (0.79)	12.16 (0.91)
<i>lbs</i>	0.69 (0.75)	9.35 (1)	3.74 (0.99)	2.08 (1)
<i>nfa</i>	0.07 (0.53)	1.20 (0.88)	0.97 (0.83)	11.87 (0.92)
<i>ltot<sup>en</sup></i>	-2.38 (0.00)	2.54 (0.99)	2.65 (0.99)	4.01 (1)

Notes: *p*-values are reported in parentheses. Tests include individual effects and linear trends.

**Table 5 – Panel cointegration tests**

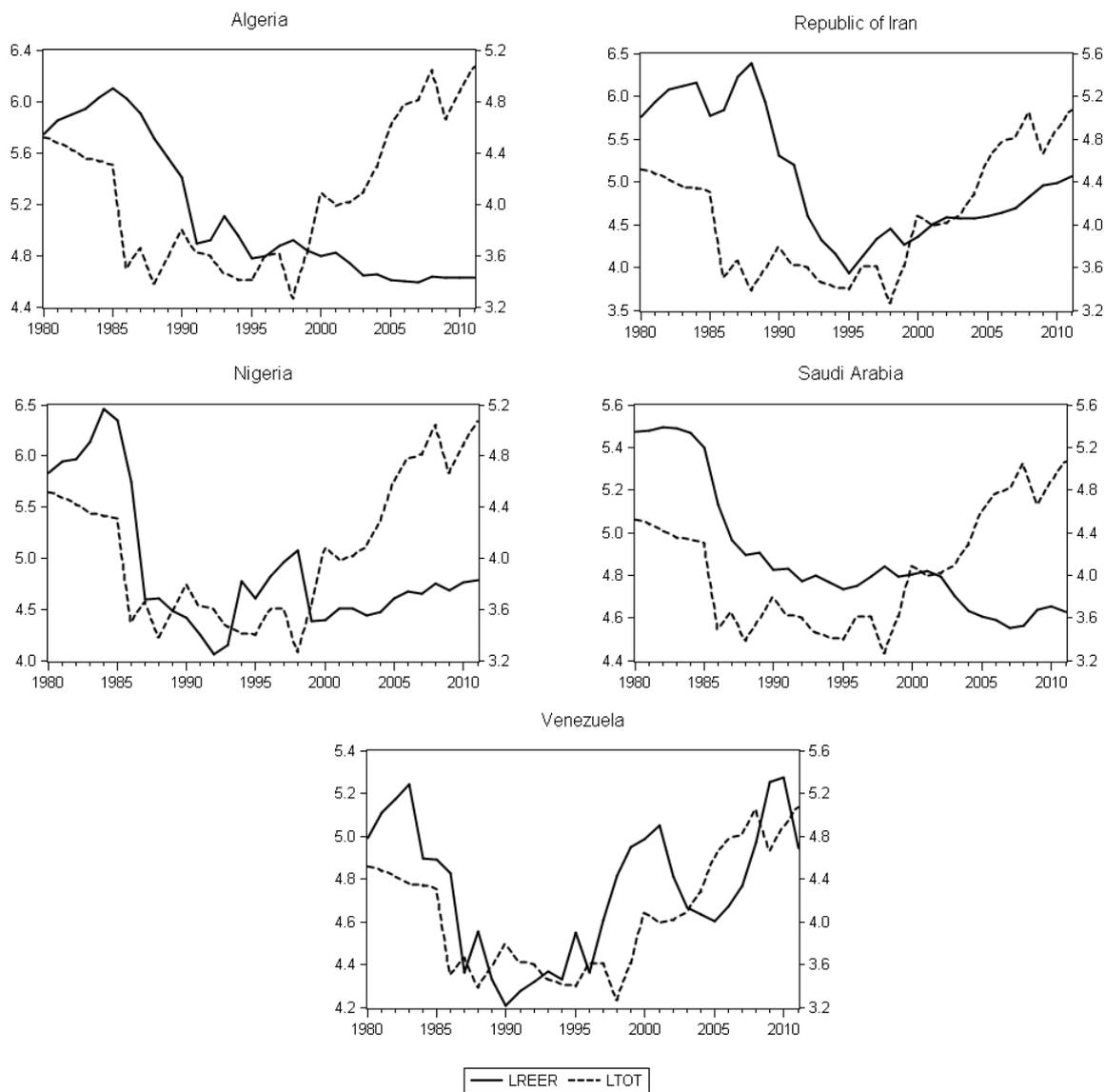
		Pedroni						Kao
		<i>within-dimension</i>			<i>between-dimension</i>			
<i>v</i> -stat	$\rho$ -stat	<i>PP</i> -stat	<i>ADF</i> -stat	$\rho$ -stat	<i>PP</i> -stat	<i>ADF</i> -stat	<i>ADF</i>	
1.89	0.02	-1.49	-1.39	0.94	-2.13	-1.65	-0.372	
(0.02) <sup>b</sup>	(0.51)	(0.06) <sup>c</sup>	(0.08) <sup>c</sup>	(0.82)	(0.01) <sup>a</sup>	(0.04) <sup>b</sup>	(0) <sup>a</sup>	

Notes: *p*-values are reported in parentheses. <sup>a</sup>, <sup>b</sup> and <sup>c</sup> denote rejection of the null of no cointegration at the 1%, 5% and 10% confidence level, respectively.

**Table 6 – Nonlinear tests (*p*-values)**

Tr. variable	Commodity exporters		Energy exporters	
	$\Delta lroil$	$ \Delta lroil $	$\Delta lroil$	$ \Delta lroil $
<i>LM</i> -stat	$5.59e^{-04}$	$4.19e^{-08}$	0.379	0.055
<i>Fisher</i> -stat	$6.68e^{-04}$	$5.24e^{-08}$	0.389	0.059
<i>LRT</i> -stat	$5.27e^{-04}$	$2.92e^{-08}$	0.379	0.054

**Figure 5 – Real exchange rates (left axis) and terms-of-trade (right axis): oil-exporting countries**



Notes: annual indexes base 2005=100. Source: energy prices were taken from the *World DataBank database* and real effective exchange rates were provided by the IMF's International Financial Statistics.