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

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### 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.

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## 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'

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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, 1998; 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 (De Gregorio and Wolf, 1994; Dornbusch, 1980; Edwards, 1994). Terms-of-trade fluctuations are usually twice as large in developing countries as in developed countries (Baxter and Kouparitsas, 2006), 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 whose wealth largely depends on commodity exports.

In the early 2000s, fuel and non-fuel 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.<sup>1</sup> The literature evidenced a positive link between the two variables, leading to the denomination “commodity currencies” (Chen and Rogoff, 2003; Cashin *et al.*, 2004a), that applies to both developed (Amano and van Norden, 1995; Chen and Rogoff, 2003) and developing countries (Cashin *et al.*, 2004a; Coudert *et al.*, 2011; Bodart *et al.*, 2012). More recently, “oil currencies” were observed (Habib and Kalamova, 2007; Korhonen and Juurikkala, 2009; Coudert *et al.*, 2011), defined as currencies that appreciate when the price of oil goes up. In this paper, we analyze the link between energy prices, terms-of-trade and the real exchange rate in two sets of economies: energy-exporting countries and commodity-exporting countries over the period 1980–2011.

Our contribution is twofold. First, we investigate whether the currency of the energy-exporting countries comprised in our panel can be referred to as “energy currencies”. We focus on ten energy producers that export either crude oil, natural gas, or coal. To our best knowledge, the existing literature has made a clear distinction between oil and other commodities (Cashin *et al.*, 2004a; Coudert *et al.*, 2011), yet coal, natural gas and oil represent 27%, 21% and 33% of the demand for primary energy worldwide, respectively.<sup>2</sup> Furthermore, they share the same feature in that they are non-renewable fossil resources, thus subject to the same depletion issue. The two main potential implications being increasing energy prices in the future and in line with the recent financialization of commodity markets, a disconnection between prices and their fundamentals (Creti *et al.*, 2013). Also, demand for energy product is rather inelastic, and energy usually accounts for a great part of the countries' export structure, even though some export other commodities (*e.g.* iron ore in Australia). 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. A significant and positive terms-of-trade effect on the real exchange rate will mean that the energy-exporting countries considered have an “energy currency”. Second, conversely to any type of commodity, oil is widely used in the production and transportation of (agricultural and mining) goods, but also in private consumption and energy production. As the engine of economic activities, and in conjunction with the development of nonlinear econometric techniques, there has been evidence of asymmetric effects of oil prices on economic activity (Huang *et al.*, 2005). We study the impact of terms-of-trade on the real exchange rate of both energy-exporting countries and commodity-exporting countries with respect to the situation on the oil market. More precisely, we investigate whether there is evidence of a sign or a magnitude effect. Our perspective is justified by (i) the fact that oil price increases generally matter more than oil price decreases and (ii) the existence of a causal relationship linking extreme movements in oil prices and terms-of-trade as evidenced by Backus and Crucini (2000), the underlying transmission mechanism here, occurring *via* intermediate input costs (Nazlioglu, 2011), and volatility spillovers among the oil and commodity

<sup>1</sup> 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 emerging countries consumption that exerted an upward pressure on the prices. *Source*: Institut Français du Pétrole et des Énergies Nouvelles (IFPEN). See Section 3.1 for greater details on energy prices' recent evolution.

<sup>2</sup> *Source*: IEA.

markets (Du et al., 2011). To this end, we rely on panel nonlinear, smooth transition regression models (PSTR) proposed by González et al. (2005). To our best knowledge, our analysis is the first aiming at exploring the nonlinear defining power of the terms-of-trade over the real exchange rate within this framework.

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. A general framework

We present a theoretical model that describes the mechanisms linking the real exchange rate and terms-of-trade that can be applied to all commodity-exporting (energy and non-fuel commodity) countries. The model depicted here adopts 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).

Cashin et al. (2004a) 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>3</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 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. Eq. (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:

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

<sup>3</sup> It is assumed to be supplied inelastically to the different sectors.

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., 2004a,b, p. 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>4</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

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

$TOT$  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, Eq. (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. (2004a) 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<sup>5</sup> that can lead to an even greater appreciation of the real exchange rate. Consequently, it can have adverse effects on the whole economy and is usually referred to as a “Dutch disease” phenomenon. As our purpose here is not investigate the presence of such effects, the reader can refer to Corden and Neary (1982) and Neary (1988) wherein theoretical mechanisms are described.<sup>6</sup>

## 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).

### 2.2.1. 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).

<sup>4</sup> The foreign consumer price index is defined in the same way.

<sup>5</sup> Arising from windfall revenues brought commodity exports, that generate greater wealth for the producers.

<sup>6</sup> For recent empirical investigations on the Dutch disease, see Kalcheva and Oomes (2007), Balász and Leonard (2007), Beine et al. (2012), and references therein.

Australia and New Zealand are found to have a “commodity currency” that appreciates by 7.3% and 10.1%, respectively, when terms-of-trade improve by 10%.<sup>7</sup> Expanding the analysis to a set of 58 developed and developing countries over the period 1980–2002, [Cashin et al. \(2004\)](#) evidence the existence of commodity currencies for 19 out of 58 commodity-exporting countries. 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>8</sup> Moreover, the real effective exchange rate is found to follow a mean-reverting process for 10 countries out of 19, and causality runs from commodity prices to the REER.

In line with the development of panel cointegration techniques, [Coudert et al. \(2011\)](#) look into the impact of terms-of-trade on the real exchange rate over the period 1980–2008 of 52 commodity-exporters. They rely on a Behavioural Equilibrium Exchange Rate (BEER hereafter) approach proposed by [Faruquee \(1994\)](#) and [Clark and MacDonald \(1998\)](#).<sup>9</sup> A 10% rise in terms-of-trade is found to appreciate their currency by 4–6.5%. [Bodart et al. \(2012\)](#) 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 ranges from 0.15 to 0.30. In addition, the authors show that the higher the specialization, the higher the elasticity.

### 2.2.2. 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>10</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](#)).

[Zaldueño \(2006\)](#) 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 (1.04–1.30) instead of parallel rates (0.44).<sup>11</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>12</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. The panel BEER approach has also supported the existence of “oil-currencies”. [Korhonen and Juurikkala \(2009\)](#) focus on how the real price of oil affects the real exchange rate of

<sup>7</sup> 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.

<sup>8</sup> This index is commonly used in the commodity-price literature. See [Cashin et al. \(2004a,b\)](#) among others.

<sup>9</sup> 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, the terms-of-trade, trade openness, public expenditure, foreign aid, etc. The authors however consider the first three variables.

<sup>10</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>11</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>12</sup> There are other studies confirming the rouble as being an oil-currency, see for instance [Kalcheva and Oomes \(2007\)](#).

nine OPEC countries and three Commonwealth Independent States over 1975–2005 and 1993–2005, respectively. This conclusion is also 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.

So far, the literature has made a clear distinction between oil and other commodities (Cashin et al., 2004a; Coudert et al., 2011), yet coal, natural gas and oil share the same feature in that they are non-renewable fossil resources, thus subject to the same depletion issue. The two main potential implications being increasing energy prices in the future and in line with the recent financialization of commodity markets, a disconnection between prices and their fundamentals (Creti et al., 2013). These prices are thus most likely to exert a considerable influence on the real exchange rate of energy exporters and commodity exporters. Moreover, to our best knowledge, the terms-of-trade – exchange rate *nexus* has not been analyzed with respect to the situation on the oil market. Throughout this paper, we intend on shedding light on these two issues.

### 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 through the terms-of-trade channel. Prior to that, we present the data, the variables and the methodology used to conduct the study.

#### 3.1. Evolution of energy prices

Figs. 1 and 2 in Appendix depict the evolution of energy prices over the period 1980–2012. Globally, they have been following an upward trend from the early 2000s 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>13</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 of shale gas resources<sup>14</sup> as well as gas storage capacity (Annual Energy Outlook 2013, IAE). On the other hand, the

<sup>13</sup> It has been the fastest-growing global energy source with an average annual growth rate of 4.8%.

<sup>14</sup> The U.S. Energy Information Administration predicts that its share in total production will increase from 34% in 2011 to 50% in 2040.

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). According to this approach, which is a refined version of the BEER methodology, a set of variables<sup>15</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.

#### 3.2.1. Sample

We consider yearly data spanning from 1980 to 2011 for two sets of countries<sup>16</sup>:

- 10 energy-exporting countries: Algeria, Australia, Canada, Colombia, 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.

#### 3.2.2. 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>17</sup> Our sample covering the period 1980–2011, 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 external 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.

<sup>15</sup> Data sources are given below.

<sup>16</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.

<sup>17</sup> [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).

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>18</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 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>19</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

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

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:

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

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

#### 4. Are there energy-currencies?

Figs. 3–5 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. Regardless of the 2008 turmoil, from the early 2000's onwards, the real exchange rate of Algeria, Saudi Arabia, and 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 countries operate under a managed exchange rate regime in which the dollar is the currency peg,

<sup>18</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.

<sup>19</sup> We acknowledge Algeria, Nigeria and 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.

whose value has been declining since 2002.<sup>20</sup> Regarding the Algerian dinar, in the aftermath of its 1994 two-step devaluation (70%), the exchange rate policy has aimed at maintaining a stable exchange rate, explaining the poor visual evidence of co-movements between terms-of-trade and the RER. For Saudi Arabia, it can be attributed to active management of international reserves through the constitution of Sovereign Wealth Fund that helped the RER to be more resilient to external shocks by sterilizing windfall revenues.<sup>21</sup> 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. Given the variables used throughout this analysis, we first perform second generation panel unit root tests that take into account the potential cross-sectional dependence between the panel individuals. As real effective exchange rates are interdependent by construction, and given that energy prices are much likely to be strongly affected by cross-correlations (Bodart et al., 2012), not taking into account cross-dependence results in tests that suffer from severe size distortion (O'Connell, 1998) and restricted power.<sup>22</sup> Accordingly, we apply Choi's (2002) and Pesaran's (2007) tests. The former lies in the removal of the deterministic components and the cross-sectional correlations by cross-sectional demeaning and GLS detrending as Elliott et al. (1996). The test suggested by Pesaran (2007) consists in including cross-section averages of the level and lagged differences to the Im-Pesaran-Shin-type regression (see Hurlin and Mignon (2005) for a survey of the second panel unit root tests). Both tests rely on the presence of a unit root as the null hypothesis although the Choi's test is based on an error-component model while the Pesaran's test relies on a dynamic factor model. Im et al.'s (2010) Lagrange multiplier-based (LM) panel unit root test is also performed. The latter allows for (i) cross-sectional dependence in the panel, and (ii) heterogeneous structural breaks in both the intercept and the slope of each cross-sectional unit.<sup>23</sup> Results are displayed in the Appendix, Tables 5 and 6.<sup>24</sup> Our findings suggest that our series are  $I(1)$  at a reasonable level of confidence.

Eq. (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 the second-generation panel cointegration test that is robust to unknown heterogeneous breaks in the intercept as well as in the slope of the cointegrating regression, proposed by Westerlund and Edgerton (2008).<sup>25</sup> As highlighted by the authors, the presence of breaks might eventually induce the non-rejection of the null hypothesis ( $H_0$ : no cointegration) when there is a break under the alternative hypothesis, therefore one should not neglect this possibility. As reported in Table 7 (Appendix), the  $p$ -values suggest that the REER and its considered drivers are cointegrated at conventional confidence levels.

<sup>20</sup> For instance, Coudert et al. (2011) find an undervaluation of the cited countries' currencies ranging from –40.32 to –32.19.

<sup>21</sup> It should be noted that Saudi Arabia does not have a SWF *stricto sensu*. Most of the oil revenues are invested in foreign assets that are administrated by the Central Bank of the Kingdom of Saudi Arabia, the Saudi-Arabian Monetary Agency (SAMA), established in 1952.

<sup>22</sup> The cross-sectionally dependence test (CD) proposed by Pesaran (2004) – based on a simple average of all pair-wise correlation coefficients of the OLS residuals from the individual regressions in the panel – confirms the existence of such correlations. See Table 4 in the Appendix.

<sup>23</sup> Our sample spanning from 1980 to 2011, one must acknowledge that the series might have been subject to various structural breaks, such as oil price shocks, or major devaluations. Moreover, several OPEC countries have recently undergone policies aiming at fostering growth through foreign investment in sectors other than energy, e.g. the "Second Generation Reforms" between 2000 and 2007 in Algeria. We thank an anonymous referee for highlighting this important issue.

<sup>24</sup> We used Matlab codes (Version 7.00) provided by Christophe Hurlin for implementing second-generation panel unit root tests ([http://www.univ-orleans.fr/deg/masters/ESA/CH/churlin\\_R.htm](http://www.univ-orleans.fr/deg/masters/ESA/CH/churlin_R.htm)) and Gauss codes provided by Junsoo Lee for implementing the third-generation panel unit root test (<http://old.cba.ua.edu/~jlee/gauss>).

<sup>25</sup> We used Gauss codes provided by Joakim Westerlund for implementing the panel cointegration test ([www.nek.lu.se/nekjwe/research.htm](http://www.nek.lu.se/nekjwe/research.htm)).

## 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 \(2001\)](#) and [Mark and Sul \(2003\)](#).<sup>26</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.

The estimated cointegrating relationship is given by<sup>27</sup>

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

(1.92)                      (4.18)                      (3.75)

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 et al. \(1983\)](#), meaning that it is the real exchange rate that adjusts towards its equilibrium value ([Amano and van Norden, 1995](#); [Cashin et al., 2004a](#); [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, 2004](#)), they are price-takers on the world commodity market.<sup>28</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 et al. \(1988\)](#) is based on the non-causality assumption against causality, and the results are displayed in [Table 1](#).

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.

<sup>26</sup> Unlike OLS estimates, DOLS estimators are not asymptotically biased and are independent of nuisance parameters. In addition, the DOLS procedure presents lower size distortion than the Fully Modified OLS method.

<sup>27</sup>  $t$ -stats are reported in parentheses.

<sup>28</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.

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

X/Y	$\Delta lreer$	$\Delta nfa$	$\Delta lbs$	$\Delta ltot$	$z_{t-1}^n$
$\Delta lreer$	–	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
$z_{t-1}^n$	0.00	0.83	0.55	0.64	–

Notes: *p*-values associated with the null of no causality from *X* (columns) to *Y* (rows) are reported. A VARECM is estimated with the number of lags *p* chosen as to minimize the SIC (*p*=3).

**Table 2**  
Estimation of PSTR models.

Countries	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.

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., 2011](#), 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 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 (PSTECM).

### 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 exporters and commodity-exporting countries:

$$\begin{aligned} \Delta lreer_{it} = & \mu_{it} + \alpha_0 \Delta nfa_{it} + \alpha_1 \Delta lbs_{it} \\ & + \alpha_3 \underbrace{(lreer_{i,t-1} - \beta_0 - \beta_1 nfa_{i,t-1} - \beta_2 lbs_{i,t-1} - \beta_3 ltot_{i,t-1})}_{Z_{i,t-1}} \\ & + \alpha_4 \Delta ltot_{it} + \alpha'_4 \Delta ltot_{it} \times G(S_t, \gamma, c) + \varepsilon_{it} \end{aligned} \quad (11)$$

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,  $\varepsilon_{it}$  is 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 ([Teräsvirta, 1994](#)):

$$G(S_t, \gamma, c) = [1 + \exp(-\gamma(S_t - c))]^{-1} \quad (12)$$

Specification (12) 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 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>29</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 oil 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  $\mathbf{1}_{\{S_t > 0\}}$ , we end up with the initial threshold model ([Hansen, 1999](#)) with a brutal transition from one regime to another.

Prior to the estimation of the nonlinear specification, we investigate the existence of “commodity currencies” in our 23 non-fuel commodity-exporting countries in order to decide whether the long-term residuals should be included or not in Eq. (11). The same panel unit root and cointegration tests – as in [Section 4.1](#) – are applied,<sup>30</sup> they conclude to the existence of a long-run relationship between the real effective exchange rate of commodity exporters and its fundamentals. The cointegrating relationship is given by ( $t$ -stats reported in parentheses):

$$lreer_{it}^{com} = \mu_i + \underset{(1.24)}{0.0001} nfa_{it}^{com} + \underset{(5.29)}{0.002} lbs_{it}^{com} + \underset{(7.63)}{0.42} ltot_{it}^{com} \quad (13)$$

A 10% increase in commodity terms-of-trade yields a long-term appreciation of the REER of approximately 4.2% for commodity-exporting countries. They all have a “commodity currency” and 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  $z_{i,t-1}^{com}$ .

We follow the three-step strategy proposed by [González et al. \(2005\)](#). Given the aim of our paper, we start by applying linearity tests considering two transition variables:  $\Delta lroil$  and  $|\Delta lroil|$ , the latter being used as a proxy for oil price volatility since it measures the magnitude of oil price fluctuations. Oil prices will be considered as highly volatile when exceeding the estimated threshold value  $\hat{c}$ . In order

<sup>29</sup> It is a simple weighted average of the three main market oil prices (UK Brent, Dubai and WTI).

<sup>30</sup> Results are available upon request to the author.

to insure the robustness of this measure as a proxy for volatility, the variance of  $\Delta loil$  ( $\sigma_{\Delta loil}^2$ ) is also tested and used as the switching variable (with  $\text{Corr}(|\Delta loil|, \sigma_{\Delta loil}^2) = 0.88$ ).<sup>31</sup> The results are reported in Table 8 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  $|\Delta loil_{it}|$  at the 10% confidence level. Thus we proceed by estimating the PSTR,<sup>32</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, 2009; 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 REER follows a mean reverting process. The speed of adjustment towards equilibrium is somewhat higher in commodity-exporting countries than in energy-exporting countries, which seems rather counter-intuitive at first. Indeed, one would expect the REER of energy-exporters to revert to its long-term target faster than the one of commodity-exporters to the extent that there are more floats in the energy panel compared to the one of commodity exporters.<sup>33</sup> On the other hand, the financial openness indicator constructed by Chinn and Ito (2006) indicates that the energy-exporters have relatively more open capital accounts (0.097 vs. –0.298), potentially pushing the REER farther away from its target.<sup>34</sup>

Let us consider the model with the growth rate of oil prices as the transition variable. The results imply a positive correlation of 0.38 between the terms-of-trade and the REER of commodity exporters, when oil prices decrease by more than 16%. The first intuition that would come to our mind is that when the price of oil follows a downward trend, production as well as transportation costs are reduced for commodity-producers, and might emphasize the positive effect of a terms-of-trade's improvement. However, when taking a closer look at the data, there are only 4 observations 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. Commodity prices were reduced by 12% on average in 1998 and 2009 and 3% in 1986. We believe that the correlation between  $\Delta ltot$  and  $\Delta lreer$  is solely 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, oil prices have little impact on the REER in the short-run. Recent studies have examined the dependence path of oil prices and exchange rates using advanced approaches such as wavelet and copula-based analyses. Although (non)linear causality tests have shown mixed results,<sup>35</sup> structure-dependence investigations have indicated a weak dependence between exchange rates and oil prices prior to the 2007 crisis (Wu et al., 2012)

<sup>31</sup> The results do not change though we do not report them. They are available upon request to the author.

<sup>32</sup> We used RATS codes provided by Gilbert Colletaz for implementing the PSTR estimation procedure (<http://www.univ-orleans.fr/deg/masters/ESA/GC/sources/gtvd.SRC>).

<sup>33</sup> Following Friedman's (1953) hypothesis, flexible exchange regimes better insulate the economy from real external shocks, and thus the real exchange rate. We have checked the exchange rate arrangements for each country within the study period with respect to the official *de jure* classification provided by the IMF and the Reinhart and Rogoff's (2004) (updated to 2010) *de facto* classification.

<sup>34</sup> The Chinn–Ito index is based on the restriction on cross-border financial transactions reported in the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER) and takes values from –1.86 to 2.44. The higher the value, the more open the country is to foreign capital flows.

<sup>35</sup> Tiwari et al. (2012) find no causal relationship between oil prices and the REER of a net oil importing country, India, at low time scales (3 months), but evidence a bi-directional causality at lower frequencies (more than 32 months). On the other hand, nonlinear causality tests implemented by Benhmad (2012) reveal a causality running from oil prices to the US dollar REER in the very short-run (2–4 months), and a feedback relationship between the two variables in the long-run.

and an increase in co-movements over the crisis period (Reboredo and Rivera-Castro, 2013; Aloui et al., 2013).<sup>36</sup> Therefore, our study period spanning from 1980 to 2011 might not allow us to identify such a regime change.

Also, another point that should not be left aside is that the asymmetric effects of oil price shocks could be due to contractionary monetary policy as argued by Bernanke and Mishkin (1997). Indeed, following an oil price increase, oil prices pass through core (imported) inflation in commodity-exporting countries, interest rates are raised which in turn attracts foreign investors since investments offer higher yieldings. Consequently, the real exchange rate has to appreciate. Hence, the REER would not be driven by oil prices *via* terms-of-trade in the short run, but by other variables such as interest rates.

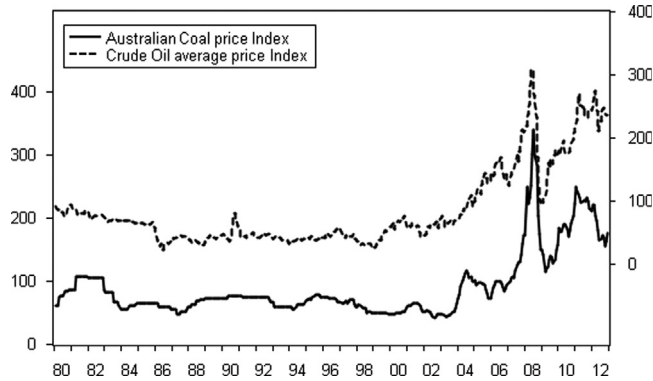
Finally, oil prices may only affect the REER of countries that produce and export specific oil-related commodities. In accordance with the recent upward trend followed by crude oil prices, biofuels prices increased due to growing demand and environmental-friendly policies. Global prices for corn and soybeans that are the main grains used in the production of ethanol and biofuels have been found to be significantly affected by the price of oil (Chen et al., 2010). However, as highlighted previously, the relationship between crude oil and agricultural commodities has essentially strengthened in the aftermath of the 2007-crisis (Nazlioglu, 2011), plus we use a weighted index accounting for the terms-of-trade, this might explain the low correlation between terms-of-trade and REERs in the short-run.<sup>37</sup>

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 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 (*i.e.* “low” oil price variations, according to the estimated threshold  $\hat{c}$ ), oil prices do not affect the real exchange rate of both energy and commodity exporters *via* the terms-of-trade. Both coefficients associated to the terms-of-trade are not significantly different from zero. For commodity-exporters, it is not surprising given the previous results since oil prices, when the crude oil markets' conditions are “normal”, do not drive exchange rates in the short-run. However, beyond a certain value of  $\hat{c}$ , 36% and 25% for commodity-exporting and energy-exporting countries, respectively, the currencies follow an “oil-currency” regime. For both our panels, high movements in oil prices impact the terms-of-trade, either through the price of imports or the price of exports. 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. This result is also supported by Du et al. (2011), and Ji and Fan (2012) who finds that the crude oil market has significant volatility spillovers effects on non-energy commodity markets. As said previously, it is most certainly due to the predominance of oil among commodity markets. Although terms-of-trade are taken to be exogenous, high movements in oil prices affect producers worldwide, therefore the world price *in fine*. Moreover, high volatility usually occurs in period of high uncertainty, and thus might affect the price of commodities on financial markets. Indeed, given the core position of oil, extreme movements on the oil market might as well be reflected in non-energy commodity markets. The former is in fact much likely to prompt investors and traders to adjust their anticipations and positions. Also, the lower threshold value found for the energy exporters might be explained by the fact that uncertainty on oil markets affects directly and thus more rapidly oil producers than commodity exporters.<sup>38</sup>

<sup>36</sup> An increase in oil prices usually being associated with a depreciation of the US dollar (the latter causing the former). There exists several interpretations of the mechanisms leading to this negative link, nevertheless, as most of the above-cited studies employ bilateral US dollar exchange rates and do not focus on oil-importing countries whose main revenues derive from commodity exports, we will not dwell on it. The reader can refer to Aloui et al. (2013) and references therein for details.

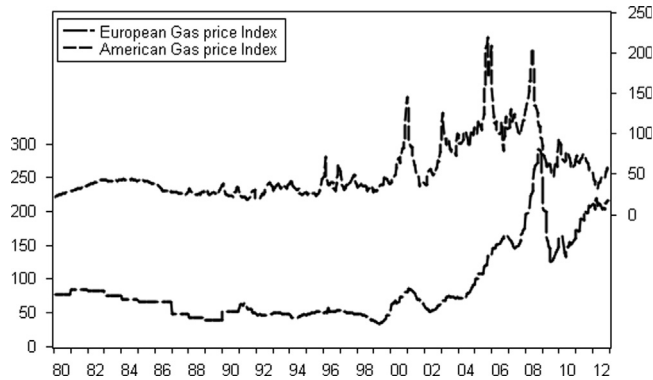
<sup>37</sup> Note that Nazlioglu and Soytaş (2012) provide strong evidence regarding the long-run impact of world oil prices on agricultural commodity prices over the period 1980–2010.

<sup>38</sup> Then again, it does not apply to Australia, Colombia and South Africa, however (i) petroleum is demanded for maritime transportation, and (ii) in our panel of energy-exporting countries, oil producers are over-represented.



**Fig. 1.** Evolution of oil prices (right axis) and coal prices (left axis): 1980–2012. *Note:* monthly price indexes base 2005M01=100.

Source: World DataBank database.



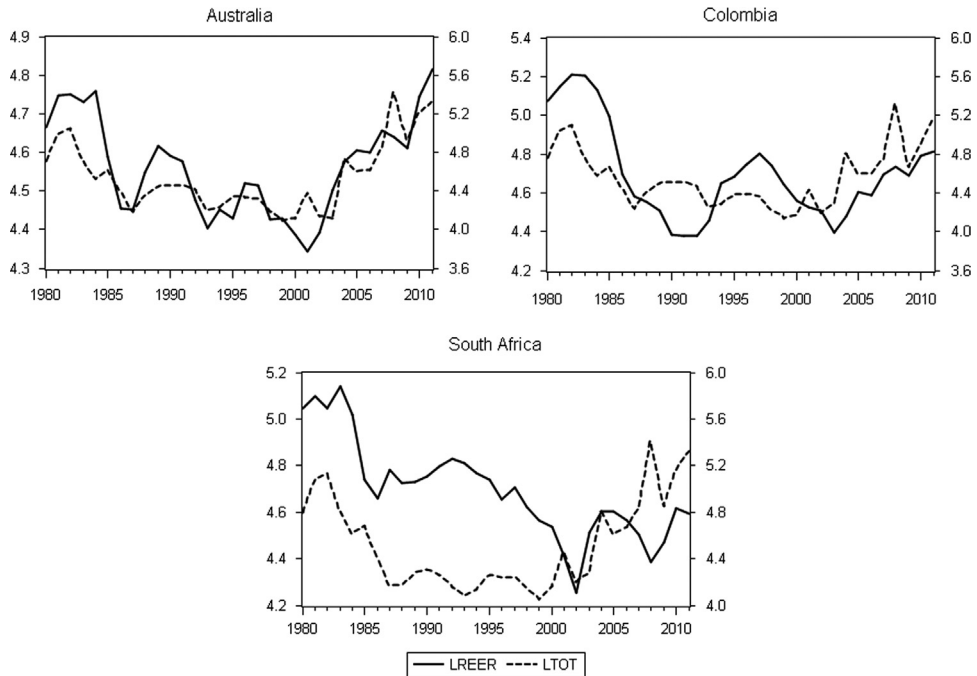
**Fig. 2.** Evolution of U.S. (right axis) and E.U. (left axis) Gas prices: 1980–2012. *Note:* monthly price indexes base 2005M01=100.

Source: World DataBank database.

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 (7 out of the 10 countries comprising our panel) might be the reason why the terms-of-trade impact is lower in the case of energy-exporting countries than commodity-exporting countries, in the short-run as well as in the long-run (see cointegrating-vectors (10) and (13)).

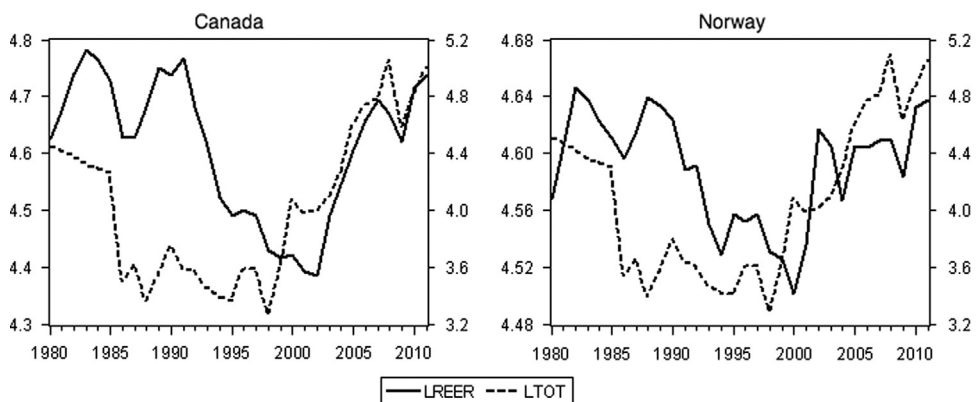
## 6. Conclusion

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”.



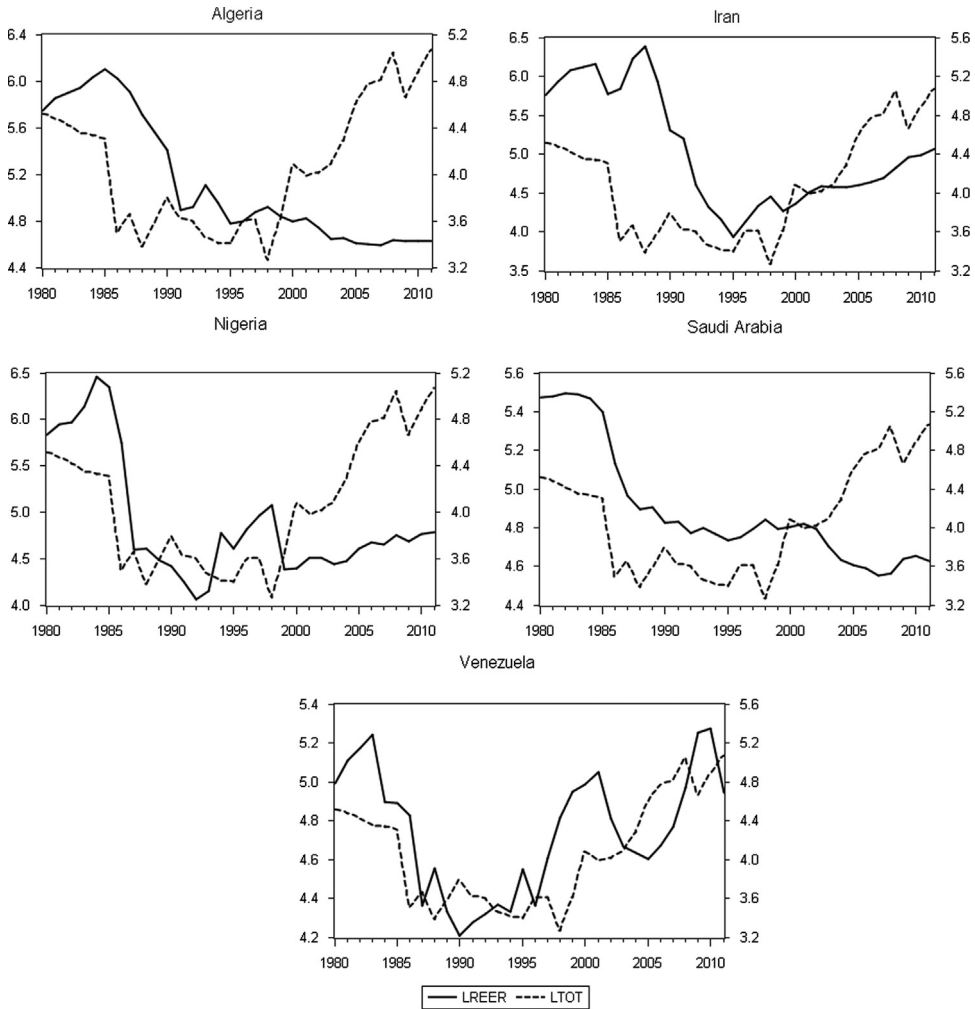
**Fig. 3.** Real exchange rates (left axis) and terms-of-trade (right axis): coal-exporting countries. *Notes:* annual indexes base 2005=100.

*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.



**Fig. 4.** Real exchange rates (left axis) and terms-of-trade (right axis): gas-oil-exporting countries. *Note:* 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.



**Fig. 5.** Real exchange rates (left axis) and terms-of-trade (right axis): oil-exporting countries. Note: 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.

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 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., 2013](#)). Given the recent co-surge in energy and commodity

**Table 3**

Commodities exported by 25 out of 33 exporting countries.

Country	Main exports			Share in commodity exports (%)		
	1	2	3	1	2	3
<i>Non-fuel commodity-exporting countries</i>						
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
<i>Fuel commodity-exporting countries</i>						
Canada	Oil	Gas		62.3	29.9	
Norway	Oil	Gas		67	13	

Notes: Weights are calculated for the period 1991–1999. Source: [Cashin et al. \(2004a, Table 1, pp. 246–247\)](#). For Canada, the weights are taken from [Chen and Rogoff \(2003, Table A3, page 158\)](#), and are calculated over the period 1972q1–2001q2.

**Table 4**

Pesaran's cross-sectional dependence test (2004).

<i>lreer</i>	<i>ltot</i>	<i>lbs</i>	<i>nfa</i>
19.18	34.82	37.94	6.51
(0)	(0)	(0)	(0)

Notes: Statistics (*p*-values) are reported (in parentheses) above. Statistics follow a standard Normal under the null of no cross-dependence.

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.

**Table 5**  
Second-generation panel unit root tests.

Choi (2002) and Pesaran (2007)				
	<i>lreer</i>	<i>ltot</i>	<i>lbs</i>	<i>nfa</i>
$P_m$	−0.99 (0.83)	−2.53 (0.99)	−3.14 (0.99)	−1.48 (0.91)
$Z$	0.79 (0.78)	3.17 (0.99)	8.38 (0.99)	1.40 (0.91)
$L^*$	0.69 (0.75)	2.95 (0.99)	9.62 (1)	1.28 (0.90)
$CIPS^*$	−2.96 (0.02)	−3.10 (0.01)	−1.86 (0.92)	−2.75 (0.09)

Notes:  $p$ -values are reported in parentheses. The critical values tabulated in Pesaran (2007) are −3.03, −2.83, and −2.73, at 1%, 5%, and 10% significance level. For the Choi's test, the optimal lag orders for each series are determined with  $p_{max}=7$ . All test statistics include individual effects and time trends.

**Table 6**  
Third generation panel unit root test.

Im, Lee and Tieslau (2010)				
Cross-sectionally augmented LM	<i>lreer</i>	<i>ltot</i>	<i>lbs</i>	<i>nfa</i>
Crash model	4.96	2.32	4.60	2.96
Breaking trend	−1.40	2.25	−0.38	2.22

Notes: critical values follow the usual  $z$ -scores of the standard Normal distribution. Here, results indicate the non-rejection of the null hypothesis, series thus being  $I(1)$ . The test proposed by Carrion-i-Silvestre et al. (2005) was also implemented, results offer the same conclusions. For the sake of simplicity, they are not reported but are available upon request to the author.

**Table 7**  
Second-generation panel cointegration test.

Westerlund and Edgerton (2007)		
Model	$\tau_N$	$\phi_N$
No break	−4.63 (0)	−3.57 (0)
Level break	−2.26 (0)	−1.37 (0.15)
Regime break	−4.63 (0)	−3.57 (0)

Notes:  $p$ -values are reported in parentheses. Two breaks were determined by grid search. Under the null,  $\tau_N$  and  $\phi_N$  are free of nuisance parameters associated with both trend and structural breaks. These tests allow heteroskedastic and serially correlated errors.

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**Table 8**  
Nonlinear tests (*p*-values).

Tr. variable	Commodity exporters		Energy exporters	
	$\Delta \text{Iroil}$	$ \Delta \text{Iroil} $	$\Delta \text{Iroil}$	$ \Delta \text{Iroil} $
<i>LM</i> -stat	5.59e – 04	4.19e – 08	0.379	0.055
<i>Fisher</i> -stat	6.86e – 04	5.24e – 08	0.389	0.059
<i>LRT</i> -stat	5.27e – 04	2.92e – 08	0.379	0.054

## Appendix A

See Figs. 1–5 and Tables 3–8.

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