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Do Commodity Price Volatilities Impact Currency Misalignments in Commodity-Exporting Countries?

Salem Boubakri[*] Cyriac Guillaumin[**] Alexandre Silanine[***]

Abstract: The aim of this paper is to investigate the relationship between the real effective exchange rate misalignments and the real commodity price volatilities in a sample of 46 commodity-exporting countries, taking into account the level of financial development as the transition variable. We first estimate the currency misalignments as the deviation of the observed real effective exchange rates from their equilibrium values estimated using the BEER approach. Then, we rely on the panel smooth transition regression methodology to estimate the non-linear impact of commodity price volatilities on currency misalignments. Our results show that the estimated coefficients are highly significant and highlight that the volatility of the real commodity prices has a non-linear impact on the currency misalignments, depending on the degree of the country's financial development. The results also highlight different dynamics based on the type of commodity exported by the country and its level of financialization.

Keywords: currency misalignments, real commodity price volatility, financial development level, commodity-exporting countries, panel smooth transition model.

JEL classification: C23, F31, F36, Q43.

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1. Introduction

Financial investors deal with commodities as an asset category in the same manner as they do equities or bonds. When investing in future markets, financial investors are supposed to be adverse to different types of risk, such as portfolio risk or currency risk. Notably, in an international context, a specific risk linked to fluctuations in exchange rates can be raised. For instance, for countries in which the main part of their income comes from commodity exports, fluctuations in the real effective exchange rate appear to be a crucial variable in determining trade capabilities and economic stability. Many empirical studies (for instance, Amano and van Norden, 1998a; 1998b; Chen and Rogoff, 2003; Cashin et al., 2004; Cayen et al., 2010)[2] have provided evidence that the real price of commodity exports is the preponderant factor in the determination of the real exchange rate of commodity-exporting countries. Therefore, policy-makers and financial investors need to fully understand the relationship between movements in the real price of commodities and fluctuations in real exchange rates.

For many years since the oil shocks of the seventies, movements in commodity prices have been attributed to fundamental factors linked to changes in demand and supply. Recently, several investigations, for example, Irwin and Sanders (2010) and Inamura et al. (2011), have highlighted the main factors that affect commodity prices, including commodity demand growth fluctuations in some emerging markets such as China and India, interruptions in oil production, demand elasticity and the increased cost of biofuels. However, the multiple and rapid slumps and increases among all major commodity prices since 2002 suggest that many macroeconomic and financial factors have to be considered in order to better understand recent commodity price movements (Mayer, 2009). Indeed, since the 2008 global crisis, it has become more difficult for policy-makers and market observers to assess the reasons for, and impacts of, commodity price movements.[3] A range of empirical studies, such as Inamura et al. (2011), among others, has stressed the increasing correlation between commodities and financial markets, and support the idea that financial investors have affected commodity price

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[2] See, for example, Coudert et al. (2015) or Boubakri et al. (2019) for a complete literature review.

[3] For example, in the oil sector, prices increased from $72 to $160 in 18 months (from January 2007 to June 2008). They then crashed from $160 to $50 in the next six months.

movements.[4] Recently, a number of financial actors such as investment banks, retail investors, hedge funds, mutual and pension funds have been investing in commodity futures and pointed out the relevance of the so-called “financialization of commodities”. For example, Domanski and Healt (2007) have highlighted the increasing number of contracts in derivative commodity markets, which tripled between 2002 and 2005.[5] Obviously, this ongoing process of financialization must be developed to an extent that warrants the continuing supervision and regulation of commodity markets, as well as diversifying and reducing the portfolio risk.[6] For example, Baker and Routledge (2012) developed a dynamic model and showed that dynamic risk sharing can generate wide variations in prices and risk premia in the commodity market.[7]

The objective of this paper is twofold. First, the aim is to understand how the real commodity price interacts with the new context of financialization of the commodity market. The second objective is to evaluate its impact on currency misalignments, taking into account the transmission channel of financial development level. The real exchange rate misalignment is one of the main pillars in the trade strategy of commodity-exporting countries. Indeed, if the currency is undervalued, commercial competitiveness is reinforced, which stimulates domestic production and exports, and reduces imports. One of the most notable empirical examples is that of the Chinese government for decades keeping the Yuan undervalued against the other major currencies, especially the US dollar,[8] which had the effect of facilitating China's exports and helping its lightning economic growth (Cline, 2010). On the contrary, when a currency is overvalued, it usually indicates that there is an increase in the probability of a possible currency crash (Frankel and Rose, 1996). In addition, persistent

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[4] See, for example, Chari and Christiano (2017) and Cheng and Xiong (2013).

[5] Mayer (2009) showed that the number of contracts on commodity futures and options markets increased more than threefold between 2002 and mid-2008. Moreover, as noted by Masters and White (2008), commodity index investments rose between 2003 and 2008 from 13 billion to 370 billion USD.

[6] See, for a literature review on the financialization of commodities, Cheng and Xiong (2013) and Zarembalver and Neumann (2015).

[7] See also Basak and Pavlova (2016) for a model of financialization of commodities.

[8] For example, Frankel (2005) found that the Yuan was undervalued by 36% in 2000. See Shröder (2013) for a review.

misalignments may generate distortions in the relative prices of traded over non-traded goods, which may generate economic instability (Edwards, 1989).

Our contribution to the existing literature is to show how commodity price movements affect the currency misalignments of commodity-exporting countries, incorporating the new process of the "financialization of commodities" into the analysis. Our aim is to capture the non-linear effect of commodity market volatilities on exchange rate misalignments. To the best of our knowledge, no previous studies have (i) investigated the impact of these commodity price movements on currency misalignments in order to better understand the stability of the exchange rate mechanism, and (ii) included the financial development level as a transition variable in order to assess this impact. Our empirical study is based on a sample of 46 commodity-exporting countries, subdivided into 4 panels: food and beverages, energy, metals, and raw materials. We rely on a panel smooth transition regression (PSTR) model proposed by González et al. (2005, 2017) in order to consider the non-linear relationship between commodity price movements and exchange rate misalignments. The main results show that the volatility of the commodity prices tends to reduce the misalignments of the real exchange rate slightly when a country is better developed financially. Our findings also confirm the change in the relationship between commodity and currency markets that may be induced by increasing financial deepening, as well as the intensification of financialization of commodities post-2000.

The rest of the paper is structured as follows. Section 2 provides a brief review of the previous literature related to the subject. Section 3 presents the empirical methodology used and the data description as well as its statistical properties. Section 4 presents the results and their implications. Section 5 concludes.

2. Literature review

Many empirical papers have studied the effect of movements in real commodity prices on real exchange rate variations of commodity-exporting countries. More careful analysis of this issue requires going deep into the understanding of real exchange rate determinants. For instance, Chen and Rogoff (2003) found that for three advanced commodity-exporting countries the real prices of commodities are a fundamental determinant of their real exchange rates. Cashin et al. (2004) confirmed this result for approximately one-third of the 58 commodity-exporting countries that they analysed. They showed, for these commodity currencies, the long-run deviations of real exchange rates from purchasing power parity depending on movements in real commodity prices. Chen et al. (2010) also evidenced the strong ties that global commodity markets have with exchange rates. More recently, Coudert et al. (2015) showed that in the short term the denomination of "commodity currency" only stands for advanced commodity exporters. In the long term, they confirmed the existence of a positive relationship between the real exchange rate and the country's commodity terms of trade, whether they are advanced, intermediate or low-income countries. Consequently, all the commodity exporters may face a "Dutch disease" problem in the long term if they do not adequately redistribute their income. Indeed, according to Sachs and Warner (1995, 2001), as the wealth of countries with high natural ressources is mainly a result of their exports, the "resource curse" hypothesis could occur in the case of a price spike.[9] These countries will lose competitiveness in exports, which will ultimately negatively impact their future growth.[10] The large body of literature on the issue of the growth effects of currency misalignments considers them to be a serious threat to economic growth. Indeed, as demonstrated initially by Cavallo et al. (1990), better economic performances are usually linked to lower levels of exchange rate misalignments.[11] In a recent empirical investigation, Ferraro and Peretto (2017)[12] showed that commodity prices affect output growth in the short term, through transitional dynamics in total factor productivity, but have no effect on growth in the long term.

As pointed out by the previous literature, we are not the first to test the relationship between the real commodity prices and real exchange rates; however, our investigation is distinguished by taking into account the currency misalignments in the analysis. Indeed, we focus on the effect of commodity price movements on the currency misalignments defined as the deviation in the observed real effective exchange rates from their equilibrium values. The currency

[9] See Papyrakis and Gerlagh (2011).

[10] On the same topic, Torvik (2009) showed that the level of economic development of commodity exporting countries is positively linked with their abilities to handle the Dutch disease that occurs.

[11] See, for example, Berg and Miao (2010) or Grekou (2018) for a literature review.

[12] See also, for example, Collier and Goderis (2012).

misalignments are sometimes used by the policy-makers of commodity-exporting countries as a tool to adjust their foreign exchange market in order to enhance growth and welfare (Kaminsky et al., 1997; Béreau et al., 2012). According to the literature, currency misalignments may create a distortion in the relative price of traded to non-traded goods (Edwards, 1989; Aguire and Calderon, 2005; Candelon et al., 2007). More recently, Thorstensen et al. (2014) have studied the impact of exchange rate misalignments on international trade instruments. They found that exchange rate misalignments could create significant distortions on international trade instruments such as tariffs. Their effects on tariffs can lead to commercial gains for countries with devalued currencies. Therefore it is important for commodity-exporting countries to control their currency misalignments in order to achieve smooth economic growth.

Exchange rates can diverge from their equilibrium for two reasons. The first reason is linked to "currency manipulation", whereby governments and central banks use several policy instruments to affect the real value of their exchange rates. The second reason for currency misalignments is the consequence of distortions in the international financial markets. Estimating equilibrium exchange rate and the degree of its misalignments appears to be a challenging task, as there are no simple answers to what are the main determinants of real exchange rate equilibrium (Williamson, 1994). For instance, MacDonald (2000) presented extensive literature on the different concepts of constructing an equilibrium exchange rate. He discussed the advantages and disadvantages of various models, such as the internal-external balance approach, which is compared to the so-called behavioural equilibrium approach.

Our investigation is also distinguished by taking into account the financial market development of commodity-exporting countries when testing the impact of commodity price movements on currency misalignments. Many empricial studies have investigated commodity price movements by considering the issue of increasing investment in the derivative market, and they have stressed the relevance of the so-called "financialization of commodities" (see for example, Chari and Christiano, 2017). Indeed, investing in commodity futures contracts has good hedging properties against inflation, as well as exchange rate variations. Some studies such as, among others, Acharya et al. (2013), Brunetti and Reiffen (2014), Tang and

Xiong (2012) find evidence that supports the financialization view.[13] Mayer (2009) has shown that financial investment has become increasingly important in commodity markets. The main empirical finding indicates that index trader positions have affected the prices of a wide range of agriculture commodities, while money managers have tended to impact the prices for some non-agriculture commodities during the sharp increases. Gilbert (2010) has made the connection between index-based investments and the exorbitant price augmentation of food between 2007 and 2008. He found that speculation caused price increases beyond the normal level that would be set by the commodity physical market. Conrad (2014) has nuanced the previous findings by showing that speculation influences commodity prices if it creates a significant excess demand during a significant time period.

In a recent study, Christoffersen and Pan (2018) found a strong link between oil price volatility and returns of the stock market after financialization of the commodity markets. Indeed, the exposure to oil volatility risk must be considered when determining the expected returns of stocks. Moreover, Li (2018) has investigated the increasing investment in the commodity future markets since 2002. Their findings suggest that financial investors in commodity markets for the purpose of risk diversification were less adverse to risk between 2005 and 2008. He also mentioned that downward speculation activity after 2009 has had a reverse impact on risk aversion and risk premiums. Brunetti et al. (2016) also argued that financialization reduces spot price volatility.

Moreover, as a result of the increasing financialization of the commodity markets, the price of commodities has became more volatile and therefore their exports riskier for commodity exporters. Indeed, the "financialization" of the commodity markets since the early 2000s, is the result of the intensification of portfolio rebalancing and hedging, and has become a new factor in the explanation of commodity prices and price volatility.[14] To explore this matter, Bastourre et al. (2010) aimed to improve general knowledge of the drivers of the price of commodities in the long term by incorporating the concept of financialization of the

[13] See, for example, Chari and Christiano (2017) for a complete literature review.

[14] The importance of the financial channel in the determination of the commodity price can be observed via the significant increase of crude oil futures traded on the New York Mercantile Exchange (NYMEX) since 2000 (Fratzscher et al., 2014).

commodity markets. The results suggest that high discrepancies between spot and fundamental prices tend to be corrected relatively fast. On the other hand, small misalignments tend to persevere over time without any endogenous correcting force taking place. Their findings support the idea that the prices of commodities tend to correct toward equilibrium, but this correction only takes place if past misalignment is sufficiently high. Thus, in the low misalignment regime correcting forces do not prevail and prices can move in any direction, possibly depending on market sentiments.

3. Empirical methodology and data description

3.1. Empirical methodology

The objective of this study is to assess the impact of the volatility of real commodity prices on currency misalignments by considering the level of financial development as a transmission channel. To evaluate this relationship, we consider the panel smooth transition regression (PSTR) model proposed by González et al. (2005, 2017). Based on this model, we test the non-linear relationship between currency misalignments and their determinants, by including the financial market development as the transition variable. Denoting the dependent variable with $|MIS_{i,t}|$, the monthly real effective exchange rate misalignments expressed in absolute value, the PSTR model is given by:

$$|MIS_{i,t}| = \alpha_i + \varphi z_{i,t} + \beta_0 \Delta\, ComPI_{i,t} + [\beta_1 \Delta\, ComPI_{i,t} * F(S_{i,t}; \gamma, c\,)] + \varepsilon_{i,t} \qquad (1)$$

for $t = 1, \dots, T$ and $i = 1, \dots, N$, with t denoting time and i the country. Furthermore, α_i denotes the country fixed effects and $\Delta\, ComPI_{i,t}$ stands for the volatility of the commodity price index. $\Delta\, ComPI_{i,t}$ is proxied by the absolute value of the monthly variation in the real commodity price index. $\Delta\, ComPI_{i,t}$ is the exogenous variable upon which the transition function F is active. $S_{i,t}$ stands for the transition variable, defined here by the financial development level, $z_{i,t}$ is a vector of exogenous control variables with constant coefficients, expressed in first differences, representing the fundamental determinants of REER,[15] and $\varepsilon_{i,t}$

[15] Note that since our focus is on the relationship between the real commodity price and the exchange rate misalignment, we assume that only the coefficient of the real commodity price varies depending on the transition variable values.

is an independent and identically distributed (i.i.d.) error term. Transition function $F(S_{i,t};\gamma,c)$ is a continuous function of $S_{i,t}$ and is normalized to be bounded between 0 and 1, and these extreme values are associated with regression coefficients β_0 and $\beta_0+\beta_1$. This transition function is given by (González et al., 2005):

$$F(S_{i,t};\gamma,c)=\left(1+exp\left(-\gamma\prod_{j=1}^{m}(S_{i,t}-c_j)\right)\right)^{-1} \quad (2)$$

where c_j $(j=1,2,\dots,m)$ are the threshold parameters $(c_1\leq c_2\leq\cdots\leq c_m)$ and γ is the slope parameter of the transition function. According to González et al. (2005, 2017), in practice, it is usually sufficient to consider $m=1$ (logistic) and $m=2$ (logistic quadratic). In the case of $m=1$, the dynamics is asymmetric and the two extreme regimes are associated with low and high values of the transition variable, where the change is centred around the threshold (c_1). In the case of $m=2$, the dynamics is symmetric, and the transition function has its minimum at $(c_1+c_2)/2$, and attains the value of 1 at both low and high values of the transition variable.

3.2. Sample of countries and real commodity prices

We consider monthly data for a panel of 46 commodity-exporting countries spanning from January 1994 to December 2016. The list of countries is given in Table 1,[16] together with the most important commodity exported by each one, which are – except for energy-exporting countries – derived from Cashin et al. (2004).

We select the commodity price index in accordance with the main type of commodity exported by the countries present in our panels. All price indices are extracted from the IMF database (*Primary Commodity Prices*). For the energy panel, we used the "energy price index", which includes the crude oil (petroleum), natural gas and coal price indices.[17] For the food and beverages panel, we opted for the "food and beverage price index", which combines the food and the beverage price indices. For the metals group, we selected the "metals price index", which incorporates the copper, aluminium, iron, ore, tin, nickel, zinc, lead, and

[16] As a result of data availability issues, we remove some countries from the initial list of Cashin et al. (2004).

[17] For oil-exporting countries, the oil price index is calculated as a simple average of US dollars prices in three major markets: Brent, Dubai, West Texas.

uranium price indices. Finally, for the raw materials panels, we chose the "agricultural raw materials index", which incorporates the timber, cotton, wool, rubber and hides price indices.[18]

As mentioned previously in the PSTR model, we introduce a financial transition variable in order to consider the increasing financialization of the commodity markets. Following Levine et al. (2000), the degree of financial integration is measure by the ratio of M2 to GDP and taken from the World Bank database (*World Development Indicators*).

3.3. Equilibrium exchange rate and currency misalignments

Various concepts of equilibrium exchange rates exist, from the short-term market equilibrium to the very long-term one of universal price convergence.[19] To account for the long-term relationship between the real exchange rate and its determinants, we follow the behavioural equilibrium exchange rate (BEER) methodology introduced by MacDonald (1997, 2000) and Clark and MacDonald (1998). This approach is adopted, for example, by the IMF (Isard, 2007), appears less normative than other methodologies (FEER, for example) and yields excellent empirical results.[20] In the BEER methodology, the real effective exchange rate is expressed as a function of three fundamental variables:[21]

$$LREER_{i,t} = \mu_i + \theta_1 LBS_{i,t} + \theta_2 NFA_{i,t} + \theta_3 LToT_{i,t}^{com} + u_{i,t} \quad (3)$$

where $LREER_{i,t}$ is the logarithm of the real effective exchange rate, $LBS_{i,t}$ is the country's productivity (Balassa-Samuelson effect) expressed in logarithm, $NFA_{i,t}$ its net foreign asset position (in percentage of GDP) and $LToT_{i,t}^{com}$ its real commodity terms of trade (expressed in logarithm). α_i accounts for individual fixed effects and $u_{i,t}$ is an i.i.d. error term.

Real effective exchange rates are provided by the Bank of International Settlements and Bruegel databases.

[18] As indicated by the IMF, "group indices are weighted averages of individual commodity price indices, with respective commodity weights derived from their relative trade values compared to the total world trade as reported in the UN Comtrade database".

[19] See, for example, Bénassy-Quéré et al. (2010) or Bussière et al. (2010) for a discussion.

[20] See, for example, Driver and Westaway (2005) and Durand and Lopez (2012) for a discussion.

[21] See, for example, Clark and MacDonald (1998), Chinn (2005) or Ricci et al. (2008).

The Balassa-Samuelson effect, or *productivity differential,* states that a country experiencing high productivity growth in tradable goods, relative to non-tradable goods, will experience a growth in wages (in both sectors). It will inexorably give rise to higher prices in non-tradable goods. Consequently, the real exchange rate appreciates. The Balassa-Samuelson effect is approximated by the GDP per capita measured in purchasing power parity (PPP) relative to the trading partners. The weights (w_j) correspond to the shares in the world GDP PPP per capita, calculated on average over the period 1980-2016. Both variables, GDP PPP and GDP data, are extracted from the IMF (*International Financial Statistics*) database.[22]

$$BS_{i,t} = \frac{PPP\ GDP\ capita_{i,t}}{\prod_{j=1,j\neq i}^{137} PPP\ GDP\ capita_{j,t}^{(w_j)}} \quad (4)$$

where $w_j = GDP_j / \sum_{k=1}^{137} GDP_k$ and $\sum_{k=1}^{137} w_j = 1$.

The net foreign asset position (NFA) refers to the value of the sum of foreign assets held by monetary authorities and deposit money banks, less the value of domestic assets owned by foreigners. It is expressed in percentage points of GDP. The net foreign asset position is a measure of indebtedness, indicating whether or not the country is a net creditor or debtor to the rest of the world. A positive NFA balance means that the country is a net lender, whereas a negative balance shows that it is a debtor to the rest of the world. The NFA position can drive changes in exchange rates, since a country that faces a growing current account deficit needs to increase its trade surpluses, which can be done by depreciating its exchange rate. Another possible reason for the impact of the net foreign asset position is that the currencies of countries with a significant negative NFA position and growing current account deficits may appear to be vulnerable to currency speculators, who may seek to drive it lower. The NFA series are obtained from the updated and extended version of the dataset constructed by Lane and Milesi-Ferretti (2007) for the period 1980-2011.[23] For all the subsequent years (2012 to 2016), we computed the variable by adding the previous (*NFA*) to the contemporaneous current account:

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[22] For robustness check, we also use Balassa-Samuelson effect data from *EQCHANGE* database (Cepii). The results, available upon request from the authors, are very similar.

[23] http://www.philiplane.org/EWN.html. See Lane and Milesi-Ferretti (2007).

$$NFA_{i,t} = NFA_{i,t-1} + CA_{i,t} \quad (5)$$

and considered the variable as a percentage of GDP. The current account and GDP (in US dollars) data was taken from the IMF World Economic Outlook (WEO) database.

The real commodity terms of trade are calculated in the same way as in Cashin et al. (2004). Consequently, the real commodity terms of trade are a weighted average price of the three main commodities exported by the country, deflated by the manufactured unit value (MUV).[24] Therefore, the real commodity terms of trade are expressed as:

$$ToT_{i,t}^{com} = \frac{\sum_{k=1}^{3} share_i^k \times p_t^k}{MUV_t} \quad (6)$$

Where share_i^k is the share of commodity k among the three main commodities exported by country i, p_t^k is the price of commodity k extracted from the IMF database (*Primary Commodity Prices*), and MUV_t is the manufactured unit value extracted from the IMF World Economic Outlook (WEO) database.

The real exchange rate misalignment, noted as $MIS_{i,t}$, is computed as follows:

$$MIS_{i,t} = \hat{u}_{i,t} = LREER_{i,t} - LREER_{i,t}^{EST} \quad (7)$$

where $LREER_{i,t}^{EST}$ is the real effective equilibrium (i.e. estimated) exchange rate. Following equation (7), the definition of the equilibrium and the effective exchanges rates, a negative sign indicates an undervaluation, that is, $LREER_{i,t} < LREER_{i,t}^{EST}$, and a positive sign indicates an overvaluation, namely, $LREER_{i,t} > LREER_{i,t}^{EST}$, of the real effective exchange rate.

4. Results

To investigate long- and short-term relationships, we have to use monthly data. We therefore reconstruct our variables of interest, namely relative productivity, net foreign assets and commodity terms of trade, at a monthly frequency using the usual interpolation procedure.[25]

[24] For oil-exporting countries, the real commodity terms of trade are calculated as the oil price deflated by the manufactured unit value (MUV). This has been done for the 11 oil-exporting countries where the oil price stands for 100% of the weight.

[25] We use the proportional Denton method. This method is robust (Chen, 2007) and recommended in IMF or Federal Reserve Bank publications (Kinda, 2011; Liu et al., 2011).

4.1. The long-term relationship and currency misalignments

We first test whether our variables are correlated across countries in order to choose the appropriate set of panel unit root and cointegration tests. We perform the CD test proposed by Pesaran (2004). The results are presented in Table 2 and indicate that the null hypothesis of cross-section independence is strongly rejected for all series used.

INSERT TABLE 2 ABOUT HERE

We then apply several panel unit root and cointegration tests. Our results show that our four series (*LREER*, *LBS*, *NFA* and $LTOT^{com}$) can be considered as unit root processes (Table 3) and are cointegrated (Tables 4 and 5).

INSERT TABLES 3, 4 and 5 ABOUT HERE

We finally estimate equation (3), namely the cointegrating relationship. Since ordinary least squares (OLS) estimates are biased and dependent on nuisance parameters, we use the Dynamic OLS (DOLS) procedure introduced by Kao and Chiang (2000) and Mark and Sul (2003) in the context of panel cointegration. We also use the estimation procedure, BKN, proposed by Bai et al. (2009).

The DOLS procedure consists in augmenting the cointegrating relationship with lead and lagged differences of the regressors to control for endogenous feedback effect. While this approach accounts for a certain form of cross-sectional dependence through possible time effects, the procedure of Bai et al. (2009) was developed specifically to deal with this property. To capture cross-sectional dependence, the BKN technique introduces unobservable common factors in the errors. The cointegration coefficient and the factors are jointly estimated by an iterative procedure.

Using DOLS and BKN procedures, we obtain the results for estimation of the cointegrating relationship, as presented in Table 6.

INSERT TABLE 6 ABOUT HERE

Whatever the procedure, DOLS or BKN, the estimated coefficients of three fundamental variables have the expected sign and are significant at conventional levels. A rise in relative productivity, NFA position and commodity terms of trade lead to an appreciation of the real effective exchange rate. Commodity terms of trade seem to be an important determinant of the real effective exchange rate, as demonstrated by Cashin et al. (2004). The currencies of our commodity-dependent countries can be considered as "commodities currency", since the long-term elasticity of the real effective exchange rate to the (commodity) terms of trade is positive and significant. We also note that the values of the estimated cointegrating coefficients are smaller when the BKN procedure is applied. Indeed, Bodart et al. (2012) showed that when correcting for the bias induced by the cross-sectional dependence, the long-term impact of the considered fundamentals is still significant, but reduced compared to the effect obtained using the DOLS methodology.[26]

In order to check if our results for the whole panel might be masking some heterogeneity across countries following the types of commodity they export, we subdivide our panel into four groups depending on the nature of the main commodity exported by each country: foods and beverages, metals, raw materials and energy. We perform the estimation of the long-term relationship for those subgroups of countries, and the estimated coefficients are presented in Table 7.

INSERT TABLE 7 ABOUT HERE

The findings confirm that commodity terms of trade are a significant determinant of the real effective exchange rate for the four commodity panels, except for the energy panel. The results for the relative productivity and the NFA position are mixed. They are sometimes non-significant (LBS for raw materials and energy and NFA for energy only).

Using these estimated coefficients, the equilibrium exchange rates for each panel are calculated. Currency misalignments are then derived, following equation (7), as the difference between the observed real effective exchange rates and their equilibrium value.[27]

[26] See also Coudert et al. (2015) for a similar result.

[27] To save space, we do not report figures that display the evolution of observed and equilibrium real effective exchange rates, and the associated misalignments. All these results are available upon request from the authors.

4.2. The non-linear relationship: the PSTR estimation results

To assess the short-term relationship between real commodity price volatilities and currency misalignments, we use a panel smooth transition regression (PSTR) model, as proposed by González et al. (2005, 2017). However, using a non-linear model such as the PSTR requires a specific modelling strategy. According to Gonzalès et al. (2005, 2017), in the case of panel data, the modelling process must be start by testing linearity against the PSTR alternative. In our study, if linearity is rejected, it means that the impact of real commodity price volatilities on currency misalignments is different, depending on whether the financial development level is low or high. The results, which are displayed in Table 8, show that the null hypothesis of linearity is rejected in favour of the PSTR alternative with two regimes.[28] These findings highlight that the volatility of real commodity prices impacts the currency misalignments differently, depending on the level of financial development.

INSERT TABLE 8 ABOUT HERE

According to the PSTR specification, the regression coefficient of the main explanatory variable (equation 1) is allowed to vary across countries, and with time, depending on the transition variable values (M2/GDP). In this prospect, we are aiming to capture the non-linear effect of real commodity prices movements on the currency misalignments. Table 9 gathers the estimation of our PSTR specification.

INSERT TABLE 9 ABOUT HERE

The results are very significant for all of the panels and highlight: (i) the impact of the volatility of real commodity prices on currency misalignments, (ii) that this impact is non-linear and takes different signs depending on the level of the transition variable, that is, the level of financial development. These findings demonstrate the dynamic relationship between commodity and foreign exchange markets. To better understand this relationship, below we propose a careful and deep analysis of the results for each panel of our sample.

[28] The linearity test also provides the appropriate order m of the logistic transition function. The results indicate that the dynamic is asymmetric $(m = 1)$ for all panels.

Let us consider first the estimated values of the threshold parameter ($\hat{c}$). The results in Table 9 indicate signficant heterogeneity between the four panels and the threshold varies from 0.15 (food and beverages) to 0.33 (energy). The value of the threshold linked to the level of financial development reveals an important heterogeneity in terms of dynamic and impact between commodity price volatilities and currency misalignments. Indeed, the different countries of the four panels have a heterogenous level of financial development, and thus their real commodity price volatility affects the currency misalignments differently.

We now focus on the estimated coefficient of our main exogenous variable which is the volatility of the real commodity prices. The results show that the estimated coefficients are highly significant for all panels and confirm that the volatility of the real commodity prices is a major determinant of the currency misalignments. Our findings also highlight different dynamics depending on both the type of commodity and the level of financial development. First, for the two panels of food and beverages and metals, the estimated coefficient is positively signed for the periods when a country is less developed financially (regime 1). Consequently, when the volatility of the commodity prices increases it will result in an increase in the currency misalignments. For the second regime, when a country has a better financial development level, there is a negative effect of the volatility of commodity price on currency misalignments. This result indicates that the growth of financial development of commodity-exporting countries for the purpose of risk diversification can reduce the currency misalignments in the case of high volatility of the commodity prices.

Second, for the other two panels of raw materials and energy, we can observe a different behaviour, compared to the first two panels, as the estimated coefficient of the main exogenous variable is negative in the first regime and positive in the second one. This means that for the periods when a country is poorly integrated financially, the greater the volatility of the real commodity prices, the smaller the gap between the real exchange rate and its equilibirum value. On the other hand, for the periods when a country is better developed financially (i.e. regime 2), unlike the first two panels studied, the estimated coefficient is positively signed. For instance, in the second regime of the energy panel, an increase of 10 per cent in the volatility of the commodity prices will induce an increase of 2.1 per cent in currency misalignments. This result may be explained by the fact that the financial development process and financialization of commodities can play a reverse role, mainly during the high levels of discrepancy in the financial markets. Indeed, they can accentuate the currency misalignments when the commodity prices are more volatile.

Moreover, the results for the raw materials and energy panels can be explained in light of the exchange rate regime. Indeed, the majority of raw materials- and energy-exporting countries have adopted (de jure or *de facto*) pegged exchange rates (with band of fluctuation allowed in some cases).[29] Even with a high level of financial development, a fixed exchange rate is not able to cushion a higher commodity price volatility. In this case, the exchange rate can not be a shock absorber (Devereux, 2004). In the opposite case, as demonstrated by Edwards and Levy-Yeyati (2005), a flexible exchange rate can be a shock absorber.

The results in Table 9 also indicate, for all panels, that the estimated coefficient of the volatility of commodity prices is lower (in absolute value) in the second regime compared to the first one. Besides the coefficient sign, this finding evidences that financial development may play an active role in terms of impact transmission between commodity and foreign exchange markets. Indeed, the increase in financial development level reduces the effect of commodity price volatilities on currency misalignments, mainly for food and beverages and metals panels.

Let us turn to the other exogenous fundamental variables, which are not subject to the transition channel. We first focus on the financial development level (M2/GDP) which is also included as an exogenous variable. Our results show that its impact on the currency misalignment is significant and its sign depends on the type of commodity. Indeed, the impact is positive for three panels (food and beverages, metals and raw materials) and negative for the last panel (energy). This finding confirms the previous evidence that the financial development of commodity-exporting countries has a significant impact on currency misalignments. However, interpretation of the coefficient sign has to be done in light of commodity-specific features. For the energy panel, the estimated coefficient is negative and the financial development may be seen as reducing currency misalignments. Indeed, if one considers that a high level of financial development is associated with more investment

[29] For a discussion about the classification of exchange rate regimes, see, for example, Reinhart and Rogoff (2004) or Ilzetzki et al. (2010).

diversification and lower portfolio risk, it could have a positive impact on trade capabilities, therefore reducing currency misalignments (Aghion et al., 2009; Baltagi et al., 2009). For the three other panels, the effect is positive and lower compared to the energy panel. One explanation may be linked to the lower financial development of the countries that export food and berverages, metals and raw materials commodities. Indeed, it appears that a new process of "commodity financialization" impacted the energy exporting-countries more than other ones (Brunetti and Reiffen, 2014; Henderson et al., 2015).

We now shed light on the other three determinants of the real exchange rate misalignments. We can first observe that the country's net foreign asset position is not significant for all panels. This result shows that the short-term relation between the exchange rate and one of its fundamental variables, namely, net foreign asset, is rather loose. For example, Lane and Milesi-Ferretti (2004) found a long-term relationship between the net foreign asset and the real exchange rate. They also highlighted that the more open an economy, the smaller the transfer effect. In our sample, a large number of countries have a high degree of openness. Therefore, in the short-term, *NFA* might not be significant in our different estimations.[30] The second exogenous fundamental variable, that is, commodity terms of trade, is significant for all panels, but the sign is negative for three of them (food and beverages, raw materials and energy) and positive only for the metals panel. This result is also evidenced by the literature (Coudert et al., 2015). For example, in the case of the metals and energy panels, variations in commodity terms of trade are a significant determinant of real exchange rate variations, mainly when the prices are subject to high volatility. Finally, the Balassa-Samuelson effect is significant and characterized by a positive impact on currency misalignments only for the food and beverages, and metals panels. Indeed, a country with a high productivity increase in tradable goods relative to non-tradable goods may induce a growth in wages, which would result in an appreciation of its real exchange rate.

To summarize, the PSTR specification allowed us to demonstrate the non-linear effect of the volatility of the commodity price on the currency misalignments, which is transmitted through the financial deepening (characterized by the ratio M2/GDP). The results also highlight

[30] See, for example, Adler and Grisse (2017) for a review.

different dynamics, depending on the type of commodity and the financial development level. Furthermore, the estimated coefficient of our main exogenous variable, in the first regime, tends to be greater (in absolute value) than in the second regime. Therefore, we can state that when a commodity-exporting country is better developed financially, the impact of the volatility of the commodity price on currency misalignments tends to be lower.

Our findings are consistent with previous studies (Fratzscher et al., 2014; Coudert and Mignon, 2016) and support the idea that the growth in volume of the commodity markets due to its financialization justifies consideration of the financial development level as an important transmission channel when analysing the effect of real commodity price volatilities on real exchange rate misalignments.

4.3. Robustness check of commodity financialization

As mentioned in Section 2, the "financialization" of the commodity markets since the early 2000s is the results of the intensification of portfolio rebalancing and hedging and has become a new factor in the determination of commodity prices, as well as real effective exchange rates. This process of "commodity financialization" was developed recently, between 2002 and 2008 and then reappeared after the global financial crisis (Henderson et al., 2015; Chari and Christiano, 2017). Therefore, it seems interesting to evaluate our relationship between the volatility of commodity price and currency misalignments during this period (2002-2016) instead of the whole sample (i.e. since 1994). The aim of this investigation is to test whether or not sensitivity increased after the intensification of commodity financialization, as the comparison can be made between the global and the sub-period, in terms of coefficient dynamics and transition threshold, which may be higher since 2002. Furthermore, our aim is to deepen our analysis of panels such as energy, which is impacted to a greater degree by the commodity financialization strategy. The results of our estimation are given in Table 10.

INSERT TABLE 10 ABOUT HERE

The findings confirm the previous evidence that the link between the commodity and foreign exchange markets is highly significant for all panels and varies from one regime to another, depending on the financial development level. Moreover, we notice some differences with the previous results when these are compared to the previous results in Section 4.2. Indeed, for all panels, during the periods when the country is less developed financially (i.e. regime 1), the volatility of real commodity prices has a positive impact on currency misalignments. In the second regime, when the country is characterized by better financial development, the impact becomes negative, but smaller (in absolute value). Therefore, the relationship during this sub-period (2002-2016) appears stronger and confirms the robustness of our results. Moreover, the estimated threshold is higher during the sub-period, except for food and beverages (for instance, for the energy panel it is equal to 0.49 instead of 0.33; and for the raw materials panel it is equal to 0.45 instead of 0.28). The food and beverages panel is the exception, with a lower threshold (0.12 in the sub-period instead of 0.15 in the whole period). This finding confirms the change in terms of relationship between commodity and foreign exchange markets, which may be induced by increasing financial deepening, as well as the intensification of financialization of commodities post-2000. Indeed, this result is evidenced by the literature and highlights the increasing financialization of the energy sector for the years post-2000 (Fratzscher et al., 2014; Henderson et al., 2015).

For the other exogenous variables, the results in Table 10 indicate that the financial deepening has a greater impact on currency misalignments, except for the energy panel. The results of the three other determinants are similar to the previous section. Indeed, the variation in the commodity terms of trade is the most significant determinant of currency misalignments.

5. Conclusion

This paper explored the relationship between the commodity price volatilities and the real effective exchange rate misalignments of 46 commodity-exporting countries, taking into account the level of financial development as the transition variable. The main objective of this study was to explore the potential non-linear impact of the volatility of real commodity price indices on currency misalignments, by considering the level of financial development. Indeed, considering the financialization process of the commodities market, it seems that the level of financial development of a country may play a key role in the transmission channel, from the real commodity price volatilities to the currency misalignments. To this end, we subdivided our sample into four panels (food and beverages, energy, metals and raw materials) according to the main type of commodity exported, in order to account for potential heterogeneity between panels.

We first estimated the currency misalignments using the BEER approach, which showed that there is a long-term relationship between real exchange rates and commodity terms of trade, productivity and net foreign assets. Then, we relied on the panel smooth transition regression methodology to estimate the non-linear impact of commodity prices volatilities on currency misalignments. Our results show that the estimated coefficients are highly significant and highlight that the volatility of the real commodity prices has a non-linear impact on the currency misalignments, depending on the degree of the country's financial development. The results also point out different dynamics based on the type of commodity exported by the country and its level of financialization. Specifically, based on the PSTR specification, with the level of financial integration development as the transition variable, we find that for all panels, the volatility of the real price index is a significant driver of currency misalignments. However, the impact intensity is different from one panel to another. Indeed, for the food and beverages and metals panels, for the periods when a country is poorly financially developed, the increase in volatility of the real price index results in an increase in currency misalignment. On the contrary, based on our results, in the second regime, when a country is better financially developed, the estimated coefficients of the price indices tend to be closer to 0 (or lower in the case of the raw materials panel). For the raw materials and energy panels, the behaviour of the currency misalignment is different. When a country is poorly financially developed, the greater the volatility of the real commodity prices, the smaller the currency misalignment. On the contrary, for the periods when a country is better financially developed, the increase in the real commodity prices induces an increase in the currency misalignment. Consequently, when a country is better financially developed, the volatility of the real price index has a limited impact on the currency misalignment. Furthermore, our findings highlight the post-2000 financialization growth of commodities. This result is evidenced by the literature and highlights the increasing financialization of the commodities market for the post-2000 years.

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Tables and Figures

Table 1: List of countries

Country	Commodity group	Country	Commodity group
Algeria	Energy	**Mexico**	Energy
Argentina	Food & beverages	**Morocco**	Raw materials
Australia	Energy	**Mozambique**	Raw materials
Bahrain	Energy	**Niger**	Metals
Bolivia	Metals	**Norway**	Energy
Brazil	Metals	**Oman**	Energy
Cameroon	Food & beverages	**Pakistan**	Food & beverages
Canada	Energy & Raw materials	**Papua New Guinea**	Metals
Chile	Metals	**Paraguay**	Food & beverages
Colombia	Energy	**Peru**	Metals
Ethiopia	Food & beverages	**Philippines**	Food & beverages
Ghana	Food & beverages	**Saudi Arabia**	Energy
Honduras	Food & beverages	**Senegal**	Raw materials
Iceland	Food & beverages	**South Africa**	Metals
India	Food & beverages	**Thailand**	Food & beverages
Indonesia	Energy	**Togo**	Raw materials
Iran	Energy	**Tunisia**	Raw materials
Ivory Coast	Food & beverages	**Turkey**	Raw materials
Kenya	Food & beverages	**Uganda**	Food & beverages
Kuwait	Energy	**United Arab Emirates**	Energy
Malawi	Raw materials	**Uruguay**	Food & beverages
Malaysia	Food & beverages	**Venezuela**	Energy
Mali	Raw materials	**Zambia**	Metals

Notes: Due to the lack of available data or extensive periods of war, which would have had for effect to distort the results, we decided to discard and remove some countries such as Syria, Libya, Central African Republic, Burundi, Nigeria, etc., from the initial list of 52 countries of Cashin et al. (2004).

Table 2: Pesaran (2004) CD test results

	t-statistic	p-value
LREER	50.96	0.00***
$LToT^{com}$	402.03	0.00***
NFA	100.38	0.00***
LBS	58.19	0.00***

Notes: CD is the cross-sectional dependence test statistic of Pesaran (2004) that is based on the pair-wise correlation coefficients. LREER, $LToT^{com}$, NFA and LBS are, respectively, the logarithm of the real effective exchange rate, the logarithm of the commodity terms of trade, the net foreign assets (in % of GDP) and the logarithm of the Balassa-Samuelson effect. Under the null hypothesis of no cross-sectional dependence, CD is distributed as standard normal. ***, **, * indicates the rejection of the null hypothesis (no cross-sectional dependence) at, respectively, 1%, 5%, 10% significance level.

Table 3: Panel unit root test

	Hadri	IPS	Choi	Pesaran
LREER	36.446***	-1.654**	-1.618*	2.681
	(0.000)	(0.049)	(0.053)	(0.996)
$LToT^{com}$	53.189***	-1.393*	-0.902	2.582
	(0.000)	(0.082)	(0.184)	(0.995)
NFA	43.263***	-0.208	0.091	11.612
	(0.000)	(0.417)	(0.536)	(1.000)
LBS	49.000***	0.975	1.263	0.845
	(0.000)	(0.835)	(0.897)	(0.801)

Notes: LREER, $LToT^{com}$, NFA and LBS are, respectively, the logarithm of the real effective exchange rate, the logarithm of the commodity terms of trade, the net foreign assets (in % of GDP) and the logarithm of the Balassa-Samuelson effect. Optimal lags are selected using the AIC and BIC information criteria. In case of different results, the BIC criteria is selected following Hurlin and Mignon (2005).
p-values are given in parentheses. ***, **, *, indicates rejection of the null hypothesis at, respectively, 1%, 5% or 10% significance level. All tests are made with individual effects and linear trends.

Table 4: Panel cointegration tests of Pedroni (1999, 2004) and Kao (1999)

		t-statistic	p-value
Panel cointegration – Pedroni			
	Panel v-stat	5.129	0.000***
	Panel rho-stat	-1.955	0.025**
	Panel pp-stat	-1.259	0.104
	Panel adf-stat	-2.148	0.016**
Group Mean cointegration – Pedroni			
	Group rho-stat	-3.174	0.001***
	Group pp-stat	-3.348	0.000***
	Group adf-stat	-6.091	0.000***
Kao's cointegration test		-2.033	0.021**

Notes: All the tests have the null hypothesis of no-cointegration. ***, **, * denote rejection of the null hypothesis of no-cointegration at, respectively, 1%, 5%, 10% significance levels. All tests are made with fixed effects.

Table 5: Panel cointegration test of Westerlund (2007)

	G_τ	G_α	P_τ	P_α
Robust p-value	0.000***	0.000***	0.010**	0.000***

Notes: Robust p-values are calculated using Bootstrap methodology (100 replications). Results for the null-hypothesis of no cointegration. ***, **, * indicates rejection of the null hypothesis at, respectively, 1%, 5% or 10% significance level.

Table 6: Results of the cointegrating relationship

	Method DOLS	Method BKN
LBS	0.119***	0.116***
	(7.439)	(7.504)
NFA	0.081***	0.080***
	(17.711)	(19.062)
$LToT^{com}$	0.033***	0.046***
	(5.047)	(7.016)

Notes: Estimation of equation (3):

$$LREER_{i,t} = \mu_i + \theta_1 LBS_{i,t} + \theta_2 NFA_{i,t} + \theta_3 LToT_{i,t}^{com} + u_{i,t}$$

This equation is estimated using (i) the DOLS procedure (column Method DOLS) proposed by Kao and Chiang (2000) and Mark and Sul (2003) and (ii) the BKN procedure (column Method BKN) proposed by Bai et al. (2009). *t-statistics* are given in parentheses. Significant coefficient at 1% (***), 5% (**) or 10% (*).

Table 7: Results of the cointegrating relationship for subgroups of countries according to the commodity classification

	Food and beverages	Metals	Raw materials	Energy
LBS	0.405***	0.325***	0.107**	0.182**
	(13.461)	(4.277)	(0.042)	(0.023)
NFA	0.102***	0.145***	0.018	0.100***
	(15.884)	(7.983)	(0.448)	(3.504)
$LToT^{com}$	0.055***	0.033**	0.051***	-0.052
	(3.916)	(1.732)	(0.008)	(-1.561)

Notes: Estimation of equation (3):

$$LREER_{i,t} = \mu_i + \theta_1 LBS_{i,t} + \theta_2 NFA_{i,t} + \theta_3 LToT_{i,t}^{com} + u_{i,t}$$

This equation is estimated using only the DOLS procedure.[31] *t-statistics* are given in parentheses. Significant coefficient at 1% (***), 5% (**) or 10% (*).

Table 8: Results of linearity tests against PSTR specification

	Food and beverages	Metals	Raw material	Energy
LM	14.087	4.288	10.034	7.070
	(0.000)	(0.005)	(0.000)	(0.000)
F	7.649	4.114	6.176	18.214
	(0.000)	(0.006)	(0.000)	(0.000)

Notes: The linearity test refers to the null hypothesis of linearity against the alternative of a PSTR model with two regimes.
LM and F are, respectively, the Lagrange multiplier and tests for linearity statistic which is asymptotically distributed as $\mathcal{X}^2(mk)$ and its *F-version* which has an approximate $F(mk, TN - N - k - mk)$ distribution. p-values are given in parentheses.

[31] Results using the BKN procedure are very similar and are available upon request from the authors.

Table 9: Estimation of the PSTR model (full sample period: 1994-2016)

Transition variable: financial development								
	Food and beverages		Metals		Raw materials		Energy	
	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2
$\Delta ComPI$	0.575***	-0.016***	0.464***	-0.271***	-0.611***	0.146***	-1.601***	0.211***
ΔNFA	0.001		0.003		0.002		0.008	
$\Delta LToT^{com}$	-3.918***		1.259**		-1.818***		-8.994***	
ΔLBS	0.146***		0.282***		-0.058		0.167	
$M2/GDP$	0.026***		0.033*		0.025**		-0.062***	
$\hat{c}$	0.149		0.272		0.278		0.334	
$\hat{\gamma}$	8974.7		1895.2		1775.9		80.560	

Notes: Estimation of equation (1):

$$|MIS_{i,t}| = \alpha_i + \varphi z_{i,t} + \beta_0 \Delta\ ComPI_{i,t} + [\beta_1 \Delta\ ComPI_{i,t} * F(S_{i,t}; \gamma, c\ )] + \varepsilon_{i,t}$$

$|MIS_{i,t}|$ stands for the misalignment expressed in logarithm (in absolute terms). $\Delta\ ComPI$ is the commodity price index volatility. $z_{i,t}$ represents the vector of the real effective exchange rate determinants, namely, the variation of net foreign assets (ΔNFA), the variation of the commodity terms of trade (ΔToT^{com}), the variation of Balassa-Samuelson effect (ΔLBS), and the level of financial development (*M2/GDP*). $\hat{c}$ represents the estimated threshold value, and $\hat{\gamma}$ is the estimated slope parameter of the transition function. Significant coefficient at 1% (***), 5% (**) or 10% (*).

Table 10: Estimation of the PSTR model (sub-period: 2002-2016)

Transition variable: financial development								
	Food and beverages		Metals		Raw materials		Energy	
	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2
$\Delta ComPI$	3.613***	-0.028***	0.613***	-0.296***	0.197***	-0.085***	0.564***	-0.169***
ΔNFA	-0.001		0.002		0.001		0.083***	
$\Delta LToT^{com}$	-3.171***		2.209*		-2.993***		-8.821***	
ΔLBS	-0.049		0.183*		0.005		-0.158	
$M2/GDP$	0.042***		-0.074**		0.093***		-0.036	
$\hat{c}$	0.117		0.271		0.454		0.487	
$\hat{\gamma}$	91.12		782.78		1032.6		265.6	

Notes: Estimation of equation (1):

$$|MIS_{i,t}| = \alpha_i + \varphi z_{i,t} + \beta_0 \Delta\, ComPI_{i,t} + \left[\beta_1 \Delta\, ComPI_{i,t} * F\left(S_{i,t}; \gamma, c\right)\right] + \varepsilon_{i,t}$$

$|MIS_{i,t}|$ stands for the misalignment expressed in logarithm (in absolute terms). $\Delta\, ComPI$ is the commodity price index volatility. $z_{i,t}$ represents the vector of the real effective exchange rate determinants, namely, the variation of net foreign assets (ΔNFA), the variation of the commodity terms of trade (ΔToT^{com}), the variation of Balassa-Samuelson effect (ΔLBS), and the level of financial development (*M2/GDP*). $\hat{c}$ represents the estimated threshold value, and $\hat{\gamma}$ is the estimated slope parameter of the transition function. Significant coefficient at 1% (***), 5% (**) or 10% (*).