The 2000s Commodities Boom and Real Estate Overvaluation in Colombia

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Contents

1 Introduction

Most raw materials are produced in low diversified Commodity-Exporting Countries (CEC), which constitute more than a third of the world population and are mostly present in Africa, Asia and Latin America.[1]

After the production or extraction process, commodities are exported and sold in commodities exchanges [2] usually traded in American Dollars (USD), to manufacturing companies in high income industrialized countries. Manufacturing poles, like the USA, EU, and China, traditionally act as an oligopsony that gives them the capacity to influence the market. Consequently, market risks, such as overproduction, variations in cyclical demand and natural losses, are mostly passed off to the CEC, whose aggregate exports and overall economic output are primarily determined by commodity price fluctuations.

Unsurprisingly the least diversified the economy is, the more prone it is to suffer from disruptive economic cycles which tend to move with exogenous commodity price cycles. Countries like Ethiopia, Rwanda or Burundi illustrate this point particularly as their export earnings rely more than 80 % on one single agricultural commodity (coffee). Equally, this trading pattern is replicated with oil; in countries like Iraq or Venezuela, where commodity-related revenues, accounted for more than 90 % of their export earnings[3]. Along the same lines, during the post-1950 period, Drechse and Tenreyro (2017) indicate that the contribution of commodity price shocks on Argentina's variability of output growth was of 38 % and "around 42 % and 61 % of the variation in consumption and investment growth, respectively".

In the case of Latin America, between 1994 and 2007, commodity price fluctuation accounted for more than 5-6 % of the variance of the regional growth. Other factors, such as external financial conditions and foreign growth made up to 35 % and 10-15 % respectively (Osterholm and Zettelmeyer (2007).

Consistent with Latin American economies, Colombia, the fourth richest country in the region in terms of GDP, has historically been a CEC with low diversified export goods. Previous to the 1990s coffee, bananas and coal were its main exports, but since the 2000s the country progressively

[1] According to the United Nations Conference on Trade and Development (UNCTAD), almost 60 emerging countries depend on three commodities or less, to produce more than 50 % of their export earnings.

[2] Such as the Chicago Mercantile Exchange (CME) and New York Mercantile Exchange (NYMEX)

[3] During the 2007-2018 period

increased its dependency on oil extraction. Since then, we can see that mining, for example, has remarkably increased from 44

Simultaneously, a less evident relation emerged. From 2000 to 2014, housing prices increased by 105% (doubling its value in real terms) while those of new housing increased by 85%. Subsequently housing supply reacted and the construction sector participation on GDP grew from 4 % to reach almost 10 % in 2014.

With regard to these economic circumstances, intuitively two questions may arise; Is there a theoretical explanation to higher commodity prices and Real Estate booming in CEC? And if so, did this relation happen in Colombia during 2000-2014 commodity boom?

Over the past decades, the academic literature has mostly been focused on the impact of commodity prices shifts on the CEC's output cyclicality, real exchange rate and the Dutch Disease (DD) periods, but not so much on its role in real estate bubble formation. This master thesis aims to answer the above concerns and fill in the existing gap. To do so it explores the theoretical dynamics of commodity booms in CEC and their role in housing prices. Along with an empirical analysis on the Colombian economy, one of the 68 commodity-dependent economies studied by Bodart (2012) and who recently suffered DD symptoms (and had robust data series).

Ultimately, if the relation is validated, authorities and economic actors in low diversified CEC, could at an early stage better flag the dynamics of housing market misalignments. This could have an important role on CEC stability, as real estate is the main asset collateral underlying private loans.

The rest of the thesis is organized as followed; In section II a brief summary of the contemporaneous literature, related to the studied subject, is presented and complemented with a short review the recent context of Colombia's economy. Then in section III, we introduce a theoretical framework to better analyze and put forward two hypothesis about the questioned correlation. In section IV, we empirically test, through an Error Correction Model (ECM), the relation between real estate prices and the value of Colombia's exported commodities. A final section is dedicated to summarizing the main conclusions of the study, along with different open doors that could be explored in further research.

2 Literature Review and contemporaneous context

In order to better apprehend the macroeconomics circumstances related to the studied topic, we review in the next subsection the existing literature about previous commodity booms, Dutch Disease periods and real estate bubbles experimented by the Colombian economy [4]. Then, we introduce the recent economic context of the country through a brief summary of events.

2.1 Colombia's contemporaneous literature

Colombia has historically been considered as commodity exporting country. Since the available time series data, agricultural and mining sectors have been the primary provider of foreign exchange but also of its cyclical output. Previous articles to 1999 must be taken with a grain of salt. During that year in the midst of a deep fiscal gap (5% of GDP) and an important speculative attack on the domestic currency, the Colombian central bank was forced to abandon its fixed exchange rate regime and let the peso (COP) float freely.

Dutch disease

Botta, Godin, and Missaglia (2016) interpret the dynamics related to Colombia's last decade Dutch Disease symptoms. The authors throw light on the large increase of mining exports, the Colombian Peso appreciation, the FDI concentration in the mining sector and the passive monetary policy of Colombian central bank, aimed to increase domestic purchasing power via the currency appreciation. They conclude their research indicating the financial risks for the country's stability.

Edwards (1984, 1985 and 1986) points out a relation between the real exchange rate in Colombia and the variations in commodity export prices during the post-1960 period. He also describes a positive relation between commodity export value and inflation. According to its research, higher coffee prices led to an accumulation of reserves and reciprocally to a higher rate of money supply, which mechanically translates to higher inflation during commodity export booms.

Mayer (1982) argues that the instability of coffee exports price had during the studied period a negative impact on Colombia's long-run economic

[4] Complementary to this literature review, we provide in the annex, a brief summary of the macroeconomic determinants of commodity prices and Dutch disease periods

development. Ocampo (1989) goes further and calls attention to the procyclical behavior of some macroeconomic variables to the coffee production (and selling) cycle, during the period of 1940 to 1987.

Otero (2001) looks closer to the 1970s and mid–1980s coffee booms, in order to identify monetary disturbances created by abnormal export revenues. He provides evidence of an association between coffee export booms and excess money supply. Otero justifies this by the central bank difficulties, to successfully conduct a monetary policy to cope with exogenous trade disturbances in a fixed exchange rate regime.

Raju and Melo (2003) test the empirical cyclical relationships between coffee revenues and traditional Colombian macroeconomic variables. As a novelty to prior studies, they explore the export booming period of 1993-1997 and focus on commodity prices impact on the current deficits, the fiscal deficit, and the real output impact. Their conclusions corroborate preceding studies about the effect of exogenous coffee price shocks in Colombian money growth, inflation, and real exchange rates. Interestingly, they also discover that real output could still be positively influenced by past commodity booms (up to 5 years). The main long-term effects found were the reduction of the current account and government deficits.

Wunder (1991) analyzes the period from 1967 until 1988 and exposes the existence of two Dutch Disease periods in Colombia, during 1976-80 and 1986. He methodologically analyzes the revenue and fiscal effects of the booming coffee prices. He also points out the resource transfer between sectors and the increase in real wages during the DD of 1976-1981.

Recent Colombian Real Estate Market

Cardenas and Badel (2003) review the causes and consequences of the 1998-2001 Colombian mortgage crisis. The main roots identified by the authors were the low banking regulation and the high dependence of the financial sector on exogenous factors such as FDI. Other elements pointed out were the historically high indebtedness of household, the elevated share of variable rate mortgages and the inability of the Colombian central bank to sterilize capital inflows and better manage the rapid trade liberalization of the economy in previous years (1993-1997).

Roch (2017), estimates, on the basis of the period from 1994 to 2016, the misalignment of Colombian housing prices, relative to their historical fundamentals, in the order of 13 %. In complement, he evaluates the overall risk for the Colombian economy. The consequence of reinforced regulation, government willingness to intervene and the financing characteristics

of Colombian housing market, he considers present risk lower than in the previous real estate bubble (1996-1998).

2.2 Context of Colombia during the 2000s commodity boom

Previous years

During the 1997 to 1999 period, the country experimented macroeconomic and financial turmoils, due to the influence of the Asian crisis (1997) and the Russian Ruble Crisis (1998), along with serious macroeconomic deterioration. From 1992 to 1998 the public deficit worsened by 4% and the current account went from a 2% surplus to a 6% deficit. Growing concerns about the short-term sustainability of Colombian imbalances influenced investors to repatriate their capital (deteriorating capital inflows) and reciprocally encouraged speculative attacks on the Colombian peso. Consequence of the precarious situation, the central bank responded by contracting the monetary policy and depreciating the exchange rate bands. In reaction to the monetary gravity, in 1999 the central bank abandoned the fixed regime, in favor of a floating exchange rate.
Consequence of this sequence of events and due to the previous overvaluations of housing prices, Colombia mortgage crisis disrupted between 1998-2000.

2000's first decade and a half

Despite Colombia's armed conflict and failed peace process tentative (1999-2002), during the 2000s first decade and a half, the country's current GDP[5] almost quadrupled its value. Going from 99 billion in 2000 to 378 billion in 2014[6], the economic success was mostly due to the progressive dependence of the economy on the mining sector that was simultaneously flourishing. Global factors, such as the growing demand of China and India for raw materials, as well as a low interest rate global environment, influenced commodity prices to reach historical records (Frankel 2008). During the period Colombian export's composition reshaped in detriment of traditional exports such as coffee, bananas, and cut flowers. Nevertheless, the Colombian economy conserved its dependence on commodity exports and even reinforced it. During the period commodity exports grew up to 76% and represented more than 70% of total exports in 2014.

This economic conjuncture stimulated foreign direct investment, which grew at an average annual growth of 30 %. More than a half of the capital inflows were framed into the oil extraction industry influencing the sectoral composition of the economy to shift from agriculture to mining. Increasing

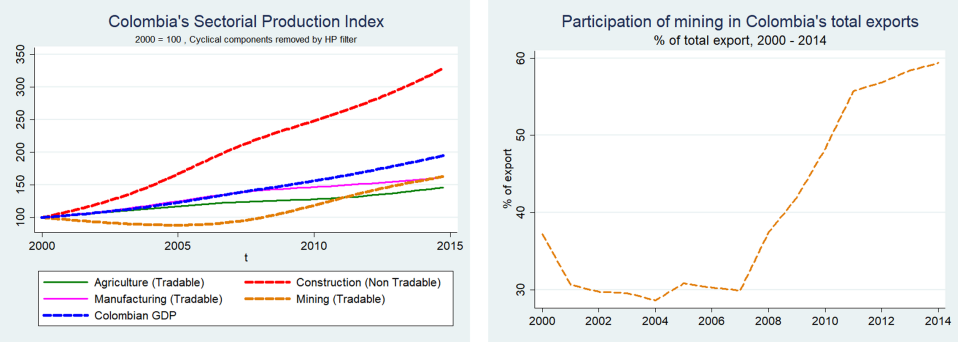
[5]Current GDP in US Dollar (USD)
[6]According to the World Bank in USD.

	Agriculture	Construction	Manufacturing	Mining
Share of GDP in 2000	9.6%	3.71%	14.48%	6.5%
Share of GDP in 2014	6.5%	7.7%	13.8%	7%

Source: DANE

Table 1: Colombia's sectorial participation on GDP

Figure 1: *In contrast with agriculture, construction, and mining sectors were the most benefited by the Commodity price boom*



exports and FDI, along with remittances, impacted during the period the nominal exchange rate. From 2003 to 2012 the Colombian Peso, (COP) appreciated 70 % in nominal terms [7] Ṡimultaneously, according to the Central Bank calculation, the real exchange rate increased 43% and GDP per capita doubled, going from 5 826 to 10 350USD.

In light of these economic indicators, and previous Dutch Disease (DD) periods experimented during the 1970s and 1980s, the government jointly with the Central bank decided to create sovereign fund[8] financed by oil revenues and inspired on the Norwegian management of commodity revenues. New mining royalties rules were also introduced.

[7] US Dollar per Peso (COP)

[8] Colombia's Savings and Stabilization Fund, also known as Fideicomiso Fondo de Ahorro y Estabilización

3 Theoretical Framework and Hypothesis

Two criteria were retained for theoretical framework selection. The first one is the Real Estate characteristic of been exclusively produced and absorbed domestically, which implies it behaves like a Non-Traded good. The second requirement was to be able to capture, by the theoretical framework, the importance of Real Exchange Rate (RER) as the main channel through which commodity prices may affect the CEC economic performance. Coherent to these needs, traditional open economy models that assume all produced goods as internationally traded were left behind in favor of the Tradable and Non-Tradable (TNT) model. This latter through its emphasis on the RER, and its separation of the economy into two sectors (tradable and non-tradable) allowed us to better study the transmission of external disturbances.

In the next subsections, we describe the main elements of the Tradable-Non-Tradable(TNT) model and the Real Estate pricing method employed. Next, we introduce two explaining hypothesis about the transmission channels through which variations of commodity prices may affect the housing market valuation.

3.1 The TNT model

The Tradable-Non-Tradable (TNT) model or also known as the Traded Non-Traded economy is an endowment open economy model useful to understand how different disturbances impact the Real Exchange Rate. The roots of the TNT model come from the Balassa-Samuelson model (1964), which was inspired by empirical regularities noted by Harrod (1939). Both models are based on the dichotomy between internationally standardized traded items with perfect foreign substitutes and heterogeneous goods with no foreign substitutes. The first ones are defined as "Traded goods (T)" and second ones are defined as "Non Traded goods (NT)" and are only priced by the domestic market on a demand and supply basis.

The main improvements brought by the TNT model, with respect to the Balassa-Samuelson model, is the concavity of the production possibility frontier (PPF). This is the consequence of its dependence on the output proportion of the different produced goods (Traded and Non-Traded). Therefore the TNT approach is more realistic than the one of its predecessor whose PPF displayed a straight line. Non-Traded's relative price was independent of the aggregate demand strength and thus the PPF, as well as the real exchange rate were static without regard to the production levels of heterogeneous goods.

In the next subsections we expose the main elements of the TNT model, based on Schmitt-Grohé and Uribe (2017) presentation.

Household utility and market assumptions As previously described, the TNT model features, on a small open economy context, where only two types of goods, Traded, and Non-Traded are produced. By definition, the economy is considered populated by identical households, who live infinitely and are composed by one single generation). Their preferences are depicted by the period utility function U. The latter (1) is assumed to be strictly positive and concave shaped. The subjective discount factor is described by the parameter β, whose value relies between 0 and 1. Households maximize their utility by picking between different sequences of goods $[{c_t}^m, {c_t}^n, d_{t+1}]_{t=0}^{\infty}$. Formally:

$$\sum_{t=0}^{\infty} \beta^t U\left(c_t\right), \tag{1}$$

Total consumption good c_t is considered a basket mixed of imported consumption goods ${c_t}^m$,and Non-Traded consumption ones ${c_t}^n$. The aggregation technology $A(.,.)$ is increasing, with a concave shape and homogeneous of degree 1.

$$c_t = A\left({c_t}^m, {c_t}^n\right), \tag{2}$$

$$\begin{aligned} {c_t}^m + {p_t}^n {c_t}^n + d_t = \frac{d_{t+1}}{1+r} + tot_t y^x + {p^n}_t y^n, \\ \lim_{j\to\infty} (1+r)^{-j} d_{t+j} \leq 0, \end{aligned} \tag{3}$$

d_t denotes the level of debt assumed in the period t_{-1} and that must be reimbursed at the end of period t. The interest rate is denoted by r and cannot be negative($r > 0$). The Terms of Trade, which represent the ratio between the country's export prices and its import prices, is formally defined as tot_t. The production of export goods is noted as y^x and the one of domestic Non-Traded goods is defined by y^n.

By definition, Non-traded goods are only produced and consumed only in the domestic market. Formally:

$$c_t^n = y^n \tag{4}$$

In contrast with Traded goods, these are equally produced abroad and domestically. The foreign and nationally made items are perfect substitutes. Consequently is there is a gap between supply and demand for Traded goods

(deficit or surplus), the market misalignment will be adjusted by foreign trade (imports):

$$c_t^m + d_t = \frac{d_{t+1}}{1+r} + tot_t y^x \tag{5}$$

Optimality conditions The First Order Conditions are the sequential budget constraint and

$$U'(c_t)A_1({c_t}^m, {c_t}^n) = \lambda_t \tag{6}$$

$$\lambda_t = \beta(1+r)\lambda_{t+1} \tag{7}$$

$${p_t}^n = \frac{A_2({c_t}^m, {c_t}^n)}{A_1({c_t}^m, {c_t}^n)} \tag{8}$$

$$F \lim_{j\to\infty} (1+r)^{-j} d_{t+j} = 0 \tag{9}$$

where λ denotes the Lagrange multipliers associated with (3). Equation (6) describes the household's demand for Non-Traded goods as a function of the relative price of Non-Traded goods, ${p_t}^n$, and domestic capacity to absorb or consume imported goods is defined by ${c_t}^m$.

Due to the fact that $A(.,.)$ is a linear homogeneous increasing function, with a concave shape, the optimality condition (6) can be rewritten as:

$${p_t}^n = P\left(\frac{{c_t}^m}{{c_t}^n}\right); \qquad with P'(.) > 0 \tag{10}$$

The household's consumption for Non-Traded goods will dependent on relative price of domestic NT goods to Imported ones. Under these circumstances, if Non-Traded goods become more expensive relative to imported goods, the reciprocal consumption of Non-Traded goods will be inferior and households will tend in favor of imported goods.

The (relative) Price of Non-Traded goods and the Real Exchange Rate The TNT model articulates a proportional relation between the relative price of Non-Traded goods ${p^n}_t$ relative to Traded goods p_t, and the country's Real Exchange Rate, RER_t. This latter corresponds to the relative price of abroad to the domestic one of a consumed basket of goods. Formally:

$$RER_t = \frac{S_t {P_t}^*}{P_t} \tag{11}$$

where ${P_t}^*$ is the average nominal price of a consumption basket in the foreign country and in foreign currency terms, P_t is the average nominal price of the same consumption basket in the domestic country and in domestic currency

terms. The nominal exchange rate es depicted by S_t and is defined as the number of units of the domestic currency that are needed to acquire one unit of foreign currency.
To better see the relation between the Real Exchange Rate and the relative price of Non-Traded goods described above; If we divide the numerator and denominator of the right side of equation (9) by the price of Imported goods P_m^t, in nominal terms, we get :

$$RER_t = \frac{\frac{S_t P_t^*}{P_t^m}}{\frac{P_t}{P_t^m}}$$

In consequence of *the law of one price*, we assume that imported goods price are equal in foreign and national markets. Therefore $P_t^m = S_t P_t^{m*}$. Then, enabling $p_t^c \equiv \frac{P_t}{P_t^m}$ and $p_t^{c*} \equiv \frac{P_t^*}{P_t^{m*}}$, which denotes the relative prices of domestic and foreign consumption.We can then write that the RER_t equals $\frac{P_t^{c*}}{P_t^c}$. As previously assumed, Traded goods are exogenously priced, which is coherent, as we later assume that the relative prices of foreign consumption P_t^{c*} is exogenously determined, stationary and by simplicity equal to one unity, $p_t^{c*} = 1$. Subsequently, we obtain that:

$$RER_t = \frac{1}{p_t^c} \tag{12}$$

The final step is to link p_t^c and p_t^n. To do so, we the market for final consumption goods is leberalized and thus decentralized. This implies that the firm's profits and production are maximize in reference to c_t c_t^m and c_t^n:

$$p_t^c A(c_t^m, c_t^n) - c_t^m - p_t^n c_t^n$$

First Oder Conditions with respect to c_t^m is:

$$p_t^c A_1(c_t^m, c_t^n) = 1$$

Combining this last equation with (10) and (12), we obtain the Real Exchange Rate $RER_t = A_1(P^{-1})(p_t^n), 1)$. Which can be translated as:

$$RER_t = e(p_t^n); \qquad \text{with } e'(.) < 0$$

Consequently in the TNT model, the RER appreciates only when the price of Non-traded goods increases, and reciprocally the inverse. This conclusion is coherent with Betts and Kehoe (2008), who studied between 1980-2005 the bilateral real exchange rate and the relative price of Non-Traded and Traded goods. According to their research the relation between the RER and the relative price of Non Traded goods is proportional to the trade intensity between two countries.

Real Exchange Rate Equilibrium According to the supply constraint of Non-traded goods (4) and using the transversality condition (9) yields on a forward infinite number of periods, we obtain

$$c^m = -\frac{r}{1+r}d_0 + \frac{r}{1+r}\sum_{t=0}^{\infty}\frac{tot_t y^x}{(1+r)^t} \tag{13}$$

Lastly,it is assumed by Schmitt-Grohé and Uribe (2017), that if we define $\beta(1+r) = 1$, then as consequence of equations (4), (6), and (7), consumption of imported goods should be considered as stationary (constant), $c_t^m = c^m$. Formally:

$$p^n = P\left(\frac{c^m}{y^n}\right) \tag{14}$$

Articulating arguments of equations (13) and (14), we conclude that the economy becomes more expensive (cheaper) in reference to the rest of the world, as a consequence of the Real Exchange Rate appreciation (depreciation)

Theoretical Summary

Therefore according to the TNT framework, a small open economy dependent on the world, such as a CEC, only becomes more expensive (RER appreciates) relative to the foreign economies only if :

- The supply of Non-Traded goods is reduced (or fixed during a situation of excess demand).
- The current Terms-of-Trade (*tot*) improve or the supply of Traded goods increases (lowering its price).
- The Terms of Trade *tot* or the supply of Traded goods is expected to expand in a future period[9] .

3.2 Real Estate Pricing model

Real Estate pricing can be a difficult process because of the heterogeneity and the infinite qualitative and quantitative factors that may influence the price of real estate properties. To simplify this latter, we ignore some of these factors and we only focus on the macroeconomic determinants.
The following model is inspired on the Discounted Cash Flow (DCF) method to value assets.

If we consider real estate like any other investment asset and assume that the real estate market is competitive. Buyers are therefore considered

[9]Only if agent expectations are internalized by the model assumptions.

as rational investors constantly equilibrating housing prices and other assets to their right value. Hence there is "No-Arbitrage" possible. This means that housing value must be in line with its returns (rent) and the risk-free rate of return of the market (interest rate). Consequently, the price of a housing property is equal to the discounted value of the expected rental incomes.

$$P_t^H = \sum_{n=0}^{N} \frac{x_{t+n}}{(1+r)^n} + \frac{P_{t+N}^H}{(1+r)^N}$$

Where P^H is the real estate value at time t, x_{t+n} is the expected annual rental income for the period $t+n$ and r is the discount rate or cost of capital. By simplicity we assume that r is equal to the return of risk free assets, and thus equal to the domestic interest rate. N is the holding period and P_{t+N}^H is the expected resale value at the date $t+N$.

Real Estate assets can be hold indefinitely, which means that if N tends to the infinity we obtain:

$$P_t^H = \sum_{n=0}^{\infty} \frac{x_{t+n}}{(1+r)^n}$$

If the annual rental income growth at constant rate g, each year, then $x_{t+n} = x_{t+n} * (1+g)$. Therefore the real estate asset brings to its holder an annual capital gain (yearly appreciation) additional to the rental income. If the real estate investor doesn't sell the property, the expected capital gains are not monetized but interiorized in the asset price.

Coherent with these assumptions, we define Real Estate price as:

$$P_{t+n}^H = H_{t+n-1}(1+g)$$

more generally:

$$P_t^H = \frac{x_t}{r-g} \tag{15}$$

We assume a perfect equilibrium between financial assets and real estate, therefore the returns of all assets must be equal to the market yield (interest rate). If it is not the case, asset prices must adjust to clear the market misalignment. If the equation is rearranged, we intuitively obtain, the cost of capital (domestic interest rate):

$$r_t = \frac{x_t}{P_t^H} + \frac{(P_{t+1}^H - P_t^H)}{P_t^H}$$

$$r = \frac{x_t}{P_t^H} + g \tag{16}$$

Intuitively from equation (15), we notice that the capital gain (g) cannot exceed the cost capital, which means there is no "free lunch", $r - g > 0$ cannot be negative.

Hypothesis about the relation between the commodity prices and housing prices

On basis of the TNT and the Real Estate Pricing model described in above, in the next subsections we introduce two hypothesis of transmission channels that could explain the relationship between the effervescence of commodity prices and the upward trend of the housing market, observed during the 2000s first decade and a half in Colombia.

3.3 H_1:*Commodity booms act like a temporary shock on the Terms-of-Trade, that fosters Real Estate value*

In this first hypothesis, we analyze the impact of temporary and permanent shocks on the Terms of Trade and Non-traded goods. These shocks are the same that those experimented by CEC during exogenous commodity cycles.

Between 2000 to 2014, oil prices increased 450%, reaching a historical point in 2008 of 580% with reference to its lowest value in 2000. Two correction periods (2001-2002) and 2008-2010 reversed oil prices near their respective 10 years historical average [10]. The Colombian economy mechanically reacted in both cases, as a result of dependence on oil exports.

In the first part of this hypothesis, we expose theoretical explanations about the adjustment of the Real Exchange Rate during temporary commodity prices shocks. Then in a second part, we assume that the shocks on the Terms-of-Trade are permanent.

Temporary Commodity prices shock

To better adapt the TNT model to the CEC reality, we assume that y^x is fully exported and the domestic demand for traded goods is only satisfied by imported ${c_t}^m$ goods. This simplification is coherent with most CEC realities, where almost the totality of the raw material produced is consumed abroad. Reciprocally, manufacturing goods are mostly imported. This simplification allows us to no confound and mix in the domestic market, foreign

[10] More recently between 2015-2017 oil prices reversed to historically low level (30USD per barrel)

and nationally made tradable goods.

We define the Terms of Trade (tot) as the relative price of imports in terms of exports. Formally:

$$tot = \frac{P_x}{P_m} * 100 \tag{17}$$

Intuitively, if the main exports of the country are commodities but imported traded goods are mostly manufactured goods, during commodity booms there is an overshooting reaction of commodity prices but not of other goods (such as manufactured or final goods) which are sticky (Belke, 2010) and imported. This overshooting reflects on the Terms of Trade(tot) who rapidly increases.

If the boom of commodity prices is temporary then tot_0 increases, while tot_t remains unchanged for all $t > 0$. From the TNT model properties (13) and (14) we obtain:

$$\left.\frac{\partial p^n}{\partial_{tot}}\right|_{\text{temporary}} = \frac{r}{1+r}\frac{y^x}{y^n}P'\left(\frac{c^m}{y^n}\right) > 0$$

As the relative price of the exported goods become more expensive, higher export revenues influence a positive revenue effect.Higher disposable income stimulates households demand for all . Imported goods whose supply is considered unlimited, keep their price constant. In contrast, Non-Traded goods whose supply is rigid y^n in the short term, cannot match the excess of demand. Therefore their prices p^n subsequently overshoot to eliminate the market disparity. Real estate, which is considered a Non-Traded good and by definition has a fixed supply [11] is directly impacted by t flourishing prices. The market adjust the excess of demand through the reciprocal increase of price.

Permanent Commodity prices shock

In parallel, we can imagine that if the trend of commodity booming prices is permanent, the income effect will be larger, and reciprocally the impact on the relative price of Non-Traded goods will also be. Formally:

The tot_t increases for all $t \geq 0$, then according to the equilibrium conditions (13) and (14) from the TNT model:

[11] Real Estate supply rigidity is due to the long stages of production (urban and land-use planning policies, building permits, construction process, etc). Consequently, in the short term, the only available housing supply is the one from the second-hand market.

$$\left.\frac{\partial p^n}{\partial_{tot}}\right|_{\text{permanent}} = \frac{y^x}{y^n} P'\left(\frac{c^m}{y^n}\right) > 0$$

The main difference between the intuition of temporary commodity prices shocks, will be that permanent changes in the Terms of Trade will have a larger effect on the relative price of Non-Traded goods. And consequently, their relative price increase will also be larger, to be able to clear the market of excess demand.

$$\left.\frac{\partial p^n}{\partial_{tot}}\right|_{\text{permanent}} > \left.\frac{\partial p^n}{\partial_{tot}}\right|_{\text{temporary}}$$

We can imagine, that if the production process of a particularly Non-traded good, such as Real Estate, is longer (and thus slower) than the one of the average Non-traded sector, then during permanent commodity prices shocks, prices will abnormally rise relative to the other goods. Contrary to temporary shocks, where the demand trend outpaces the lagged supply trend to be later readjusted by the market itself, during permanent shocks this healthy correction do not exist and in extreme cases may foster speculation on the existing stock, and thus inflate a bubble.

Because of the relative rise of the price of Non-traded goods, based of the TNT model dynamics, we can expect a reciprocal appreciation of the real exchange rate RER_t, accordingly to the improvements of the Terms of Trade. As a result, the domestic economy becomes relatively more expensive vis a vis to the rest of the world.

Hypothesis summary: Higher commodity prices act like a shock on the CEC's term of trade. Booming export revenues, stimulate consumption of Traded and Non-Traded goods(NT). Due to the short-term fixed supply, NT increase of relative price to eliminate demand excess. Real Estate which is characterized by rigid and lagged supply has a higher price increase than others NT. The more prolonged is the commodity prices upward trend, the more intense will be the effect on NT. Reciprocally to the NT relative rising prices, the real exchange rate appreciates.

During 2000-2014 period, the elements that support the first hypothesis, in the case of Colombia, are[12]:

- Main export prices increased by (Oil by 250%, Coffee by 138% and Coal by 188 % in nominal terms)[13]

[12]The following elements or figure interpretations are given for illustrative purposes only. At this stage of the analysis, causality or long-term relation cannot be inferred.

[13]In reference to 2000 and 2014 annual average, in nominal terms

- Real Estate Prices doubled in real terms
- Real Exchange rate appreciated by 25%.

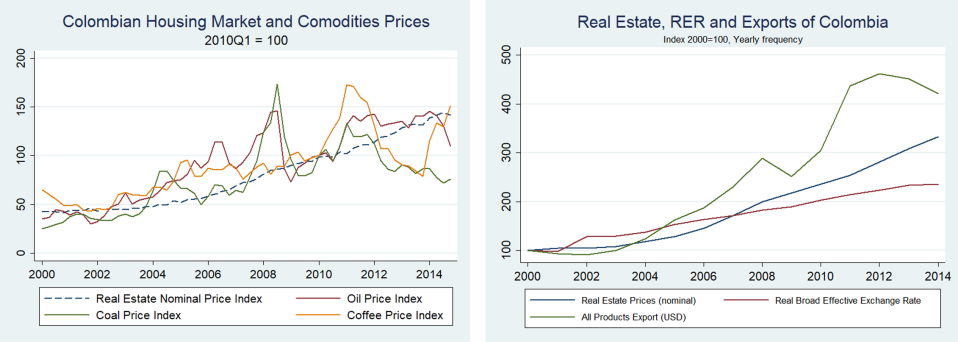


Figure 2: *The exogenous upward trend of commodity prices exported by Colombia, seem to positively influence the country Real Estate prices and the Real Exchange Rate*

3.4 H_2: *Commodity prices influence lower interest rates, which stimulates Housing prices*

In this second hypothesis, we analyze the impact of lower interest rates on the adjustment of the Real Exchange Rate. In the first paragraphs, we expose two mechanisms through which domestic interest rate may fluctuate without the intervention of the central bank. Then, we expose on basis of the TNT and Real Estate Pricing model the corresponding Real Exchange Rate adjustment and how it influences the price of Real Estate assets in CEC.

Commodity prices and Risk Premium

Commodity booms generate a surplus on the balance of payments and a reciprocal accumulation of foreign exchange reserves in CEC. But price variations of commodities are not only channelized through the exchange rate (trade competitiveness), they can also be via the financial channel (interest rate). Min (1999) and Bastourre (2012) argue that when a CEC economic fundamentals improve, the difference between the borrowing rate and the US Treasury Yield becomes smaller.

In the basic TNT model exposed at the beginning of section III, we assumed that the domestic interest rate r was constant and exogenous. To include commodity prices influences on the CEC interest rate we must adapt framework's assumptions. To do so, we consider the country premium ρ, as given by r-$r*$ and being endogenously determined[14]. Formally:

$$r = r^* + \rho \tag{18}$$

Where r^* is the world interest rate[15] and ρ is the risk premium [16]. If the country's economic fundamentals and policy credibility improve, the domestic interest rate r should tend to r^* (due to ρ tending to zero).

According to Min (1999), the most significant variables to reduce the bond's spread are low domestic inflation rates, the terms of trade *tot* improvements, and higher foreign asset holding. Other factors evoked in the literature are the ratios of external debt to exports, the debt service to exports (Calvo,1992) and the country's fiscal revenues (or relative fiscal consolidation and a balanced budget).

[14]We assume that the risk Premium ρ is the reflection of the country's sovereign credit rating. See table 2.

[15]US Long-Term Government Bond Yields (10-year) are taken as reference.

[16]According to the International Country Risk Guide (ICRG) the main indicators that could influence sovereign bond risk premiums are: Economic Risk Rating(ERR), Financial Risk Rating (FRR) and Political Risk Rating (PRR)

Interestingly, during commodity price booms, most of these factors converge in CEC. Intuitively, after higher commodity prices, exports increase and simultaneously improve the terms of trade. Consequently, the balance of payments is on surplus and so foreign exchange reserves. Fiscal revenues are also improved during commodity price booms, as argued by Vladkova-Hollar and Zettelmeyer (2008). She argues that this as a consequence of higher revenues from royalties and taxed imports. Inflation trend during commodity booms is more uncertain because it will depend on the central bank sterilization policy of foreign exchange reserves.

Lower world interest rate

Domestic interest rate variations Δr can also be the effect of exogenous shocks resulting from the monetary policy of an influential foreign economy, such as the United States. *Ceteris paribus*, lower world interest rate Δr^*, should proportionally decrease domestic rates, if the risk premium is untouched $\rho_0 = \rho$.

$$\Delta r = \Delta r_* + \rho \tag{19}$$

During the studied period (2000-2014) US interest rates were historically low and had a negative trend between the years 2000 to 2006 and 2007 to 2014. Because of the US monetary influence on the global economy, world interest rates were also low and so did Colombia's interest rate.

Interest rate shocks and RER adjustments (TNT model)

We suppose that at te period t_0 the interest rate experiments a negative variation $r_0 < r$ during a temporary period, in consequence of lower risk premiums or lower world interest rates. To verify how the RER is influenced by the interest rate decline, we first estimate the relation between the interest rate and the consumption of Importable goods. To do so we partially differentiate ${c_0}^m$ with respect to the new interest rates r_0 .

$$\frac{\partial c_0^m}{\partial r_0} > 0 \tag{20}$$

Negative interest rate shocks impact the consumption of Imported goods. This relation can intuitively be explained by the impact of lower interest rates on household motivation to save (less) and consume (more).
According to the previous expression (20), together with TNT model properties (4) and (10), the Real Exchange Rate appreciates in response to the

temporary decline of interest rates. Formally:

$$\frac{\partial p_0^n}{\partial r_0} = P' \left(\frac{c_0^m}{y^n} \right) \frac{1}{y^n} \frac{\partial c_0^m}{\partial r_0} < 0 \tag{21}$$

Influenced up by lower interest rate households demand for both goods rise. As a consequence of the fixed supply of Non-Traded goods in the short term, NT (and so Real Estate) prices must increase to clear the market.

Interest rate shocks and Real Estate Pricing

Another complementary argument to take into account is that after the ease off on interest rate, housing returns will be higher[17]than other asset yields. Consequently, and due to the fact that real estate stock is limited, prices will go up, until the new housing returns equal the market yield (interest rate).

To corroborate the latter, on basis of the Real Estate Pricing model, we differentiate the price of housing P^H with respect to the interest rate.

$$\frac{\partial P^H}{\partial r_0} < 0 \tag{22}$$

Hypothesis summary: the Interest rate of CEC may fluctuate as a result of exogenous (r^*) and endogenous (ρ) factors indirectly influenced by higher (lower) commodity prices. During temporary interest rate shocks, RER appreciates (depreciates) and because of the fixed supply of NT goods, their prices must increase (decrease) to clear the market misalignment. Complementary, Real Estate returns must be equal to the domestic interest rate, if it is not the case, the price automatically is adjusted by the market.

During 2000-2014, the elements that support the second hypothesis, in the case of Colombia, are[18]:

- Lower world interest rates (US Government Bond Yields (10Year) decreased from 6% to 2.5% (See figure3).
- Colombia's Sovereign Credit Rating improved from"speculative" to "lower medium grade", which mitigated the country's risk premium ρ
- Colombia's long-term rate decreased to half its value

[17]if the rental income is unchanged.

[18]The following elements or figure interpretations are given are for illustrative purposes only. At this stage of the analysis, causality or long-term relation cannot be inferred.

- Real Estate prices doubled in real terms
- Commodity prices increases, oil prices increased 450%
- Colombian government tax revenues (% of GDP) increased from 16.2% to 20.4

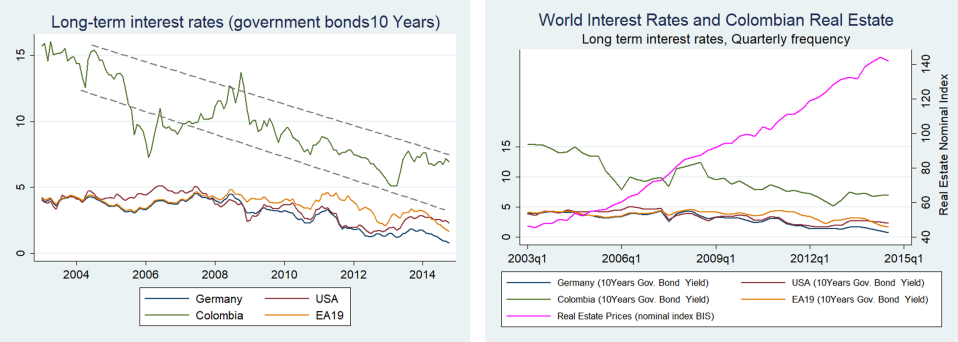


Figure 3: *From 2003 to 2015, Colombia's long-term interest rate (r) spread (ρ) conjointly decreases and follows world rates trend (r^*). Simultaneously Colombia's Housing Price Index surges.*

Table 2: Colombia's sovereign credit ratings

	Fitch	Moody's	Standard & Poor's	Grade
2000	BB+	Ba2	BB	Speculative
2014	BBB	Baa2	BBB	Lower medium

Source: Bloomberg

4 Empirical Analysis

4.1 Data

In this section, we provide an overview of the sample and the different data sources used. Then, we summarize the method and the major variables employed for the empirical analysis.

Data set

As a consequence of the abandon of the fixed exchange rate in 1999 by Colombian Central bank and the oil price drop after 2014 due to oversupply, we concentrate our attention on the 2000-2014 period. According to our criteria, we believe this time interval is representative of the commodity price shocks that CEC may be exposed in the long term. Like the initial booming commodity cycle (2002-2008), the lagged response (and mutation) of the economy from agriculture to mining exports, along with other Dutch Disease symptoms.

Sample of countries and selection

Our selection criteria for the empirical analysis and validation of the relationship between commodity prices and real estate in CEC was determined by:

- Be referenced by Bodart (2012) in his research about *Real exchanges rates in commodity producing countries* (68 countries available)[19]
- Be a low diversified CEC with at least 40% of the total exports dependent on less than 5 commodities in the last 3 decades) (21 countries available)
- Solid macroeconomic data available(15 countries)
- Dispose of property price statistics (8 countries)
- Same housing price data caption method[20] (4 countries)
- Floating Exchange Rate regime (2 countries)
- Long historical length (min.10 years) and monthly or quarterly series (1 country)

[19]The list of countries analyzed by Bodart (2012), along with their respective commodity weight in total exports is available in the Annex

[20]By simplicity we took the BIS's residential property prices (RPP) and commercial property prices (CPP) data compilation.

After filtering the list of countries with the above criteria, the empirical analysis had to limit itself to only one country, Colombia. As a result of this restrictions, the abundance and thus the quality of data profoundly limited the validation and generalization of this master thesis (empirical) conclusions to other CEC.

Building a New Dataset

One of the main empirical novelties of this paper, with respect to previous ones, is the use of an "export composite index" (τ) to better proxy the impact of commodity prices on CEC economic variables. The previous research considered (by the need of simplification) that the country's export composition was stationary (constant), which neglects the fact that this latter varies across time. Bodart and Carpentier (2012), in an attempt to solve the issue,"*compute the 1998-2008 average ratio of the export value of each commodity export by the country in the total value of all commodity exports*". Inspired by their proceed, we built a new dataset composed of traditional commodities exported, along with a composite index covering the whole commodities exported and their respective weight changes in the total exports. Formally:

$$\tau = \sum_{t=1}^{n} P_{i,t} \frac{X_{i,t}}{X_t} \tag{23}$$

Where $P_{i,t}$ is the price of commodity i in t, $X_{i,t}$ is the export volume of commodity i in t and X_t is the total export volume in t.

Accurately integrate export composition variation in the data-set is a preponderant empirical concern in CEC. In consequence of their low diversified economy and abundant natural resources, these economies are more prone to develop Dutch Disease (DD) symptoms than industrialized countries. Therefore during DD periods is common that primary exporting sectors may rapidly mutate and be replaced by others. This was the case of Colombia, where, in the last 30 years it suffered two Dutch Disease periods and transformed itself from being a world leader in bananas and coffee exports into an important oil exporter, at the detriment of the agricultural sector.

The main variables selected for the following empirical analysis are:

- Price of Oil, Coffee, and coal
- Export composite index τ
- Real estate prices

The sources of the data are the Internal Monetary Fund, the Bank of International Settlements (BIS) and the Colombian Institute of National Statistics (DANE). All retained variables, analyzed in the period from 2000 to 2014, were converted to the CEC domestic currency (Colombian Peso, COP), then transformed into index numbers and are expressed in monthly or quarterly frequency. Monthly variables were transformed to quarterly in order to homogenize the historical length.

Data collecting difficulties

Finding the necessary data to build pertinent variables to validate the two theoretical hypothesis, about the real estate relation with commodity prices, was the main difficulty encountered in the empirical work. In most cases, the historical length and frequency were rarely the same and official sources of data were insufficiently garnished. This constrains delayed and limited some empirical procedures. The second constraint encountered was the characteristic volatility of short-term series of commodities and CEC macroeconomic variables. These two constraints, unfortunately still common when working with Emerging markets. The statistical software employed was Stata[21].

First empirical approach and preliminary apparances

Previously to proceed to do any advanced empirical analysis, we tested the data series through a basic Ordinary Least-Squares (OLS) technique and a single-equation framework. The initial results based on this conventional approach showed promising results but indicated exorbitant coefficients with high Root Square. Consequently, the exposed sensitivity of real estate valuations to the price variation of exported commodities was excessive and inaccurate.

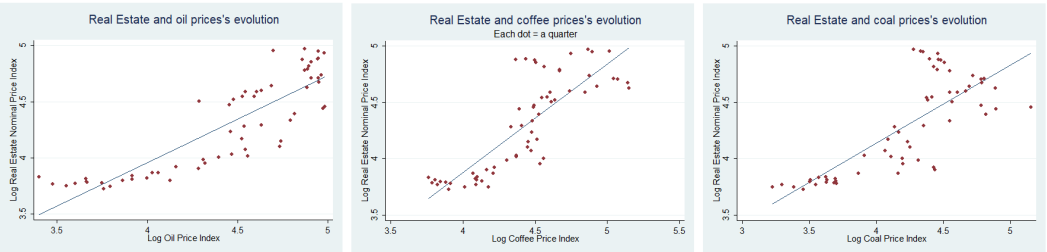


Figure 4: Basic OLS perfomed to initially apprehend the possible relations

[21] Codage is provided in the Annex

4.2 Empirical procedure

Stationarity test

First, of all, we check the possible stationarity of our data series. To do so, we use the Augmented Dickey-Fuller (ADF) test.

We define the null hypothesis as the existence of a unit root (H_0: $\theta = 0$) against the alternative that there is no unit root (H_1: $\theta < 0$). We reject the null hypothesis at the level of significance $\alpha = 0.05$, if the p-value is lower than α. If the values are higher, then we can not reject the null hypothesis and therefore the series should not be stationary.

Cointegration test

The second step is to test the series for co-integration. To do so, we use the Johansen test. Checking the cointegration of the series allow us to verify the existence (or not) of a stable long-term relationship between two non-stationary variables, even if they include lagged relations.

Formally, the null hypothesis for the trace test statistic translates that "there is no more than r[22] numbers of the co-integrated relations".

We reject the null hypothesis if the value of the trace test statistic is higher than the 5 % critical value. If the trace statistic is less than its critical value at rank r, H_0 is not rejected and it is accepted that there is a maximum of r cointegration relation between the variables.

If the series are non-stationary and cointegrated, we can proceed to apply the Error Correction Model (ECM).

4.3 ECM specification

The purpose of an ECM is to enable us to model the short-run dynamics between x and y. The cointegration equation measures the long-run relationship. Formally:

$$\Delta x_t = \gamma_1 \Delta x_{t-1} + \gamma_2 \Delta y_{t-1} + \alpha_x (y_{t-1} - \beta x_{t-1}) + \epsilon_{x,t}$$

Where Δ corresponds to the first difference, x is the dependent variable, y is the independent variable (exogenous) and α_x is the adjustment term. Consequently, the higher this parameter is, the greater the response of x

[22] Johansen nomenclature is kept, therefore r is not any more related to previous sections, where r was defined as the interest rate

to past deviations from the long-term equilibrium y. β is the cointegration parameter and γ is the short run coefficients. γ_2 must be significant for x to respond to shocks of y.

In our case, x represents the real estate price and y represents the commodities price (considered as exogenous to the domestic economy).

Formally:

$\Delta RealEstate_t = \gamma_1 \Delta RealEstate_{t-1} + \gamma_2 \Delta Commodity_{t-1,i} + \alpha_i (Commodity_{t-1,i} - \beta RealEstate_{t-1}) + \epsilon_{x,t}$

Where the index i represents each individual commodity variable.
Between the commodity variables (Oil, Coal, Coffee), there is also the composite index of exports[23]. We will also estimate this model with a general index regrouping the three commodities. This index is constructed by calculating the weighted sum of commodity prices based on their weight in Colombian exports.

4.4 Empirical Model application

The descriptive statistics for each series are presented below. All series were expressed in natural logs.
In the following table, we represent the number of observations, the mean, the standard deviation and the fluctuation interval (minimum and maximum) of each series.

	Oil*	Coal*	Coffee*	Real Estate*	Index*
Number of data	60	60	60	60	60
Mean	92.40693	75.18894	89.30828	79.61617	83.57396
Standard deviation	37.20513	32.20637	32.52603	33.25714	42.98371
Min/Max	29.99 - 145.99	25.19 - 173.44	43.03 - 172.71	41.5 - 144.14	26.36 - 160.78
Fluctuation interval	116.01	148.25	129.68	102.64	134.42

* Here, express in index (100=2010q1)

Figure 5: Descriptive statistics

Before starting the estimation, it is necessary to empirically verify the following four points:
· the stationarity of the variables (through the Dickey-Fuller test)
· the optimal number of lags for the two-variable analysis
· the existence of a cointegration relationship between each commodity and the real estate price
· the stationarity of residuals (in the regression of Colombian real estate

[23]For more details, see Data subsection

prices on commodity prices).

	Real estate	Oil	Coal	Coffee	Index
***p-value* Dickey-Fuller test**	0.1369	0.2758	0.2804	0.1729	0.0853
***p-value* Dickey-Fuller test (at first difference)**	0.0001	0.0000	0.0003	0.0000	0.0001
Optimal number of lags		2	2	4	2
Cointegration test (with real estate prices)		there is a max. of 1 cointegration relation between the variables	there is a max. of 1 cointegration relation between the variables	there is a max. of 1 cointegration relation between the variables	there is a max. of 1 cointegration relation between the variables
***p-value* Dickey-Fuller on residuals**		0.0004	0.0000	0.0000	0.0001
Model used		ECM	ECM	ECM	ECM

Figure 6: Pre-estimation Tests

The augmented Dickey-Fuller (ADF) test indicates a p-value greater than 0.10 for all the variables, except for the index variable. Therefore the unit root null hypothesis cannot be rejected at that specified level of significance. Consequently, we conclude that the variables are not stationary. For the index, the null hypothesis H_0 of a unit root is rejected by the augmented Dickey-Fuller test at the level of significance $\alpha = 0.10$. But since $\alpha = 0.05$ and 0.01 are smaller than the p-value (0.0853) the null hypothesis can not be rejected. This means that there is a 90 % chance that the commodity index may be stationary.
The Dickey-Fuller tests are iterated on the one lag series. In this case, since the p-values of all the variables are smaller than the value of alpha (0,01), we reject the null hypothesis of unit root. And reciprocally, accept the alternative hypothesis that the series is stationary at first difference (I(1) processes).

On basis of the Akaike criteria (AIC), Schwarz's Bayes criteria (BIC), Hannan and Quinn's criterion (HQIC) and the final prediction error (FPE), we obtain the optimal number of lags, allowing us to do the cointegration test. Coherent to the theoretical framework requirement, we keep the one with the smallest criteria value.

We can now follow the Johansen method to determine the number of cointegrating equations. Through this procedure, we discover that there is a maximum of one cointegrating relationship between the real estate price and the commodity price variables, as well as with the composite index. It's pretty obvious as we compute a single-equation ECM with just two variables, we can't have more than one cointegrating relationship between them.
To summarize, we conclude that the series are cointegrated and that they

exhibit a long-run relation. Consequently, even if in the short-run they may depict volatility after an external shock, over the long run the series tend to revert to their respective mean.

Estimation results in ECM

Since the variables are I(1) processes and are not cointegrated, we might estimate a dynamic model in first differences. The results of the ECM are shown below (where Oil denotes the log of the Oil prices Index, Coal denotes the log of the Coal prices Index, Coffee denotes the log of the Coffee prices Index, and Index denotes the log of the composite Index) and are obtained by estimating a simple two-variable model with a single lag. We will further estimate a model with the optimal lag number that the criteria gave us.

	Coefficient	Oil	Coal	Coffee	Index
ΔReal Estate $_{t-1}$	γ_1	-0,5802345***	-0,5198228***	-0,4833236***	-0,0622935***
ΔCommodity $_{t-1,i}$	γ_2	-0,0442001*	0,0034225	-0,0148253	-0,4625584***
Commodity $_{t-1,i}$ − βReal Estate $_{t-1}$	α	-0,0625414***	-0,0227414***	-0,0123153***	-0,027011
Real Estate $_{t-1}$	β	-1,245506***	-1,921123***	-2,739716***	-0,9471201***
Observations	N	58	58	58	58
Statistics	R^2	0,6457	0,5523	0,5101	0,5304
Autocorrelation test		Residual autocorrelation	Residual autocorrelation	Residual autocorrelation	Residual autocorrelation
Normality test		errors are not normally distributed	errors are normally distributed	errors are not normally distributed	errors are not normally distributed
Stability test		Ok	Ok	Ok	Ok

[***, ** and * = estimators are significantly different from zero, at 1%, 5% and 10% respectively (99%, 95% and 90% confidence intervals)].

Figure 7: ECM results

For most variables, coefficients appear highly significant, at a 99% confidence interval.

The main contributions of this estimation can be summarized by analyzing the three coefficients of the equation, α, β, and γ.

β is the coefficient of the cointegration relationship that exists between real estate price and the commodity price. It measures the long-term impact of a shock of the commodity on the real estate price. The cointegration relationship seems to be confirmed in all estimations since coefficients are significant at 99% confidence interval. Therefore, the error correction term seems to work to push the real estate prices back toward the equilibrium. Note that the signs of the coefficients are reversed in the long-run. So, in our case, the commodities price have the expected negative sign which stands for a positive impact on the real estate price, in the long-run.

The γ coefficient measures the short-term impact on real estate prices of

a shock on the commodities. The coefficient γ_2 shows the direct relationship between the price of the real estate and the commodity price of the previous period (a lag corresponding to a quarter). This coefficient is expected to be positive and significant. However, most are negative and insignificant. We do not worry about this result; firstly because most coefficients are not significant and secondly because the gamma coefficients measure only the short-term impact of a shock on the real estate prices.

α coefficient gives information about the long-term relationship between variables. It determines the speed of adjustment back to equilibrium after a shock on commodity price occurs. The higher this coefficient, the more important is the response of real estate prices to shocks on the commodity price. But the lower the coefficient, the more persistent the shock will be and will take time to affect real estate prices.
These adjustment terms (-0.062, -0.023, -0.012, -0.027 for Oil, Coal, Coffee and the composite index respectively) are statistically significant at the 99% level, suggesting that the previous quarter's error (or deviation from long-run equilibrium) are corrected for within the current quarter at a speed of 6.2 These rather low coefficients, especially for Coal and Coffee, mean that shocks take a long time to affect the real estate market.

The R^2 or R-squared is a way of measuring how well the explanatory or independent variable explains the dependent variable. A value of R^2 that is nearly equal to zero indicates a poor explanatory power. The R^2 reported in our equations are in the order of 64.6% for oil, 55.2% for coal, 51% for coffee and 53% for the composite index (τ).
Hence, taking the composite index (τ)for an overall view, the variation in commodity prices explains about 53% of the variation in the real estate market. That means that only 47% of the real estate variations is left unexplained.

ECM's estimation with the optimal lag number

The results are almost the same than those estimated in the single lag model. Indeed, when we specify the ECM with (p) lags, Stata estimate the model with ($p-1$) lags. So, the results for oil, coal and the index are the same.

For the coffee, we found an optimal lag of 4, here is the results updated.

The R^2 of the coffee is higher with the optimal lag, which means the explanatory power improved. With respect of the cointegration parameter, it remains significative as well as the speed parameter, but this last one is higher and goes up to 4% (from 1,2% previously).

	Coefficient	Oil	Coal	Coffee	Index
Optimal lag-number		2	2	4	2
Δ**Real Estate** $_{t-1}$	γ_1^1	-0,5802345***	-0,5198228***	-0,4436086***	-0,0622935***
Δ**Real Estate** $_{t-2}$	γ_1^2			0,2353873**	
Δ**Real Estate** $_{t-3}$	γ_1^3			0,2172716*	
Δ**Commodity** $_{t-1,i}$	γ_2^1	-0,0442001*	0,0034225	-0,050829*	-0,4625584***
Δ**Commodity** $_{t-2,i}$	γ_2^2			0,0031748	
Δ**Commodity** $_{t-3,i}$	γ_2^3			-0,091151***	
Commodity $_{t-1,i} - \beta$**Real Estate** $_{t-1}$	α	-0,0625414***	-0,0227414***	-0,0404903***	-0,027011
Real Estate $_{t-1}$	β	-1,245506***	-1,921123***	-1,429402***	-0,9471201***
	N	58	58	56	58
	R^2	0,6457	0,5523	0,6598	0,5304
Autocorrelation test		Residual autocorrelation	Residual autocorrelation	Residual autocorrelation	Residual autocorrelation
Normality test		errors are not normally distributed	errors are not normally distributed	errors are not normally distributed	errors are not normally distributed
Stability test		Ok	Ok	Ok	Ok

[***, ** and * = estimators are significantly different from zero, at 1%, 5% and 10% respectively (99%, 95% and 90% confidence intervals)].

Figure 8: ECM results with optimal lags

Impulse Response Function

It is often interesting to investigate the impulse response relationship between two variables in a higher dimensional system. Therefore, we will trace out the effect of an exogenous shock or innovation in the commodity price on the real estate price. To do so, we compute Impulse Response Functions which describe the evolution of the variable of interest along a specified time horizon after a shock in a given moment.

The vertical axis of the followings figures indicates the estimated percentage point change in the respective response variable due to a one-percent shock, after s period (here one period = a quarter).

From the above figures, it appears that real estate prices respond positively to the oil, coal and coffee's shocks but the extent of the phenomenon is somewhat different for each commodity. The shock of 1% on oil and coal prices induce a 0.05% change in real estate price after 8 periods, that is two years. Shock of 1% on coffee cause real estate price to slightly increases during the two first period (i.e. a half year), then decrease over one period and finally get his long-term uptrend. As for oil and coal, after 8 periods a shock of 1% induce a 0.05% change in real estate price.
Looking at the composite index, we conclude that overall, the effect is positive in the long run and that a shock of 1% on the commodity prices cause the real estate price to increase by 0.05% after 8 to 10 periods.

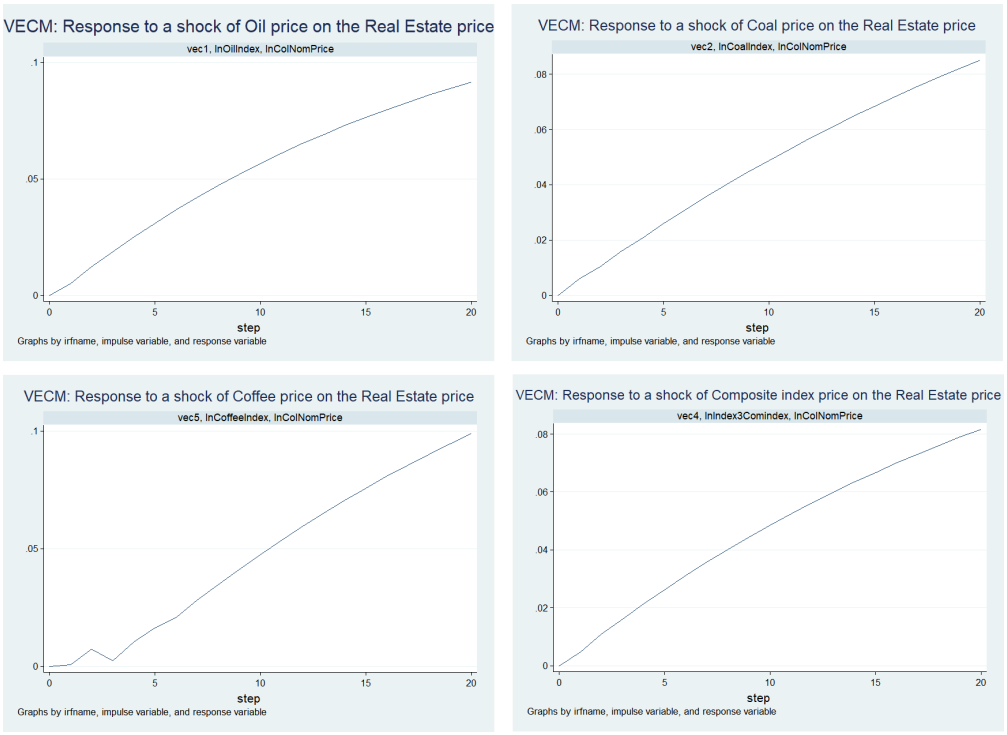


Figure 9: Impulse Response Functions

Empirical Summary and Robustness

The results obtained using a time series analysis on an Error Correction Model (ECM) indicate that Colombian real estate price changes have indeed been closely related to the commodity price booming period of 2000-2014. On basis of the export composite index (τ) the variation in commodity prices and their proportional impact on exports value explains about 53% of the variation of Colombian housing prices. Oil had a bigger influence, in the order of 64.6% for oil.

Despite the fact that our previous results look robust in a sense, they may neglect other factors that could be implied. Hence, the possible relation could just be a correlation without having any causality. Another statistical weakness to point out is the lack of observations. The period of 2000 to 2014, in quarterly frequency, only offered a sample of 60 observations. This is an important issue because sampling errors are inversely proportional to the R^2, thus the smaller is the number of observations the bigger are the differences.

5 Concluding Remarks and Directions for Future Research

The empirical analysis of this master thesis offers a first overview of the impact of commodity price booms on the housing market of Colombia.

Through a time series analysis on an Error Correction Model (ECM), the results indicate a positive relationship during the period of 2000 to 2014 between the housing market and commodity prices in the manner predicted by the theoretical framework. The latter, based on the TNT and a Real Estate Pricing model, which explored two hypothesis supporting the relationship described above.
The first one justifies Colombian housing overvaluation as a consequence of the commodity prices shocks that the country's Terms of Trade experimented during the above mentioned period, which exasperated domestic consumption on Non-Traded goods (Real Estate) and pushed-up its prices. The second hypothesis analyzed the role of commodity prices on Commodity Exporting Countries (CEC) bond yield. Higher exports revenues influenced creditors risk perception (reducing risk premiums), which translated as an interest rate shock that impacted the Real Exchange Rate and backed higher prices of Non-Traded goods (Real Estate).

The consequences of these dynamics are various. First, we hope that that the findings of this research motivate the Colombian authorities, as well as other countries concerned by commodity price fluctuations, to put in place the policies that could avoid the transmission of commodity price volatility to exchange rates and asset valuations. Secondly but more importantly to encourage the long-term transition to a more diversified economy, concentrated into manufacturing and services sectors.

An open door to further research

Although we cannot generalize the conclusions of this thesis to other CEC (due to the lack of statistical robustness)[24]. We nonetheless believe that because of the characteristics of the Colombian economy and its similarities with other low diversified CEC, our research opens the way to many other possible extensions. Consequently, it could be interesting for future research to explore and test the conclusions of this master thesis in other CEC. We believe that Ecuador could be an excellent candidate due to its export composition similarities and dependence in oil. Secondly, because Ecuador is a dollarized economy, comparing both countries dependence on commodity

[24]The statistical sample only was composed of one country and a short period of 60 observations (2000-2014)

prices, and their respective impact on real estate, could be a useful way to identify and filtrate the impact of the Federal Reserve's monetary policy on CEC and their Non-Traded sector.

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6 Annex

6.1 Economic data of Colombia(2000-2016)

Series Name	1990	2000	2010	2016
Population, total (Millions)	34.27	40.40	45.92	48.65
Population growth (annual %)	1.9	1.5	1.1	0.9
Population density (people per sq. km of land area)	30.9	36.4	41.4	43.9
Poverty headcount ratio at national poverty lines (% of population)		49.7	37.2	28.0
Poverty headcount ratio at $1.90 a day (2011 PPP) (% of population)	8.9	16.4	7.8	4.5
GNI per capita, Atlas method (current US$)	1220	2320	5540	6350
GNI, PPP (current international $)	158.25	260.33	471.22	682.45
GNI per capita, PPP (current international $)	4620	6440	10260	14030
Income share held by lowest 20%	3.7	1.9	3.3	3.9
Life expectancy at birth, total (years)	68	71	73	74
Urban population growth (annual %)	2.7	1.9	1.5	1.2
Electric power consumption (kWh per capita)	842	829	1078	
GDP (current Billions US$)	40.27	99.89	287.02	280.09
GDP growth (annual %)	6.0	4.4	4.0	2.0
Inflation, GDP deflator (annual %)	26.1	31.8	3.9	4.9
Agriculture, forestry, and fishing, value added (% of GDP)	16	8	7	7
Industry (including construction), value added (% of GDP)	37	27	32	30
Exports of goods and services (% of GDP)	21	16	16	15
Imports of goods and services (% of GDP)	15	17	18	22
Gross capital formation (% of GDP)	19	15	22	25
Revenue, excluding grants (% of GDP)		15.5	21.5	24.2
Net lending (+) / net borrowing (-) (% of GDP)		-3.1	-4.6	-2.5
Domestic credit provided by financial sector (% of GDP)	36.4	30.4	66.0	53.7
Tax revenue (% of GDP)		11.2	12.1	13.3
Individuals using the Internet (% of population)	0.0	2.2	36.5	58.1
Statistical Capacity score (Overall average)			84	89
Merchandise trade (% of GDP)	31	25	28	27
Net barter terms of trade index (2000 = 100)	81	100	163	110
External debt stocks, total (DOD, current Millions US$)	17404	34272	64097	120282
Total debt service (% of exports of goods, services and primary income)	43.1	30.5	20.5	28.9
Personal remittances, received (current US$)	495	1610	4031	4903
Foreign direct investment, net inflows (BoP, current US$)	500	2436	6430	13849
Net official development assistance received (current US$)	88.5	186.7	673.8	1106.7

Source: World Bank

Literature Review

6.2 Macroeconomic determinants of commodity prices

Borensztein and Reinhart (1994) divide short-term macroeconomic determinants of commodity prices in two categories, the "demand-driven" framework, in line with Dornbusch (1985) and Gilbert (1989), and the "supply-driven" factors, based on Reinhart and Wickham (1994).

On a demand driven framework, the state of the business cycle in the industrial countries (commodity buyers), as well as the real exchange rate of the US Dollar have a relevant explaining power on the variation of commodity prices.

On the supply side, the authors note that the debt situation of the CEC plays a predominant role. As saw during the period of debt crisis of 1984-88, world commodity supply grew three times faster than the previous ten years average annual rate. Causing an important decline of raw material quotations. This non Marshall-Walras behavior of producers, comes from the fact that previous to the demand and price downward trend, CEC were already highly indebted. Thus when confronted to borrowing restrictions[25], authorities from CEC encouraged exports through fiscal stimulus in an attempt to adjust their balance of payments and ease the burden of debt repayments.

Whilst commodity prices can usually be explained by demand and supply factors, as previously described, exogenous monetary shocks may also influence commodity price volatility (in nominal and real terms). Frankel (2006) argues that on average commodity prices have a negative relationship with US interest rates.

To justify this relation, Frankel underlines three transmission channels through which an ease of US interest rate may affect commodity spot prices. Firstly, by discouraging the extraction in the present, secondly by increasing companies aim to hold inventories and third by incentivizing financial investors to sell US Treasuries and simultaneously buy commodity related securities. Through these channels the commodity spot prices would tend to rise.

Coherent to this, two effects would take place; On one hand, monetary disturbances reflected on commodity prices fluctuations would be transferred towards CEC (producers) and on the other, to CEC bond holders and com-

[25]Borrowing restrictions may come from advanced economies rising interest rates and/ or higher risk premiums asked, result of a credit quality deterioration or contagion (such as saw during the Latin American and Asian financial crises). Consequently the Emerging Market Bonds contracts

modity investors. As it could be expected, in both cases, when monetary conditions change, commodity investors would rebalance their portfolio with other types of securities[26].

6.3 Dutch Disease

According to Frankel (2010) in his article "The Natural Resource Curse: A Survey"(p19) the Macroeconomics of the Dutch Disease are:

"The phenomenon arises when a strong, but perhaps temporary, upward swing in the world price of the export commodity causes:

- *a large real appreciation in the currency (taking the form of nominal currency appreciation if the country has a floating exchange rate or the form of money inflow and inflation if the country has a fixed exchange rate);*
- *an increase in spending (especially by the government, which increases spending in response to the increased availability of tax receipts or royalties –discussed below);*
- *an increase in the price of nontraded goods (goods and services such as housing that are not internationally traded), relative to traded goods (manufactures and other internationally traded goods other than the export commodity)*
- *a resultant shift of labor and land out of non-export-commodity traded goods (pulled by the more attractive returns in the export commodity and in non-traded goods and services), and*
- *a current account deficit (thereby incurring international debt that may be difficult to service when the commodity boom ends)".*

[26]In recent times, as noted by Inamura, Kimata, Kimura and Muto (2011), the sensitivity of commodity markets to interest rate fluctuations has been reinforced. This is the consequence of current "financialization" of commodity markets (Adams, 2015), that give easier access to commodity based investments, thanks to new derivative securities, such as Exchange traded Commodities (ETC). This new trend has massively increase the transaction volumes of commodity markets in the last decade.

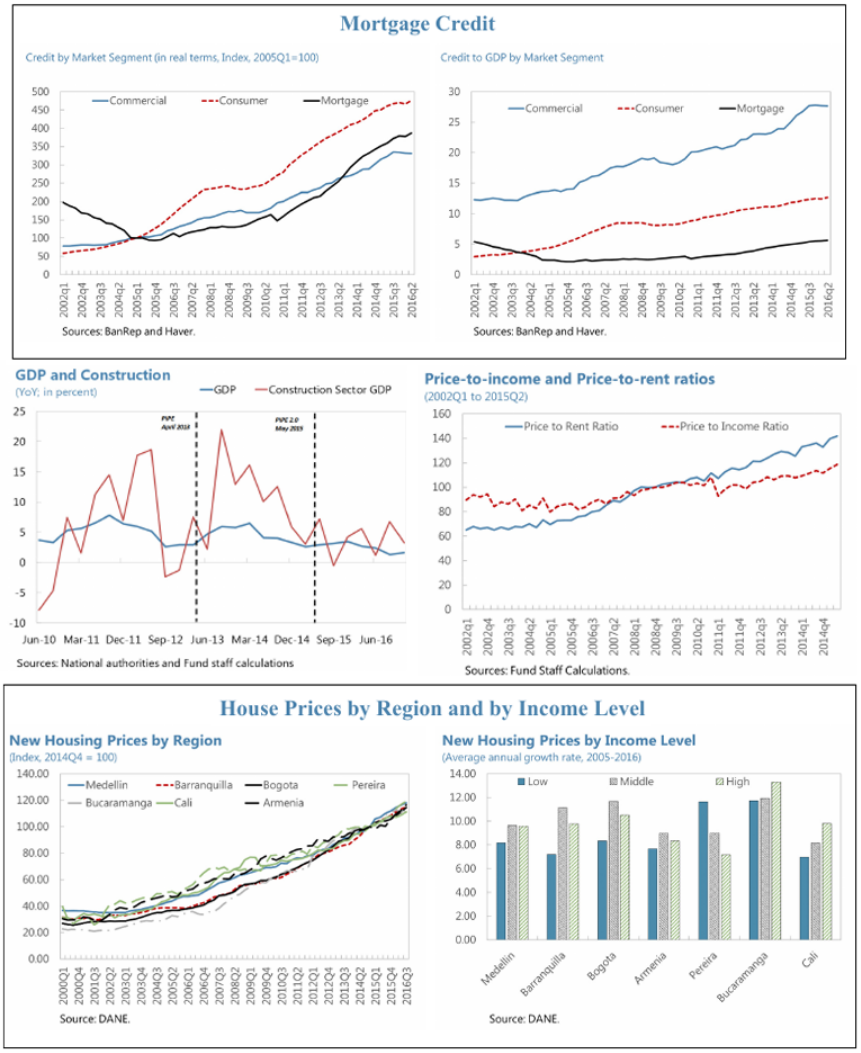
Dutch Disease symptoms Mardaneh (2012),in his paper "Inflation Dynamics in a Dutch Disease Economy" (p.8) explores six symptoms of Dutch Disease according to the literature:

- *" Rise in the price of oil and appreciation of the real exchange rate (exchange rate is define as home currency price of the foreign currency) simultaneously.*
- *Ousted manufacturing sector over time.*
- *Higher growth rate for services sector compared to the manufacturing sector.*
- *Rise in government expenditures, which results in domestic inflationary pressures.*
- *Increase in investment in the oil sector.*
- *Higher average nominal wages in the natural resource sector."*

6.4 Colombian Mortage Crisis (1998-2000)

The following figures were retained from ROCH (2017) research, due to their pertinence of content.

Figure 10: Roch (2017) Main figures related to the subject



6.5 Theoretical Framework definitions

The variables and interaction mechanisms described in both theoretical models, the TNT and the Real Estate Pricing model, are based on assumptions that oversimplify the reality. To correctly construct and interpret these models, we define in the next subsection of this annex the components and circumstances took into account:

Commodity Exporting Countries (CEC):

First: Commodities are the predominant export of the CEC. Their prices are exogenous to the producer, and are traded in foreign currency.

Second : The proportion of fiscal revenues related commodity revenues (ex. mining royalties) is a share (percentage) rigid in the short term. Which means that the fiscal policy is procyclical to the commodity price cycle. Therefore there is a negative relationship between the fiscal deficit and the behavior of commodity prices (Ilzetzki 2008 and Cespedes 2014)

Third : The higher is the export value, the higher will be the solvency of the producer. Ergo, the lower will be the risk premium perceived by the international investors (lower yield spreads and devaluation expectations).

About commodities:

Storable commodities (except gold) are cross-correlated in the short term and thus react equally to monetary shocks. This assumption is based on recent increasing homogeneity of the commodity markets, the financialization trend of commodities and the fact that "investor sees commodities as one single (homogenous) kind of asset category" for their short term investment decisions (Chevallier and Ielpo (2013,chap.5), Pindyck and Rotemberg (1990) and (Fernandez,2015).

Real Estate Market Hypothesis and definitions

First : Real Estate construction is considered such a Non-Tradable good, which can only be produced domestically.

Second: Based on the Bohm-Bwerk's idea, we suppose that as the more the stages of production there are (building license, construction, etc) the longer is the average period of production, and thus the higher will be the time need it, and thus the capital intensity. This means that the Real Estate supply (construction) and thus Real Estate Prices are sensitive to interest rate changes (and thus to market liquidity fluctuations).

Third: Real Estate production is taken as rigid on the short term, as the result of long stages of production (urban and land-use planning policies, building permits, construction process, etc.). Construction Innovation, which could lower production cost and increase productivity, is not taken into account.

Fourth: When faced to lower interest rate buyers or investors in real estate property reduce their savings and increase their investment positions on higher yield assets, such as Real Estate, because their time preference has not changed.

Fifth: Real Estate prices are totally free and are not fixed or stimulated by any public or private policy. They also don't depend on the real estate developer's cost of construction but on the willingness of the buyer to pay (Thalmann,2016). Because of this, Real Estate assets can be considered an speculative investment asset.

Empirical Analysis

Data set

The following tables are from V. Bodart et al. / Journal of International Money and Finance 31 (2012) 1482–1502

Figure 11: Country's specialization in commodity prices

Table 3
Country's specialization in commodity exports.

	Commodity weights in country's total exports		
Commodity	1	2	3
Oil	Nigeria 95.12%	Yemen 82.76%	Iran 79.72%
Cotton	Benin 61.00%	Mali 33.48%	Pakistan 20.52%
Tobacco	Malawi 60.50%	Zimbabwe 19.53%	Tanzania 6.35%
Copper	Zambia 59.99%	Chile 30.79%	Peru 13.93%
Gold	Mali 54.05%	Burundi 35.45%	Ghana 28.56%
Coffee	Burundi 50.98%	Ethiopia 46.43%	Uganda 36.87%
Uranium	Niger 41.73%	Benin 29.90%	Brazil 0.01%
Cocoa	Côte d'Ivoire 34.10%	Ghana 33.16%	Cameroon 9.75%
Aluminum	Mozambique 33.44%	Bahrain 12.89%	United Arab Emirates 12.77%
Soya	Paraguay 32.72%	Argentina 4.45%	Brazil 4.22%
Fish	Mauritania 30.96%	Mozambique 19.87%	Madagascar 14.34%
Bananas	Dominica 29.20%	Ecuador 17.83%	Costa Rica 12.83%
Tea	Kenya 21.20%	Sri Lanka 15.12%	Malawi 7.97%
Crustaceans	Mozambique 18.96%	Madagascar 13.35%	Nicaragua 10.67%
Iron	South Africa 11.24%	Zimbabwe 10.45%	Dominican Rep. 10.17%
Sugar	Guatemala 9.71%	Malawi 9.15%	Nicaragua 6.28%
Rice	Myanmar 8.99%	Uruguay 7.72%	Pakistan 7.08%
Coal	Colombia 8.85%	South Africa 6.24%	Indonesia 3.01%
Beef	Nicaragua 6.15%	Uruguay 4.78%	Paraguay 4.70%
Tin	Bolivia 6.03%	Peru 0.68%	Indonesia 0.64%
Rubber	Sri Lanka 5.81%	Thailand 5.10%	Indonesia 3.81%

Notes: Weights are defined as the ratio between the commodity exports of the country and all the commodity exports of the country. Annual averages over the period 1988–2008.

Figure 12: List of countries in Bodart(2012) data set

List of countries.

Countries		
Algeria	India	Papua New Guinea
Argentina	Indonesia	Paraguay
Bahrain	Iran	Peru
Bangladesh	Jordan	Qatar
Benin	Kenya	Saudi Arabia
Bolivia	Kuwait	South Africa
Brazil	Madagascar	Sri Lanka
Burundi	Malawi	Sudan
Côte d'Ivoire	Malaysia	Suriname
Cameroon	Mali	Syria
Central African Rep.	Mauritania	Tanzania
Chile	Mexico	Thailand
Colombia	Morocco	Togo
Costa Rica	Mozambique	Tunisia
Dominica	Myanmar	Turkey
Dominican Rep.	Nicaragua	Uganda
Ecuador	Niger	United Arab Emirates
Egypt	Nigeria	Uruguay
Ethiopia	Norway	Venezuela
Gabon	Oman	Yemen
Ghana	Pakistan	Zambia
Guatemala	Papua New Guinea	Zimbabwe
Honduras	Paraguay	

6.6 Stata programming code

```
    import excel Data, sheet("COP2") firstrow clear
rename CrudeOilpetroleumDatedBre Oil
rename CoalAustralianthermalcoal12 Coal
rename CoffeeOtherMildArabicasInte Coffee
rename Index3Commodities Index3Com

g qtr=qofd(date)
collapse Oil Coal Coffee Index3Com, by(qtr)
format qtr %tq

merge 1:1 qtr using realestate, nogenerate
rename qtr date
drop if date¿219
drop if date¡160

rename ColombiaRealEstatePricesNom ColNomPrice
rename ColombiaRealEstatePricesRea ColRealPrice
tsset date, quarterly

egen Index3Comindex = total(Index3Com * (date == 200))
replace Index3Comindex = 100 * Index3Com / Index3Comindex

egen OilIndex = total(Oil * (date == 200))
replace OilIndex = 100 * Oil / OilIndex

egen CoalIndex = total(Coal * (date == 200))
replace CoalIndex = 100 * Coal / CoalIndex

egen CoffeeIndex = total(Coffee * (date == 200))
replace CoffeeIndex = 100 * Coffee / CoffeeIndex

gen lnColNomPrice = ln(ColNomPrice)
gen lnIndex3Com = ln(Index3Com)
gen lnOilIndex = ln(OilIndex)
gen lnCoalIndex=ln(CoalIndex)
gen lnCoffeeIndex =ln(CoffeeIndex)
gen lnIndex3Comindex = ln(Index3Comindex)
label variable lnOilIndex "Log Oil Price Index"
label variable lnCoalIndex "Log Coal Price Index"
label variable lnCoffeeIndex "Log Coffee price Index"
label variable OilIndex "Oil Price Index"
label variable CoalIndex "Coal Price Index"
label variable CoffeeIndex "Coffee Price Index"
label variable ColNomPrice "Real Estate Nominal Price Index "

summarize ColNomPrice OilIndex CoalIndex CoffeeIndex Index3Comindex

    ********************************************
********** OLS **********
********************************************
reg lnColNomPrice lnOilIndex lnCoalIndex lnCoffeeIndex
twoway scatter lnColNomPrice lnOilIndex, mlabel(date) mlabposition(12)
```

```
graph twoway (lfit lnColNomPrice lnOilIndex) (scatter lnColNomPrice lnOilIndex), ti-
tle("Real Estate and oil prices's
evolution") subtitle("Each dot = a quarter") ///
xtitle("Log Oil Price Index") ytitle("Log Real Estate Nominal Price Index") legend(off)
graph twoway (lfit lnColNomPrice lnCoalIndex) (scatter lnColNomPrice lnCoalIndex), ti-
tle("Real Estate coal prices's
evolution") subtitle("Each dot = a quarter") ///
xtitle("Log Coal Price Index") ytitle("Log Real Estate Nominal Price Index") legend(off)
graph twoway (lfit lnColNomPrice lnCoffeeIndex) (scatter lnColNomPrice lnCoffeeIndex),
title("Real Estate and coffee
prices's evolution") subtitle("Each dot = a quarter") ///
xtitle("Log Coffee Price Index") ytitle("Log Real Estate Nominal Price Index") legend(off)

reg lnColNomPrice lnOilIndex lnCoalIndex lnCoffeeIndex
estat dwatson
dfuller lnColNomPrice, trend regress lags(1)
dfuller lnOilIndex, trend regress lags(1)
dfuller lnCoalIndex, trend regress lags(1)
dfuller lnCoffeeIndex, trend regress lags(1)
dfuller D.lnColNomPrice, trend regress lags(1)
dfuller D.lnOilIndex, trend regress lags(1)
dfuller D.lnCoalIndex, trend regress lags(1)
dfuller D.lnCoffeeIndex, trend regress lags(1)

reg lnColNomPrice lnIndex3Comindex
estat dwatson
dfuller lnColNomPrice, trend regress lags(1)
dfuller lnIndex3Comindex, trend regress lags(1)
dfuller D.lnColNomPrice, trend regress lags(1)
dfuller D.lnIndex3Comindex, trend regress lags(1)

**********************************************
******** Selection of the optimal lag-order **********
**********************************************
varsoc lnColNomPrice lnOilIndex lnCoalIndex lnCoffeeIndex
varsoc lnColNomPrice
varsoc lnOilIndex
varsoc lnCoalIndex
varsoc lnCoffeeIndex

varsoc lnColNomPrice lnIndex3Comindex
varsoc lnColNomPrice
varsoc lnIndex3Comindex

    ******************************************
*************** Johansen Test *****************
******************************************
vecrank lnColNomPrice lnOilIndex lnCoalIndex lnCoffeeIndex, trend(constant) max

    vecrank lnColNomPrice lnOilIndex, trend(constant) lags(3)
vecrank lnColNomPrice lnCoalIndex, trend(constant) lags(2)
vecrank lnColNomPrice lnCoffeeIndex, trend(constant) lags(4)

vecrank lnColNomPrice lnIndex3Comindex, trend(constant) max
```

```
vecrank lnColNomPrice lnIndex3Comindex, trend(constant) lags(1)

*******************************************
************ Residuals stationarity ***************
*******************************************
regress D.lnColNomPrice L.lnColNomPrice L.D.lnColNomPrice
predict ehat, residual
regress D.ehat L.ehat L.D.ehat, noconstant
dfuller ehat, regress lags(1)

regress D.lnOilIndex L.lnOilIndex L.D.lnOilIndex
predict ehat1, residual
regress D.ehat1 L.ehat1 L.D.ehat1, noconstant
dfuller ehat1, regress lags(1)

regress D.lnCoalIndex L.lnCoalIndex L.D.lnCoalIndex
predict ehat2, residual
regress D.ehat2 L.ehat2 L.D.ehat2, noconstant
dfuller ehat2, regress lags(1)

regress D.lnCoffeeIndex L.lnCoffeeIndex L.D.lnCoffeeIndex
predict ehat3, residual
regress D.ehat3 L.ehat3 L.D.ehat3, noconstant
dfuller ehat3, regress lags(1)

regress D.lnIndex3Comindex L.lnIndex3Comindex L.D.lnIndex3Comindex
predict ehat4, residual
regress D.ehat4 L.ehat4 L.D.ehat4, noconstant
dfuller ehat4, regress lags(1)

*******************************************
********** estimation du ECM without lag **********
*******************************************
vec lnColNomPrice lnOilIndex, trend(rconstant) rank(1) lags(2)

veclmar // Autocorrelation test
vecnorm, jbera // Normality test
vecstable // Stability test

    vec lnColNomPrice lnCoalIndex, trend(rconstant) rank(1) lags(2)
veclmar // Autocorrelation test
vecnorm, jbera // Normality test
vecstable // Stability test

vec lnColNomPrice lnCoffeeIndex, trend(rconstant) rank(1) lags(2)
veclmar // Autocorrelation test
vecnorm, jbera // Normality test
vecstable // Stability test

vec lnColNomPrice lnIndex3Comindex, trend(rconstant) rank(1) lags(2)
veclmar // Autocorrelation test
vecnorm, jbera // Normality test
vecstable // Stability test
```

```
*******************************************
********** estimation du ECM with lag ***********
*******************************************
vec lnColNomPrice lnCoffeeIndex, trend(rconstant) rank(1) lags(4)
veclmar, mlag(4) // Autocorrelation test
vecnorm, jbera // Normality test
vecstable // Stability test

*******************************************
******************** IRF ******************
*******************************************
vec lnColNomPrice lnOilIndex, trend(rconstant) rank(1) lags(2)
irf create vec1, set(vecirfs) step(20)
irf graph oirf, impulse(lnOilIndex) response(lnColNomPrice)

    vec lnColNomPrice lnCoalIndex, trend(rconstant) rank(1) lags(2)
irf create vec2, set(vecirfs2) step(20)
irf graph oirf, impulse(lnCoalIndex) response(lnColNomPrice)

vec lnColNomPrice lnCoffeeIndex, trend(rconstant) rank(1) lags(2)
irf create vec3, set(vecirfs3) step(20)
irf graph oirf, impulse(lnCoffeeIndex) response(lnColNomPrice)

vec lnColNomPrice lnIndex3Comindex, trend(rconstant) rank(1) lags(2)
irf create vec4, set(vecirfs4) step(20)
irf graph oirf, impulse(lnIndex3Comindex) response(lnColNomPrice)

vec lnColNomPrice lnCoffeeIndex, trend(rconstant) rank(1) lags(4)
irf create vec5, set(vecirfs5) step(20)
irf graph oirf, impulse(lnCoffeeIndex) response(lnColNomPrice)
```