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Commodities prices volatility, expected inflation and GDP levels: an application for a net-exporting economy

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Abstract

This work applies time series methods, such as VAR, ARMA-GARCH and Cointegration/VEC, in order to test for short and long term relationships between commodities prices changes and relevant macroeconomic variables in Brazil, from January/2005 to May/2013. The main evidences have shown the existence of short term effects of commodities prices shocks on the expected and current consumer inflation, as well as on GDP and exchange rate levels; in turn, the long term relationships have been verified through changes in commodities prices volatility: in long term, an increase of the latter means a context of higher expected inflation and lower GDP levels, thereby showing that economic authorities have scientific reasons to concern with abrupt fluctuations in commodities markets. In this sense, volatility in commodity markets is not neutral.

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Key-words: commodities prices; consumer inflation; monetary policy; Brazil.

1. Introduction

Commodities prices changes have become an important variable in determining consumer inflation in developed countries, as well as in emerging economies. This is one of the reasons by which there has been a prominent literature that studies the main relationships between commodities prices behavior, its statistical properties and dynamics in parallel with its correlation or causality relationships with monetary policy regimes that aim at maintaining price stability, such as the so called inflation targeting regime. In the latter, a monetary policy which reacts to consumer inflation changes, caused by supply shocks, can create social losses such as output volatility (Clarida, Galí & Gertler, 1999; Bofinger, Mayer & Wollmershauser, 2006; Galí & Gertler, 2007), and perhaps commodities prices fluctuations are the main source of these supply shocks nowadays (Bernanke & Mishkin, 1997). Social losses occur when the Central Bank adjusts the short term

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interest rate so as to eliminate consumer inflation deviations that were caused mainly by prices fluctuations not correlated with demand or output behavior. Commodities prices are an example: these prices are formed in international markets and are not necessarily correlated with economic activity of any specific economy. Therefore, if there is an increase of the consumer inflation, caused by upward movements in commodities prices, imposing higher interest rates can reduce consumer inflation but only through generating lower output and employment levels. Under this perspective, two basic research questions arise: a) How do commodities prices fluctuations impact Brazilian consumer inflation and monetary policy in short and long terms?; b) Is it possible to say Brazilian Central Bank has reacted efficiently to consumer inflation changes? Moreover, if there is empirical evidence of long term effects of commodities prices on real economic variables, such as real GDP, then it would be possible to say economic authorities have scientific reasons to concern with changes in commodities markets. The fact that Brazil is a *commodity net-exporting country* does not mean that any increase of related prices has positive impacts in its economy. Let us assume that the increase of commodities prices is big enough to increase the variance or volatility in the market. As the higher the volatility the higher the uncertainty on future prices and on demand and supply conditions, so that some contracts can be avoided or disrupted, it is usual to think that the initial increase of commodities prices is followed by constraints on economic activities linked to export sectors, thereby creating social losses. Does it really occur in practice? The main goal of this work is to assess these questions, based on time series methods and data applied on Brazil, from January 2005 to May 2013. We have chosen this period sample because it is from 2005 that the Brazilian inflation target was stabilized in 4.5% per year. With such a sample, we can avoid methodological problems regarding inflation target changes, which would occur if we adopted a more backward-looking sample, e.g. from 1999, when the inflation target system was really introduced in Brazil.

De Gregorio (2012) has shown that commodities prices fluctuations have expressive impacts on consumer inflation, specially due to food prices changes (rather than to energy prices) which are responsible for higher percentages of the consumer basket, particularly in emerging economies. Besides, it has been argued that improvements of the inflation target's credibility can contribute in increasing the efficiency of monetary policy reactions to the commodities prices' effects on consumer inflation. As food prices have large presence at the consumer basket, their fluctuations generate secondary effects on consumer inflation through wages and other prices. This kind of second-round effect can make the duration of shocks in commodities prices more persistent.

In turn, Mallick & Sousa (2013) investigated the impacts of commodities prices shocks on the five main emerging economies: Brazil, Russia, India, China and South Africa, i.e. the BRICS, by applying a *Bayesian Vector Auto-Regressive* method, with quarterly data from 1990:1 to 2012:1. The main results can be summarized as follows: a) a positive shock of commodities prices has been translated into an increase of inflation and a aggressive response of monetary policy; b) in net-oil exporting countries, such a shock causes an overvaluation of domestic currency and more optimism of investors; c) the response of monetary policy to that commodities prices shock has been followed by a contractionary impact on the real GDP growth and by overvaluation of the domestic currency, but with some persistence of inflation.

Specially for Brazil, a recent empirical work is Moreira (2012). It investigated the nature of the Brazilian consumer inflation rate in the period from January/2005 to June/2011, through implementing the *Vector Autoregressive (VAR)* method. It was verified that the Brazilian consumer inflation rate change is basically determined with time lags (Granger sense) by commodities prices fluctuations, instead of by the domestic activity dynamics. Hence, Moreira (op. cit.) found statistical significance for the hypothesis of supply shocks as the main cause on the country's consumer inflation trajectory and, as a consequence, on monetary policy decisions in Brazil's inflation targeting regime; on the other hand, evidences for rejecting the hypothesis of demand shocks were also observed. In turn, these evidences confirmed that the domestic monetary policy was under the trade-offs effects situation.

Although Moreira (2012) should be used as an important reference for this subject in Brazil, we propose improve it by at least two important aspects. We will apply a more robust model as short term interest rate and expected inflation, which are important macroeconomic series, will be included into the analysis. At last, we will investigate how the uncertainty on commodities prices, measured by *ARMA-GARCH approaches*, behaves jointly with other Brazil's relevant macroeconomic variables. This stage will be done through *Cointegration* and *Vector Error Correction* methods.

2 – Theoretical aspects: commodities net-exporting economies and monetary policy

The model expresses the dynamic relationships among relevant macroeconomic variables which will be used in the empirical analysis ahead. It is a dynamic, auto-regressive and stochastic model, with forward-looking components. Although the specification and notation are not conventional, such a model reflects a wisdom that can be found in models presented in Clarida, Galí & Gertler (1999), among others. We have introduced explicitly the commodities prices component into the model, so that it is closer to works dealing directly with such an issue, like Medina & Soto (2005) and Lee & Song (2009). In the short term, the output behavior in an economy with some degree of price stickiness can be defined as:

$$y_t = \sum_{j=1}^{n} \alpha_{-j} y_{t-j} - \sum_{j=1}^{n} b_{-j} i_{t-j} - E_t \sum_{j=0}^{n} \beta_j i_{t+j} + \vartheta_1 e_{t-1} + \vartheta_2 p^{comm}{}_{t-1} + u_t \quad (1)$$

Where y is the output, i the (nominal) basic interest rate, e the exchange rate, p^{comm} the commodities prices index and u is a demand shock (white noise term). All the parameters α, b, β, ϑ_1 and ϑ_2 are positive. The *backward-looking components* are expressed in lag variables, from period t-1 up to t-n (by means of the summation operator), while the *forward-looking component* – for the basic interest rate – is denoted also by the expectation operator (E) from period t up to t+n. Moreover, all the variables can be regarded as deviations to their normal values. By (1), an increase of commodities prices has a positive impact on output. It is natural to think that the higher the commodities exporting sector on output the higher the ϑ_2. In a *commodities net-exporting economy*, its dynamics is expressively dependent on the value of $\vartheta_1 + \vartheta_2$, as the higher the undervaluation of the domestic currency[†], along with increasing commodities prices, the higher the stimulus to exporting sectors and thereby output. Indeed, e and p^{comm} jointly can be used to measure the gain of commodities exporting sectors in terms of domestic currency.

On the other hand, *commodities net-importing countries* are constrained facing an increase of commodities prices, so that such an increase represent a kind of negative supply shock or negative technological shock, and ϑ_2 becomes a negative parameter. In turn, the consumer inflation can be specified as:

$$\pi_t = \sum_{j=1}^{n} l_{-j} \pi_{t-j} + E_t \sum_{j=0}^{n} \lambda_j \pi_{t+j} + \sum_{j=1}^{n} q_{-j} y_{t-j} + E_t \sum_{j=0}^{n} v_j y_{t+j} + \varsigma_1 e_t + \varsigma_2 p^{comm}{}_{t-1} + g_t \quad (2)$$

Where π is the consumer inflation. Like (1), the *backward-looking* and *forward-looking* components are denoted by lags from period t up to t-n and by expectations from t up to t+n, along with, respectively,

[†] In such a notation, the exchange rate means the amount of domestic currency someone needs to buy one unit of the US dollar. Hence, an increase (or a decrease) of e expresses an undervaluation (or overvaluation) of the domestic currency facing the US dollar.

summation and expectations operators. The parameters l, λ, q, v, ς_1 and ς_2 are positive, while *g* represents a supply shock with zero mean and constant variance. Effects of commodities prices on consumer inflation will depend basically on previous exchange rate changes. In a commodities net-exporting economy, in general, an increase of commodities prices causes an overvaluation of the domestic currency, as there exists growth of foreign currency reserves, so that impacts on consumer inflation can be lower, given ς_1 and ς_2. It means that *e* and p^{comm} co-moves in inverse direction for the case of commodities net-exporting countries. However, in commodities net-importing countries, an increase of commodities prices imposes undervaluation of the domestic currency, as there exists a decrease of foreign currency reserves, so that impacts on consumer inflation can be higher. In such countries, *e* and p^{comm} co-moves in the same direction. Now, let us to define the monetary policy as an *inertial forward-looking Taylor rule*:

$$i_t = \rho(i_{t-1}) + (1-\rho)\left[(i^n{}_t) + \sum_{j=1}^{n} m_{-j}\pi^*{}_{t-j} + E_t\sum_{j=0}^{n}\phi_j\pi^*{}_{t+j} + \sum_{j=1}^{n} n_{-j}y_{t-j} + E_t\sum_{j=0}^{n}\kappa_j y_{t+j}\right] + \eta_t \quad (3)$$

In (3), ρ is the inertial coefficient, which gives the proportion of i_{t-1} translated into i_t; therefore, the higher ρ the higher the monetary policy's inertia or smoothness. In turn, i^n is the equilibrium nominal interest rate, that is, the nominal interest rate to which the economy converges when consumer inflation and output deviations are eliminated. The parameters *m*, ϕ, *n* and κ are positive and the *Taylor's principle* (Taylor, 1993) defines the counter-cyclical monetary policy as the case in which *m* and ϕ are higher than 1. Like (1) and (2), backward and forward-looking components are denoted over time by means of summation of lagged and expected variables, while η means a monetary policy shock (white noise).

The problem to be solved by the Central Bank can be expressed in terms of a quadratic social loss function (*L*), such as:

$$L_t = E_t\sum_{j=0}^{n} w_{1j}(\pi_{t+j})^2 + E_t\sum_{j=0}^{n} w_{2j}(y_{t+j})^2 \quad (4)$$

Given $w_1 + w_2 = 1$, the Central Bank should adjust its main current instrument so as to minimize expected deviations of both output and consumer inflation over time. However, this conventional way of thinking the Central Bank's main problem does not incorporate the issue of the commodities prices volatility. Such an issue has had prominent role in international discussions regarding energy and food allocations and impacts on consumer's goods basket across the world. In turn, farmers are also damaged when commodities prices stay below expected levels, and the significant amount of subsidies for them in developed countries shows that avoiding losses with prices oscillations is an old theme in practice, at least in fiscal debates.

Hence, we can stipulate a new social loss function putting the commodities prices volatility ($\sigma^2{}_{p^{comm}}$) explicitly as a target to be controlled. In such a new rule, the Central Bank should adjust its basic interest rate, along with other available regulatory and prudential instruments, in order to minimize fluctuations in commodities markets, as well as in conventional consumer inflation and output. As we are considering commodities prices fluctuating everyday according to supply and demand through spot and future contracts, it is not easy to control such prices only with basic interest rate adjustments, so that the minimization of $\sigma^2{}_{p^{comm}}$ requires probably coordinated efforts between the Central Bank, market players, regulatory institutions and fiscal authorities. The proposed new social loss function is specified in (5), allowing for $w_1 +$

$w_2 + w_3 = 1$:

$$L_t = E_t \sum_{j=0}^{n} w_{1j} (\pi_{t+j})^2 + E_t \sum_{j=0}^{n} w_{2j} (y_{t+j})^2 + E_t \sum_{j=0}^{n} w_{3j} \sigma^2{}_{p^{comm}}{}_{t+j} \quad (5)$$

2 – Methodological Strategy

The current methodological strategy can be defined as follows: a) we used *Augmented Dickey-Fuller tests* to identify the integration order of the series, so that appropriate methods could be chosen; b) a *Vector Autoregressive* model (Sims, 1980; 1986), along with *Granger-causality tests*, was implemented to analyze dynamic relationships between commodities prices changes and Brazil's relevant macroeconomic variables; c) in order to extract a series of variance – used as a proxy for uncertainty – of the commodities prices over time, we applied an *Autoregressive Moving Average* (ARMA) and a *Generalized Autoregressive Heterocedastic (GARCH)* model *(*Bollerslev, 1986*) ; d)* we have adopted *Cointegration* and *Vector Error Correction* (VEC) (Johansen & Juselius, 1990; Johansen, 1991) as methods to test for impacts of the commodities prices uncertainty on a more restrict macroeconomic group of variables.

3 – Data

All the monthly time series were collected for Brazil, from January/2005 to May/2013: COMM: the commodities prices index of the Brazilian Central Bank, i.e. the IC-Br, which expresses the commodities prices in domestic currency (source: Brazilian Central Bank); I: the annual current Selic interest rate, i.e. the Brazilian basic interest rate (source: Brazilian Central Bank); EXP_I: the annual expected Selic interest rate for 12 months ahead (source: Brazilian Central Bank); P: the annual current consumer inflation, based on the *Broad Consumer Prices Index* (source: Brazilian Central Bank); EXP_P: the annual expected consumer inflation for 12 months ahead (source: Brazilian Central Bank); YBC: the GDP index estimated by the Brazilian Central Bank, that is, the IBC-Br (source: Brazilian Central Bank); E: the nominal exchange rate (R$/US$) (source: Ipeadata).

4 – Results

VAR results

As some variables have presented unit root in level values based on the *Augmented Dickey-Fuller test*[‡] (COMM, EXP_P, P and YBC), we have implemented their first differences so as to estimate de VAR model. The other variables, regarded as I(0), were used in level values. The optimal unrestricted VAR has 01 lag, based on information criteria, such as Akaike (AIC), Schwarz (SC) and Hannan-Quinn (HQ). In sequence, we tested for *Granger causality relationships* among the variables. The commodities prices changes cause individually, with time lags, D(EXP) and D(P) at 1% of confidence. In turn, at 10%, D(COMM) Granger-causes E and D(YBC).

From the impulse-response functions (Figure A.1 – Appendix), and regarding effects of D(COMM) on D(P), this last one exhibits a positive deviation until around the 4º month after the shock and the peak occurs in the second month. The same pattern can be observed when we look at the response of D(EXP_P) from a positive shock in D(COMM). There is a positive deviation of inflationary expectations changes until around the 4º month after the shock and the peak occurs in the second month. These remarks mean that the Brazilian consumer inflation is affected directly and indirectly by commodities prices changes: directly by means of the commodities exporting/importing sectors' decisions on new prices; and indirectly through an increase of inflationary expectations, as such expectations Granger-cause D(P).

In turn, D(COMM) also causes D(YBC) in Granger sense. We observe a positive effect until the 3º month after the shock and from the 3º month up to around the 5º month there is a smooth negative deviation, which is eliminated rapidly. This evidence is important because it shows that Brazil's economic activity changes have not been affected by commodities prices changes in long term. A possible challenge is to seek methods for generating dynamic and consistent positive externalities from the short term effects on the commodities exporting sectors. For instance, it can be made by law (or tax) that forces companies to invest the short term gains created by higher commodities prices on professional qualification or on funds to be applied exclusively on productivity returns in the general industry. With this kind of policy, more persistent effects on D(YBC) would be possibly seen from positive shocks of D(COMM). The effects of a positive shock of D(COMM) on E are another important macroeconomic aspect, although they are not the main issue of this work. We can observe a quick domestic currency undervaluation after the shock, until around the 2º month. However, there exists a domestic currency overvaluation from that last month up to around the 8º month after the shock. It is not possible to see direct and indirect effects of exchange rate changes on consumer inflation and inflationary expectations with statistical significance in Granger sense, but the domestic currency overvaluation is an important variable for controlling consumer inflation and to stimulate imports of manufactured goods**.** In such a case, positive shocks in commodities prices can be followed by a loss of competitiveness in manufacturing sectors as well as by a smooth behavior of the consumer inflation, as the overvaluation contributes to anchor *tradeables* prices. Indeed, the effects of D(COMM) on D(P) and D(EXP_P) are not expressive nor persistent in our estimations.

Regarding reactions of monetary policy instruments, we can observe two main channels: a) at 10% of confidence for the Granger test, D(P) positive shocks have demonstrated impacts on the Selic basic interest rate, which stays above its normal value even after 12 months of such a shock (Figure A.1 – Appendix). It corroborates the principle according to which the basic interest rate is the main instrument in controlling inflation dynamics under an inflation target regime (Clarida, Galí & Gertler, 1999). In turn, the expected basic interest rate (EXP_I) is also positively affected by a shock of D(YBC). As expected interest rates can be regarded as a Central Bank's indirect instrument, because such rates affect long term interest rates and thereby impacting investment decisions and output (Moreira et. al., 2013), then the positive response of EXP_I to an increase of D(YBC) is a kind of a counter-cyclical transmission mechanism of Brazil's monetary policy through public's expectations. At last, it was applied the test of *inverse roots of the characteristic polynomial* for verifying the stability of the estimated VAR. As all the *characteristic roots* lie inside the unit circle, the estimated VAR can be regarded as stable.

ARMA-GARCH results

In turn, the VAR's results demonstrate linear and dynamic relationships among the time series; on the other hand, would there be relationships between D(COMM) and other relevant macroeconomic variables regarding the volatility of the former? To assess this question, we have used the conditional variance of D(COMM) as the proxy for uncertainty on commodities prices, and the way of extracting such a proxy is to apply a GARCH equation on a well specified ARMA equation, which in turn describes appropriately the univariate trajectory of D(COMM). After testing for better specifications of ARMA equations on D(COMM), we have found:

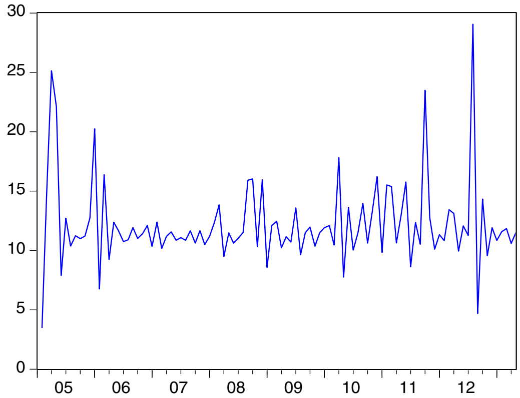
$$D(COMM)_t = 122.4269 + 0.9716\ D(COMM)_{t-1} + \varepsilon_t - 0.3585\ \varepsilon_{t-1}$$

Where ε_t and ε_{t-1} are error terms. Hence, based on this main equation, we tested for a GARCH equation, as:

$$\sigma^2_{D(COMM)t} = 15.7725 + 0.1587\ \upsilon^2_{t-1} - 0.4531\ \sigma^2_{D(COMM)t-1}$$

Where $\sigma^2_{D(COMM)t}$ is the conditional variance of D(COMM) in period t and υ is the error term. The Graph 1 shows the estimated behavior of $\sigma^2_{D(COMM)}$. In sequence, so as to verify if there are long term relationships between $\sigma^2_{D(COMM)}$ and relevant macroeconomic variables in Brazil, we tested for *Cointegration* and *Vector Error Correction* model, taking into account four time series: $\sigma^2_{D(COMM)}$, P, EXP_P and YBC.

Graph 1 – Conditional variance of D(COMM) extracted by the GARCH approach



Source: Own elaboration.

Cointegration and VEC results

The optimal specification of the Johansen test, based on Schwarz Criteria, is one in which there is a constant, but without trend in data. We can observe that the *Trace* and *Maximum Eigenvalue statistics* have demonstrated the existence of at least 01 cointegration equation for the time series. Indeed, based on the Trace statistics we would have 03 cointegration equations, but based on the Maximum Eigenvalue we find only 01 cointegration equation. In such a case, we prefer to choose the more parsimonious specification, i.e. only 01 equation.

Table 1 presents the main statistics of the estimated cointegration equation, using all the series in their log form. Two results are relevant: a) the increase of 1% in EXP_P means a context of more 0.44% in $\sigma^2_{D(COMM)}$; in turn, the increase of 1% in YBC means a context of less 0.44% in $\sigma^2_{D(COMM)}$. Such coefficients have statistical significance at 1%. It is important to note that this cointegration equation does not represent a specific theory, that is, we are not saying EXP_P and YBC cause or affect $\sigma^2_{D(COMM)}$; such coefficients should be interpreted in this way: in long term, the higher the commodities prices' volatility the higher the inflationary expectations and the lower GDP levels in Brazil. It means that the estimated coefficients are translating long term correlations, and not causality relationships. Therefore, there is a *non-neutrality of volatility*, as lower GDP levels are associated with higher volatility in commodities markets, so that economic authorities and market players have reasons to aim at controlling such fluctuations. However, current consumer inflation is not correlated with $\sigma^2_{D(COMM)}$, even at 10%.

The short term reactions for correcting long term disruptions can be seen in Table 2, through the *Error Correction Model*. In the short term, only $\sigma^2_{D(COMM)}$ reacts with statistical significance to restore the long term equilibrium among the variables: 1% of cointegration equation error in period t-1 is followed by – 1.65% of $\sigma^2_{D(COMM)}$ in period t. It means that the entire correction takes around 7 months. The fact that disruptions in the long term equilibrium are corrected by changes in $\sigma^2_{D(COMM)}$ is not strange. It means that changes in commodities prices' volatility have lower persistence in short term than the other macroeconomic variables, which, in turn, are expressed in level changes. In such a case, we can say the commodities market adjusts itself as long as necessary, so that a new long term relationship among the variables is found.

Table 1 – Cointegration equation

LOG($\sigma^2_{D(COMM)}$ (-1))	1.000
LOG(P(-1))	0.0133 (0.1024) [0.13033]
LOG(EXP_P(-1))	0.441 (0.1917) [2.29737]
LOG(YBC(-1))	-0.443 (0.1989) [- 2.22705]
C	3.919 (0.8703) [4.50251]

Source: Own elaboration.

Table 2 – Error Correction Model

	D(LOG($\sigma^2_{D(COMM)}$))	D(LOG(P))	D(LOG(EXP_P))	D(LOG(YBC))
u_{t-1}	-1.650118	-0.019184	0.001887	-0.006984
St. errors	(0.15404)	(0.03223)	(0.0292)	(0.0069)
t-statistics	[-10.7119]	[-0.59514]	[0.06462]	[-1.01246]

Note: “ut-1” refers to the cointegration equation errors in period t-1. Source: Own elaboration.

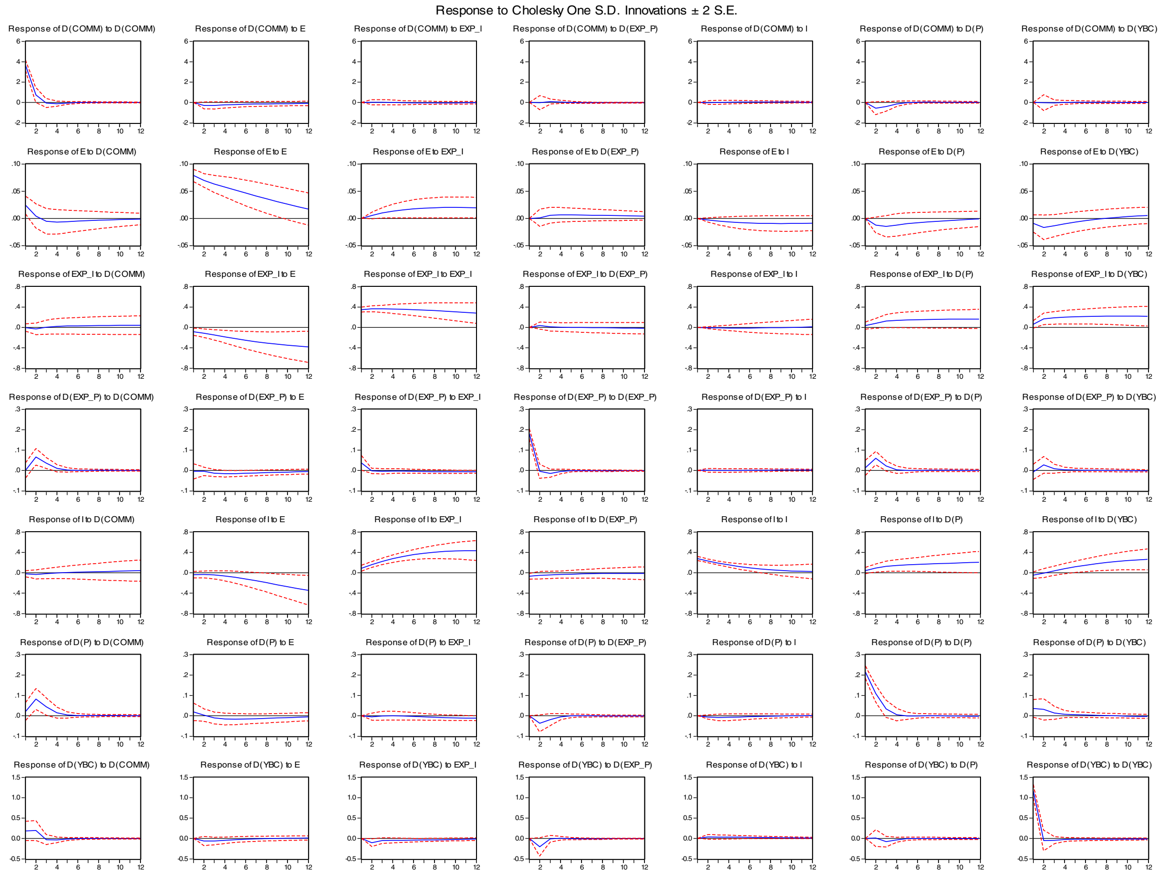
5 – Concluding remarks

Based on the results of the applied time series methods, some judgments on monetary policy’s responses can be considered facing fluctuations of commodities prices. Monetary authorities really have reasons to concern with high volatility in commodities markets, as the estimated cointegration equation has shown that the higher the volatility in commodities prices the lower the GDP level and the higher the inflationary expectations in Brazil. Therefore, it is important to elaborate regulatory mechanisms for minimizing the intensity of prices changes in commodities markets, even taking into account the fact that some of these fluctuations are out of the Brazilian Central Bank’s control.

To improve the current research a possible way would be through trying to observe these relationships for other countries or sample of countries, using appropriate methods such as Panel Data approaches. At the same time, it would be important to test for the robustness of our results, using other existing time series methods and varying possible indexes of real economic activity and commodities prices.

Appendix

Figure A.1 – Impulse-response functions of the unrestricted VAR with 01 lag



Source: Own elaboration.

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