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Abstract

This paper explores the importance of the terms of trade to explain output fluctuations in Colombia, a developing country where almost 60% of the exports correspond to four commodities: oil (32%), coal (17%), coffee (5%) and nickel (2%), and where 80% of its imports are intermediate and capital goods. This research is motivated fundamentally by the particular importance of short run fluctuations in developing economies, the fact that the Colombian terms of trade are procyclical and the current debate in Colombia about eventual economic policies toward sterilization of the effects of changes in commodities prices in a context of an appreciation of the nominal exchange rate. The study includes a time series analysis, for the period 1994-2009 with quarterly data, which follows the Box-Jenkins methodology for an ARMAX model. I find robust evidence that indicates that the quarterly growth of GDP is positively and significantly affected by variations in the terms of trade, which explain 1/3 of GDP growth variability. This result is consistent with the possible outcome of the three-goods model for an open small economy in which the terms of trade can be the source of the aggregate output fluctuations.

1 Introduction

A better understanding of economic activity in the short run is a challenging and important task. It is demanding in the sense that a quantitative description of the short run is inevitably evaluated by its ability to say something coherent about a near future that can soon test our theory even if forecasting is not the main objective. On the other hand, even though the welfare of a society is mostly discussed in a long-run context in macroeconomics, it is well known that the discussion cannot be unlinked from economic conditions in the short run. For instance, accumulation of capital through investment, the main source of the dynamics of a capitalist system, is commanded by firm owners and managers who make decisions according to current and the expected profitability. In fact, current changes in the prices of inputs and final products will affect both the level of investment and the current allocation and use of productive resources, labor among them. These changes surely impact households´ welfare.

Similarly, regarding the effects on consumption and the associated savings, economic theory usually assumes that more volatile consumption decreases individuals' utility. Depending, therefore, on the degree which people can smooth their consumption after a shock to their income,

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different outcomes might be observed on their welfare and the financial resources available for the accumulation of productive factors like physical and human capital.

Other channels that connect shocks, stability and welfare can be related to: responses of the economic policy authorities whose objectives may be to guarantee stability and to limit the uncertainty faced by economic agents, international trade scenario changes and its effects on the domestic productive sectors, financial fragility or even natural disasters.

In such a complex system, developing countries are usually more exposed and sensitive to the effects of macroeconomic ups and downs. The welfare implications of these fluctuations are deeper in developing economies than in developed countries where, for example, social safety nets have already been created to mitigate the impacts on the poorest population and where the levels of wealth permit individuals to face less traumatically adverse shocks of income. Higher levels of unemployment and poverty in developing countries make people less capable of smoothing their consumption when positive shocks appear, and the more variable tax base may constrain the ability of the public sector to implement long run projects necessary to remove the obstacles that hinder the development of these economies. Similarly, the use of policy tools to guarantee the stability of economic performance will always depend on the degree of knowledge about the output fluctuations, its determinants and its implications. Understanding the short run output fluctuations in developing countries is thus especially relevant.

In order to explain this short run variability in a particular developing country, Colombia, I agree in this paper with most of the literature on development macroeconomics that the theoretical framework of a small open economy is the starting point. As it will be shown in section 2, this setup frequently assumes, following the dependent economy model with its variation for three goods (exportable, importable and nontradable), that the small economy faces an infinitely elastic demand for its goods and an infinitely elastic supply of imported goods. Hence, the prices of exports (P_x) and imported goods (P_I) are determined in the international markets where the domestic economy has negligible market power. Likewise, one important feature of this framework is that external shocks to those prices, usually captured through changes in the terms of trade ($\frac{P_x}{P_I}$), are an important source of output fluctuations in the domestic economy.

The dependent economy with three goods[1] may be preferred to the well known Mundell-Fleming model for an open small economy in which the terms of trade, when variable, are endogenous. The endogeneity in the Mundell-Fleming model occurs because there exists some degree of market power in the exportable good. The price of the exportable good may be altered by internal conditions despite the fact that the economy is small and a price taker with respect to the importable goods. This assumption does not seem plausible for several developing countries, including Colombia, whose exports are concentrated in few commodities whose prices cannot be affected by the domestic markets. On the other hand, other dependent economy models with only two goods[2], traded and nontraded, have their own limitation. They do not permit us to evaluate the terms of trade as a source of macroeconomic fluctuations. In this case, both exportable and importable goods are aggregated in a composite good (the traded good). The variability of the terms of trade is thus not defined and cannot be the origin of macroeconomic fluctuations.

[1] i.e [Greenwood, 1984]
[2] i.e [Buiter, 1988]

The last motivation of this paper is to make a contribution to the current debate about the eventual negative effects on output of the boom in commodity prices that Colombia is experiencing lately. We will see that it is not necessarily true that a boom-appreciation-recession mechanism is operating in Colombia. Our comments, however, will be limited to the short run.[3]

Section 3 presents a time series analysis that aims to examine in a rigorous way the effect on aggregate output of the shocks to the terms of trade (TOT) perceived by the Colombian economy. The effect is apriori unclear. The statistical analysis will take into account not only the contemporaneous effect but also the possibility of some persistence. Likewise, the study of the relationships between GDP and the TOT must be controlled by relevant variables that may affect the short run performance of the output. This work will thus also permit us to make some comments about the effects of the interest rate and the nominal exchange rate as the main channels of transmission of monetary policy. Concluding remarks are presented in section 4.

2 Related Literature

The role of the terms of trade has been discussed in development and open macroeconomics issues in different ways for a long time. Adam Smith in book IV of the Wealth of Nations [Smith, 1776] recalls for instance how a high price of exports relative to imports is essential for the mercantilist strategy to achieve a higher level of wealth:

> "Though the encouragement of exportation, and the discouragement of importation, are the two great engines by which the mercantile system proposes to enrich every country, yet with regard to some particular commodities, it seems to follow an opposite plan: to discourage exportation and to encourage importation. Its ultimate object, however, it pretends, is always the same, to enrich the country by an advantageous balance of trade. It discourages the exportation of the materials of manufacture, and of the instruments of trade, in order to give our own workmen an advantage, and to enable them to undersell those of other nations in all foreign markets; and by restraining, in this manner, the exportation of a few commodities, of no great price, it proposes to occasion a much greater and more valuable exportation of others. It encourages the importation of the materials of manufacture, in order that our own people may be enabled to work them up more cheaply, and thereby prevent a greater and more valuable importation of the manufactured commodities" (p.424)

In the same way, the address by John Maynard Keynes [Keynes, 1923] about the decline of the relative price between the manufactured goods produced in the "Old World" and the raw materials offered by the "New World" after 1900 is another example of how the terms of trade has been associated directly to indicators of prosperity and welfare in the context of competition in international markets. In this sense, the terms of trade work as a ratio of real exchange of goods among the two groups of countries.

> "If for example, the wheat grown in Great Britain per head were at the present stage in our economic development to show a considerable increase, it might well indicate

[3] see i.e[Basu and McLeod, 1991]for a long-run analysis

> a serious deterioration in our prosperity; for it might mean that as a result of hostile tariffs or other causes we were no longer able to obtain food on favourable terms in exchange for our manufactured exports and were being driven, as a last resort, to grow and increased quantity of food for ourselves" (p.480)

From the developing countries' perspective, the hypothesis of uneven development between industrialized and non-industrialized economies [Prebisch, 1950];[Singer, 1950]also considers the terms of trade as a key element. In this case, the terms of trade reflect the world technical changes and the demand conditions faced by the countries regarding their degree of specialization and the type of product in which they are specialized. The hypothesis claims that economies specialized in the export of food and raw materials will face adverse terms of trade and will benefit less from trade than industrialized economies. First, because technical innovation in manufactured goods is not translated into a reduction of price. Producers of these goods have a market power that permit them to appropriate the advantages of technical change in form of profits . Second, the demand for food and raw materials is income inelastic while the demand for manufactures is elastic.[4] As a result, higher levels of world income will favor the demand for the goods produced in countries already industrialized.

The effects of technical change on prices reminds us about another interesting aspect. A country that experiences a deterioration in its terms of trade as it develops may end up with lower real income after growth [Meier, 1968]. This claim is known as "immiserizing growth"[Bhagwati, 1958]. Gerald Meier explains it succinctly:

> "For example, an increase in factor supply or technical progress would raise real income by the amount of the change in output at constant prices, but if the factor accumulation or "factor saving" is so export biased that the terms of trade worsen, the negative income effect of the actual deterioration in the terms of trade may then be greater than the positive effect of the expansion in output" (p.51).

The role of the terms of trade on economic performance, independently of short or long run analysis, is variable. It depends on the structure of the domestic markets, the reaction by the economic policy authorities to changes in this relative price, the degree of openness, the degree of specialization, the exchange rate regime and other international market conditions that each country faces. As an example of the multiple conditions that determine a particular result, let's take the model with three goods for a developing economy presented by[Agénor and Montiel, 2008]. An improvement in the terms of trade, say, because of a boom in commodity prices, may result in an appreciation in the real exchange rate that increases real wages in the sectors that produce importable goods. Aggregate output can fall due to this mechanism (Dutch Disease). This outcome occurs because the benefits to the booming sector are more than offset by the loss of competitiveness in the sector that produces importable goods. This argument extended to other exportable sectors is precisely one of the most used in the current debate in Colombia about the perverse effects of the terms of trade boom. The result, however, depends theoretically on critical assumptions about labor

[4] See [Feenstra, 2004], chapter 10, for a criticism of the theory of uneven development. For empirical studies i.e [Grilli and Yang, 1988], [Cuddington and Urzúa, 1989],[Ocampo and Parra, 2003], [Blattman et al., 2007], [Tytell and Spatafora, 2009]

markets and the degree of price flexibility (the market clearing conditions), among others. The most common assumption in this case is that the non-traded sector clears due to the variation of prices rather than by an adjustment in output. Furthermore, whether these effects are displayed in the long or short run depends also on the speed of adjustment of the markets involved.

Although twenty years ago economists who studied output fluctuations in developing countries found that most of literature was about developed countries, nowadays there are a good number of works that study the short run economic performance of small, developing economies. Several of these papers have had a particular emphasis on the effects of the terms of trade. [Mendoza, 1995], for instance, is probably the most influential paper about the relationship between the terms of trade the economic fluctuations. Working with an annual database for 30 countries that includes industrial and developing countries, Mendoza describes several macroeconomic empirical regularities that are used in the calibration of a three sector inter-temporal model for a small open economy. One of the suggested regularities, particularly interesting for our study, is a positive contemporaneous correlation between the cyclical component of real GDP and the cyclical component of the terms of trade (for most of the countries in his sample). Although explaining the magnitude differences requires deeper investigation, the mean of that correlation goes from 0.26 for the developing countries to 0.79 for the seven industrial countries (1965-1990). The reported correlations for the developing countries of the western hemisphere are: Brazil (0.76), Mexico (0.64), Peru (0.24), Chile (0.15), Argentina (0.10) and Venezuela (0.01), with a mean of 0.32.

Even though Mendoza does not include Colombia in his sample, other studies have reported a positive correlation for this country.[Suescun, 1997] observed that the relative price of coffee (in terms of imported goods) was procyclical and used this fact for the calibration of an open small economy model for Colombia that however failed to describe properly the volatility of the Colombian cycle as a result of the variation in coffee prices in international markets. [Agénor et al., 2000][5]examined the correlation for Colombia, Korea and Mexico using quarterly data and the cyclical components of the industrial output and the terms of trade (with both the Hodrick Prescott HP and the Band-Pass methodologies BP).

> "These three countries show a strong positive correlation between the cyclical components of industrial production and the terms of trade index.[6]For Colombia and Korea the BP filtered data yield the strongest correlations. This suggests that the positive relationship between output and the terms of trade might be obscured when using the HP filter because of the large amount of high frequency variation in the terms of trade data" (p.275)

[Parra, 2008], with quarterly data from 1994 to 2007, reports a correlation equal to 0.24 and [Mahadeva and Gómez, 2009] report a positive correlation between the terms of trade and real GDP per capita for Colombia equal to 0.32 (using annual data for 1970-2007).

For quarterly data from 1994 to 2009, I found a correlation that ranges from 0.15 to 0.45 depending on the variable used for the calculations: value added, real GDP, the cyclical component

[5] see also [Rand and Tarp, 2002]for a description of the stylized facts of the business cycles in developing countries

[6] The contemporaneous correlation for Colombia is 0.10 when HP used and 0.34 when BP. The authors also calculate the correlation for the fourth and eighth lags of the terms of trade

of GDP or different definitions of the terms of trade. These definitions will be presented in section 3.

Although the numbers suggest that the terms of trade are procyclical, further analysis is clearly necessary to estimate how the terms of trade may explain variability of the GDP. [Mendoza, 1995]obtained the following result once his model was calibrated: "TOT[7] shocks in the DC[8] model explain 37 percent and 56 percent of the actual variability of GDP at import prices and domestic prices respectively" (p. 127). This outcome depends of course on the particular setup of the three goods model (exportable, importable and non traded goods) built by Mendoza. In this particular framework, the dominant effect that explains the short run effect of the terms of trade on output is basically that a terms of trade gain induces an increase in the marginal profitability of the exportable sector, inducing an investment boom in the exportable sector. The additional investment corresponds to an international and domestic reallocation of capital. The latter comes from the importable goods sector (not from the non traded sector by assumption). Similarly, regarding labor allocation: "labor is inelastically supplied in traded-sector industries, and the labor supply response in the nontraded sector is negligible" (p.130).

The impact of a positive shock in the terms of trade on output is positive. Mendoza concludes in his Impulse Response Analysis (p.129):

> "GDP at import prices also booms, reflecting mainly the direct positive impact of TOT on the purchasing power of exports"

More crucial assumptions are present in [Mendoza, 1995]. One is that the nontraded market clears through a classical mechanism. This means that adjustment is driven by prices rather than by a change in output in this sector. Hence, the real exchange rate appreciates due to the price increase of the nontraded goods. Even though this is an standard result from the three-goods model, Mendoza recalls that different parameters could yield a different result: "A high labor elasticity combined with a low elasticity of substitution between traded and nontraded goods would strengthen the labor supply response in the nontraded sector and weaken the real appreciation" (p.131). Likewise, some offsetting effects are avoided because variability of the consumption of the importable goods is less than the variability in GDP and investment (the permanent income hypothesis holds).

After the short run impact, adjustment mechanisms start to work to drive the economy to the long run equilibrium that is by assumption equal to the initial equilibrium. The adjustment of the real exchange rate toward its long run equilibrium reduces the short run interest rate differential so that the foreign capital that entered to the domestic economy during the investment boom goes out. Investment displays a decline before reaching equilibrium and "The GDP boom weakens reflecting the declining purchasing power of exports and the adjustment of K[9] back to the initial level..." (p.131).

Although Mendoza's framework presents a plausible scenario for the positive correlation between the terms of trade and GDP in the short run, different theoretical assumptions could tell a

[7] terms of trade
[8] developing country
[9] capital

different story. Indeed, empirically, in his own sample, some countries displayed a negative correlation: Egypt (-0.455), Philippines (-0.285), Algeria (-0.234), Zaire (-0.107) and Tunisia (-0.309). These cases are not, however, covered by the general equilibrium model in his paper.

[Kose, 2002], who establishes some differences from Mendoza´s results, also uses a small open economy model as a tool to explain the positive correlation between the terms of terms and aggregate output. He finds that disturbances in the prices of capital goods and intermediate goods may account for 87.6% of the output variability.[10]

> "I now compare my decomposition results with some of the key related findings: [Mendoza, 1995] finds that terms of trade disturbances explain 56% of output fluctuations. This is smaller than what my variance decomposition results suggest. There are several reasons for this difference: first, I consider the role of intermediate inputs and sector specific capital goods without imposing any limit on the supply of capital in the non-traded goods sector, which constitutes a significant fraction of aggregate output in small open developing economies. Mendoza considers a model in which capital in the non-traded goods sector is inelastically supplied. Second, both sectors are directly affected by world price shocks since the primary sector uses imported capital goods and the non-traded sector employs imported intermediate inputs in my model. Terms of trade shocks only indirectly affect the non-traded goods sector in Mendoza's model because this sector does not employ any imported factor. Third, I consider the main import and export prices, which happen to be more volatile than the terms of trade. In particular, relative price shocks I employ are up to five times more volatile than productivity shocks. In Mendoza's model, terms of trade shocks are three times more volatile than productivity shocks." (p.318)

[Kose and Riezman, 1999] developed a general equilibrium model for a small open African economy, also to be calibrated. The model has two sectors: exportable primary goods and nontraded goods. The selection of a two goods model instead of a three goods model responds to the authors' interest in focusing on the prices changes of the main export and import items instead of terms of trade disturbances. Their result is that world prices shocks can explain around 45% of output fluctuations, basically because both the primary good and the nontraded sectors use imported capital goods as factors of production and therefore a decline in the international prices of imports leads to an expansion of aggregate output.

Likewise, relying on imported inputs as factors of production, and following a different strategy from [Mendoza, 1995], [Hoffmaister et al., 1998] studied macroeconomic fluctuations in two groups of Sub-Saharan Africa economies with different exchange rate regimes: CFA franc and non-CFA franc countries. Based on a long run economic model, they estimate, among several effects, the effect of shocks in the terms of trade (TOT) on GDP following a structural vector autoregression approach (VAR) with annual data from 1971 to 1993. The terms of trade shocks are captured theoretically by the price of intermediate inputs assuming that a positive change in this price acts as negative technological progress. This way, positive TOT shocks are positive supply shocks that relax the intermediate inputs constraint.

[10] His sample includes 28 non-oil exporting developing countries

> "In general, an improvement in the terms of trade and/or a structural reform that removes distortions leads to a positive response in total GDP in the long run"(p.138).

The VAR is restricted by two groups of theoretical assumptions. First, the small open economy assumption: domestic shocks do not affect the world interest rate or the country's terms of trade. Second, the long run level of output is not affected by nominal shocks (long run neutrality). The impulse response (for their model 1), which permits us to see the effect of shocks in the terms of trade not only in the long run but also on impact, are consistent with the expected positive relation between the terms of trade and GDP. In particular, in the CFA countries, a terms of trade shock leads on impact to an expansion of output of about 1/2 percent above the baseline and explains around nine percent of the variation of output in the first year. This result, along with others on the real exchange rate, supports the authors'conclusion that external shocks, especially terms of trade shocks, are important to understand output fluctuations in CFA countries.

On the other hand, in the non CFA franc countries, domestic supply shocks seem to be the most important variable in the determination of output fluctuations. Although the relation is still positive, the variation of output explained by the terms of trade shock, despite larger terms of trade shocks, is only 0.1% in the first year and 0.4% after ten years.

[Izquierdo et al., 2007], with quarterly data, observe the positive effects of the terms of trade over GDP in Latin America. Their results show that a positive terms of trade shock of one standard deviation generates a quarterly variation in the GDP growth rate equal to 0.21% in the second quarter after the shock for the seven countries included in their sample.[11]

Nevertheless, other studies undermine the role of international prices in explaining output fluctuations relative to domestic shocks. In a study of Brazil and Korea, [Hoffmaister and Roldos, 2001], again using a long run model, obtain a reduced form equation that relates GDP to the exogenous variables in the model: positively with the level of technology, negatively with the domestic price of imported intermediate inputs, and ambiguously with government spending. The parameters in the theoretical model´s relations are then estimated by a structural VAR in a similar way to the version that was referenced above for the African economies. The variance decompositions report that external shocks (world output, world interest rate and world import prices) account for about 25-30% of the output movements.

> "This evidence contrasts with the (simulation-based) evidence in [Mendoza, 1995] that suggests that terms of trade shocks are a much larger source of output movements in countries where the export base is concentrated in a few commodities, and points in the direction that domestic factors may be more important to understand macroeconomic fluctuations in small open economies" (p.233).

Similarly,[Ahmed, 2003]who studied the economic fluctuations of six Latin American economies (Argentina, Brazil, Chile, Colombia, Mexico and Venezuela) concludes:

> "A one standard deviation positive shock to the terms of trade, an improvement of about 12%, increases domestic output with the effect peaking after 1 year about a 1% rise; the level of output remains elevated in the long run, but only the 1 year lagged

[11] p.13

> effect is statistically significant. Even though these effects on output are of economically significant magnitude, the variance decompositions in table 1 show that the terms of trade shock explain less than 8% (statistically insignificant) of domestic output growth fluctuations at 1 to 6 year horizon" (p.193)

[Broda, 2004] also affirms that his evidence contrasts [Mendoza, 1995]. Broda finds that the contribution of terms of trade shocks accounts for less than 10% of actual real GDP volatility in countries with flexible exchange regime (working with a sample of 75 developing countries with annual data from 1973 to 1996).

Likewise, [Raddatz, 2007] challenges the emphasis given in the literature to external shocks, although he recognizes that the structure of some developing economies dependent on primary commodities may suggest that approach. Using a VAR model with annual data for 40 low-income countries and a variance decompositions analysis, Raddatz finds that exogenous external shocks, including the commodity prices, explain a small fraction of the total variance of the real per capita GDP in low income countries.

> "The general picture that emerges is that although external shocks have an economically meaningful effect on real activity, especially when compared with the average economic performance of low-income countries, they account for only a small fraction of the volatility of these countries´real GDP. To the extent that these shocks cover the most important external contingencies faced by the low-income countries, our results suggest that the economic instability experienced by these countries is largely the result of internal factor" (p.185)

Out of the literature that treats the terms of trade as the center of attention, this relative price has also been used as a control variable in explaining the relationship between the short run fluctuations of GDP and other variables in Latin American countries. Some examples are [Barro, 1979], [Edwards, 1983] and [Edwards, 1986]. Barro, who studied the effects of monetary policy on output in Mexico, Colombia and Brazil, includes the terms of trade in the equation for Mexico: "A measure of Mexican terms of trade (TT) which should have a positive effect on output" (p.185). His results confirmed the expectation of a positive effect. Likewise,[Edwards, 1983]includes the terms of trade in five cases: Brazil, Chile, Colombia, Mexico and Peru. The estimate of the parameter that relates terms of trade and output is however only significant in the equation for Chile and Mexico.

Focusing on testing the hypothesis that devaluation of the nominal exchange rate may have contractionary effects in the short run, [Edwards, 1986]also uses the terms of trade as a control variable. Different from [Barro, 1979], Edwards claims that "the terms of trade coefficient cannot be determined apriori" (p.503). Using a panel data that includes India, Sri Lanka, Malaysia, Philippines, Thailand, Greece, Israel, South Africa, Yugoslavia, Brazil, El Salvador, and Colombia for the period 1965-1980, Edwards concludes that:

> "...changes in the terms of trade have no perceptive effect on real output in developing countries" (p.506).

As far as I know, literature that present a negative effect of the variations in the terms of trade on short run output fluctuations are related to the effects on the real exchange rate and the nominal exchange rate. Nevertheless, it is not clear a priori that, for example, an appreciation of the nominal or the real exchange rates is going to decrease aggregate output unambiguously. First, as we have seen in the literature review, nontraded goods production could increase with a small change in the real exchange rate. In this case the increase in absorption due to the boom that expands the real income (a demand side effect) is adjusted by a change of output rather than by a change of prices. Second, an eventual appreciation of the nominal exchange rate, given a larger supply of foreign currency, could have expansionary effects on output like a nominal devaluation may have contractionary effects.

[Krugman and Taylor, 1978] is perhaps the most influential theoretical paper about the contractionary effects of devaluation. [12] It is important to summarize his main implications. First, total output rises or falls "depending on whether trade is initially in surplus or deficit" (p.449). A devaluation of the nominal exchange rate in the case when imports exceed exports results in a reduction of real income. This occurs basically because the devaluation raises not only export prices but also the prices of imports[13] that enter with fixed coefficients into the domestic production. Second, the authors permit a Kaleckian mechanism in their model. "Devaluation redistributes income from wages to profits and rent" (p.449). The increase in the price of imported inputs is automatically translated into an increase in the price of the home goods, which reduces real wages. Because the marginal propensity to consume is higher for workers than for capitalists, the redistribution from wages to profits reduces aggregate demand and the home output. Third, "if there are ad valorem taxes on exports or imports, higher traded goods prices will redistribute income to government" (p.450), affecting the profitability of the private sector and the home output.[14]Including a monetary approach in which the quantity theory holds, [Krugman and Taylor, 1978] also find that when the economic authorities follow a strategy of a constant monetary aggregate, "Devaluation by raising prices, increases the demand for nominal money at any given level of output and employment. The impact effect is contractionary, either more or less so than when the interest rates are held constant" (p.453). The effect on output occurs due to the short run deflation, as a classical negative feedback that adjust the positive shock on prices.

[Razmi, 2007] extends the theorethical framework of [Krugman and Taylor, 1978] and offers empirical evidence that supports one of his critical assumptions, that the pass-through from the nominal exchange rate into import prices is higher for developing countries than for industrial economies.[15]The extended framework, that includes the role of transnational corporations and the type of commercial partners for exports (either a developing or an industrialized economy) suggests that the likelihood of contractionary short-run effects of devaluation may be greater for developing

[12] See[Lizondo and Montiel, 1989] for a deep overview of the theory with a particular framework for developing countries

[13] prices in local currency

[14] This effect as the others could go in a different direction depending on specific features of the economy´s structure.

[15] In the particular case of Colombia, included in his sample (43 countries, 24 of them developing economies, and annual data for the period 1983-2003), Razmi estimates the effect of a variation in the nominal exchange rate on import prices that is around 0.45, significant at the 5% level. Similarly, [Rowland, 2004], with a monthly time series analysis (1983-2002), reports a pass through coefficient of 0.48 from the nominal exchange rate to the import prices after three months and 0.8 after one year

countries.[16]

In general, features of the Colombian economy seem to support the role of the terms of trade in the three goods model. Total exports represent around 1/6 of the total Colombian gross domestic product (GDP), and annual data for 2009 show that at least 57% of total Colombian exports correspond to commodities whose prices are determined in international markets with negligible Colombian market power (petroleum and derivatives 32%, coal 17%, coffee 5% and nickel 2%). Furthermore, around 80% of the imports are intermediate and capital goods. These shares suggest high exposure to changes in the external environment that may affect Gross Domestic Product (GDP).

The positive correlation between the terms of trade and GDP in Colombia, its special characteristics and the previous literature lead us to think of other channels through which the terms of trade may be relevant to understanding this country's economic performance in the short run. Take a commodity price boom as an example. Once the commodities' prices arise, extra profits will be generated for the firms linked directly or indirectly to the production of those commodities, fostering expansion of consumption and output in other sectors.[17] Additionally, with a higher level of wealth, the economy allows its agents to acces financial credit more easily,[18] which is also available thanks to the greater availability of foreign currency that relaxes the monetary constraints. This process boosts credit, investment, consumption and also profits for the financial system that nowadays accounts for around 18% of total Colombian value added (the most important sector). This is clearly plausible in Colombia where there has been a large accumulation of international reserves despite the Central Bank's inflation targeting policy with a flexible exchange rate regime.

In the same way, another reason for the procyclical terms of trade comes from the public sector. Around 60% of the total volume of exported oil is exported by Ecopetrol (National Enterprise of Petroleum). Some of the revenues obtained by this institution make up part of the revenues of the Non-financial Public Sector and it is also reasonable to expect that a commodity price boom that increases the profits of the firms and stimulates the economy through other channels will also expand tax revenues. The result is not necessarily a fiscal surplus. For instance, [Kaminsky, 2010] finds evidence of a procyclical fiscal policy in middle income countries when terms of trade shocks occur.[19]

Regarding international trade, after the United States and the European Community, Venezuela and Ecuador are the most important markets of the Colombian exports. These two countries are oil exporters and net buyers of Colombian manufactures. This means that a commodity price boom that increases the income of these commercial partners may also increase the demand for Colombian products. On the other hand, Colombian data shows that the current account moves in a different direction than the terms of trade. This means that a boom in the terms of trade is

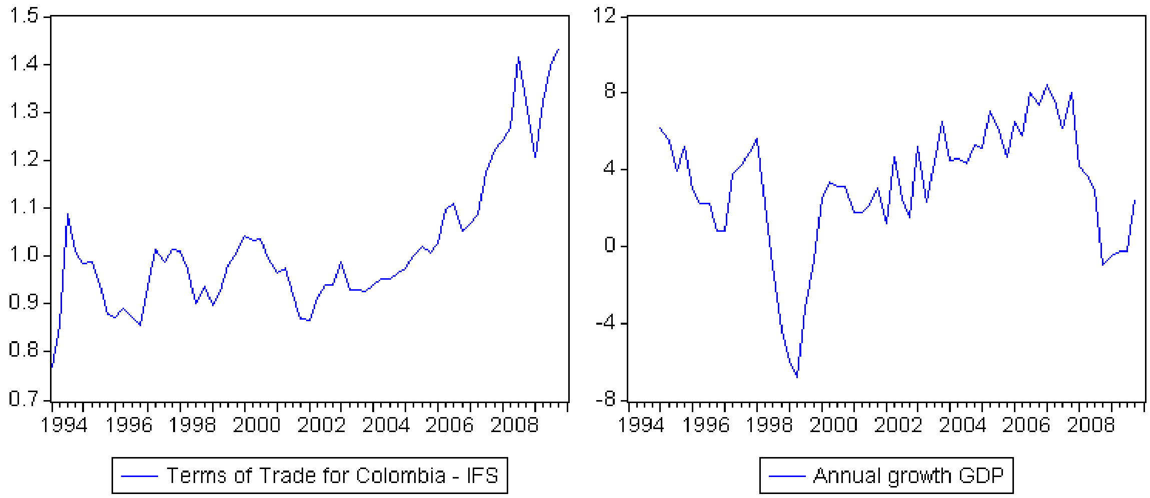
[16] As an opposite example,[Reinhart and Reinhart, 1991]finds that a devaluation is expansionary in the short run for Colombia in a simulation-based model for a Neo-Keynesian structure

[17] In the Colombian case we would expect a higher effect on the output in other sectors than in the sectors related to the four most important commodities. To illustrate this, the value added in mining is negatively correlated to the variation in the terms of trade despite oil, coal and nickel represent 51% of total exports.

[18] [Tenjo et al., 2007]describes, for example, a financial accelerator mechanism in Colombia

[19] see also i.e. [Tornell and Lane, 1999]and [Frankel, 2010]for institutional aspects that can explain this procyclical aspect in developing countries and [Medina, 2010] for Latin America.

Figure 1: Terms of trade for Colombia and GDP



accompanied by an increase of imports and a reduction of exports.[20]

In summary, the background literature contains several cases of positive, negative and null effects of the terms of trade. They motivate the following empirical question: to establish the magnitude of the net effect of the terms of trade on GDP variations in the short-run for the Colombian economy.

3 Empirical Strategy

This section aims to offer a parsimonious and robust time series model for Colombia for the period 1994-2009 to describe its output fluctuations using quarterly data, to estimate the partial effect of the terms of trade on GDP variations, and to test the significance of that estimate.

Our period of analysis was selected for several reasons. First, the data is easily available without substantial methodological changes in the national accounts and the balance of payments. Second, our analysis excludes one of the most important structural break points in the Colombian economic policy: the trade liberalization in the early nineties. [21]Third, the period includes the commodities prices boom that started in 2003, the subsequent downturn in the end 2008 (for the Colombian terms of trade)[22]and a recovery during 2009 (figure 1). In the same way, this period also includes the sharpest recession known in Colombian economic history (1999) and a period of high growth (2003-2007).[23] This feature of high variability in the database is convenient to test the ability of our model to describe important downturns and upturns.

Regarding the statistical procedure, this paper follows the Box-Jenkins technique for a univariate model. The type of model that is estimated is usually known in the literature as ARMAX,

[20] i.e [Obstfeld, 1982],[Svensson and Razin, 1983] and [Kent and Cashin, 2003]for a discussion about the effects of the terms of trade on the current account

[21] A further work might also examine if our findings for 1994-2009 can be extended to former periods. Before the nineties, the exportable structure was different and coffee was the main engine of the Colombian economy.

[22] the figure correspond to the ratio unit value total exports/ unit value total imports. An index calculated with the prices of the four most important commodities that Colombia export: petroleum, coal, coffee and nickel will also be used.

[23] probably related to the terms of trade

a model for stationary series with three components: first, the autoregressive part (AR), second, the moving average part (MA) and third, the set of other explanatory variables (X). The general model is thus:

$$y_t = \alpha + \sum_{p=1}^{n} \lambda_p y_{t-p} + \sum_{q=1}^{n} \theta_q \mu_{t-q} + \sum_{m=0}^{n} \gamma_{i,m} X_{i,t-m} + \mu_t \tag{3.1}$$

where y represents the dependent variable, a stationary series of the GDP, t time, μ the error, X the set of explanatory variables (also stationary) that includes the terms of trade and α, λ, θ andγ the parameters to estimate.

There are several reasons that justify the specification in equation 3.1 (See i.e [Montenegro, 2002]). First, stationary series reduce the possibility of spurious correlations due to similar trends between the dependent and an explanatory variable. Second, the Wold Decomposition shows that any stationary process can be approached through the combination of both the autoregressive and the moving average models. Third, the combination of both models contributes to the parsimony of the model once the autocorrelation of the errors that would affect our significance tests are taken into account[24] and fourth, the use of an ARMA model permits us to control for any possible persistence of the output fluctuations following the work by[Campbell and Mankiw, 1987].[25] Once the X variables are included, it is possible to interpret not only the contemporaneous effects on GDP but also to estimate the total effects of the explanatory variables over time.

Besides the ARMA specification and our key variable, the terms of trade (TOT), other control variable might be considered in X . From the aggregate demand side[26]: fiscal policy variables[27] and monetary variables[28]. Empirically, the first one, the public expenditure, is already included in the definition of GDP. However, a robustness test that includes public expenditure will be presented. The second, the set of monetary variables (policy instruments among them) are connected through two main final channels to GDP: interest rates and the nominal exchange rate. Interest rates are key variables in the determination of the investment component that corresponds to 1/4 of Colombian output. Although the consumption share is higher, approximately 2/3 of GDP, we can observe that the correlation between the variability of value added and the variability of investment is the highest in relation to other demand components (table 1. See column 1). Furthermore, investment is the most volatile component of aggregate demand (figure 2) and the component most correlated with the terms of trade (table 1. columns 11 and 12). Because the effect of changes in the terms of trade on aggregate output are correlated to changes in consumption and investment, the interest rate is quite an important control variable.

Inclusion of the nominal exchange rate will permit us not only to control for the effect of the terms of trade, but also to examine if the short run effects of a depreciation (or an appreciation) of the exchange rate is contractionary (or expansionary).

[24] The use of Least Squares when serial autocorrelation exists impedes the inference because the covariance matrix for the estimators given by the estimation is wrong.

[25] See also [Nelson and Plosser, 1982] and[Blanchard and Quah, 1989]for the discussion about the persistence of the output fluctuations.

[26] [Shapiro and Watson, 1988] divide the source of output fluctuations in demand and supply components

[27] i.e Edelberg et al., 1998

[28] see for example the St. Louis equation in Romer, 1996p.258

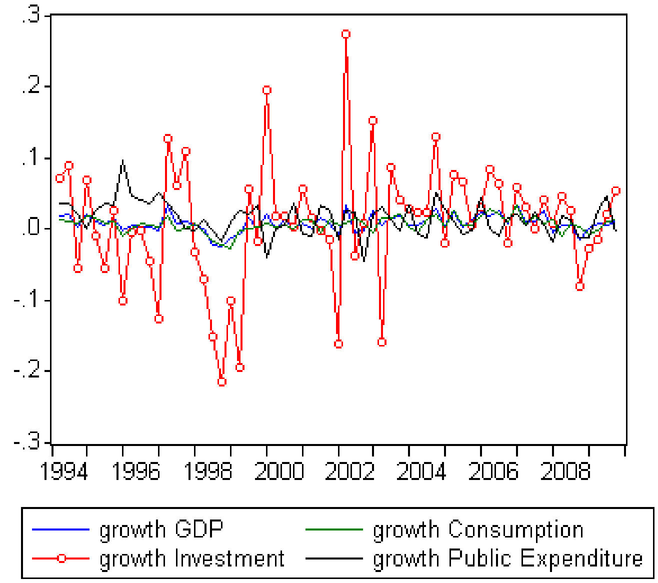
Table 1: Correlation matrix: value added by sectors, terms of trade, demand components

Correlation Matrix: value added by sectors, terms of trade and aggregate demand

All the variables correspond to the first difference of the logarithm

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1 Value added	1.00																
2 Agriculture, hunting, forestry and fishing	0.42	1.00															
3 Financial intermediation services	0.43	-0.10	1.00														
4 Wholesale, retail trade, restaurants and hotels	0.75	0.24	0.33	1.00													
5 Construction	0.56	0.23	0.11	0.23	1.00												
6 Electricity, gas and water supply	0.53	0.02	0.16	0.60	0.12	1.00											
7 Manufacturing	0.78	0.32	0.22	0.75	0.26	0.49	1.00										
8 Mining and quarrying	-0.11	-0.04	-0.14	-0.41	0.04	-0.25	-0.39	1.00									
9 Public administration services	0.32	0.11	-0.01	0.12	-0.18	0.35	0.12	-0.07	1.00								
10 Transport, storage and communication	0.67	0.17	0.18	0.59	0.12	0.45	0.61	-0.15	0.39	1.00							
11 Terms of Trade DLTOTCL	0.33	0.15	0.06	0.20	0.21	0.12	0.27	-0.08	0.18	0.18							
12 Terms of Trade DLTOTIFS	0.28	0.08	0.04	0.24	0.22	0.03	0.31	-0.12	0.07	0.12	0.61						
13 Consumption	0.58	0.11	0.31	0.83	0.07	0.50	0.58	-0.43	0.19	0.59	0.14	0.23	1.00				
14 Investment	0.75	0.36	0.15	0.64	0.54	0.50	0.72	-0.25	0.13	0.50	0.30	0.33	0.43	1.00			
15 Public Expenditure	0.23	0.17	0.00	0.05	-0.14	0.16	0.05	0.01	0.74	0.22	0.23	0.17	0.07	-0.01	1.00		
16 Exports	0.25	0.19	0.23	0.19	-0.10	0.08	0.20	0.19	0.05	0.34	-0.18	-0.16	0.10	-0.03	-0.14	1.00	
17 Imports	0.60	0.17	0.18	0.76	0.10	0.60	0.66	-0.40	0.27	0.63	0.22	0.28	0.69	0.80	0.12	0.16	1.00

Figure 2: Investment and GDP variability



The specification leaves aside technological shocks[29], which are an important element in the real business cycle literature. There are some reasons that justify this decision: first, it is unlikely the existence of technological shocks with enough variance that can explain variations of GDP quarter to quarter even with common theoretical amplifiers[30]; second, proxies of technical change, like total factor productivity are not usually reliable and third, despite the fact that a clear identification is impossible, it might be said that our ARMA is already controlling for the new information (innovations), including non-observable shocks that changes the output.

As another supply side shock, the climate phenomenon El Niño was considered in our analysis. I revised the multivariate ENSO (El Niño/Southern Oscillation Phenomenon) index [31] that is positive when the warm phase (El Niño) occurs. I examined the index directly as well as several dummy variables related to it (for example, if the quarter was in the warm phase or not; if the quarter was in a warm phase with an index that was one standard deviation higher than the average or not; if the absolute value of the index was relatively high to its average or not and some more). Although for some of these dummies the expected negative correlation was found in the case of the value added in agriculture, the evidence is not satisfactory to offer a clear explanation about aggregate output. There is not a systematic relation between El Niño and GDP for the period of analysis. On the other hand, our examination does not conclusively deny that El Niño can explain some variations in particular quarters.

Other sets of dummies might be suggested by the literature, especially from cross-country and panel data works: of electoral decisions and changes in government, financial crisis in related countries or capital account shocks were also explored as an exercise; however, the interpretation of some dummies in our time series analysis can be misleading. Selecting specific quarters (in

[29] Unless we think of terms of trade as technological shocks as we saw in some of the literature in section 2

[30] see i.e. Mankiw [1989]for a formal criticism over the real business cycle theory or Holland and Scott [1998]as an empirical defense for the technical changes to explain the business cycle in the United Kingdom.

[31] http://www.esrl.noaa.gov/psd/enso/enso.mei_index.html

which the dummy would be equal to 1) when an election period can be relevant to explain output fluctuations lacks a solid theoretical background. For example, the effects on investment of an electoral process could start one year before, sixth months before or the day in which the winner is announced. If there is no theory that supports the specification of this dummy, the estimate cannot be interpreted correctly. This point is also true for our comments on the climate changes.

Likewise, I am conscious of the omission of the expectations of economic agents and also the management of these expectations as an instrument of economic policy (i.e in monetary policy). This paper will not have them into account and of course this is a limitation of our work despite the difficulty of having a reliable proxy for that variable. Again, although some changes in expectations were approached by a dummy variable built from the short-run capital account, it is not clear either that a dummy is a good proxy of the expectations that may affect the aggregate outcome of the economy. To some extent, shocks to the capital account are going to be captured by the interest rates and the exchange rates.

Finally, the next step for our empirical strategy is to test our simple model. Even though in further research we can explore if particular events may explain what the model cannot [32], the main purpose of the study is not to obtain a forecasting model, but to evaluate the role of the terms of trade. The exclusion of the dummies is only crucial depending on the degree to which we expect that they can undermine the importance of the terms of trade. Finally, robustness checks will be performed.

3.1 Variables of the Model and Data Description

Gross domestic product (GDP)

The dependent variable is the first difference of the logarithm of GDP (DLGDP) for Colombia (approximately quarterly growth of the GDP) (figure 3). This transformation is necessary for two reasons: the economic meaning of the variable in terms of output fluctuations and the stationarity requirement in the Box-Jenkins technique. According to different tests, we reject the null hypothesis that this series has a unit root (The Dickey-Fuller tests for this and other variables are reported in the appendix 1). The weak stationarity of DLGDP is thus assumed.

The cyclical component of the GDP was also estimated through the Hodrick-Prescott filter (GDPCYCLE) as a proxy of the business cycle. This series is also stationary.

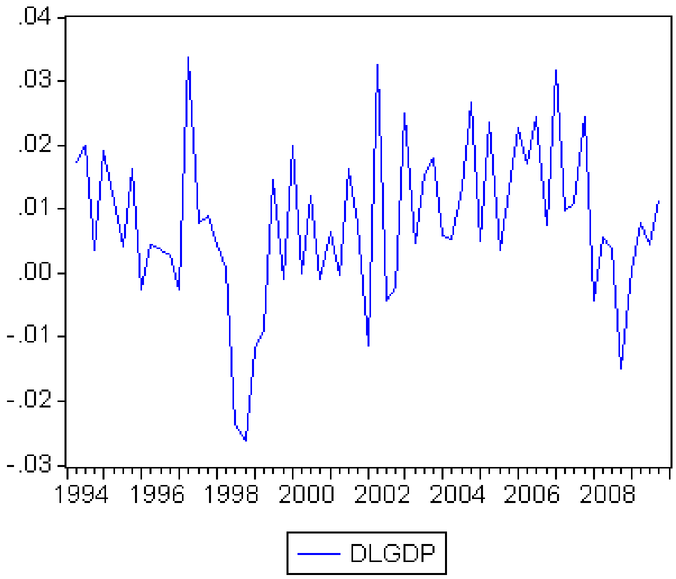
The quarterly data for GDP, already seasonally adjusted, was obtained from the Departamento Administrativo Nacional de Estadística-Dane (National Department of Statistics in Colombia).

Terms of trade (TOT) and related variables

Two definitions for the terms of trade (TOT) are used. The first was constructed with statistical information from the Balance of Payments from the Colombian Central Bank (Banco de la República de Colombia) and the International Financial Statistics (IFS). It corresponds to the ratio ($\frac{P_x}{P_I}$), where the denominator is the unit value of imports used by the IFS and the numerator is

[32] For example, the peak in the GDP for the first quarter of 2007 was accompanied by an extraordinary surplus in the short-run capital account due to a external public debt issue. However, concluding an economic interpretation is still complex. The effects and the reasons for that extraordinary issue are multiple.

Figure 3: First difference of the logarithm of the GDP (DLGDP)



Histogram of DLGDP

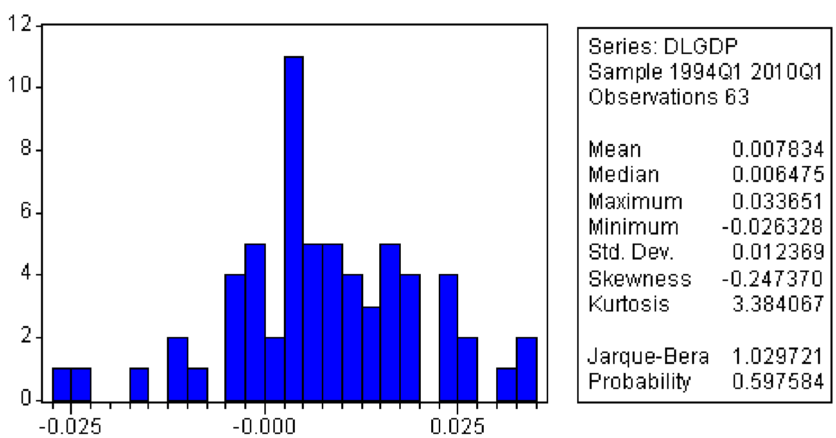
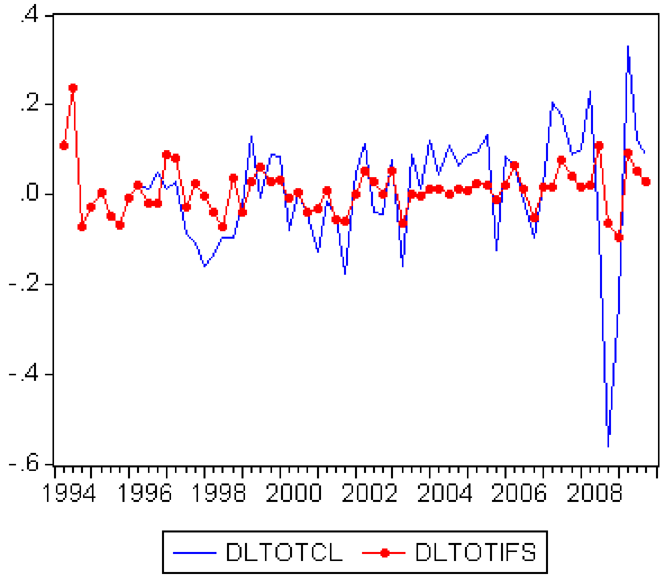


Figure 4: First difference of the logarithm of the terms of trade



a Laspeyre index for a basket of the most important Colombian exportable commodities (oil, coal, coffee and nickel). This variable is called TOTCL. I use the variable DLTOTCL (first difference of logarithm of TOTCL). The second definition is called TOTIFS, available from the International Financial Statistics (IFS) by the International Monetary Fund (IMF) which corresponds to the ratio between the unit value of total exports and the unit value of total imports. The transformed variable will be called DLTOTIFS (first difference of logarithm of TOTIFS)(figure 4).

Based on the terms of trade definitions and GDP, Figures 5 and 6 present the suggestive correlation between the output fluctuations and the variations in the terms of trade in Colombia. Figure 5 shows the simple correlation. Figure 6 shows the co-movement between the two cyclical components, obtained through the Hodrick-Prescott filter.

Our analysis is assuming from the dependent economy framework that the terms of trade are exogenous and that they cause the output fluctuations, not the other way around. This is a very plausible assumption given the Colombian economic features described in the background section. Additionally, a Granger causality test was performed. The test suggests that we cannot reject the null hypothesis that the GDP variations do not cause the variations of the terms of trade (table 2).[33]

In addition to our terms of trade definitions, I work with four more related variables: a Laspeyre index [34] for the prices of oil, coal, coffee and nickel (PXCL), the oil prices (OILPR)[35], the unit value of imports (PIIFS) and the unit value of exports (PXIFS).[36] Given that the notation DL means the first difference of the logarithm, the transformed variables are called DLPXCL, DLOILPR DLPIIFS and DLPXIFS respectively (figure 7). Similarly to the dependent variable, DLTOTIFS,

[33] Appendix 2 shows the test in the other direction.
[34] I also calculated the Paasche index that did not exhibit a substantial difference from the Laspeyre one
[35] Implicit prices of Colombian exports of oil. They correspond to the total value of exports / exported volume of oil. The information comes directly form the Colombian Balance of Payments where the values are expressed in American dollars.
[36] The last two from the International Financial Statistics

Figure 5: Correlation GDP and terms of trade

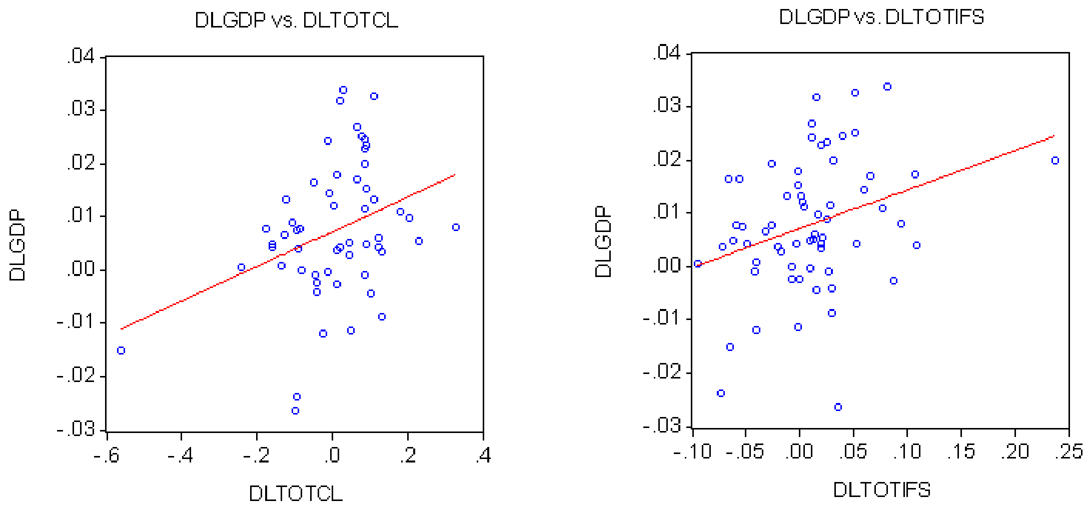


Figure 6: Business cycles and cycles of the terms of trade

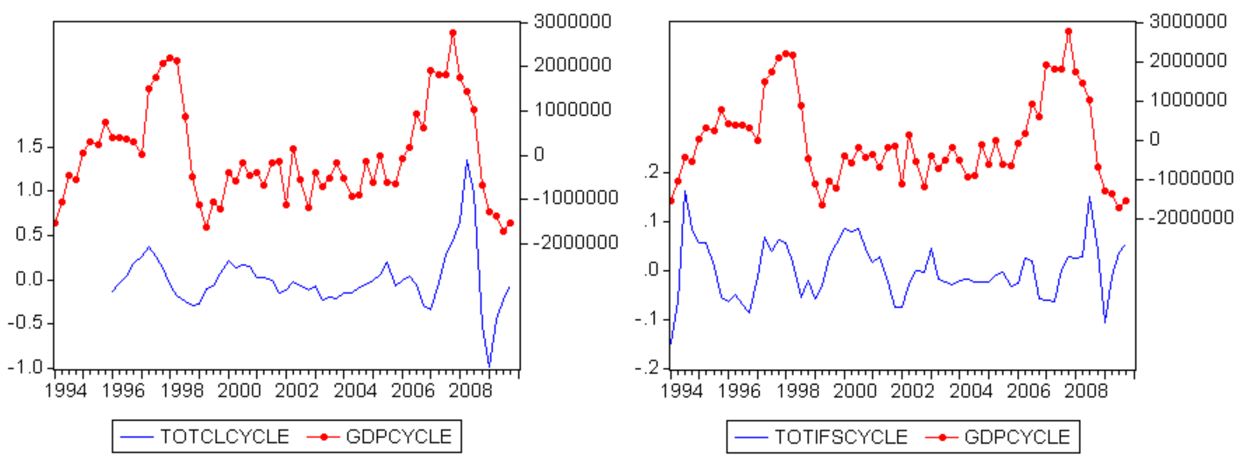


Table 2: Granger causality tests

P-value for Granger causality tests				
	Null Hypothesis: DLGDP (quarterly growth of the GDP) does not Granger cause Z			
Variable Z	lag length 4	lag length 3	lag length 2	lag length 1
Terms of Trade (with all exports) (DLTOTIFS)	0.66042	0.89958	0.91327	0.74141
Terms of Trade (four commodities) (DLTOTCL)	0.55380	0.84143	0.70921	0.82642
Unit Value of Exports (DLPXIFS)	0.25081	0.39914	0.32142	0.32587
Unit Value of Imports (DLPIIFS)	0.47624	0.44232	0.54587	0.35288
Price of Oil (DLOILPR)	0.51409	0.98746	0.96794	0.73056
Index price four commodities (DLPXCL)	0.45600	0.91805	0.79361	0.62366

DLTOTCL, DLPXCL and DLOILPR are stationary (see the appendix for some unit root tests).

Using different definitions from DLTOTIFS permits us to evaluate whether the variation in the relative prices of these four commodities are significantly correlated with output fluctuations, to narrow the set of possible theoretical mechanisms in the relationship between the terms of trade and GDP, and to study the separate effects from the price of exports and the price of importable goods.

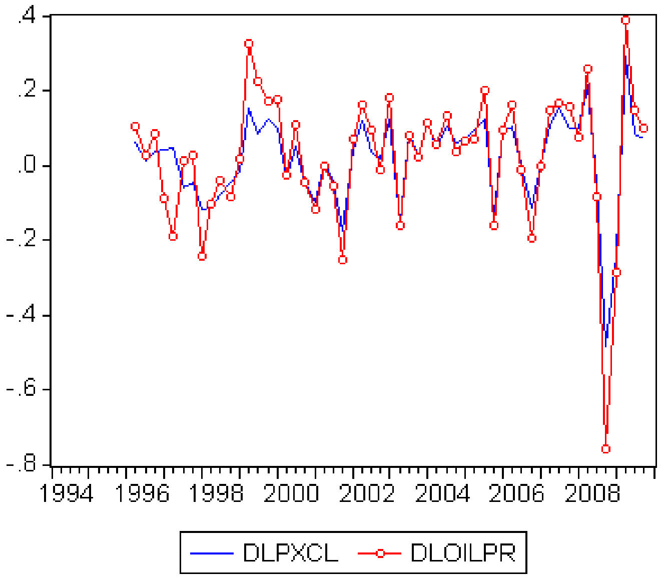
Lending Interest Rate (LIR) and Nominal Exchange Rate (NER)

Two control variables are included in the right hand side of our regression. The first is DLIR (the first difference of the lending interest rate). The lending rate was obtained from the Colombian Central Bank and corresponds to a weighted average of effective rates for the whole banking system including all types of credit (i.e. for investment and credit cards). The second is DLNER, the nominal depreciation of the exchange rate (the first difference of the logarithm of the nominal exchange rate)[37]. DLNER corresponds to quarterly depreciation of the exchange rate when the value is positive and to an appreciation when negative.

It is important to notice that the explanatory variables could be correlated as well. For instance, changes in the structure of interest rates along with some degree of capital mobility may put pressure on the exchange rate. The same can be said for the relationship between the terms of trade and interest rates, or between the terms of trade and the exchange rate. Additionally, we have to be careful with the fact that causation might be running in the other direction, for example, from GDP to the monetary variables. Regarding possible multicollinearity, Figure 8 shows that the Colombian data only shows a negative correlation between the terms of trade and the depreciation of the nominal exchange rate. Different specifications should let us avoid eventual shortcomings in

[37] also from the Colombian Central Bank

Figure 7: First difference of the logarithm of PXCL and OILPR



First difference of the logarithm of PIIFS and PXIFS

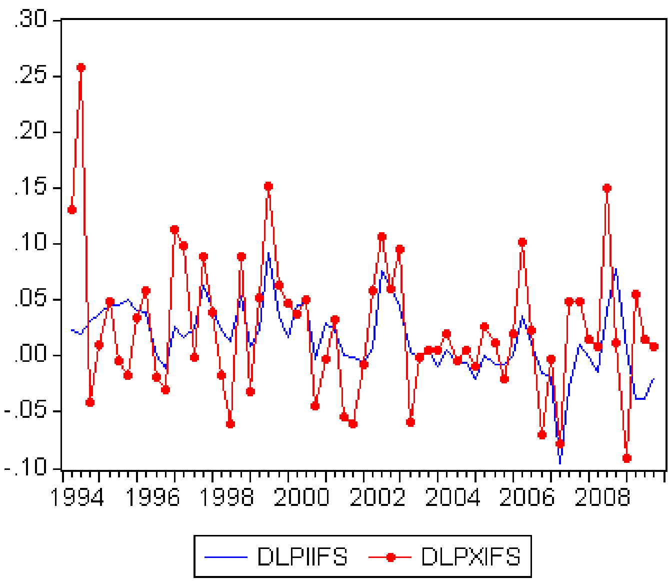
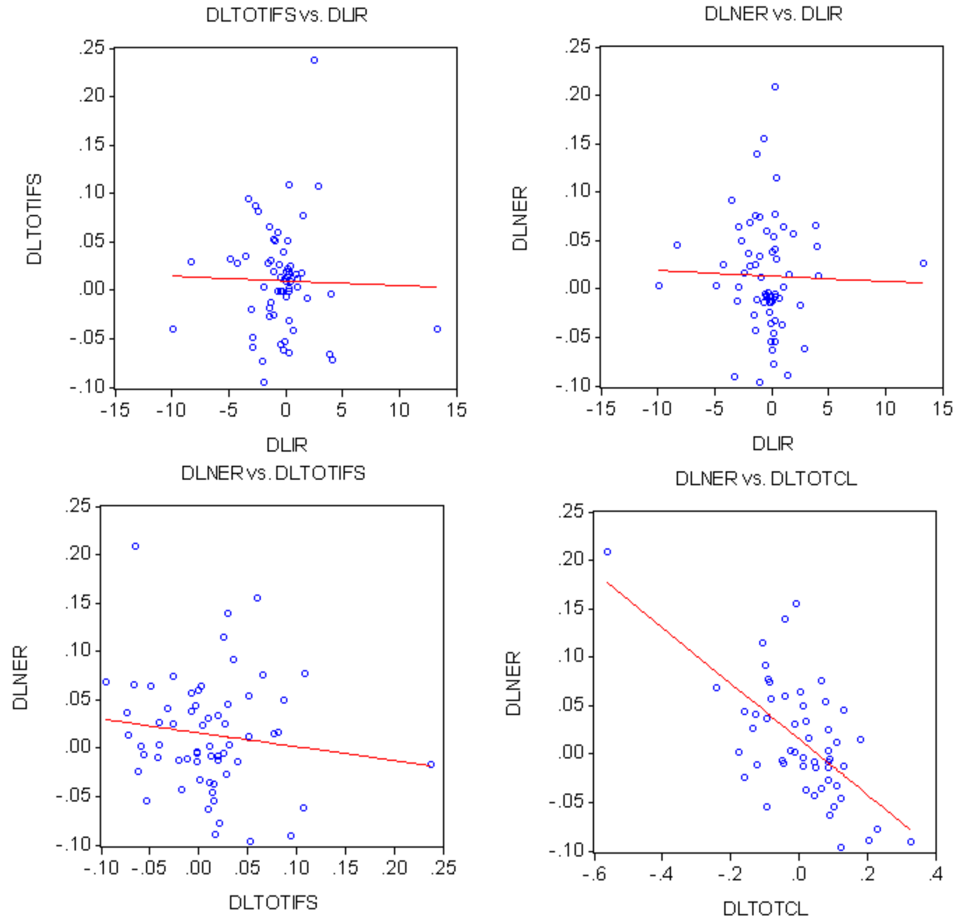


Figure 8: Simple correlations explanatory variables



our interpretation.

3.2 Model Specification and Results

The specification of the ARMA component of the model was based on the correlogram for the dependent variable. Both the autocorrelation and the partial correlation functions start falling after the third lag suggesting a specification around the ARMA(3,3). After observing different combinations, I decided to use the ARMA(2,4) without including the first lag for the autoregressive component and without the first and second lags for the moving average. The number of lags seem to be reasonable to interpret the effects on the dependent variable. Given our quarterly data, the second and fourth lags refer to one semester and one year lags respectively. Our basic ARMA model corresponds to:

$$DLGDP_t = \alpha + \lambda_2 DLGDP_{t-2} + \theta_3 \mu_{t-3} + \theta_4 \mu_{t-4} + \mu_t \tag{3.2}$$

where μ are the errors.

As table 3 shows, this basic specification seems to be robust once the other explanatory variables are added. While the estimates for the moving average can be associated with the effect of the statistical innovations, the positive and significant estimate in the autoregressive part suggests the existence of an important degree of persistence in the Colombian GDP fluctuations. All the estimates for this ARMA model (see regression 1) are significant at least at the 5% level. The ARMA model can explain 28% of the total variation in the dependent variable. The Durbin Watson statistic and the correlogram of the residual suggest that we do not have a problem with autocorrelation. Furthermore, given the assumption of weak stationarity, we are not concerned about heteroskedasticy. This means that we can rely on the t-statistics and the p-values that we use to establish significance at the 1%, 5% and 10% in table 3.

Regression 2 includes the first difference of the logarithm of the terms of trade for the four most important Colombian commodities (DLTOTCL):

$$DLGDP_t = \alpha + \gamma_1 DLTOTCL_t + \lambda_2 DLGDP_{t-2} + \theta_3 \mu_{t-3} + \theta_4 \mu_{t-4} + \mu_t \tag{3.3}$$

The estimate is significantly positive at 1% level. The magnitude of the estimate for the contemporaneous effect means that a 1% increase in the growth of the terms of trade increases in 0.018% the quarterly growth of GDP (holding other variables constant). This magnitude is important. One standard deviation in DLTOTCL equal to 13.56% will change the quarterly growth of GDP by 0.25%. This change is around 20% of one standard deviation in the quarterly growth of GDP. Once the persistence effect is calculated, the same standard deviation of DTOTLC is associated with a change in the quarterly GDP growth of around 0.37%[38] (30% of one standard deviation in the quarterly growth of the GDP). Therefore, we might say that according to our model around 1/3 of the variability in GDP quarterly growth is driven by the terms of trade for the four most important Colombian exportable commodities.

This effect is completely robust when the definition of the terms of trade is extended to include the unit value of all the Colombian exports (DLTOTIFS). In this case (regression 3) the estimate is higher (0.049) but the standard deviation of DLTOTIFS is lower (5.4%). The regressor is still explaining around 1/3 of the variation in GDP growth.

Regression 4 adds the first difference of the lending nominal interest rate (DLIR) lagged two quarters to the ARMA model[39]:

$$DLGDP_t = \alpha + \gamma_2 DLIR_{t-2} + \lambda_2 DLGDP_{t-2} + \theta_3 \mu_{t-3} + \theta_4 \mu_{t-4} + \mu_t \tag{3.4}$$

The estimate is statistically significant at the 1% level and negative as theory would suggest, especially if it captures the effect on investment. The magnitude of the estimate (for the contemporaneous effect) is, however, smaller than the magnitude for the terms of trade: -0.000908. This means that one standard deviation in DLIR (2.9%) would decrease the quarterly growth rate of GDP by -0.0026% (almost 100 times less than the effect of one standard deviation of the terms of trade). Regressions 8 and 9 include both the terms of trade and the lending interest rate:

[38] To get the total effect given the persistence, I used the estimate for the autoregressive component. The total effect will be equal to $0.018 * (1 + 0.32 + 032^2 + 0.32^3 ...) \approxeq \frac{0.018}{1-0.32} = 0.027$. Then $13.56 * 0.027 = 0.37$

[39] other lags and the contemporaneous form were not significant and excluded

$$DLGDP_t = \alpha + \gamma_1 DLTOTCL_t + \gamma_2 DLIR_{t-2} + \lambda_2 DLGDP_{t-2} + \theta_3 \mu_{t-3} + \theta_4 \mu_{t-4} + \mu_t \quad (3.5)$$

Both estimates are significant at the 5% level (and less), with the expected signs and similar estimates in comparison to the specifications in which the variables were included separately. Furthermore, the R squared increased from 0.33 and 0.38 to 0.48, improving the ability of the model to explain the quarterly GDP variations. It is clear that the use of all the time series information in our complete ARMAX model increases the percentage of variation that is explained by the model.[40]In addition, the F-test rejects the null hypothesis that all our estimates are equal to zero, showing that the explained sum of squares is relatively higher than the residual sum of squares.

Including the depreciation of the nominal exchange rate and the first difference of the logarithm of the nominal exchange rate (Col. pesos per US dollar) lagged one quarter (DLNER), was well received in regressions 5 and 7 but not in 6 when the other two variables (terms of trade and the lending interest rate) were included as well. Regressions 8 and 9 do not include DLNER in order to get a parsimonious model with all the effects significant (figure 9 shows the actual, fitted and residuals of regression 8). However, the significant negative sign for the nominal devaluation when the variable is included separately (or without the interest rate) supports the theories associated with the contractionary effects of devaluations commented on section 2 (namely that an appreciation may increase output in the short run).

In general, as the specification gets more complicated with the inclusion of more variables, when taking into account the ARMA components and the lagged forms of the explanatory variables, the relationships become less tractable and the significance of the estimates can be affected. This may occur due to some degree of multicollinearity between the lagged terms and the autoregressive component which could inflate the variance of the estimate and reduce its significance.

In summary, the estimate of the impact of the terms of trade on the output fluctuations is positive, significant, very important in magnitude, and robust to the inclusion of other important variables (see figure 10 for some partial correlation plots for DLTOTCL and DLTOTIFS in relation to DLGDP).[41]

In order to provide some robustness checks, table 4 shows some regressions that control for the quarterly variations of the US GDP. The results suggest that this variable does not affect the Colombian output unless the terms of trade are a possible mechanism. [42]

Econometric results (2) (table 5) report the effects of decomposing the price index of exports and the price index of imports. Different levels of aggregation in the sample of exportable goods are examined in regressions 12, 13 and 14. They confirm the positive effects of the prices of the most important Colombian exported commodities (oil, coal, coffee and nickel) on output. Regression 15 shows the estimate for the unit value of imports without any index for the exports and regression

[40] Regressions 10 and 11 show that the signs and magnitudes of our estimates are robust if the ARMA structure were removed.

[41] The set of other independent variables is composed by DLIR(-2) and DLGDP lagged two and three periods

[42] United States is the destination for approximately 40% of the total Colombian exports and 70% of the Colombian exported oil.

Table 3: Econometric Results (1)

Dependent variable: First Difference of Logarithm of GDP (DLGDP)
Method: Least Squares
MA derivatives use accurate numeric methods

Terms of Trade equal to:	1	2 (DLTOTCL)	3 (DLTOTIFS)	4	5	6 (DLTOTCL)	7 (DLTOTCL)	8 (DLTOTCL)	9 (DLTOTIFS)	10 (DLTOTIFS)	11 (DLTOTCL)
Constant	0.00752***	0.007460***	0.007259***	0.007114***	0.007935***	0.006782***	0.007702***	0.006568***	0.006811***	0.007473***	0.007084***
	(0.002335)	(0.002442)	(0.002411)	(0.002508)	(0.002193)	(0.002406)	(0.002359)	(0.002429)	(0.00257)	(0.00154)	(0.001645)
AR(2)	0.301423**	0.316435**	0.323033**	0.341024**	0.287768*	0.305298*	0.292644*	0.324005**	0.352134**		
	(0.148172)	(0.145102)	(0.137908)	(0.140779)	(0.145580)	(0.152136)	(0.146654)	(0.147239)	(0.133424)		
MA(3)	0.565445***	0.536161***	0.575699***	0.608194***	0.546958***	0.571979***	0.531594***	0.568050***	0.617092***		
	(0.077092)	(0.092885)	(0.085181)	(0.084603)	(0.082987)	(0.088147)	(0.097650)	(0.087620)	(0.089905)		
MA(4)	-0.405488***	-0.419524***	-0.38828***	-0.365899***	-0.433397***	-0.419463***	-0.433542***	-0.403123***	-0.34068***		
	(0.096232)	(0.103615)	(0.096184)	(0.086637)	(0.097222)	(0.114018)	(0.105385)	(0.114326)	(0.09332)		
TERMS OF TRADE		0.018079***	0.04917**			0.013760**	0.013225**	0.017547***	0.046765**	0.048664*	0.023753**
(DLTOTCL and DLTOTIFS)		(0.004878)	(0.022947)			(0.005931)	(0.005720)	(0.005081)	(0.022006)	(0.028317)	(0.009064)
LENDING INTEREST RATE				-0.000908***		-0.001161***		-0.001177***	-0.000907***	-0.000954	-0.001133*
(DLIR Lagged two quarters)				(0.000255)		(0.000333)		(0.000321)	(0.000261)	(0.000709)	(0.000597)
NOMINAL DEVALUATION					-0.033720***	-0.017684	-0.022851*			-0.038514	-0.031885
(NDEV Lagged one quarter)					(0.011340)	(0.014003)	(0.012152)			(0.025497)	(0.02638)
R squared	0.284831	0.362077	0.332203	0.382560	0.328808	0.491508	0.377814	0.480806	0.424681	0.160843	0.195189
Adjusted R squared	0.247190	0.308917	0.284503	0.337655	0.280865	0.425183	0.311624	0.425573	0.371411	0.117438	0.147847
Durbin Watson Stat	1.715103	1.808246	1.771280	1.784114	1.748307	1.813010	1.789207	1.841878	1.784321	1.938316	2.015731
F-statistic	7.567142	6.811051	6.964457	8.519372	6.858406	7.410592	5.708020	8.704988	7.972199	3.705656	4.122976
Prob (F-statistic)	0.000240	0.000200	0.000127	0.000020	0.000145	0.000014	0.000341	0.000007	0.000011	0.016507	0.01079
Number of observations	61	53	61	60	61	53	53	53	60	62	55
Time period	1994Q4 2009Q4	1996Q4 2009Q4	1994Q4 2009Q4	1995Q1 2009Q4	1994Q4 2009Q4	1996Q4 2009Q4	1996Q4 2009Q4	1996Q4 2009Q4	1995Q4 2009Q1	1994Q3 2009Q1	1996Q2 2009Q4

Consistent standard errors in parentheses, *significant at10%, **significant at 5%, ***significant at 1%, (-1), (-2) mean variable lagged 1 and 2 periods respectively.

Figure 9: Results regression number 8

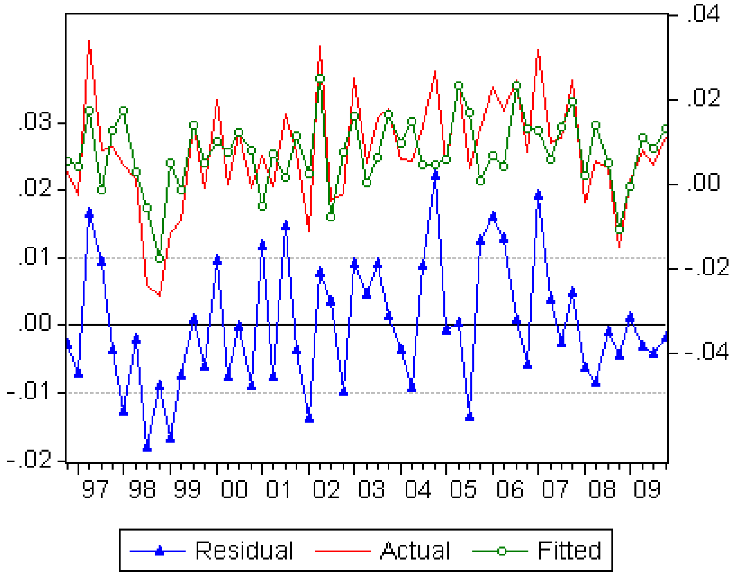


Figure 10: Partial correlation plots

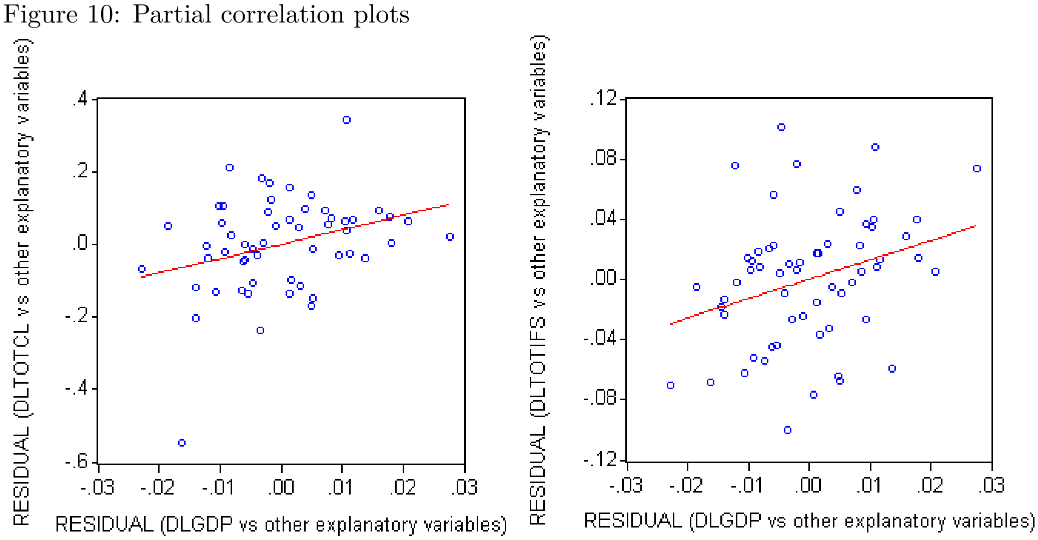


Table 4: Controlling for US GDP

Method: Least Squares
MA derivatives use accurate numeric methods
Constant, AR(2), MA(3) and MA(4) included in regressions but not reported

DEPENDENT VARIABLE:	8 **DLGDP**	**DLGDP**	**DLGDP**	**DLGDP**
TERMS OF TRADE	0.017547***		0.017809***	0.014924**
(DLTOTCL)	(0.005081)		(0.006297)	(0.006096)
LENDING INTEREST RATE	-0.001177***			-0.001243***
(DLIR Lagged two quarters)	(0.000321)			(0.000306)
USA GDP		0.231881	0.020691	0.149890
(DLUSGDP)		(0.167884)	(0.216267)	(0.194470)
R squared	0.480806	0.302772	0.362156	0.489636
Adjusted R squared	0.425573	0.25297	0.294300	0.423067
Durbin Watson Stat	1.841878	1804815	1.816211	1923367
F-statistic	8.704988	6079524	5.337144	7355305
Prob (F-statistic)	0.000007	0.00039	0.000578	0.000015
Number of observations	53	61	53	53
Time period	1996Q4 2009Q4	1994Q4 2009Q4	1996Q4 2009Q4	1996Q4 2009Q4

Consistent standard errors in parentheses, *significant at10%, **significant at 5%
***significant at 1%

16 includes both the unit value of exports and the unit value of imports. Previous results are still robust in terms of the direction, magnitude and significance. While 12, 13 and 14 confirm the importance of the commodities prices, in particular oil prices, regression 16 recalls also the importance of the unit value of imports. The estimation of the terms of trade ($\frac{P_x}{P_I}$), divided in its two components, displays the expected signs and significance. This robustness check shows that is not only one component of the terms of trade which is determining the output in the short run, it is both the price of exports and the price of imports. This is quite an important result that supports, in accordance with the three-goods model for a developing country, that the purchasing power of exports (in terms of imported inputs) may be the channel through which terms of trade and output are connected.

As another check of robustness and in line with the literature on business cycles, econometric results (3) (table 6) suggest that the background presented in this paper is also relevant to explain the cyclical component of quarterly GDP through the cyclical components of the variables related to the terms of trade.[43]

The last robustness test includes different components of aggregate demand in regression number 8. We know, by definition, that these components must be correlated to GDP. What we do not know is if the effect of the terms of trade holds once we include those components. Econometric Results (4) (table 6) shows that even when the growth of consumption, growth of public expenditure or the growth of exports are included, the estimates for the terms of trade and the lending interest rate are robust. Regressions 24 and 26, however, give us more information. First, in regression 24, the estimate of the public expenditure effect is not significant at the 5% level. This suggests that the correlation between the terms of trade and public expenditure may be creating some variance inflation that affects the significance. Second, in regression 26, which includes the

[43] All the cyclical components were obtained by the filter Hodrick-Prescott. Their stationarity was also tested.

Table 5: Econometric Results (2)

Dependent variable: First Difference of Logarithm of GDP (DLGDP)
Method: Least Squares
MA derivatives use accurate numeric methods

	8 **Z=DLTOTCL** **Terms of Trade** (four commodities)	9 **Z=DLTOTIFS** **Terms of Trade** (all exported goods)	12 **Z=DLOILPR** **Price index exports** (only oil)	13 **Z=DLPXCL** **Price index exports** (four commodities)	14 **Z=DLPXIFS** **Price index exports** (all exports)	15	16 **Z=DLPXIFS** **Price index exports** (all exports)
Constant	0.006568***	0.006811***	0.006547**	0.006396***	0.006808**	0.007944***	0.007514***
	(0.002429)	(0.002570)	(0.002568)	(0.002524)	(0.002655)	(0.00229)	0.002521
AR(2)	0.324005**	0.352134**	0.311522**	0.328263**	0.342276**	0.35382**	0.359251**
	(0.147239)	(0.133424)	(0.148726)	(0.144122)	(0.135785)	(0.152924)	0.144946
MA(3)	0.568050***	0.617092***	0.593752***	0.571687***	0.622091***	0.55373***	0.597257***
	(0.087620)	(0.089905)	(0.093395)	(0.089607)	(0.094137)	(0.090233)	0.097348
MA(4)	-0.403123***	-0.340680***	-0.364075***	-0.388490***	-0.343055***	-0.437585***	-0.368951***
	(0.114326)	(0.093320)	(0.109680)	(0.114158)	(0.091827)	(0.094078)	0.097023
LENDING INTEREST RATE	-0.001177***	-0.000907***	-0.001147***	-0.001161***	-0.000912***	-0.000943***	-0.000919***
(DLIR Lagged two quarters)	(0.000321)	(0.000261)	(0.000332)	(0.000326)	(0.000255)	(0.000285)	0.000262
Z	0.017547***	0.046765**	0.010318**	0.017622***	0.016376		0.044642*
	(0.005081)	(0.022006)	(0.004225)	(0.005960)	(0.022193)		0.023826
UNIT VALUE OF IMPORTS						-0.0646**	-0.100166***
(DLPIIFS)						(0.028122)	0.027679
R squared	0.480806	0.424681	0.458061	0.471256	0.389668	0.413762	0.449751
Adjusted R squared	0.425573	0.371411	0.400408	0.415007	0.333156	0.359480	0.387459
Durbin Watson Stat	1.841878	1.784321	1.788954	1.815943	1760753	1.861581	1.843274
F-statistic	8.704988	7.972199	7.945124	8.377985	6895294	7.622542	7.220012
Prob (F-statistic)	0.000007	0.000011	0.000017	0.000010	0.000048	0.000018	0.000012
Number of observations	53	60	53	53	60	60	60
Time period	1996Q4 2009Q4	1995Q4 2009Q1	1996Q4 2009Q4	1996Q4 2009Q4	1995Q1 2009Q4	1995Q1 2009Q4	1995Q1 2009Q4

Consistent standard errors in parentheses, *significant at10%, **significant at 5%, ***significant at 1%

Table 6: Econometric Results (3)

Dependent variable: cyclical component of the GDP (GDPCYCLE)				
Method: Least Squares				
In all the regressions AR(1) and MA(2) were included (not reported) with estimates significant at 1% or less				
Explanatory variables Cyclical components		R squared	Durbin-Watson	F-statistic
17. Terms of Trade (with all exports)	2541280**	0.753025	1.950565	5996355
(TOTIFS-CYCLE)	(1032001)			
18. Terms of Trade (four commodities)	512213.7**	0.753815	1.954073	52.05380
(TOTCL-CYCLE)	(210773.8)			
19. Unit Value of Exports	2681.049	0.734017	1.923223	54.27283
(PXIFS-CYCLE)	(8811.369)			
20. Unit Value of imports	-22204.13	0.742609	1.974296	56.74121
(PIIFS-CYCLE)	(16249.13)			
21. Price of Oil	14218.48**	0.752865	1.944413	51.78831
(OILPR-CYCLE)	(5748.527)			
22. Index price four commodities	6441.935**	0.754864	1.948890	52.34918
(PXCL-CYCLE)	(2555.627)			
23.Unit Value of Exports	31624.22***	0.758451	1.947747	45.52922
(PXIFS-CYCLE)	(11867.82)			
and Unit Value of imports	-65296.22*			
(PIIFS-CYCLE)	(35233.76)			
Consistent standard errors in parentheses, *significant at10%, **significant at 5%, ***significant at 1%				

Table 7: Econometric Results (4)

Method: Least Squares								
MA derivatives use accurate numeric methods								
Constant, AR(2), MA(3) and MA(4) included in regressions 8 and 24 to 27 but not reported								
	8	**24**	**25**	**26**	**27**	**28**	**29**	**30**
DEPENDENT VARIABLE:	**DLGDP**	**DLGDP**	**DLGDP**	**DLGDP**	**DLGDP**	**DLPUBEX**	**DLINV**	**DLCONSUM**
TERMS OF TRADE	0.017547***	0.0139**	0.015761**	0.008437	0.023183***	0.034791**	0.179738***	0.010095
(DLTOTCL)	(0.005081)	(0.0057)	(0.005937)	(0.006232)	(0.005561)	(0.013421)	(0.061471)	(0.008936)
LENDING INTEREST RATE	-0.001177***	-0.000968**	-0.000923***	-0.000471	-0.001206***	-0.001194*	-0.007623*	-0.000602
(DLIR Lagged two quarters)	(0.000321)	(0.000378)	(0.000316)	(0.000301)	(0.000282)	(0.000615)	(0.004097)	(0.000701)
PUBLIC EXPENDITURE		0.062362						
(DLPUBEX)		(0.057232)						
CONSUMPTION			0.467377***					
DLCONSUM)			(0.100836)					
INVESTMENT				0.098556***				
(DLINV)				(0.01373)				
EXPORTS					0.070840***			
(DLEX)					(0.024761)			
R squared	0.480806	0.493389	0.628432	0.665025	0.517925	0.080591	0.154578	0.043799
Adjusted R squared	0.425573	0.427309	0.579967	0.621333	0.455046	0.045229	0.122062	0.007022
Durbin Watson Stat	1.841878	1.940794	2.464994	1.794988	1.792884	1.882330	2.133770	1.331776
F-statistic	8.704988	7.466578	12.96663	1522064	8.236810	2.279032	4753885	1.190929
Prob (F-statistic)	0.000007	0.000013	0.000000	0.000000	0.000004	0.112520	0.012703	0.312091
Number of observations	53	53	53	53	53	55	55	55
Time period	1996Q4 2009Q4	1996Q4 2009Q4	1996Q4 2009Q4	1996Q4 2009Q4	1996Q4 2009Q4	1996Q4 2009Q4	1996Q4 2009Q4	1996Q4 2009Q4
Consistent standard errors in parentheses, *significant at10%, **significant at 5%, ***significant at 1%								

investment, the estimate of terms of trade effect on GDP stops being significant (for the first time). Similarly, something is occurring due to the correlation between terms of trade and investment. Regressions 28 and 29 show that the variables used to explain the performance of short run GDP are still correlated with the public expenditure and the investment. These tests of robustness hence permitted us not only to ratify the significant role of the terms of trade but also to suggest on a more detailed level that the effects on aggregate output may be occurring because of the positive effects of the terms of trade on investment and public expenditure. As mentioned in the beginning of this section, investment is the component of aggregate demand whose changes are the most correlated with the changes in the GDP.

4 Concluding remarks

Although it is sometimes claimed that the positive correlation between the terms of trade and aggregate output can be established apriori, a vast literature describes the complexity in the relationship of these two variables. First, not only a positive but also a negative correlation has been found in some developing countries. Second, the usual theoretical framework used to describe open small economies permits outcomes in which the relationship can be negative or null. Everything depends on the plausibility of the assumptions made for a particular economy and the way in which domestic markets adjust after external shocks. The idea of an ambiguous effect has lately been part of a debate in Colombia about the perverse effects of the terms of trade and the well known Dutch Disease. This outcome that is commonly associated with the long run might also act in the short run depending on how fast possible contractionary effects of a commodity price boom can be transmitted.

The estimate of the impact of the terms of trade on the GDP is, however, not only significantly positive but also very important in magnitude. Around 1/3 of the variation in quarterly GDP growth could be explained by one standard deviation in the growth of the terms of trade (holding other variables constant). The results are robust to different decompositions of the terms of trade and the inclusion of two control variables: the nominal lending interest rate and depreciation of nominal exchange rate. The positive effect of the terms of trade is much higher (100 times) than the significant negative effect (in absolute value) of one standard deviation in the change of the lending interest rate.

In addition, depreciation of the nominal exchange rate seems to have a negative effect on output in the short run. This preliminary result could support the theory of contractionary effects of a depreciation. This might be important when analyzing potential policies to control, for example, the appreciation of the nominal exchange rate that Colombia is experiencing. Likewise, some long-run analysis that suggest devaluation is a convenient tool for growth, if applied to Colombia, could need to take into account the short run dynamic that would describe an initial cost in the terms of output.

In summary, robust evidence supporting the hypothesis that the terms of trade have a very important role in the determination of the short-run variations of the Colombian GDP in the period 1994-2009 is found. Different models and tests for stationary series along with the particularities of the Colombian economy suggest that the terms of trade are exogenous and a source of the output fluctuations as described in the three-goods model for a dependent economy. The evidence also indicates that investment may be the most important demand component driving the aggregate outcome. At least in the short run, the evidence does not indicate that the negative effects of the terms of trade (Dutch Disease), if they exist, can offset the positive effects on aggregate output.

Appendix 1: unit root tests

Null Hypothesis: DLGDP has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.878121	0.0038
Test critical values:	1% level	-3.542097	
	5% level	-2.910019	
	10% level	-2.592645	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DLGDP)
Method: Least Squares
Date: 05/05/10 Time: 11:44
Sample (adjusted): 1994Q4 2009Q4
Included observations: 61 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLGDP(-1)	-0.639216	0.164826	-3.878121	0.0003
D(DLGDP(-1))	-0.282031	0.124597	-2.263550	0.0274
C	0.004671	0.001998	2.338363	0.0228

R-squared	0.491122	Mean dependent var	-0.000141
Adjusted R-squared	0.473574	S.D. dependent var	0.016564
S.E. of regression	0.012018	Akaike info criterion	-5.956897
Sum squared resid	0.008377	Schwarz criterion	-5.853084
Log likelihood	184.6854	F-statistic	27.98810
Durbin-Watson stat	2.106772	Prob(F-statistic)	0.000000

Null Hypothesis: DLTOTCL has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.653277	0.0000
Test critical values:	1% level	-3.560019	
	5% level	-2.917650	
	10% level	-2.596689	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DLTOTCL)
Method: Least Squares
Date: 05/05/10 Time: 16:14
Sample (adjusted): 1996Q4 2009Q4
Included observations: 53 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLTOTCL(-1)	-0.912704	0.161447	-5.653277	0.0000
D(DLTOTCL(-1))	0.299268	0.136158	2.197946	0.0326
C	0.005414	0.017654	0.306695	0.7603

R-squared	0.405858	Mean dependent var	0.001424
Adjusted R-squared	0.382093	S.D. dependent var	0.163379
S.E. of regression	0.128427	Akaike info criterion	-1.211970
Sum squared resid	0.824678	Schwarz criterion	-1.100444
Log likelihood	35.11720	F-statistic	17.07750
Durbin-Watson stat	1.939870	Prob(F-statistic)	0.000002

Null Hypothesis: DLTOTIFS has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.084088	0.0000
Test critical values:	1% level	-3.540198	
	5% level	-2.909206	
	10% level	-2.592215	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DLTOTIFS)
Method: Least Squares
Date: 09/03/10 Time: 17:33
Sample (adjusted): 1994Q3 2009Q4
Included observations: 62 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLTOTIFS(-1)	-0.884325	0.124833	-7.084088	0.0000
C	0.007212	0.006874	1.049194	0.2983

R-squared	0.455458	Mean dependent var	-0.001286
Adjusted R-squared	0.446382	S.D. dependent var	0.071631
S.E. of regression	0.053298	Akaike info criterion	-2.994123
Sum squared resid	0.170438	Schwarz criterion	-2.925506
Log likelihood	94.81782	F-statistic	50.18430
Durbin-Watson stat	1.920810	Prob(F-statistic)	0.000000

Null Hypothesis: DLPXCL has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.775395	0.0000
Test critical values:	1% level	-3.560019	
	5% level	-2.917650	
	10% level	-2.596689	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DLPXCL)
Method: Least Squares
Date: 09/03/10 Time: 17:37
Sample (adjusted): 1996Q4 2009Q4
Included observations: 53 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLPXCL(-1)	-0.956780	0.165665	-5.775395	0.0000
D(DLPXCL(-1))	0.288203	0.135758	2.122925	0.0387
C	0.017242	0.016272	1.059577	0.2944

R-squared	0.422143	Mean dependent var	0.001047
Adjusted R-squared	0.399029	S.D. dependent var	0.150551
S.E. of regression	0.116711	Akaike info criterion	-1.403301
Sum squared resid	0.681067	Schwarz criterion	-1.291775
Log likelihood	40.18749	F-statistic	18.26329
Durbin-Watson stat	1.977345	Prob(F-statistic)	0.000001

Null Hypothesis: DLPXIFS has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.136832	0.0000
Test critical values:	1% level	-3.540198	
	5% level	-2.909206	
	10% level	-2.592215	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DLPXIFS)
Method: Least Squares
Date: 09/03/10 Time: 17:38
Sample (adjusted): 1994Q3 2009Q4
Included observations: 62 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLPXIFS(-1)	-0.894576	0.125346	-7.136832	0.0000
C	0.020618	0.008395	2.456075	0.0170

R-squared	0.459140	Mean dependent var	-0.001960
Adjusted R-squared	0.450125	S.D. dependent var	0.082569
S.E. of regression	0.061228	Akaike info criterion	-2.716712
Sum squared resid	0.224929	Schwarz criterion	-2.648095
Log likelihood	86.21807	F-statistic	50.93436
Durbin-Watson stat	1.949602	Prob(F-statistic)	0.000000

Null Hypothesis: DLOILPR has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.958722	0.0000
Test critical values:	1% level	-3.560019	
	5% level	-2.917650	
	10% level	-2.596689	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DLOILPR)
Method: Least Squares
Date: 05/05/10 Time: 16:17
Sample (adjusted): 1996Q4 2009Q4
Included observations: 53 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOILPR(-1)	-0.977238	0.164001	-5.958722	0.0000
D(DLOILPR(-1))	0.318162	0.134547	2.364683	0.0220
C	0.021993	0.023464	0.937315	0.3531

R-squared	0.432601	Mean dependent var	0.001343
Adjusted R-squared	0.409905	S.D. dependent var	0.219962
S.E. of regression	0.168970	Akaike info criterion	-0.663257
Sum squared resid	1.427537	Schwarz criterion	-0.551731
Log likelihood	20.57630	F-statistic	19.06072
Durbin-Watson stat	1.942847	Prob(F-statistic)	0.000001

Null Hypothesis: DLPIIFS has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.266146	0.0011
Test critical values:	1% level	-3.540198	
	5% level	-2.909206	
	10% level	-2.592215	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DLPIIFS)
Method: Least Squares
Date: 09/03/10 Time: 17:42
Sample (adjusted): 1994Q3 2009Q4
Included observations: 62 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLPIIFS(-1)	-0.474742	0.111281	-4.266146	0.0001
C	0.006746	0.003885	1.736370	0.0876

R-squared	0.232737	Mean dependent var	-0.000674
Adjusted R-squared	0.219949	S.D. dependent var	0.030972
S.E. of regression	0.027354	Akaike info criterion	-4.328164
Sum squared resid	0.044895	Schwarz criterion	-4.259547
Log likelihood	136.1731	F-statistic	18.20000
Durbin-Watson stat	1.847489	Prob(F-statistic)	0.000072

Null Hypothesis: DLIR has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.255725	0.0000
Test critical values:	1% level	-3.536587	
	5% level	-2.907660	
	10% level	-2.591396	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DLIR)
Method: Least Squares
Date: 09/03/10 Time: 17:43
Sample (adjusted): 1994Q2 2010Q1
Included observations: 64 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLIR(-1)	-0.616359	0.117274	-5.255725	0.0000
C	-0.263359	0.344399	-0.764691	0.4474

R-squared	0.308211	Mean dependent var	-0.001406
Adjusted R-squared	0.297053	S.D. dependent var	3.251579
S.E. of regression	2.726188	Akaike info criterion	4.874437
Sum squared resid	460.7901	Schwarz criterion	4.941902
Log likelihood	-153.9820	F-statistic	27.62265
Durbin-Watson stat	1.912616	Prob(F-statistic)	0.000002

Null Hypothesis: DLNER has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.624217	0.0000
Test critical values:	1% level	-3.538362	
	5% level	-2.908420	
	10% level	-2.591799	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DLNER)
Method: Least Squares
Date: 09/03/10 Time: 17:43
Sample (adjusted): 1994Q3 2010Q1
Included observations: 63 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLNER(-1)	-0.745610	0.132571	-5.624217	0.0000
D(DLNER(-1))	0.269082	0.122985	2.187916	0.0326
C	0.011547	0.006751	1.710249	0.0924

R-squared	0.352497	Mean dependent var	0.000857
Adjusted R-squared	0.330914	S.D. dependent var	0.062852
S.E. of regression	0.051412	Akaike info criterion	-3.051460
Sum squared resid	0.158589	Schwarz criterion	-2.949406
Log likelihood	99.12099	F-statistic	16.33186
Durbin-Watson stat	1.940547	Prob(F-statistic)	0.000002

Null Hypothesis: GDPCYCLE has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.101559	0.0020
Test critical values:	1% level	-3.544063	
	5% level	-2.910860	
	10% level	-2.593090	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(GDPCYCLE)
Method: Least Squares
Date: 09/03/10 Time: 17:45
Sample (adjusted): 1995Q1 2009Q4
Included observations: 60 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDPCYCLE(-1)	-0.326315	0.079559	-4.101559	0.0001
D(GDPCYCLE(-1))	0.086135	0.120907	0.712411	0.4792
D(GDPCYCLE(-2))	0.355896	0.119452	2.979412	0.0043
D(GDPCYCLE(-3))	0.411692	0.122432	3.362609	0.0014
C	10450.64	71097.51	0.146990	0.8837

R-squared	0.299848	Mean dependent var	-16472.13
Adjusted R-squared	0.248928	S.D. dependent var	632023.4
S.E. of regression	547739.4	Akaike info criterion	29.34464
Sum squared resid	1.65E+13	Schwarz criterion	29.51917
Log likelihood	-875.3393	F-statistic	5.888594
Durbin-Watson stat	1.916899	Prob(F-statistic)	0.000511

Null Hypothesis: TOTIFSCYCLE has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.598014	0.0000
Test critical values:	1% level	-3.540198	
	5% level	-2.909206	
	10% level	-2.592215	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(TOTIFSCYCLE)
Method: Least Squares
Date: 09/03/10 Time: 17:46
Sample (adjusted): 1994Q3 2009Q4
Included observations: 62 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
TOTIFSCYCLE(-1)	-0.659710	0.117847	-5.598014	0.0000
D(TOTIFSCYCLE(-1))	0.336719	0.115905	2.905123	0.0052
C	0.001891	0.005747	0.328988	0.7433

R-squared	0.348116	Mean dependent var	0.001871
Adjusted R-squared	0.326019	S.D. dependent var	0.055044
S.E. of regression	0.045189	Akaike info criterion	-3.308754
Sum squared resid	0.120480	Schwarz criterion	-3.205828
Log likelihood	105.5714	F-statistic	15.75348
Durbin-Watson stat	1.776415	Prob(F-statistic)	0.000003

Null Hypothesis: DLUSGDP has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.879025	0.0536
Test critical values:	1% level	-3.540198	
	5% level	-2.909206	
	10% level	-2.592215	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DLUSGDP)
Method: Least Squares
Date: 09/22/10 Time: 19:34
Sample (adjusted): 1994Q4 2010Q1
Included observations: 62 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLUSGDP(-1)	-0.364404	0.126572	-2.879025	0.0055
D(DLUSGDP(-1))	-0.285004	0.123982	-2.298763	0.0251
C	0.002308	0.001075	2.147980	0.0358

R-squared	0.316456	Mean dependent var	4.42E-05
Adjusted R-squared	0.293285	S.D. dependent var	0.006824
S.E. of regression	0.005737	Akaike info criterion	-7.436639
Sum squared resid	0.001942	Schwarz criterion	-7.333713
Log likelihood	233.5358	F-statistic	13.65742
Durbin-Watson stat	1.874583	Prob(F-statistic)	0.000013

Appendix 2: Granger causality tests

P-value for Granger causality tests

	Null Hypothesis: Z does not Granger cause DLGDP (quarterly growth of the GDP)			
Variable Z	lag length 4	lag length 3	lag length 2	lag length 1
Terms of Trade (with all exports) (DLTOTIFS)	0.77599	0.61992	0.92921	0.64462
Terms of Trade (four commodities) (DLTOTCL)	0.16010	0.21306	0.25311	0.11655
Unit Value of Exports (DLPXIFS)	0.96230	0.99119	0.93587	0.70771
Unit Value of Imports (DLPIIFS)	0.48936	0.61581	0.47063	0.12575
Price of Oil (DLOILPR)	0.69885	0.59523	0.74088	0.51609
Index price four commodities (DLPXCL)	0.23341	0.27894	0.28395	0.18889

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