# Terms of trade and output fluctuations in Colombia

*Gonzalo Hernández*

**ABSTRACT**

This paper explores the impact of the terms of trade on output fluctuations in Colombia, a developing country where as much as 62% of export earnings come from just four commodities: oil (42%), coal (14%), coffee (5%), and nickel (1%). This research was prompted by: the particular role of short-run fluctuations in developing economies, the fact that the Colombian terms of trade are procyclical, and the discussion on economic policies towards sterilization of the effects of commodity prices. Following time series analysis for the period 1994 -2011, robust evidence was found indicating that around one third of Colombia's quarterly growth is attributable to changes in the terms of trade.

**KEYWORDS** International trade, terms of trade, economic growth, productivity, time series analysis, Colombia

**JEL CLASSIFICATION** F41, F44, O54

**AUTHOR** Gonzalo Hernández, Professor, Department of Economics, Pontificia Universidad Javeriana, Bogota, Colombia. Ph.D candidate, Department of Economics, University of Massachusetts, Amherst, United States, gonzalo@econs.umass.edu

# I
# Introduction

The role of short-run output fluctuations in developing economies is particularly important. Developing countries are usually more exposed than developed economies to the effects of macroeconomic ups and downs. In addition, welfare implications may be asymmetrical, depending on the degree of development. Some examples of a possible uneven effect are: first, that developing economies lack the proper social safety nets to mitigate the impact of bad phases on the poorest population; second, poverty and unemployment in developing countries make people less capable of adjusting their consumption when temporary shocks appear;[1] and third, the more variable tax base may constrain both the ability of the public sector to implement long-run projects necessary to remove the obstacles that hinder the development of these economies as well as the responsiveness of short-run fiscal policy.

This study focuses on the terms of trade to explain these output fluctuations. This decision is motivated by the literature on development macroeconomics based on a small open economy framework.[2] In particular, the dependent economy model (with its three goods variant: exportable, importable and non-tradable) assumes that small economies face an infinitely elastic global demand for their goods, and an infinitely elastic supply of imported goods.[3] This means that prices of exports and imports are determined in the international markets where the domestic economy has no market power. The framework predicts that external shocks to terms of trade may be an important source of output fluctuations in the domestic economy. An improvement in the terms of trade, say, because of a boom in commodity prices, works as an incentive to expand output in the sectors that benefit from a higher price. However, the shock may result also in an appreciation of the real exchange rate that increases real wages in the sectors that compete with importable goods. Therefore, the initial aggregate output increase might be offset by the loss of competitiveness in the sectors that compete with importable goods (Dutch Disease). The same mechanism may be easily extended to other exportable goods. The net result, however, depends theoretically on critical assumptions regarding the labour markets and the degree of price flexibility (market-clearing conditions). The most common assumption is that the non-tradable sector clears through price variations rather than through an adjustment in output. Furthermore, whether these effects are displayed in the short run will depend not only on the type of market adjustment but also on its speed, the reaction of the economic policy authorities to changes in this relative price, the degree of openness, the degree of specialization in exportable goods, and the exchange-rate regime, among other elements.

Some facts justify the selection of Colombia as a case study. First, recent Colombian exporting structure seems to support the role of exogenous terms of trade as in the three goods model. Annual data for 2010 show that Colombian exports (62%) are concentrated mainly in four commodities in respect of which Colombian market power is negligible: petroleum and derivatives (42%), coal (14%), coffee (5%), and nickel (1%). Second, quarterly information for the period 1994-2011 reports a positive correlation between quarterly variations in terms of trade and quarterly growth of gross domestic product (GDP) equal to 0.35. This magnitude is important relative to other studies on developing economies (see section II). Lastly, the period 1994-2011 shows high variability in both the terms of trade and GDP. This variability is useful for testing the validity of the results from the time series analysis.

Although this study is limited to aggregate results, there are other channels that can illustrate the relevance of terms of trade in Colombia's economic performance in the short run. Let's take again a commodity price boom as an

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1 Economic theory usually assumes that more volatile consumption decreases individuals' utility in the presence of risk and incomplete financial markets.

2 See, for example, Agénor and Montiel (2008).

3 For this study, the dependent economy with three goods seems to be a more convenient framework than the Mundell-Fleming model, where the terms of trade, when variable, are endogenous. The endogeneity in the Mundell-Fleming model occurs because there is some degree of producer market power in the exportable good. The price of the exportable good may be altered by internal conditions (that is, domestic demand) even if the economy is a price taker regarding the importable goods. Likewise, the two goods dependent economy model (traded and nontraded) has its own limitation: both exportable and importable goods are aggregated in a composite good (the traded good). Therefore, the variability of the terms of trade is not defined and cannot be the origin of macroeconomic fluctuations. See, for example, Greenwood (1984) and Buiter (1988), for other dependent economy model specifications.

example. Once the commodity price rises, extra profits will be generated for the firms involved directly or indirectly in the production of that commodity. Thus, this shock fosters the expansion of consumption and output in other sectors. In addition, a higher level of wealth allows investors to access financial credit more easily. This credit is available due to the greater availability of foreign currency, which relaxes the monetary constraints. Therefore, the process boosts credit, investment and consumption, and also profits for the financial system, which currently accounts for around 18% of total Colombian value added. This mechanism is clearly plausible in Colombia where there has been a large accumulation of international reserves, and where, despite the central bank's inflation targeting policy, some interventions have been made to curb the appreciation of the exchange rate.

Another reason for the procyclical terms of trade in Colombia may be found in the public sector. Around 60% of the total volume of exported oil is exported by Empresa Colombiana de Petróleo (ECOPETROL). Some of the revenues obtained by this institution make up part of the revenues of the non-financial public sector. In addition, it is reasonable to expect that by increasing profits of the firms, and stimulating the economy, a commodity price boom 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.[4]

Regarding international trade, after the United States and the European Union, the Bolivarian Republic of Venezuela and Ecuador are the most important markets for 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 trading partners may also increase the demand for Colombian products. However, preliminary evidence shows that the Colombian current account is not positively correlated with the terms of trade.[5]

This paper sets out to resolve the theoretically ambiguous relationship between terms of trade and output. Specifically, this paper presents a time series analysis that examines the relationship between quarterly GDP growth and quarterly variations in the terms of trade. For that purpose, a price index has been constructed for the four main exportable commodities, and a simple econometric methodology (Box-Jenkins methodology) is used, which is consistent with: the exogeneity of the Colombian terms of trade, the non-co-integration between GDP and terms of trade, and the stationarity of the key variables. The study offers different robustness tests, starting with the inclusion of relevant control variables whose absence may cause a potential bias in the estimate for terms of trade. For example, real and nominal exchanges rates are two such control variables because a negative effect of the variations in the terms of trade on short-run output fluctuations could be associated with a Dutch disease mechanism. Nevertheless, it is not clear a priori either that positive terms of trade shocks result in an appreciation or that an appreciation is going to decrease aggregate output unambiguously. First, non-traded goods production could increase with the shock while the expansion of the real income would be adjusted by a change in output rather than by a change in prices. Second, an eventual appreciation of the nominal exchange rate, given a larger supply of foreign currency, could have expansionary effects on output just as a nominal devaluation may have contractionary effects. In a seminal theoretical model, Krugman and Taylor (1978) describe this possibility.[6] Among different mechanisms presented by the authors, one of them, following the Kaleckian tradition, states that an appreciation may redistribute income from profits and rent to wages. The reduction in the price of imported inputs is automatically translated into a reduction in the price of home goods, which increases real wages. Because the marginal propensity to consume is higher for workers than for capitalists, the redistribution from wages to profits increases aggregate demand and domestic output.

Thus, following a review of the related literature in section II, the empirical strategy in section III is essential to evaluate the direct effect of changes in the terms of trade after taking into account eventual indirect effects through other variables. Concluding remarks are presented in section IV.

[4] See, for example, Tornell and Lane (1999) and Frankel (2010) for institutional aspects explaining procyclical public expenditure in developing economies. For Latin America, see, for example, Medina (2010).

[5] See Obstfeld (1982), Svensson and Razin (1983) and Kent and Cashin (2003) for discussions about the effects of the terms of trade on the balance-of-payments current account.

[6] See Lizondo and Montiel (1989) for a detailed overview of the theory on contractionary effects of devaluation applied to developing countries. Razmi (2007) extends the theoretical framework of Krugman and Taylor (1978). This extension, including the role of transnational corporations and the type of trading partners for exports (developing or industrialized economy), suggests that the likelihood of contractionary short-run effects of devaluation may be greater for developing economies. As an opposite example, Reinhart and Reinhart (1991) find that a devaluation is expansionary in the short run in Colombia in a simulation-based model with a neo-Keynesian structure.

# II
## Related literature

Empirical evidence on the effects of the terms of trade on output fluctuations in developing economies may be classified in three groups: (i) studies that describe a correlation between business cycles and cycles in terms of trade as a stylized fact; (ii) simulation-based models; and (iii) vector autoregression models (VAR).

Agénor, McDermott and Prasad (2000) find, for instance, a strong positive correlation for Colombia, Mexico and the Republic of Korea between the cyclical components of industrial output and the terms of trade (with both the Hodrick Prescott and the band-pass methodologies using quarterly data). Also in this group of papers, Parra (2008), with quarterly data from 1994 to 2007, reports a correlation equal to 0.24 for Colombia, and Mahadeva and Gómez (2009), 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).[7] However, this type of stylized fact becomes more persuasive when it is used either for the calibration of simulated-based models or for the specification of an econometric model.

For instance, Mendoza (1995), in a seminal work in the second category, not only reports a positive correlation between terms of trade and GDP but also claims that his intertemporal model predicts that terms of trade shocks may account for between 37% and 56% of the actual variability of GDP in developing countries. This outcome depends of course on the particular setup of his three goods model (exportable, importable, and non-traded goods). In that framework, the dominant effect that explains the short-run effect of the terms of trade on output is basically that terms-of-trade gains induce an increase in the marginal profitability of the exportable sector, which fosters an investment boom in that sector. Investment corresponds to an international and domestic reallocation of capital where the importable goods sector is the only source of domestic capital (not the non-traded sector). On the other hand, labour supply is inelastic in traded-sector industries, and the labour supply response in the non-traded sector is assumed to be negligible. After the short-run impact, adjustment mechanisms start to work to drive the economy to a long-run equilibrium, which is by definition equal to the initial equilibrium. The adjustment of the real exchange rate towards its long-run equilibrium reduces the short-run interest rate differential, and thus, the foreign capital that entered the domestic economy during the investment boom flows back out. As expected, the initial GDP boom weakens.

Although Mendoza's framework (1995) presents a plausible scenario for the positive correlation between the terms of trade and GDP in the short run, different theoretical assumptions could obviously tell a different story. Indeed, empirically, in his own sample, some countries displayed a negative correlation: Algeria (-0.234), Democratic Republic of the Congo (-0.107), Egypt (-0.455), Philippines (-0.285) and Tunisia (-0.309). These cases are not, however, covered by the general equilibrium model in his paper.

Kose and Riezman (1999) and Kose (2002) offer other examples of how empirical evidence may be conditioned by the particular theoretical setup. Kose and Riezman (1999), developing a general equilibrium model for a small open African economy with two sectors (exportable primary goods and non-traded goods), find that world price shocks can explain around 45% of output fluctuations, basically because both the primary good and the non-traded sectors use imported capital goods as factors of production. Therefore, a decline in the international prices of imports leads to an expansion of aggregate output. On the other hand, Kose (2002) finds that disturbances in the prices of capital goods and intermediate goods may account for 87.6% of the output variability. The greater effect in this case occurs because the author focuses on main export and import prices (which are more sensitive than terms of trade to productivity shocks), and the role of intermediate inputs in the non-traded sector, which, according to his small open economy model, does not face any limit on the supply of capital.

The third group of studies have used VAR techniques to examine the effects of terms of trade on output fluctuations in developing countries They include Hoffmaister, Roldós and Wickham (1998); Hoffmaister and Roldós (2001); Ahmed (2003); Broda (2004); Izquierdo, Romero and Talvi (2007), and Raddatz (2007). These analyses are usually based on long-run theoretical models whose reduced forms become specific structural VARS. For instance, Hoffmaister, Roldós and Wickham (1998) point out that terms-of-trade shocks act through the price of intermediate inputs, assuming that a positive change in

[7] See Rand and Tarp (2002) for a description of stylized facts of the business cycles in developing countries.

this price behaves as negative technological progress. This way, positive terms-of-trade shocks are positive supply shocks that relax the intermediate inputs constraint.

Regardless of the specifics of the technique, most of the literature suggests a positive effect of terms of trade on output fluctuations in developing countries. However, some of the documented literature undermines the role of international prices. For example, Broda (2004) affirms that his evidence contradicts that from Mendoza (1995). Broda, working with a sample of 75 developing countries with annual data from 1973 to 1996, finds that the contribution of terms-of-trade shocks accounts for less than 10% of actual real GDP volatility in countries with flexible exchange regimes. Similarly, Ahmed (2003), who studied the economic fluctuations of six Latin American economies (Argentina, Bolivarian Republic of Venezuela, Brazil, Chile, Colombia and Mexico), concludes that the terms-of-trade shocks may account for (although significant in statistical terms) less than 8% of domestic output fluctuations.

The terms of trade have also been used as a control variable in explaining the relationship between the short-run fluctuations in GDP and other variables in Latin American countries, for example, in Barro (1979) and Edwards (1983 and 1986). Consistent with the studies described before, the effect is usually positive. However, Edwards (1983) finds that the estimate of the effect of terms of trade on output is only significant for Chile and Mexico, and not significant for Brazil, Colombia and Peru. Furthermore, Edwards (1986), who checks whether a devaluation of the nominal exchange rate may display contractionary effects in the short run, concludes that the terms-of-trade effect on real output in developing countries is negligible.

To the author's knowledge, no previous study determines the extent to which output fluctuations in the recent Colombian context are attributable to the terms of trade. Colombia's own specific features and status as a developing economy may allow the use of a simple but powerful econometric tool to pursue that quantification and test its robustness. Given that the background literature contains several cases of positive, negative and null effects of the terms of trade, the question examined in the Colombian case is fundamentally empirical.

# III
## Empirical strategy

This section aims to offer a parsimonious model for Colombia for the period 1994-2011 to describe its output fluctuations, to estimate the partial effect of the terms of trade on GDP variations, and to test the significance of that estimate, using quarterly data.

This period of analysis was selected for several reasons. First, the data are available without substantial methodological changes in the national accounts and the balance of payments.[8] Second, the analysis excludes one of the most important structural break points in the Colombian economic policy: trade liberalization in the early 1990s. Third, the period includes: the commodity price boom that started in 2003, the subsequent downturn at the end of 2008 (for the Colombian terms of trade), and a recovery starting in 2009. In the same way, this period also includes the sharpest recession known in Colombian economic history (year 1999) and a period of high growth (2003-2007) (see figure 1).

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 the autoregressive moving average model with exogenous variables (ARMAX), a model for stationary series with three components: (i) the autoregressive part (AR), (ii) the moving average part (MA), and (iii) the set of other explanatory variables (X). The general model is thus:

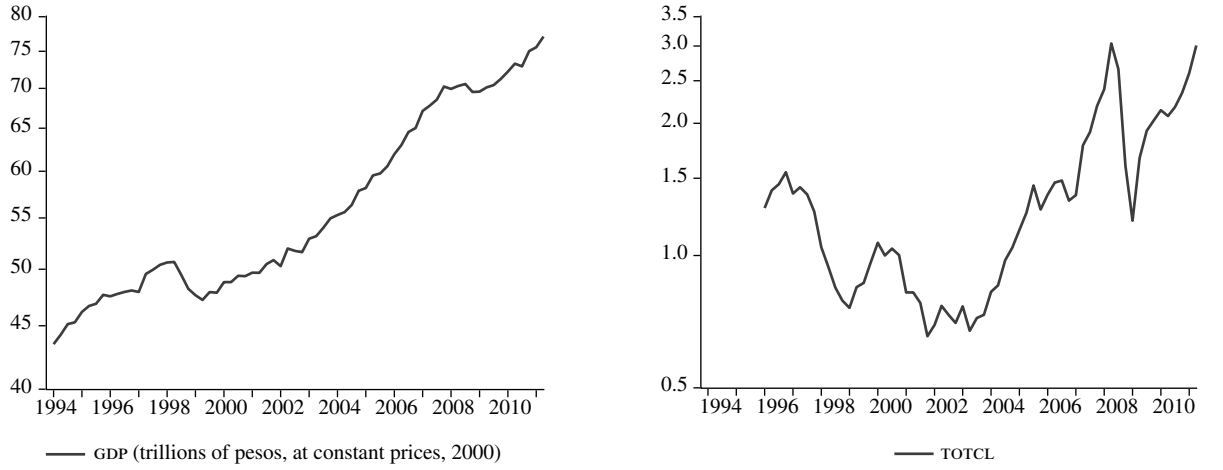
$$y_t = \alpha + \sum_{p=1}^{n} \lambda_p y_{t-p} + \sum_{q=1}^{n} \theta_q \mu_{t-q} + \sum_{m=0}^{n} \gamma_{i,m} X_{i,t-m} + \mu_t \quad (1)$$

Where $y$ represents the dependent variable (a stationary series of GDP in this paper), $t$ indexes time, μ is the error term, $X$ is the set of explanatory variables (stationary, and that includes the terms of trade), and $\alpha$, $\lambda$, $\theta$, and $\gamma$, the parameters to estimate.

[8] The information was obtained directly from the National Administrative Department of Statistics (DANE) of Colombia; the dataset of International Financial Statistics (IFS) does not report quarterly GDP data for Colombia until 1994.

FIGURE 1

**Real GDP and terms of trade**
*(Logarithmic scaling)*




*Source:* prepared by the author on the basis of data from the National Administrative Department of Statistics (DANE) of Colombia and the central bank of Colombia (Banco de la República de Colombia).

TOTCL: terms of trade for four commodities (oil, coal, coffee and nickel).

There are several reasons that justify the specification in equation (1) given that GDP and terms of trade are not cointegrated (see table A.1).[9] 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 components contributes to the parsimony of the model, once the autocorrelation of the errors that would affect the significance tests is taken into account. Lastly, the use of an ARMA model allows one to control for any possible persistence of output fluctuations.[10] In addition to estimating the contemporaneous effect, this specification allows an estimate of the total effect of the terms of trade on GDP over time.

Besides the ARMA specification and the terms of trade, control variables must be considered in the set of explanatory variables. The main reason is that their omission may result in a biased estimate for the effect of the terms of trade. From the aggregate demand side,[11] robustness tests include two groups of monetary variables: lending interest rates, and exchange rates. Interest rates may be important in the determination of the investment component, which explains most of the variability in GDP, and may also be responsive to changes in the terms of trade through the relaxation of balance-of-payment constraints. On the other hand, by including the nominal and real exchange rates, it is possible not only to test the robustness of the effect of the terms of trade but also to examine if the short-run effect of a depreciation (or an appreciation) of the exchange rate is contractionary (or expansionary). Lastly, quarterly growth of United States GDP (GDPUS) and net financial flows (inflows minus outflows) in the Colombian balance of payments (NFF) will also be treated as control variables. Both variables might also be correlated simultaneously with the terms of trade and Colombian GDP.

The specification leaves aside technological shocks, which are an important element in the literature on real business cycles.[12] This decision is justifiable on three

[9] See, for example, Montenegro (2002).

[10] See, for example, Nelson and Plosser (1982), Campbell and Mankiw (1987), and Blanchard and Quah (1989), for more information on the persistence of output fluctuations.

[11] See Shapiro and Watson (1989), in whose work the source of output fluctuations is divided between demand and supply components.

[12] See Mankiw (1989) for a criticism of the real business cycle theory and Holland and Scott (1998) for an empirical defence of the technical change explaining the business cycle in the United Kingdom.

counts. First, given the volatility of the quarterly data, technological shocks correlated with the terms of trade and that can explain variations of GDP quarter to quarter are unlikely (even if some amplifiers are considered). Second, proxies of technical change, like total factor productivity, are not usually reliable, especially in developing countries. Third, despite the fact that a clear identification is impossible, the ARMA specification is already controlling for the new information (innovations) through its moving average term, including non-observable shocks that affect output.[13]

The study does not take into account the expectations of economic agents or the management of these expectations as an instrument of economic policy through, for example, monetary policy. This is a limitation of the study, despite the difficulty of finding a good proxy for that variable.

While further research can explore whether particular variables may improve the fit of the model, the main purpose of the study is not to obtain a forecasting model, but to evaluate the role of the terms of trade.

## 1. Variables and data description

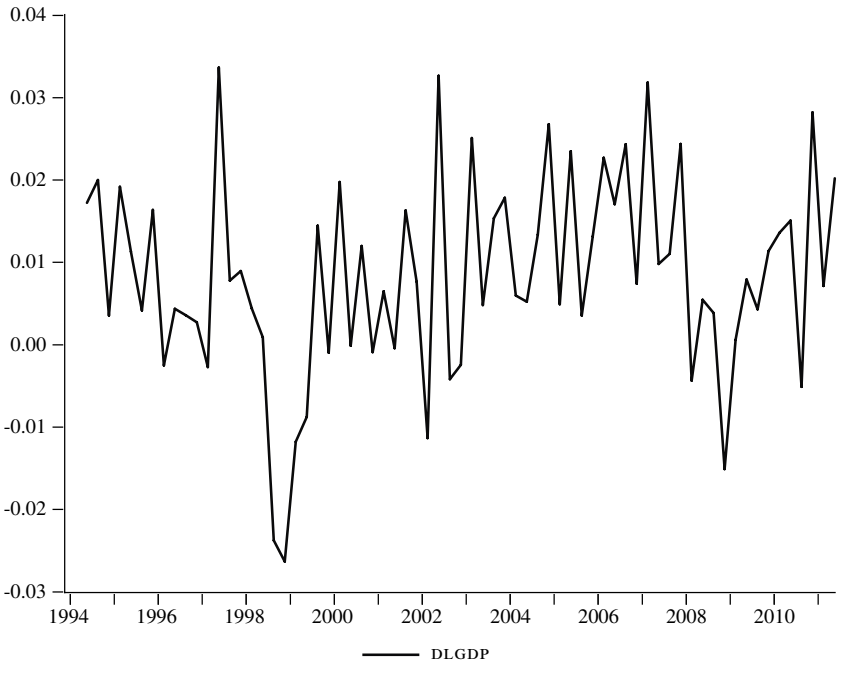
*— Gross domestic product (GDP)*

The quarterly data for real GDP, seasonally adjusted, was obtained from the National Administrative Department of Statistics (DANE) of Colombia (see table A.2). The dependent variable is the first difference of the logarithm of GDP (DLGDP) for Colombia (approximately quarterly GDP growth) (see figure 2). This transformation is necessary for two reasons: it defines the variable in terms of output fluctuations, and it fulfils the stationarity requirement in the Box-Jenkins technique. According to different tests, weak stationarity of DLGDP is verified by rejecting the null hypothesis that this series has a unit root (see table A.3).

[13] The El Niño Phenomenon, another supply-side shock not correlated with the terms of trade but potentially useful for understanding the nature of the Colombian business cycle, was examined in a previous analysis not reported in this paper. Using the multivariate El Niño-Southern Oscillation index, I used different alternative definitions to create a dummy variable, according to whether the quarter was in the warm phase or not, whether the quarter was in a warm phase with an index that was one standard deviation higher than the average or not, or whether the absolute value of the index was relatively high to its average. No clear relationship between El Niño and GDP was found for the period under analysis.

FIGURE 2

**First difference of the logarithm of GDP**




*Source:* prepared by the author on the basis of data from the National Administrative Department of Statistics (DANE) of Colombia.

DLGDP: first difference (quarter to quarter) of the logarithm of real GDP.

As an alternative definition of output fluctuations, the cyclical component of GDP (GDPCYCLE) was estimated by means of the Hodrick-Prescott filter. This series is also stationary.

*— Terms of trade and related prices*

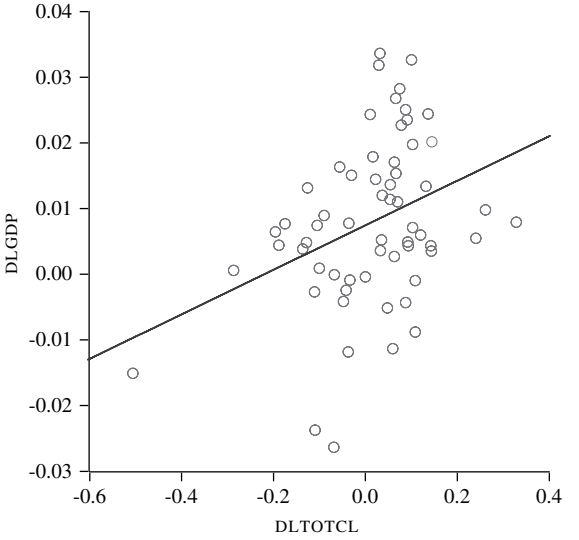
Two definitions for the terms of trade are used in this paper. The first was constructed with statistical information from the balance of payments and the wholesale imports price index from the central bank of Colombia. This definition, called TOTCL, corresponds to the ratio (*PXCL/PI*), where the denominator is the wholesale imports price index and the numerator is a Laspeyres index[14] for the basket of the most important Colombian exportable commodities (oil, coal, coffee and nickel). I use the variable DLTOTCL (unit value of all Colombian exports). The second definition is called TOTT, available also from the central bank of Colombia, and is the ratio of the wholesale exports price index to the wholesale imports price index (*PX/PI*). The transformed variable is called DLTOTT (first difference of logarithm of TOTT).

As a preliminary graphical diagnosis of the key relationship in this paper, figures 3 and 4 present the correlation between the output fluctuations and the variations in the terms of trade in Colombia. Figure 3 depicts the simple correlation (the correlation coefficient is 0.35). Figure 4 shows the correlation between the cyclical components of GDP and TOTCL (the correlation coefficient is 0.48). Besides the positive correlation, both scatter plots suggest that these correlation coefficients are not augmented by potential outliers. Most of the observations in the sample follow the same pattern described by the simple ordinary least squares (OLS) regression between DLGDP and DLTOTCL in figure 3 and between GDPCYCLE and TOTCLCYCLE in figure 4.

This empirical analysis assumes, based on the dependent economy framework, and the construction of our series related to terms of trade, that the terms of trade are exogenous and that they cause the output fluctuations, not the other way around. Although this is a very plausible assumption for Colombia as described in the introduction, a Granger causality test was performed. The test suggests the non-rejection of this assumption (see table 1).

[14] A Paasche index was also calculated but it did not exhibit a substantial difference from the Laspeyres one.

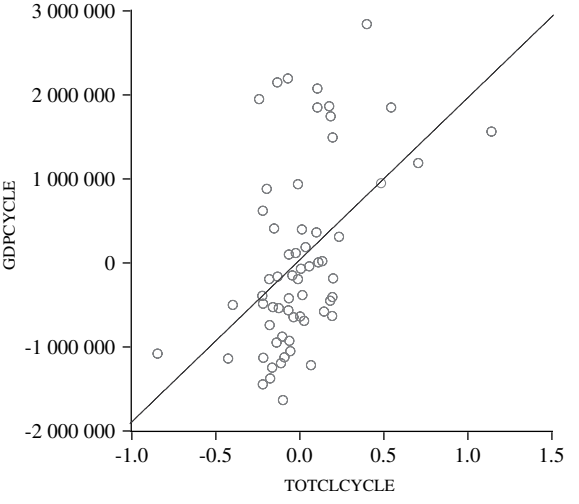
FIGURE 3
**Correlation DLGDP and DLTOTCL**
*(Correlation coefficient simple: 0.35)*




*Source:* prepared by the author on the basis of data from the National Administrative Department of Statistics (DANE) of Colombia and the central bank of Colombia (Banco de la República de Colombia).

DLGDP: first difference (quarter to quarter) of the logarithm of real GDP.
DLTOTCL: first difference (quarter to quarter) of the logarithm of the terms of trade for four commodities (oil, coal, coffee and nickel).

FIGURE 4
**Correlation cyclical components of GDP and TOTCL**
*(Correlation coefficient simple: 0.48)*




*Source:* prepared by the author on the basis of data from the National Administrative Department of Statistics (DANE) of Colombia and the central bank of Colombia (Banco de la República de Colombia).

TOTCLCYCLE: cyclical component of the terms of trade for four commodities (oil, coal, coffee and nickel).
GDPCYCLE: cyclical component of real GDP.

TABLE 1

**Granger causality test**

| Null hypothesis: DLGDP does not Granger cause DLTOTCL | | | | |
|---|---|---|---|---|
| | Lag length 1 | Lag length 2 | Lag length 3 | Lag length 4 |
| *P* value | 0.80 | 0.79 | 0.82 | 0.52 |
| Observations | 60 | 59 | 58 | 57 |
| Null hypothesis: DLTOTCL does not Granger cause DLGDP | | | | |
| *P*-value | 0.15 | 0.41 | 0.33 | 0.22 |
| Observations | 60 | 59 | 58 | 57 |

*Source:* prepared by the author on the basis of data from the National Administrative Department of Statistics (DANE) of Colombia and the central bank of Colombia (*Banco de la República de Colombia*).

DLGDP: first difference (quarter to quarter) of the logarithm of real GDP.
DLTOTCL: first difference (quarter to quarter) of the logarithm of the terms of trade for four commodities (oil, coal, coffee and nickel).

This diagnostic test also suggests that DLTOTCL does not Granger cause DLGDP (although the p values are relatively smaller than those in the other hypothesis in table 1). More formal empirical results on the relationship DLTOTCL and DLGDP will be presented in the following section. In addition to the terms-of-trade definitions above, four more related prices are used (as alternative to TOTCL) in the right hand side of the regressions: a Laspeyres index for the prices of oil, coal, coffee and nickel (PXCL), the oil prices (OILPR), the wholesale imports price index (PI), and the wholesale exports price index (PX). The transformed and stationary variables are called DLPXCL, DLOILPR, DLPIIFS and DLPXIFS, respectively.

*— Lending interest rates, exchange rates, net financial flows, and United States output fluctuations*

Four stationary control variables are included in the right hand side of the regression. The first is the first difference of the nominal lending interest rate (DNIR) which was obtained from International Financial Statistics (IFS) and corresponds to a weighted average of effective rates for the whole banking system including all types of credit. As an alternative, the first difference of the real interest rate (DRIR) was calculated using the inflation in the producer price index.

The second variable is the nominal depreciation of the exchange rate (the first difference of the logarithm of the nominal exchange rate (DLNER). DLNER corresponds to quarterly depreciation of the exchange rate when the value is positive. Likewise, the first difference of the logarithm of the real exchange rate (DLRER) is also used.

The third variable is the first difference of the net financial flows (inflows minus outflows in the Colombian balance of payments). Although interest rates and exchanges rates should capture the role of financial flows to some extent, this variable is included as a potential omitted variable.

Lastly, the econometric analysis controls for the quarterly growth of United States GDP (DLGDPUS). This series is available in IFS. The United States is the destination for approximately 40% of total Colombian exports and 70% of Colombian oil exports.

Control variables may be correlated with each other. For instance, changes in the structure of interest rates along with some degree of capital mobility may put pressure on the exchange rates and such correlation could affect the respective significance tests. However, the key issue in this paper is a possible bias that may exist if these control variables are omitted given their simultaneous correlation with terms-of-trade and output fluctuations.

## 2. Econometric results

The specification of the ARMA component of the model was based on the correlogram for the dependent variable (see table A.4), and a set of regressions (see table A.5) that evaluate the significance of the estimated coefficients for the ARMA elements (DLGDP as the left hand side variable). Both the autocorrelation and the partial correlation functions suggest a specification around the ARMA (3, 3). However, the set of regressions (even including a fourth lag with an possible economic interpretation) reveals a robust and

parsimonious specification. Table A.5 shows the results for regressions, including: (i) only the autoregressive elements (column 1); (ii) only the moving average elements (column 2); (iii) a baseline regression with all the ARMA elements (column 3); (iv) a specific regression obtained after removing one by one the elements whose estimated coefficients were not significant at the 5% level in the baseline regression (column 4); and (v) individual regressions for the elements AR(2), MA(3) and MA(4) (columns 5 to 7), which along with the regressions in columns 1 and 2 show that the elements AR(2) and MA(3) are the most robust. Therefore, a parsimonious version of the ARMA (2, 3) was used without including the first lag for the autoregressive component and without the first and second lags for the moving average (column 8). The estimates in the ARMA (2, 3) are robust to the inclusion of the terms-of-trade and control variables. The number of lags was reasonable for interpreting the effects on the dependent variable in the short run. Given the quarterly data, the second lag in the autoregressive component refers to a half-year lag.

Table 2 (column 1) reports positive and significant estimates for the ARMA coefficients. While the estimates for the moving average coefficient can be associated with the effect of the statistical innovations, the 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 are significant at least at the 5% level. The ARMA model can explain 17% of the total variation in the dependent variable. The Durbin h's statistic, the p value of the Chi-Square test, the Breusch-Godfrey test for the residual, and the correlogram of the residual (see table A.6) suggest the absence of autocorrelation. Furthermore, given the assumption of weak stationarity, DLGDP does not face heteroskedasticity. This means that the t-statistics and the p-values used to establish significance at the 1.5% and 10% are reliable.

TABLE 2

**Terms of trade and output fluctuations I**

| Dependent variable: DLGDP (quarterly growth rate of real GDP) | | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) Standardized variable |
| Constant | 0.0082*** | 0.0075*** | 0.0082*** | |
| | (3.00) | (4.87) | (2.72) | |
| AR(2) | 0.3273*** | | 0.3227*** | 0.3227*** |
| | (3.14) | | (2.96) | (2.96) |
| MA(3) | 0.3377** | | 0.3659** | 0.3659** |
| | (2.40) | | (2.56) | (2.56) |
| DLTOTCLt | | 0.0339*** | 0.0215*** | 0.2315*** |
| | | (3.95) | (4.08) | (4.08) |
| Total effect | | | 0.0318*** | 0.3418*** |
| (including persistence) | | | [10.24] | [10.24] |
| $R^2$ | 0.17 | 0.12 | 0.26 | 0.26 |
| $R^2$ adjusted | 0.14 | 0.11 | 0.22 | 0.22 |
| Durbin-Watson statistic | | 1.96 | | |
| Durbin h | 0.71 | | 0.14 | 0.14 |
| Prob. Chi-square (Breusch-Godfrey) | 0.20 | | 0.32 | |
| S.E. of regression | 0.01 | | 0.01 | |
| Akaike's information criterion | -6.06 | | -6.04 | |
| Schwarz information criterion | -5.96 | | -5.90 | |
| F-statistic (*p*-value) | 0.00 | 0.00 | 0.00 | |
| Observations | 67 | 61 | 59 | 59 |

*Source:* prepared by the author on the basis of data from the National Administrative Department of Statistics (DANE) of Colombia and the central bank of Colombia (Banco de la República de Colombia).

Note:
(t-statistic), **p*<0.10, ***p*<0.05, ****p*<0.01, [Chi-square].
Least squares and MA derivatives that use accurate numeric methods.
Consistent standard errors.
DLGDP: first difference (quarter to quarter) of the logarithm of real GDP.
DLTOTCL: first difference (quarter to quarter) of the logarithm of the terms of trade for four commodities (oil, coal, coffee and nickel).

Column 3 of table A6 corresponds to the regression including DLTOTCL:

$$DLGDP_t = \alpha + \gamma_1 DLTOTCL + \lambda_2 DLGDP_{t-2} + \theta_3 \mu_{t-3} + \mu_t \quad (2)$$

The estimate for the effect of DLTOTCL on DLGDP is significantly positive at the 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 by 0.02% the quarterly growth of GDP (holding other variables constant). This magnitude is important. One standard deviation in DLTOTCL (equal to 13.22%) will change the quarterly growth of GDP by 0.28%. This change is around 23% of one standard deviation in the quarterly growth of GDP (column 4, table A.6). Once the persistence effect is calculated, the same standard deviation of DTOTLC is associated with a change around 34% of one standard deviation in the quarterly growth of the GDP. Therefore, one third of the quarterly variability in GDP is driven by the terms of trade for the four most important Colombian commodities.

The terms of trade effect holds when the definition of the terms of trade is extended to include the unit value of all Colombian exports (DLTOTT) (column 1, table 3). The estimate is higher but the standard deviation of DLTOTT is lower (5.79%). The independent variable still accounts for around 27% of one standard deviation of the GDP growth (column 2, table 3). Table 3 (columns 5, 6, 7 and 8) and table 4 (using cyclical components) also offer evidence confirming that prices of the four most important Colombian export goods, in particular oil, are the ones that lead the short-run effect on output.

TABLE 3

**Terms of trade and output fluctuations II**

Dependent variable: DLGDP (Quarterly growth rate of real GDP)

| | (1) | (2) Standard deviation | (3) | (4) | (5) | (6) | (7) | (8) | (9) Standard deviation |
|---|---|---|---|---|---|---|---|---|---|
| DLTOTTt | 0.0364* | 0.1715* | | | | | | | |
| | (1.69) | (1.69) | | | | | | | |
| DLPXt | | | 0.0253 | | 0.0365* | | | | |
| | | | (1.33) | | (1.69) | | | | |
| DLPIt | | | | 0.0028 | -0.0367 | | 0.0197 | | |
| | | | | (0.09) | (-1.03) | | (0.61) | | |
| DLPXCLt | | | | | | 0.0252*** | 0.0260*** | | |
| | | | | | | (4.29) | (3.96) | | |
| DLOILPRt | | | | | | | | 0.0147*** | 0.2043*** |
| | | | | | | | | (3.29) | (3.29) |
| Total effect | 0.0566 | 0.2664 | | | | 0.0377*** | | 0.0219*** | 0.3052*** |
| (including persistence) | [2.37] | [2.37] | | | | [11.96] | | [7.24] | [7.24] |
| $R^2$ | 0.20 | 0.20 | 0.19 | 0.17 | 0.20 | 0.27 | 0.28 | 0.25 | 0.25 |
| $R^2$ adjusted | 0.16 | 0.16 | 0.15 | 0.13 | 0.15 | 0.23 | 0.22 | 0.21 | 0.21 |
| Durbin h | 0.15 | 0.15 | 0.47 | 0.75 | 0.08 | 0.28 | 0.50 | 0.65 | 0.65 |
| Prob. Chi-Square (Breusch-Godfrey) | 0.22 | | 0.23 | 0.20 | 0.22 | 0.33 | 0.33 | 0.31 | |
| S.E. of regression | 0.01 | | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | |
| Akaike's information criterion | -6.07 | | -6.06 | -6.03 | -6.04 | -6.06 | -6.03 | -6.03 | |
| Schwarz information criterion | -5.94 | | -5.93 | -5.90 | -5.88 | -5.92 | -5.85 | -5.89 | |
| F-statistic ($p$-value) | 0.00 | | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | |
| Observations | 67 | 67 | 67 | 67 | 67 | 59 | 59 | 59 | 59 |

*Source:* prepared by the author on the basis of data from the National Administrative Department of Statistics (DANE) of Colombia and the central bank of Colombia (Banco de la República de Colombia).

Note:
(t-statistic), *$p$<0.10, **$p$<0.05, ***$p$<0.01, [Chi-square]
Least squares and MA derivatives that use accurate numeric methods. Consistent standard errors.
The ARMA component is included in all the regressions but not reported.
DLTOTT: first difference (quarter to quarter) of the logarithm of the terms of trade (wholesale export and import prices).
DLPX: first difference (quarter to quarter) of the logarithm of the total exports price index (wholesale).
DLPI: first difference (quarter to quarter) of the logarithm of the total imports price index (wholesale).
DLPXCL: first difference (quarter to quarter) of the logarithm of the Laspeyres price index for exports of four commodities (oil, coal, coffee and nickel).
DLOILPR: first difference (quarter to quarter) of the logarithm of the Laspeyres price index for oil.

TABLE 4

**Terms-of-trade and output fluctuations III**
*(Cyclical components)*

| | Estimate | Adjusted R2 | Durbin h. | Prob. Chi-square (Breusch-Godfrey) | S.E. of regression (x100.000) | Akaike's information criterion | Schwarz information criterion | F-statistic (*p*-value) | Observations |
|---|---|---|---|---|---|---|---|---|---|
| TOTCLt | 542 217** (2.42) | 0.75 | 0.59 | 0.80 | 5.7 | 29.41 | 29.58 | 0.00 | 61 |
| TOTTt | 2 170 543** (2.36) | 0.74 | 0.73 | 0.85 | 5.3 | 29.29 | 29.45 | 0.00 | 69 |
| PXt | 14 030* (1.95) | 0.74 | 0.72 | 0.66 | 5.4 | 29.31 | 29.47 | 0.00 | 69 |
| PIt | -105.4 (-0.01) | 0.72 | 0.89 | 0.72 | 5.6 | 29.36 | 29.52 | 0.00 | 69 |
| PXCLt | 5 928*** (3.00) | 0.74 | 0.53 | 0.75 | 5.6 | 29.39 | 29.56 | 0.00 | 61 |
| OILPRt | 12 718** (2.64) | 0.74 | 0.59 | 0.75 | 5.7 | 29.41 | 29.6 | 0.00 | 61 |

*Source:* prepared by the author on the basis of data from the National Administrative Department of Statistics (DANE) of Colombia and the central bank of Colombia (Banco de la República de Colombia).

Note:
(t-statistic), **p*<0.10, ***p*<0.05, ****p*<0.01.
Least squares and MA derivatives that use accurate numeric methods.
Consistent standard errors. AR(1) MA(2) and MA(3) are included but not reported.
TOTCL: terms of trade for four commodities (oil, coal, coffee and nickel).
TOTT: terms of trade (wholesale export and import prices).
PXt: total exports price index (wholesale).
PIt: total imports price index (wholesale).
PXCL: Laspeyres price index for exports of four commodities (oil, coal, coffee and nickel).
OILPR: Laspeyres price index for oil.

## 3. Robustness tests

The results in section III.2 are robust to the inclusion of the control variables: lending interest rates, exchange rates, net financial flows, and quarterly growth of United States GDP (see table 5). The estimate for DLTOTCL not only remains significant at 1% in most of the regressions (at 5% in column 4, table 6) but also its magnitude is stable.

In order to expose the results to a stronger robustness test, lagged control variables were included that were independently significant when a regression for DLGDP was run. These variables are: DNIR and DLGDPUS (both lagged two quarters). Once these variables are included, only DNIR (-2) remains significant (columns 1 and 3, table 6). The estimates for standardized DLTOTCL are still robust and the total effect, including persistence, accounts for 30% of GDP variability (column 4, table 6).

Results for standardized variables (column 4, table 6) also report a theoretically consistent negative effect of DNIR (-2), which is significant and important in magnitude. Although the estimate is not robust when ARMA components are removed, the inclusion of DNIR (-2) increases the $R^2$ from 0.17 to 0.39. Although it is true that the purpose of this paper is not to evaluate either the model's forecasting properties or the robustness in the estimate for the effect of DNIR (-2), the negative estimate, along with a higher $R^2$, may reflect the fact that DNIR is acting through investment, which is the aggregate

TABLE 5

**Robustness to additional variables I**

| Dependent variable: DLGDP (quarterly growth rate of real GDP) | | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Constant | 0.0082*** | 0.0082*** | 0.0081*** | 0.0079** | 0.0081*** | 0.0086*** | 0.0078** |
| | (2.72) | (2.72) | (2.70) | (2.60) | (2.71) | (3.07) | (2.66) |
| AR(2) | 0.3227*** | 0.3204** | 0.3231*** | 0.3356*** | 0.3241*** | 0.3105*** | 0.2855** |
| | (2.96) | (2.29) | (2.90) | (3.12) | (3.06) | (3.00) | (2.44) |
| MA(3) | 0.3659** | 0.3624** | 0.3626** | 0.3657** | 0.3581*** | 0.3627** | 0.3843** |
| | (2.56) | (2.19) | (2.50) | (2.52) | (2.53) | (2.42) | (2.58) |
| DLTOTCLt | 0.0215*** | 0.0221*** | 0.0217*** | 0.0279** | 0.0226*** | 0.0237*** | 0.0201*** |
| | (4.08) | (3.86) | (4.11) | (2.57) | (4.02) | (2.69) | (3.63) |
| DNIRt | | 0.0144 | | | | | |
| | | (0.23) | | | | | |
| DRIRt | | | -0.0008 | | | | |
| | | | (-0.29) | | | | |
| DLNERt | | | | 0.0234 | | | |
| | | | | (0.77) | | | |
| DLRERt | | | | | 0.0127 | | |
| | | | | | (0.56) | | |
| DLGDPUS | | | | | | -0.0878 | |
| | | | | | | (-0.32) | |
| DNFF | | | | | | | 0.0000 |
| | | | | | | | (0.48) |
| $R^2$ | 0.26 | 0.26 | 0.26 | 0.27 | 0.26 | 0.26 | 0.26 |
| $R^2$ adjusted | 0.22 | 0.21 | 0.20 | 0.21 | 0.21 | 0.21 | 0.20 |
| Durbin h | 0.14 | ... | 0.15 | 0.27 | 0.26 | 0.25 | 0.41 |
| Prob. Chi-square (Breusch-Godfrey) | 0.32 | 0.29 | 0.34 | 0.36 | 0.33 | 0.29 | 0.35 |
| S.E. of regression | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Akaike's information criterion | -6.04 | -6.00 | -6.01 | -6.02 | -6.01 | -6.01 | -6.00 |
| Schwarz information criterion | -5.90 | -5.83 | -5.94 | -5.84 | -5.84 | -5.83 | -5.93 |
| F-statistic ($p$-value) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Observations | 59 | 59 | 59 | 59 | 59 | 59 | 58 |

*Source:* prepared by the author on the basis of data from the National Administrative Department of Statistics (DANE) of Colombia, the central bank of Colombia (Banco de la República de Colombia) and International Financial Statistics (IFS).

Note:
(t-statistic), *$p$<0.10, **$p$<0.05, ***$p$<0.01.
Least squares and MA derivatives that use accurate numeric methods. Consistent standard errors.
DLTOTCL: first difference (quarter to quarter) of the logarithm of the terms of trade for four commodities (oil, coal, coffee and nickel).
DNIR: first difference (quarter to quarter) of the nominal lending interest rate.
DRIR: first difference (quarter to quarter) of the real lending interest rate.
DLNER: first difference (quarter to quarter) of the logarithm of the nominal exchange rate.
DLRER: first difference (quarter to quarter) of the logarithm of the real exchange rate.
DLGDPUS: first difference (quarter to quarter) of the logarithm of the real GDP of the United States.
DNFF: first difference (quarter to quarter) of net financial flows.

TABLE 6

**Robustness to additional variables II**
*(Including lags)*

| Dependent variable: DLGDP (quarterly growth rate of real GDP) | | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) Standard variation | (5) Non-ARMA | (6) Non-ARMA standard variation |
| DLTOTCLt | 0.0182*** | 0.0189*** | 0.0146** | 0.1961*** | 0.0319*** | 0.3432*** |
| | (3.81) | (3.08) | (2.33) | (3.81) | (4.05) | (4.05) |
| DNIRt-2 | -0.1777** | | -0.1813*** | -0.3552** | -0.1251 | -0.2500 |
| | (-2.61) | | (-2.72) | (-2.61) | (-1.28) | (-1.28) |
| DLGDPUSt -2 | | -0.1762 | -0.2637 | | | |
| | | (-1.19) | (-1.61) | | | |
| Total effect DLTOTCL (including persistence) | | | | 0.3076*** [8.46] | | |
| Total effect DNIRt-2 (including persistence) | | | | -0.5573** [4.96] | | |
| $R^2$ | 0.39 | 0.27 | 0.41 | 0.39 | 0.18 | 0.18 |
| $R^2$ adjusted | 0.34 | 0.21 | 0.35 | 0.34 | 0.15 | 0.15 |
| Durbin-Watson statistic | | | | | 2.09 | 2.09 |
| Durbin h | -2.33 | 0.34 | -1.77 | -1.77 | | |
| Prob. Chi-square (Breusch-Godfrey) | 0.43 | 0.24 | 0.42 | | | |
| S.E. of regression | 0.01 | 0.01 | 0.01 | | 0.01 | |
| Akaike's information criterion | -6.20 | -6.02 | -6.19 | | | |
| Schwarz information criterion | -6.02 | -5.84 | -5.98 | | | |
| F-statistic ($p$-value) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Observations | 59 | 59 | 59 | 59 | 61 | 61 |

*Source:* prepared by the author on the basis of data from the National Administrative Department of Statistics (DANE) of Colombia, the central bank of Colombia (Banco de la República de Colombia) and International Financial Statistics (IFS).

Note:
(t-statistic), *$p$<0.10, **$p$<0.05, ***$p$<0.01, [Chi-square].
Least squares and MA derivatives that use accurate numeric methods. Consistent standard errors.
The ARMA component is included but not reported in (1) to (4).
DLTOTCL: first difference (quarter to quarter) of the logarithm of the terms of trade for four commodities (oil, coal, coffee and nickel).
DNIR: first difference (quarter to quarter) of the nominal lending interest rate.
DLGDPUS: first difference (quarter to quarter) of the logarithm of the real GDP of the United States.

demand component whose variations explain most of the short-run variation in GDP. Although investment is one fourth of Colombian GDP, while consumption is two thirds, investment is the most volatile component of GDP (its standard deviation is 8 times greater than for consumption). An initial exploration of the channels in aggregate demand relevant to understanding more deeply the significant and robust effect of terms of trade on output fluctuations in Colombia (see table 7) suggest that investment (DLI) is the main channel. One standard deviation in DLTOTCL seems to explain one third of the variability in investment (only for the contemporaneous effect). Future research will be oriented towards examining what type of investment terms-of-trade shocks are fostering in the short run. This might also require a better understanding of the mechanisms through which terms of trade may affect credit markets and interest rates. The next channel suggested in table 7, but apparently less responsive, is public expenditure (DLG). Lastly, the current account (DLX for exports and DLM for imports) does not seem to be correlated with terms of trade in the short run.

TABLE 7

**Terms of trade and aggregate demand components**
*(Ordinary least squares (OLS) regressions)*

| Dependent variable: | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | DLC | DLI | DLG | DLX | DLM | DLI |
| Constant | 0.0068*** | 0.0086 | 0.011*** | 0.0099** | 0.0129** | 0.0037 |
| | (4.53) | (0.82) | (4.18) | (2.36) | (2.04) | (0.36) |
| DLTOTCLt | 0.0130 | 0.2096*** | 0.0330** | -0.0296 | 0.0972 | 0.1939*** |
| | (1.36) | (3.30) | (2.22) | (-0.74) | (1.65) | (3.22) |
| DNIRt-2 | | | | | | -1.0042 |
| | | | | | | (-1.65) |
| $R^2$ | 0.02 | 0.10 | 0.04 | 0.01 | 0.06 | 0.19 |
| $R^2$ adjusted | 0.004 | 0.09 | 0.03 | -0.003 | 0.05 | 0.16 |
| Durbin-Watson statistic | 1.33 | 2.05 | 1.93 | 1.98 | 1.42 | 2.25 |
| S.E. of regression | 0.01 | 0.09 | 0.03 | 0.03 | 0.05 | 0.08 |
| F-statistic ($p$-value) | 0.26 | 0.01 | 0.11 | 0.37 | 0.05 | 0.00 |
| Observations | 61 | 61 | 61 | 61 | 61 | 61 |

*Source:* prepared by the author on the basis of data from the National Administrative Department of Statistics (DANE) of Colombia, the central bank of Colombia (Banco de la República de Colombia) and International Financial Statistics (IFS).

Note:
(t-statistic), *$p$<0.10, **$p$<0.05, ***$p$<0.01.
DLI: first difference (quarter to quarter) of the logarithm of real aggregate investment.
DLC: first difference (quarter to quarter) of the logarithm of real aggregate consumption.
DLG: first difference (quarter to quarter) of the logarithm of real aggregate public spending.
DLX: first difference (quarter to quarter) of the logarithm of real exports.
DLM: first difference (quarter to quarter) of the logarithm of real imports.
DLTOTCL: first difference (quarter to quarter) of the logarithm of the terms of trade for four commodities (oil, coal, coffee and nickel).
DNIR: first difference (quarter to quarter) of the nominal lending interest rate.

# IV
## Concluding remarks

Although it is sometimes claimed that a positive correlation between the terms of trade and aggregate output can be established a priori, a vast literature describes the complexity of the relationship of these two variables. First, a positive as well as a negative correlation have been found in some developing countries. Second, the usual theoretical framework used to describe small open economies permits outcomes in which the relationship may be negative or null. A lot 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, which 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 GDP is found not only to be significantly positive but also to be very great in magnitude. One standard deviation in the growth of the terms of trade results in around one third of one standard deviation of quarterly GDP growth. The results are robust to different specifications that include: price components of the terms of trade,

alternative definitions of business cycles, and control variables whose omission might lead to a biased estimate.

In addition, depreciation of the nominal exchange rate does not seem to have a significant short-run effect as stated by the contractionary devaluation hypothesis. This might be important when analysing potential new policies, costly or distortionary, oriented towards controlling the appreciation of the nominal exchange rate that Colombia and other developing countries have been experiencing lately. Likewise, this short-run dynamic might complement analysis that suggests that devaluation is a useful tool for growth. On the other hand, this paper finds preliminary evidence that supports the belief that the lending interest rate can have a negative effect on output fluctuations.

In summary, robust evidence was found in support of the hypothesis that the terms of trade played an important role in determining the short-run variations in GDP in Colombia over the period 1994-2011. Results from simple specifications for stationary series, justified by time series tests (cointegration and Granger), along with the particular features 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. At least in the short run, evidence does not indicate that eventual negative effects of the terms of trade (Dutch Disease), if they exist, can offset the positive effects on aggregate output.

Preliminary evidence also indicates that investment may be the most important demand component driving the aggregate outcome. One limitation of this study is the use of aggregate data. Therefore, a future extension would be to study the relationship between terms of trade and investment demand disaggregated by components and by industrial sectors to determine the foundation of the observed fast adjustment of the external shocks in the short run. Future research related to this finding will also explore short-run effects of terms of trade fluctuations on credit markets, interest rates, and investment in Colombia. These studies would allow a more detailed evaluation of the mechanisms behind the quick investment and output responses to external shocks.

**ANNEX**

TABLE A.1

**Summary of cointegration tests (GDP and TOTCL)**

Sample: 1993Q4 2011Q2

Included observations: 59

Series: TOTCL GDP

Lags interval: 1 to 2

Selected (0.05 level*) Number of cointegrating relations by model

| Data trend: | None | None | Linear | Linear | Quadratic |
|---|---|---|---|---|---|
| Test Type | No intercept No trend | Intercept No trend | Intercept No trend | Intercept Trend | Intercept Trend |
| Trace | 0 | 0 | 0 | 0 | 0 |
| Max-Eig | 0 | 0 | 0 | 0 | 0 |

* Critical values based on MacKinnon, Haug and Michelis (1999).

Information criteria by rank and model

| Data trend: | None | None | Linear | Linear | Quadratic |
|---|---|---|---|---|---|
| Rank or No. of CEs | No intercept No trend | Intercept No trend | Intercept No trend | Intercept Trend | Intercept Trend |
| | Log likelihood by rank (rows) and model (columns) | | | | |
| 0 | -864.2456 | -864.2456 | -860.4798 | -860.4798 | -858.4805 |
| 1 | -860.1549 | -859.1981 | -856.0961 | -854.2298 | -852.4016 |
| 2 | -859.5365 | -855.9931 | -855.9931 | -851.0928 | -851.0928 |
| | Akaike's information criterion by rank (rows) and model (columns) | | | | |
| 0 | 29.56765 | 29.56765 | 29.50779 | 29.50779 | 29.50781 |
| 1 | 29.56457 | 29.56604 | 29.49478 | 29.46542 | 29.43734* |
| 2 | 29.6792 | 29.62689 | 29.62689 | 29.52857 | 29.52857 |
| | Schwarz information criterion by rank (rows) and model (columns) | | | | |
| 0 | 29.84935* | 29.84935* | 29.85991 | 29.85991 | 29.93036 |
| 1 | 29.98712 | 30.0238 | 29.98776 | 29.99361 | 30.00074 |
| 2 | 30.2426 | 30.26071 | 30.26071 | 30.23282 | 30.23282 |

*Source:* prepared by the author on the basis of data from the National Administrative Department of Statistics (DANE) of Colombia and the central bank of Colombia (Banco de la República de Colombia).

TABLE A.2

**Data and sample definition**

| Code | Definition | Source | Coverage |
|---|---|---|---|
| D | First difference (quarter to quarter) of... | | |
| DL | First difference (quarter to quarter) of the logarithm of... | | |
| GDP | Real GDP | National Administrative Department of Statistics (DANE) | 1994 I - 2011 II |
| TOTCL | Terms of trade for four commodities (oil, coal, coffee and nickel) | Central bank, author's calculations | 1996 I - 2011 II |
| TOTT | Terms of trade (wholesale export and import prices) | Central bank | 1994 I - 2011 II |
| PX | Total exports price index (wholesale) | Central bank | 1994 I - 2011 II |
| PI | Total imports price index (wholesale) | Central bank | 1994 I - 2011 II |
| PXCL | Laspeyres price index for exports of four commodities (oil, coal, coffee and nickel) | Central bank, author's calculations | 1996 I - 2011 II |
| OILPR | Laspeyres price index for oil | Central bank, author's calculations | 1996 I - 2011 II |
| NIR | Nominal lending interest rate | International Financial Statistics | 1994 I - 2011 II |
| RIR | Real lending interest rate (using inflation of the producer price index) | International Financial Statistics, author's calculations | 1994 I - 2011 II |
| NER | Nominal exchange rate (pesos per United States dollar) | Central bank | 1994 I - 2011 II |
| RER | Real exchange rate (using producer price index) | Central bank | 1994 I - 2011 II |
| GDPUS | Real GDP of the United States | International Financial Statistics | 1994 I - 2011 II |
| NFF | Net financial flows (inflows-outflows) | Central bank | 1996 I - 2011 II |
| C | Real aggregate consumption | National Administrative Department of Statistics (DANE) | 1994 I - 2011 II |
| I | Real aggregate investment | National Administrative Department of Statistics (DANE) | 1994 I - 2011 II |
| G | Real aggregate public spending | National Administrative Department of Statistics (DANE) | 1994 I - 2011 II |
| X | Real exports | National Administrative Department of Statistics (DANE) | 1994 I - 2011 II |
| M | Real imports | National Administrative Department of Statistics (DANE) | 1994 I - 2011 II |

*Source:* prepared by the author on the basis of information from National Administrative Department of Statistics (DANE) of Colombia, the central bank of Colombia (Banco de la República de Colombia) and International Financial Statistics (IFS).

TABLE A.3

**Augmented Dickey-Fuller unit root tests**

| | MacKinnon one-sided *p*-values |
|---|---|
| Variable | Null hypothesis: variable has a unit root |
| DLGDP | 0.002 |
| DLTOTCL | 0.000 |
| DLTOTT | 0.000 |
| DLPX | 0.000 |
| DLPI | 0.000 |
| DLPXCL | 0.000 |
| DLOILPR | 0.000 |
| GDP (CYCLE) | 0.001 |
| TOTCL (CYCLE) | 0.000 |
| TOTT (CYCLE) | 0.000 |
| PX (CYCLE) | 0.000 |
| PI (CYCLE) | 0.008 |
| PXCL (CYCLE) | 0.000 |
| OILPR (CYCLE) | 0.000 |
| DNIR | 0.000 |
| DRIR | 0.000 |
| DLNER | 0.000 |
| DLRER | 0.000 |
| DLGDPUS | 0.000 |
| DNFF | 0.000 |
| DLC | 0.000 |
| DLI | 0.000 |
| DLG | 0.000 |
| DLX | 0.000 |
| DLM | 0.000 |

*Source:* prepared by the author on the basis of data from the National Administrative Department of Statistics (DANE) of Colombia, the central bank of Colombia (Banco de la República de Colombia) and International Financial Statistics (IFS).

Note: Schwarz information criterion.
DLGDP: first difference (quarter to quarter) of the logarithm of real GDP.
DLTOTCL: first difference (quarter to quarter) of the logarithm of the terms of trade for four commodities (oil, coal, coffee and nickel).
DLTOTT: first difference of the logarithm of TOTT.
DLPX: first difference (quarter to quarter) of the logarithm of the total exports price index (wholesale).
DLPI: first difference (quarter to quarter) of the logarithm of the total imports price index (wholesale).
DLPXCL: first difference (quarter to quarter) of the logarithm of the Laspeyres price index for exports of four commodities (oil, coal, coffee and nickel).
DLOILPR: first difference (quarter to quarter) of the logarithm of the Laspeyres price index for oil.
GDPCYCLE: cyclical component of real GDP.
TOTCLCYCLE: cyclical component of the terms of trade for four commodities (oil, coal, coffee and nickel).
TOTT: terms of trade (wholesale export and import prices).
PI: total imports price index (wholesale).
PX: total exports price index (wholesale).
PXCL: Laspeyres price index for exports of four commodities (oil, coal, coffee, and nickel).
OILPR: Laspeyres price index for oil.
DNIR: first difference (quarter to quarter) of the nominal lending interest rate.
DRIR: first difference (quarter to quarter) of the real lending interest rate.
DLNER: first difference (quarter to quarter) of the logarithm of the nominal exchange rate.
DLRER: first difference (quarter to quarter) of the logarithm of the real exchange rate.
DLGDPUS: first difference (quarter to quarter) of the logarithm of the real GDP of the United States.
DLG: first difference (quarter to quarter) of the logarithm of real public spending.
DLX: first difference (quarter to quarter) of the logarithm of real exports.
DLM: first difference (quarter to quarter) of the logarithm of real imports.

TABLE A.4

**Specific ARMA**
*(Correlogram for DLGDP)*

| Lag | Autocorrelation | Partial correlation | Q-statistic | Prob. Q statistic |
|---|---|---|---|---|
| 1 | 0.09 | 0.09 | 0.52 | 0.47 |
| 2 | 0.30 | 0.30 | 7.17 | 0.03 |
| 3 | 0.24 | 0.22 | 11.48 | 0.01 |
| 4 | -0.07 | -0.20 | 11.82 | 0.02 |
| 5 | -0.04 | -0.20 | 11.93 | 0.04 |
| 6 | 0.00 | 0.04 | 11.93 | 0.06 |
| 7 | 0.04 | 0.23 | 12.06 | 0.10 |
| 8 | -0.10 | -0.09 | 12.88 | 0.12 |
| 9 | 0.19 | 0.09 | 15.78 | 0.07 |
| 10 | 0.01 | 0.00 | 15.78 | 0.11 |
| 11 | -0.03 | -0.07 | 15.83 | 0.15 |
| 12 | 0.11 | 0.03 | 16.93 | 0.15 |
| 13 | 0.00 | 0.07 | 16.93 | 0.20 |
| 14 | -0.08 | -0.09 | 17.50 | 0.23 |
| 15 | 0.02 | -0.05 | 17.52 | 0.29 |
| 16 | -0.10 | -0.10 | 18.48 | 0.30 |
| 17 | -0.01 | 0.14 | 18.48 | 0.36 |
| 18 | -0.20 | -0.23 | 22.24 | 0.22 |
| 19 | 0.03 | 0.01 | 22.30 | 0.27 |
| 20 | -0.07 | 0.08 | 22.78 | 0.30 |
| 21 | -0.11 | -0.05 | 23.96 | 0.30 |
| 22 | 0.04 | -0.08 | 24.09 | 0.34 |
| 23 | -0.14 | -0.07 | 26.06 | 0.30 |
| 24 | -0.02 | 0.03 | 26.11 | 0.35 |
| 25 | -0.08 | 0.02 | 26.86 | 0.36 |
| 26 | -0.01 | -0.03 | 26.87 | 0.42 |
| 27 | -0.12 | -0.04 | 28.57 | 0.38 |
| 28 | -0.05 | -0.07 | 28.81 | 0.42 |

*Source:* prepared by the author on the basis of data from the National Administrative Department of Statistics (DANE) of Colombia.

TABLE A.5

**Specific ARMA**
*(Regressions for ARMA components)*

| Dependent variable: DLGDP (quarterly growth rate of real GDP) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) Specific I | (5) | (6) | (7) | (8) Specific II |
| Constant | 0.0081*** | 0.0085*** | 0.0082*** | 0.0082*** | 0.0079*** | 0.0085*** | 0.0082*** | 0.0082*** |
| | (3.33) | (3.82) | (3.27) | (3.48) | (3.80) | (4.43) | (6.08) | (3.00) |
| AR(1) | 0.0498 | | -0.5984* | | | | | |
| | (0.33) | | (-1.89) | | | | | |
| AR(2) | 0.3426*** | | -0.5704** | 0.3724*** | 0.3055*** | | | 0.3273*** |
| | (3.69) | | (-2.36) | (2.79) | (3.12) | | | (3.14) |
| AR(3) | 0.2285* | | 0.2419 | | | | | |
| | (1.98) | | (1.02) | | | | | |
| AR(4) | -0.2163* | | -0.1293 | | | | | |
| | (-2.00) | | (-0.65) | | | | | |
| MA(1) | | 0.0096 | 0.6289*** | | | | | |
| | | (0.07) | (2.81) | | | | | |
| MA(2) | | 0.4205*** | 1.0886*** | | | | | |
| | | (3.97) | (5.75) | | | | | |
| MA(3) | | 0.3443** | 0.2901 | 0.5052*** | | 0.3593** | | 0.3377** |
| | | (2.33) | (1.51) | (6.24) | | (2.55) | | (2.40) |
| MA(4) | | -0.0671 | 0.6383*** | -0.4013*** | | | -0.0981 | |
| | | (-0.48) | (3.91) | (-4.36) | | | (-0.94) | |
| $R^2$ | 0.18 | 0.24 | 0.28 | 0.27 | 0.09 | 0.08 | 0.01 | 0.17 |
| $R^2$ adjusted | 0.12 | 0.19 | 0.17 | 0.23 | 0.08 | 0.07 | -0.01 | 0.14 |
| Prob. Chi-square (Breusch-Godfrey) | 0.23 | 0.86 | 0.72 | 0.69 | 0.46 | 0.03 | 0.01 | 0.20 |
| S.E. of regression | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Akaike's information criterion | -5.99 | -6.10 | -6.00 | -6.16 | -6.00 | -6.00 | -5.92 | -6.06 |
| Schwarz information criterion | -5.82 | -5.94 | -5.70 | -6.03 | -5.98 | -5.93 | -5.86 | -5.96 |
| F-statistic ($p$-value) | 0.02 | 0.00 | 0.01 | 0.00 | 0.01 | 0.02 | 0.50 | 0.00 |
| Observations | 65 | 69 | 65 | 67 | 67 | 69 | 69 | 67 |

*Source:* prepared by the author on the basis of data from the National Administrative Department of Statistics (DANE) of Colombia.

Note:
(t-statistic), *$p$<0.10, **$p$<0.05, ***$p$<0.01.
Least squares and MA derivatives that use accurate numeric methods. Consistent standard errors.

TABLE A.6

**Correlogram of residuals for the selected regression** [a]

| Lag | Autocorrelation | Partial correlation | Q-statistic | Prob. Q statistic |
|---|---|---|---|---|
| 1 | 0.03 | 0.03 | 0.08 | |
| 2 | 0.07 | 0.07 | 0.47 | |
| 3 | -0.03 | -0.03 | 0.53 | 0.47 |
| 4 | -0.22 | -0.23 | 4.13 | 0.13 |
| 5 | -0.16 | -0.15 | 5.98 | 0.11 |
| 6 | 0.01 | 0.05 | 5.99 | 0.20 |
| 7 | 0.09 | 0.12 | 6.62 | 0.25 |
| 8 | -0.04 | -0.11 | 6.75 | 0.34 |
| 9 | 0.22 | 0.15 | 10.59 | 0.16 |
| 10 | -0.01 | 0.00 | 10.60 | 0.23 |
| 11 | -0.09 | -0.09 | 11.33 | 0.25 |
| 12 | 0.04 | 0.04 | 11.43 | 0.33 |
| 13 | 0.00 | 0.08 | 11.44 | 0.41 |
| 14 | -0.10 | -0.08 | 12.21 | 0.43 |
| 15 | 0.07 | 0.02 | 12.58 | 0.48 |
| 16 | 0.00 | -0.03 | 12.59 | 0.56 |
| 17 | 0.09 | 0.16 | 13.25 | 0.58 |
| 18 | -0.13 | -0.22 | 14.88 | 0.53 |
| 19 | 0.08 | 0.06 | 15.46 | 0.56 |
| 20 | -0.02 | 0.07 | 15.49 | 0.63 |
| 21 | -0.05 | -0.05 | 15.78 | 0.67 |
| 22 | 0.07 | -0.03 | 16.23 | 0.70 |
| 23 | -0.10 | -0.06 | 17.28 | 0.69 |
| 24 | 0.01 | 0.01 | 17.30 | 0.75 |
| 25 | -0.02 | 0.01 | 17.33 | 0.79 |
| 26 | 0.06 | -0.02 | 17.70 | 0.82 |
| 27 | -0.06 | 0.00 | 18.16 | 0.84 |
| 28 | 0.01 | -0.05 | 18.16 | 0.87 |

*Source:* prepared by the author on the basis of data from the National Administrative Department of Statistics (DANE) of Colombia.

[a] See column (1) of table 2.

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