Borradores de ECONOMÍA

The international cycle and Colombian monetary policy

Por: Lavan Mahadeva
Javier Gómez Pineda

Núm. 557
2009

tá - Colombia - Bogotá - Colombia - Bogotá - Colombia - Bogotá - Colombia - Bogotá - Colombia - Bogotá - Colombia - Bogotá - Col

BANCO DE LA REPÚBLICA
COLOMBIA

The international cycle and Colombian monetary policy*

Lavan Mahadeva†
Javier Gómez Pineda‡

Abstract

The objective of this paper is to analyze how international cycles affect the real GDP cycle and so monetary policy decisions in Colombia. We estimate that cycles in world GDP, export prices and capital inflows are strongly associated with the Colombian business cycle both on impact and even during the first year. We find evidence that, because of inefficiencies in the domestic financial sector, external gains are channelled into nontradable spending through credit expansions. This creates large appreciations during booms. The reverse happens during world slowdowns. These swings in the Exchange rate restrict the scope for a countercyclical monetary policy.

Keywords: Capital inflows, Terms of trade, International Business Cycles, Developing Country, Colombia, Monetary policy, Business Cycle.

JEL Classification: E32, E44, E52, F41.

All the data are linked to this paper **here**, along with a description of **their construction**.

* The contents of this paper reflects the opinions of the authors alone, and not those of the Board of Directors of the Banco de la República. We would like to thank especially Jenny Segura Osuna, but also Diego Cancino Suárez and Mónica Rangel, for their research assistance. We would like to thank Hernán Rincón Castro for his comments on an earlier version of this paper.
† Adviser to the Governor, Banco de la República, Colombia, corresponding author, email: lavanito@gmail.com
‡ Senior Researcher, Banco de la República, Colombia

The international cycle and Colombian monetary policy*†

Lavan Mahadeva‡ Javier Gómez Pineda§

April 8, 2009

1 Introduction: Motivation, focus and methodology

The monetary transmission mechanism describes how changes in central bank interest rates affect macroeconomic variables such output and inflation. But monetary policy actions are often responses to an exogenous change in the environment. In developing countries like Colombia, many monetary policy changes are reactions to turns of events in world markets. The objective of this paper is to characterize and quantify the impact of these external factors as a starting point for an analysis of the monetary transmission mechanism in Colombia.

As an illustration of how international market forces affect Colombia, Charts 1 and 2 plot a simple measure of the cyclical component of Colombian real GDP in constant pesos against the cyclical components of real dollar export prices and capital inflows respectively.

Chart 1. Colombia's real dollar export price and real GDP cycles

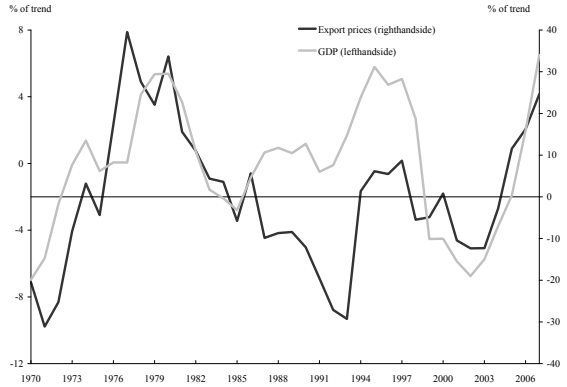
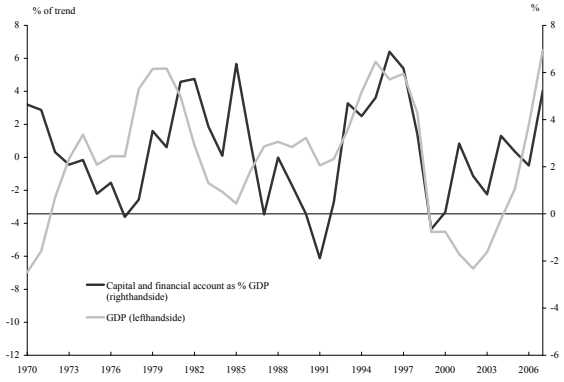


Chart 2. Colombia's capital account/GDP ratio and real GDP cycle



Source: DANE, BEA and Banco de la Repùblica

Note: Real GDP and real dollar export prices are the cyclical components after removing a log-linear trend

Note: Export prices is the export price deflator converted to dollar terms divided by the US GDP deflator

*The contents of this paper reflects the opinions of the authors alone, and not those of the Board of Directors of the Banco de la República.

†We would like to thank especially Jenny Segura Osuna, but also Diego Cancino Suárez and Mónica Rangel, for their research assistance. We would like to thank Hernán Rincón Castro for his comments on an earlier version of this paper.

‡Adviser to the Governor, Banco de la República, Colombia, corresponding author, email: lavanito@gmail.com

§Senior Researcher, Banco de la República, Colombia

We should expect some relationship between international market fluctuations and the Colombian business cycle. After all, Colombia is a developing country whose domestic residents need to buy in capital, consumer and raw material products from abroad and then export and borrow from international capital markets to pay for those imports. But that the two series shown in the chart are so close is startling. After all, 65% of real GDP in Colombia is household consumption, and therefore ultimately the outcome of the decisions of more than forty million Colombians while world prices are of a handful of commodities and flows of capital are into large firms, banks and government institutions[1].

Naturally there has been a lot written about the role of world export prices and global liquidity on the Latin American and the Colombian business cycle. Some recent papers which find a significant relationship between cycles in these international variables and domestic output are by Villar, Salamanca and Murcia (2005), Tenjo, Charry, López and Ramírez (2007), Abrego and Österholm (2008) and Uribe (2007) for Colombia and Zettelmeyer (2006) Ocampo (2007), Österholm and Zettelmeyer (2007), Izquierdo, Romero, Talvi (2008) and Titelman, Pérez Caldentey and Minzer (2008) for Latin America generally.

The implication that we draw from these close correlations is that the starting point of an analysis of the transmission mechanism of monetary policy in Colombia should be a characterization of the impacts of exogenous events. One way about thinking about the objective of this paper is that it is to provide sufficient information to calibrate these external factors in what could be a dynamic stochastic general equilibrium (DSGE) model of Colombia's monetary transmission mechanism. We leave it to other researchers to build the rest of that model and then explore how the monetary policy reactions to these shocks help to promote policy goals.

Our purpose is to answer the following questions about Colombia's external factors.

- How large and how volatile are the *impacts* of external factors on domestic variables? By impact we refer to the immediate reaction of a domestic variable to a change in the external factor, with all other variables constant. We measure impacts by calculating the first-order approximation of the partial elasticity of the domestic endogenous variables to exogenous variables.

- What is *the first-year reaction* of domestic macroeconomic variables to these external factors? The reaction averaged over the year can be different to the impact if the shock is smoothed or amplified by the internal workings of the domestic economy in that year. To answer this question, we estimate partial bivariate correlations between shocks and domestic variables and also a multivariate model that relates all the shocks together to the domestic variables, both on annual data.

- How are the external factors interrelated? To answer this, we also estimate the correlation and synchronization between these variables themselves.

[1] We are on quite firm ground in arguing that here correlation is causality. Export prices are in real dollar terms and Colombia has little or no market power in any of its export markets. In Section 2.3 we provide some strong evidence that cyclical capital flows too are not caused by the domestic cycle in Colombia.

- How likely is it that the external factors revert to their mean? We estimate a general process for the exogenous variables, and from that model make some inferences about likelihood of mean reversion in these series.
- On which sectors do they impact? We estimate the correlations between the shocks and disaggregated components of GDP and financial variables. The greater detail helps us isolate the most likely explanations for why the correlation is so strong.
- Is this what we should expect from a developing country, or from any primary commodity exporter? We compare some of our findings for Canada which is also an open economy that exports primary commodities (Cross and Ghanem, 2005).

Our study is guided by three principles. First we aim to estimate only the impact and first-year reaction to these variables. To trace through the later effects of the external factors within the economy would need a structural dynamic model that fits the data reasonably well, a task that is beyond the scope of this chapter. Second, the variables we analyse should be exogenous, so that the inference is not complicated by analysing variables that, for the large part, are endogenous. Third, we should try and give some idea of how confident we can be about our estimates and try and make them robust to outliers and small sample effects.

With these principles in mind, we restrict ourselves to analyse the impact of only four external factors: export prices, of import prices, of capital inflows and of world GDP (the weighted GDP in Colombia's main export markets) all in real dollar terms. We justify this focus as follows. First all our chosen series impact on the same variable, real GDP. This makes it easy to scale them and compare between them. Second they are all international market variables — they are all in dollars and all determined in world markets — and as such are more likely to be exogenous. Third we can at least get a long enough time series for these four variables.

By the same token we had to leave out some other exogenous variables which are none the less potentially important. For example we left out world interest rates and the spreads on Colombian international borrowing. The problem is that the only data we have on spreads is from 1990. And at least in part the information in the price of borrowing is captured by the value (capital inflows) as we shall argue below.

We also left out total factor productivity (TFP) because we did not feel confident enough about the estimates of the series that we would have to use. TFP would have to be calculated as a residual from a production function and so any errors in measuring the inputs or in the function itself would pass on to this estimate. As our empirical work is based on correlations, our inference would be particularly prone to this source of error.

We have also ignored exogenous movements in fiscal policy. The problem here was that data on government spending has an important endogenous component and we would need some model to identify the exogenous fiscal impulse (see Restrepo and Rincón, 2006). That said, we were able provide some information on how chosen shocks themselves affect fiscal revenue and government consumption. For similar reasons, we have not tried to estimate and test for the impact of exogenous shifts in

monetary policy institutions, or important domestic structural changes like financial market liberalisation, or improvements in security. These structural changes have been without a doubt important but it is difficult to imagine how we can get decent time series data on these variables over the whole sample.

Another excluded important exogenous series is local climatic conditions. The prices of domestically produced food in Colombia are very sensitive to droughts, heavy rainfall and flooding. The complication we would need to overcome if we want to allow for the effect of climatic conditions is that this exogenous variable affects not just consumer prices, but also intermediate input prices and the output and income of agricultural producers. So if we were to include weather we would need a model to separate price from quantity effects.

In the next section, Section 2, we describe our four chosen external factors in detail. Section 3 explains what we mean by the elasticity of an impact and the contribution on impact of an external variable to real GDP. There we also explain how we construct data on these concepts. In the rest of Section 3, we estimate the correlations between these series themselves and against real GDP during the first year of impact in pairs and also in a dynamic factor model. In this section we also formally investigate the extent of mean reversion.

The following sections look into which components of GDP are most affected by the external factors, disaggregating along the lines of expenditure, production, and household income. These results are presented in Sections 4.1, 4.2 and 4.3 respectively. We also check how these variables affect private sector credit, money, asset prices and the real exchange rate in Section 4.4. In Section 4.5 we bring all this information together by assessing different explanations for the close relationship between the business cycle and the external factors. Section 5 compares our findings for Colombia with some estimations on Canadian data. Section 6 presents a smoothing hypothesis for our shocks and checks to see if that holds for Colombia and Canada. Section 7 concludes.

2 A description of the external factors

The purpose of this section is to provide some colour for our statistical description of the external factors by reviewing the stylized facts. This also helps to justify our methodological choices about which data series we chose and how we modelled that relationship. A detailed explanation of all the data we used is provided in Appendix 9.1. All the data are linked to this paper here, along with a description of their construction.

2.1 Export prices and diversification

We begin by looking at the prices of Colombia's exports. Table 1 summarizes the shares of different exports over time.

Table 1. Products in Colombian exports

	1970-1989	1990-2007
Coffee	50.9	15.4
Petrol and derivatives	9.8	24.1
Coal	1.6	8.4
Ferronickel	0.7	2.3
Other products	36.9	49.7

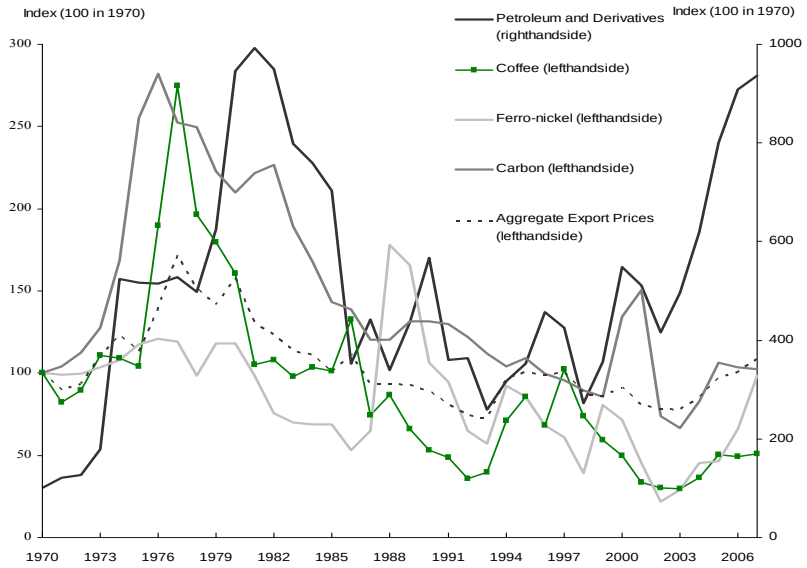
Source: Banco de la República.

Up until the 1980s, Colombian exports were dominated by coffee. Since then, although coffee's share fell dramatically, the three other most important products other than coffee (fuel and minerals) increased to partially compensate: the share of the rest of products after excluding the four most important by value has increased from 37% to only 50% across our two subsamples of twenty years. Table 1 tells us then that although Colombia's exports have been diversified, they remain concentrated in commodities.

This pattern of limited diversification has implications for how world prices affect Colombia's export prices. Chart 3 plots the dollar price of Colombia's four main exports and the aggregate export price deflator all deflated by the US GDP deflator. We can see that the wide fluctuations in world commodity prices matter for Colombia's export deflator.

That said, the chart also shows us that the commodity price swings seem to have less effect on the export deflator towards the end of the sample, thanks to what diversification has recently taken place. Yet we are ultimately interested in the effect of international prices on GDP, on not just on the deflator. It is then important to bear in mind that the export share of GDP had also increased in later years with greater openness, as we shall see below. On balance, it is very possible that the effect of international commodity prices on Colombian GDP may not have diminished, and may even have increased and will increase even further as the economy opens up.

Chart 3. Real dollar export prices of Colombian export products



Source: BEA and DANE.

2.2 Import prices, the opening up of the Colombian economy and the world cycle

Turning now to import prices, Chart 4 compares detrended real dollar import and export prices for Colombia and shows a close but not perfect comovement between the two. This relationship between the detrended series also holds in nominal peso terms or in nominal dollar terms. This might seem startling because on the whole, Colombia imports quite different goods to what its exports. It imports capital, consumer goods and import raw material in very roughly equal proportions. Within consumer imports, durables dominate. Colombia exports very little capital and some but still much less consumer durables. The largest concentrations of exports are in primary products (see Table 1 above) and in manufactured goods to Venezuela, and to the US. Only perhaps imported raw materials, for example refined petroleum, follow similar cycles to Colombia's commodity exports.

Chart 4. Real dollar import and export prices (detrended)

Source: DANE and own calculations.

On these grounds, the correlation would then seem to be because world market prices follow very similar swings even for different types of traded goods. To prove this we confirmed that there was a strong comovement in detrended export and import prices in real terms for the United States and Canada. Though, it is interesting that US import prices were more volatile than export prices, while the opposite is true of the Colombian and Canadian cases. This is probably because the US imports a greater share of raw materials and commodities than what it exports while for Colombia and Canada, the reverse is true.

However it turns out that cyclical movements in the relative peso price of these imports (the price in pesos related to domestic CPI) are negatively correlated with cyclical movements in the relative dollar import price. This is because higher world prices lead to a strong appreciation of the Colombian peso. It seems that whenever Colombia benefits from higher export prices, it is also likely to benefit from cheaper import prices in terms of domestic income. Conversely when dollar export prices are low, it is likely that the impact on real GDP will be exacerbated by more expensive imports in pesos. This pattern has some important implications for this study which aims to separately estimate the influence of exogenous real dollar export and import prices on Colombia: it explains why a statistical relationship between real dollar import prices and GDP is unlikely to tell us about the true effect of import prices on GDP independent of what is happening to export prices and the nominal exchange rate. We take this up later on in our interpretations of the effect of import price movements.

When considering the effect of import prices, and also export prices, it is important to recognize that there has been a gradual but persistent liberalisation of Colombian trade. This process sped up in the 1990s, a structural break which is known in Colombia as the apertura. Chart 5 plots the share of imports in GDP in Colombia. What stands out is that the share has been gradually increasing since the 1970s, but then in the late 1990s and onwards it rises much more quickly. The same pattern can be seen in exports.

Chart 5. Import share of GDP

Source: DANE

This matters for our study because we would expect that exogenous trade prices are more related to GDP after the 1990s than before. Clearly we need to adjust for openness. Our solution was to use indices with shifting weights when we calculate the contribution .

2.3 Capital inflows and development

We decided to include capital inflows as an external factor because we think that for the large part the cyclical flow of Colombia's net borrowing is determined by international market sentiment within the same year. This might seem very controversial. For example it might seem related to the heated debate on whether national savings causes foreign borrowing or vice versa. So we should defend this both with evidence and argument. Another important issue that needs to be discussed is whether structural changes in the size and nature of capital flows would affect our results.

Note first that for the results in this paper to hold we only require that *cyclical* capital inflows be *weakly* exogenous to GDP. Weak exogeneity (Creel, 2005, page 202) does not mean that the cyclical component of capital inflows has to be exogenous to GDP in all senses, it just means that in so far as we are interested in the estimation of the correlation between the capital and financial account and GDP in the first year, we do not expect temporary movements in the capital account to be affected by GDP cycle within the same year, or that both affected by a third unobserved exogenous variable. Thus excess demand can spill over into a current account deficit with a lag of more than a year and still be consistent with our interpretation.

Then we should clarify that the capital inflows data series we use is the capital and financial account, which is of course equal to the current account deficit plus any net changes in foreign reserves. So it does not include policy-determined foreign exchange interventions which we would expect to be endogenous.

The mechanism by which the current account is supposed to be endogenous to GDP over the cycle is simply that an excess of domestic demand over supply would inevitably leak out in a current account deficit and so cause a capital inflow. Conversely when income is higher than spending, the nation as a whole repays external debt. But with respect to countries like Colombia we would argue that even if the current account deficit and changes in official reserves do depend on domestic GDP contemporaneously, the capital and financial account need not do so.

For example an increase in demand above supply potential could be consistent with unwillingness of international investors to lend out for reasons unrelated to the domestic cycle. In this situation the policy authorities will have one of two choices. They can either rein in that excess demand through drastic monetary policy tightening or they can cash in what international reserves they have to pay for the current account deficit. In the first scenario, with higher interest rates, the GDP cycle is made subordinate to the availability of capital inflows. In the second, with a greater exchange rate depreciation and without rises in interest rates, the cushioning might lead to a greater consumption of nontradable items and possibly domestic inflation than otherwise. The point is that in both cases, the domestic authorities cannot do much in the same year to elicit greater lending from an international market that is reluctant to supply it.

Conversely, when the international financial markets want to lend, the choices of the policy authorities are limited either to loosening monetary policy and thus to letting a current account deficit build up or to use foreign exchange intervention, exchange rate appreciation or other forms of exchange rate stabilization to offset the effect of capital inflows on the current account.

One possible way in which the GDP cycle could affect capital inflows is when the authorities successfully act to stop private inflows directly by imposing capital controls in the same year that the GDP gap is very positive. But Villar and Rincón (2000) provide evidence for Colombia since 1994 that capital controls do not have much effect on private capital inflows. Edwards (1998) reports a similar result for Chile. Our assumption is that capital controls were either ineffective or came into operation with a lag of one year.

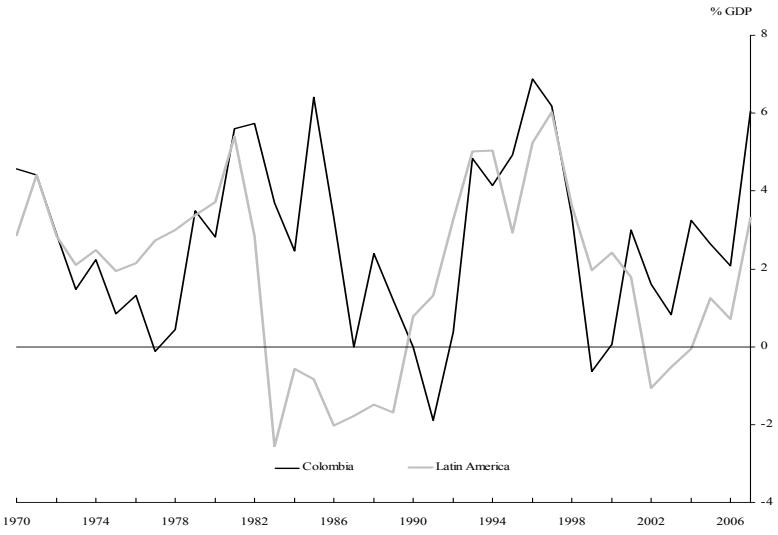
Finally it could be that private stabilization funds were in operation, making private capital inflows endogenous to domestic GDP. The most famous stabilization fund operating in our data would be the Fondo Nacional de Café, which was important during the early part of our sample when coffee was a major export. However this fund did not invest much of the gains from coffee GDP abroad but rather in domestic projects and hence did not create much capital outflows. In 1980 and 1981 the fund's holdings in foreign currency reached a maximum share of GDP of 0.24%, but this would have been swamped by capital inflows in those years of over 5.5% of GDP (Contraloría General de la República,1985)

Chart 6 provides some evidence that the capital and financial account of Colombia is to a great extent driven by international market sentiment. The chart presents the capital and financial accounts of Colombia and Latin America. We can see the two big waves of capital inflows in the early 1980s and the 1990s and also the subsequent seizing up of those flows in the 1980s debt crisis and the end of century episode. As Latin American countries have very different domestic policy decisions and frameworks, the graph suggests that lending to Colombia over the cycle is more a question of an international push

rather than a domestic pull, confirming an early but more formal investigations of Calvo, Leiderman, and Reinhart (1993) and Reinhart and Talvi (1997). Importantly, in the chart we can see that this comovement seems to have strengthened with recent financial globalization: the correlation is 0.174 in 1970-2007 while from 1990-2007 it is 0.630.

Chart 6. Capital and financial account

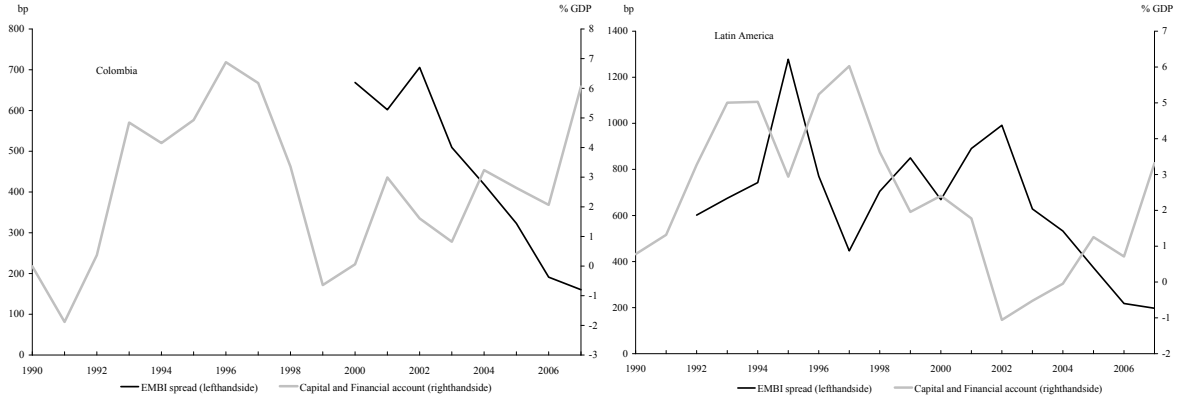
(Colombia and Latin America)



Source: Balance Payments Statistics IMF and own calculations.

Another argument for the capital inflow endogeneity is that the price of international borrowing can adjust sufficiently to make the volume of capital inflows endogenous to the domestic country's needs. This is unlikely to be the case with Colombia. When international financial market lending is restricted, the cyclical cost of borrowing rises and the cyclical flows of capital available fall. When international financial markets are eager to lend, the cyclical cost of borrowing falls and capital flows rise. Chart 7 describes the negative relationship between the capital and financial account and the EMBI spread both for Colombia and also for Latin America.

Chart 7. Capital and Financial Account and EMBI Spreads Colombia and Latin America

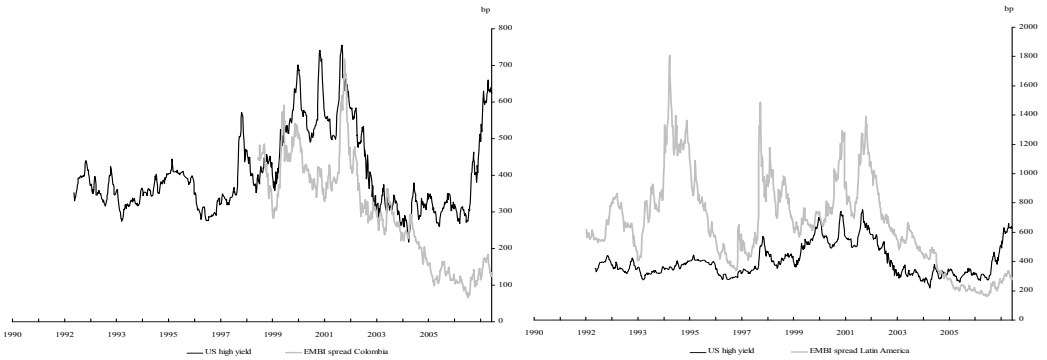


Note: The capital account for Latin America is a common factor between Brazil, Chile, Colombia, Mexico and Peru, and is calculated with a Kalman Filter.

Source: Bloomberg and Balance Payments Statistics, IMF and own calculations.

As further proof, we can also show that these EMBI spreads are in turn related to other measures of international market appetite for risk that have little to do with Colombia such as the US high yield spread. See Chart 8.

Chart 8. EMBI Spreads for Colombia and Latin America and US High Yield rate



Source: Bloomberg and J. P. Morgan.

We also applied a formal econometric test that capital inflows are indeed weakly exogenous to GDP in Colombia. The results are in Appendix 9.4. Although these tests are often themselves subject to criticism in the literature (Bound, Jaeger, Baker, 1993), these findings are at least consistent with the other arguments in this section. Drawing all this evidence together, we feel that have enough evidence to support our argument that over the cycle, the capital and financial account can be considered to be weakly exogenous to GDP with respect to the estimation of its first-year correlation.

Another issue we need to address is the possible implications of structural changes in the nature of inflows over our sample. One decomposition is presented in Chart 9. It shows that in the 1970s and 1980s inflows were predominantly bank lending (the category other), since the mid-1990s, foreign direct investment (FDI) has increased its share dramatically (Uribe, 1995).

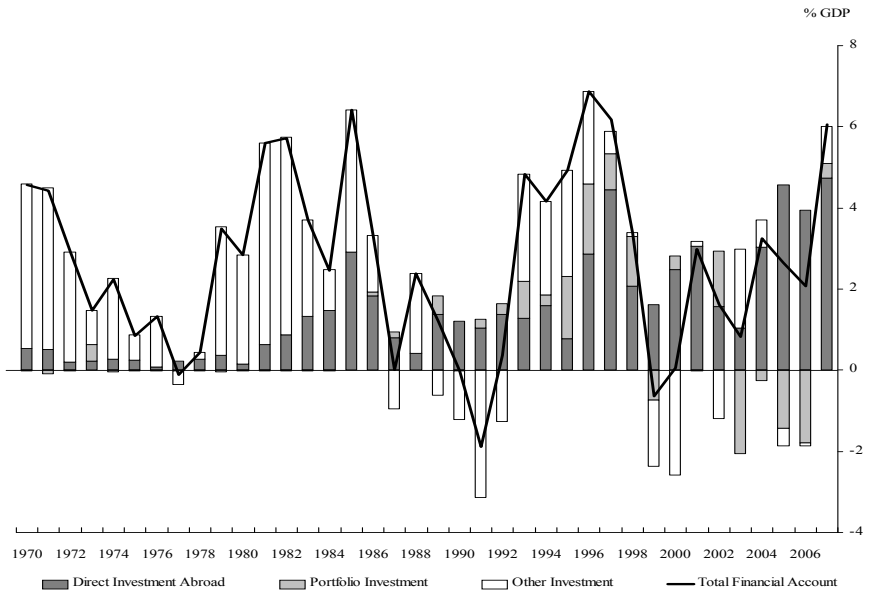
Consequently Colombian capital inflows are more likely to go to the private sector since the 1990s. This shift — common to other emerging market countries — could lead to an important change in the nature of our capital inflows, because FDI is estimated to be less volatile and less likely to reverse than other types of flows (Hausmann and Fernandez-Arias, 2000).

That said, we should also point out that FDI in Colombia while certainly more steady than portfolio inflows is by no means invariant to the global liquidity cycle. For example, although we did not see net outflows of foreign direct investment from Colombia during the crisis year 1999 it dropped below its average of previous years. A study by the IMF (International Monetary Fund, 2003) suggests that much of the recent FDI depends on debt raised in the international capital market or directly with international banks. Also, the recent important vintages of foreign direct inflows may now be more like portfolio flows in their nature than previous their ancestors. This is especially true if they are recently more motivated by tax efficiency (Cummins and Hubbard, 1994) and in some part, an evasion of controls on portfolio flows rather than a commitment on the part of nonresidents to share more risk with Colombian residents. The importance of this structural shift is then an empirical issue.

Similarly it might be important that remittances became an important source of finance to Colombia since the mid 1990s. Although not considered a capital inflow in the data, they can be used to finance investment, for example in residential construction or in small scale physical capital.

In Section 3.2 we report some robustness checks to investigate if these structural changes have any consequence for our study.

Chart 9. The capital and financial account and its components



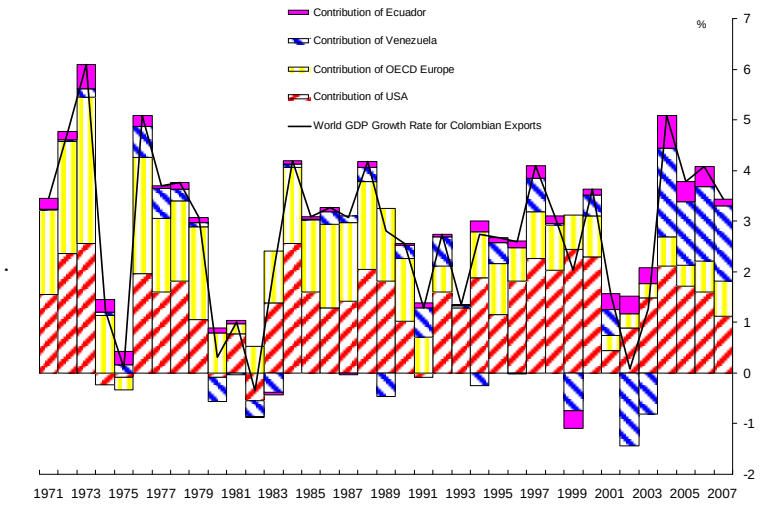
Source: Balance Payments Statistics IMF.

2.4 World GDP and globalization

Our final series is for world GDP. Here we need to explain why that series should be constructed as a shifting weight index and cannot be simply the GDP of the United States for example.

Chart 10 shows our created Colombian world GDP series and breaks it down into the contributions of the four trading partners that make it up. As is explained in Appendix 9.1, the series was constructed as an index from the real GDP of Colombia's four main trading partners (including all of OECD Europe as one) and using export shares as weights. Those shares are summarized in Table 2.

Chart 10. Colombian world GDP growth



Source. See Appendix 9.1.

Table 2. Destinations of Colombian exports

	1970-1989	1990-2007
Venezuela	5.19	9.00
Ecuador	1.82	4.28
United States	31.63	39.61
OECD Europe	40.54	20.83
Rest	20.83	26.27

Source: Banco de la República.

Clearly our Colombian world GDP series would be poorly approximated by an off the shelf series such as US GDP or an index of world trade volume. Chart 10 shows how volatile movements in Venezuelan GDP have come to impact heavily on the demand for Colombia exports, especially towards the later half of the sample. Our world GDP had to be built as a weighted combination to take account of this special influence. Table 2 shows that Europe has lost half of its share over the

sample. So that index had to have shifting weights.

3 Characterizing the external factors

3.1 Measuring the contribution on impact to real GDP

Our first step is to was to calculate the elasticity of a percentage change in each external factor on a percentage change in real GDP on impact. This is done by calculating the first-order approximation of an initial impact of the variable on real GDP, with all other variables held fixed. We call that creation an *impact elasticity* and with time-varying weights, it will be a series. We then multiplying that by the raw data series on the external factor in an index formula to calculate what we call *the contribution of the impact to real GDP.*

The *impact elasticity* is different to *the first-year effect of a shock.* That distinction can be made clear with the use of a simple model. In what follows, variables are all in per capita terms. In this model, the representative consumer at time t experiences lifetime utility in consumption $c_t, \ldots, c_{t+s}$ where β is the discount factor and σ is the intertemporal elasticity of substitution,

$$E_t \sum_{s=0}^{\infty} \left(\frac{1}{1+\beta} \right)^{t+s} \frac{\sigma}{\sigma - 1} \left(c_{t+s} \right)^{\frac{\sigma-1}{\sigma}} . \tag{1}$$

All income (y_{t+s}) is either consumed or invested (inv_{t+s})

$$y_{t+s} = c_{t+s} + inv_{t+s}, \tag{2}$$

and capital is accumulated from investment according to

$$k_{t+s} = \frac{(1-\delta)}{(1+n)} k_{t+s-1} + inv_{t+s}; \tag{3}$$

where δ is the intertemporal rate of discount and n is population growth. Output is produced from capital and labour

$$y_{t+s} = \left(k_{t+s} \right)^{\alpha_1} \left(\frac{k_{t+s-1}}{(1+n)} \right)^{\alpha_2} \eta_{t+s} \text{ with } \eta_{t+s} \equiv \left(e^{z_{t+s}} e^{(t+s)\mu_g} \right)^{1-\alpha_1-\alpha_2} ; \tag{4}$$

$$z_{t+s} = (1-\rho_z)\, z + \rho_z z_{t+s-1} + \varepsilon_{z,t+s} ; \tag{5}$$

$$\text{and } \varepsilon_{z,t+s} \sim N\left(0, \sigma_z^2\right). \tag{6}$$

Note that part, but not all, of the capital produced in the same period can be put to work within that period, with $0 \leq \alpha_1, \alpha_2 \leq 1$ and $0 \leq \alpha_1 + \alpha_2 \leq 1$. As we are working with low frequency annual data, this seems plausible.

z_{t+s} is an autoregressive technological productivity shock, the only shock in this model. Note also that the technological

progress shocks are temporary, and not permanent on the level of output.

The information set at time t includes all parameters and only the time t and previous values of the variables:

$$I_t = (c_t,\ y_t,\ k_t,\ inv_t,\ z_t,\ I_{t-1})\,. \tag{7}$$

The representative agent's problem at time t is to maximize 1 subject to restrictions 2, 3, 4, 5, 6 and 7, looking ahead for $s = 0, \ldots, \infty$. In Appendix 9.2 we show that the solution to the agent's problem can be written in terms of capital

$$\begin{aligned} \widehat{k}_t &= \lambda_1 \widehat{k}_{t-1} + q\widehat{z}_t \\ &= q\sum_{j=0}^{t} (\lambda_1)^i\, \widehat{z}_{t-j} \text{ for } t = 0, \ldots, \infty \end{aligned} \tag{8}$$

with λ_1 and q are both functions of all parameters except those determining the exogenous productivity process and where

$$\widehat{x}_t \equiv \ln \frac{\widetilde{x}_t}{\widetilde{x}_{ss}}\ ,\ \widetilde{x}_t \equiv \frac{x_t}{e^{t\mu_g}} \text{ and } \widetilde{x}_{ss} \text{ is the balanced growth steady state value of } \widetilde{x}_t.$$

In our terminology, the contribution of the impact of the productivity shock is the log-linearized contribution of the exogenous productivity process to output, when both are in terms of their deviations from the steady state. Clearly then the contribution of the impact at time t, $\widehat{\eta}_t$, is different to the reaction of output at time t ($\widehat{y}_t$) because of the endogenous reaction of capital, comparing

$$\widehat{\eta}_t = (1 - \alpha_1 - \alpha_2)\,\widehat{z}_t$$

and

$$\widehat{y}_t - \widehat{\eta}_t = \alpha_1 \widehat{k}_t + \alpha_2 \widehat{k}_{t-1}. \tag{9}$$

This difference is still there even when the economy begins at the steady state $\left(\text{even if } \widehat{k}_{t-1} = 0\right)$ because some new capital can be installed put to work in the first year, given that $\alpha_1 \neq 0$.

Our exposition is in terms of a productivity shock, but could be applied to other shocks. In fact, a data analogue for the shock impact can only be constructed when good data on that shock exists, as we have argued is more likely to be the case in our four shocks.

Having explained what the impact contribution means, how then do we measure it? A first step is to calculate the impact elasticity by a log-linear approximation. Let $f(\mathbf{X})$ be a single-valued function of a vector of n variables $\mathbf{X}$ and let Ξ be the operator that converts a function of variables into log deviations from a point somewhere in between before and after the

change. Then the elasticity of $f(\mathbf{X})$ in terms of log deviations from that point is

$$\Xi f(\mathbf{X}) = \sum_{i=1}^{N} \left[\frac{df(\mathbf{X})}{dX_i} \frac{X_i}{f(\mathbf{X})} \right]_{\mathbf{X}=\mathbf{X}^*} \widetilde{x_i} \tag{10}$$

where each $\left[\frac{df(\mathbf{X})}{dX_i} \frac{X_i}{f(\mathbf{X})} \right]_{\mathbf{X}=\mathbf{X}^*}$ is a function of the fixed-point values only.

We can take the export price series as an example. The consolidated consumers' budget constraint in nominal terms is

$$P_{Xt}E_tX_t - P_{Mt}E_tM_t + A_t = P_{GDPt}GDP_t$$

where X_t is the real volume of exports, P_{Xt} is the export price in dollars and E_t as the PPP dollar peso exchange rate. M_t is the real volume of imports, P_{Xt} is the import price in dollars. A_t is nominal absorption, $P_{GDPt}GDP_t$ is nominal value added income with P_{GDPt} being the GDP deflator. In order to approximate the impact of the real dollar export price on real GDP, we rewrite the identity as

$$\frac{P_{Xt}}{P_{USGDPt}} \frac{P_{USGDPt}E_t}{P_{GDPt}} X_t - \frac{P_{Mt}}{P_{USGDPt}} \frac{P_{USGDPt}E_t}{P_{GDPt}} M_t + \frac{A_t}{P_{USGDPt}} = GDP_t$$

where P_{USGDPt} is the United States GDP deflator. The elasticity of real dollar export prices on Colombian real GDP is then approximated by

$$\frac{\Delta \log(GDP_t)}{\Delta \log \frac{P_{Xt}}{P_{USGDPt}}} = \left[\frac{P_{Xs}E_sX_s}{P_{GDPs}GDP_s} \right]_{s\in(t,t-1)} \tag{11}$$

ignoring second and higher order terms. We approximate the elasticity series by $\left[\frac{P_{Xt}E_tX_t}{P_{GDPt}GDP_t} \right]_{s\in(t,t-1)}$ as a Törnqvist weight, the arithmetic average of the value in time t and time $t-1$. In the first period we use the time $t-1$ share only. This series is what we call the time-varying impact elasticity of the external factor and is a time-varying version of the elasticity in 10. The product of the impact elasticity and the accumulated growth rate of the external factor gives us an index of the contribution on impact of real dollar export prices to real GDP.

It is important to clarify that as this is a calculation of an impact, it deliberately does not account for any behavioural response on the part of domestic residents to the exogenous change. In particular it takes all other variables such as imports and consumption constant. This can then differ from the actual response of real GDP to a movement in the external factor within the same year, which is what would be measured by a correlation on annual data. For example if there is some consumption smoothing of the higher export earnings within the same year, then the actual response of real GDP will be less than our measured impact and the shock variable will be less correlated with GDP. In general if within the year there is an offsetting movement in another series, this calibration will overstate the first-year response. On the contrary, exacerbating movements will imply understatements.

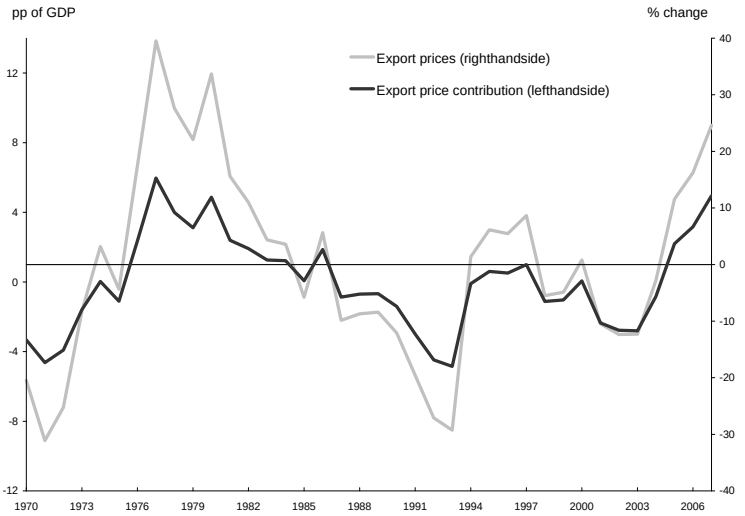
Later on in Section 3.3 we estimate a model that allows us to estimate the first-year effects of these shocks on GDP. There we show that it is indeed the case that sometimes the impact is cushioned, and sometimes it is amplified. A fully identified structural model would be needed to go beyond that and trace through the effects of shocks with more precision and over longer horizons.

Of course our measures of the impact are only first-order approximations; if there were large second-order effects then this would not capture the true impact. We would argue that our measures do represent a decent approximation of the impact of an exogenous variable on real GDP.

Chart 11 plots our measured contribution to real GDP of real dollar export prices against the rate of change of real dollar export prices. Clearly one difference is in terms of scale, the elasticity transforms the raw series into units of real GDP. But there are also some cyclical differences which adjust for when exports were more or less important for real GDP.

Chart 11. Real dollar export prices

and their cyclical contribution to GDP



Source: DANE, Banco de la República and BEA.

The contributions of two other external factors, the real dollar import prices and real dollar world GDP, are calculated using similar formulae (in Table 3a below and in Appendix 9.3). However the series for real dollar capital inflows can take negative values. Therefore we cannot separate out a level series and a elasticity for capital inflows; we can only calculate an approximation to their product, which is the contribution to real GDP growth.

Table 3 summarizes our findings. The first column presents the standard deviation of the raw series after being detrended with a log-linear trend. This is not possible for capital inflow series as we explained above. The next three columns summarize the value of the elasticity of the impact of this series on GDP. Remember that the time-varying elasticity series multiplied by the level of the series within an index formula gives us an indexed series of the contribution of that series in impacting GDP. The formulae for the contribution are in Table 3a.

We then took the index of the contribution of the impact to real GDP of each series, detrended that index for a log-linear trend and calculated the average amplitude and the standard deviation of the cyclical component of the impact of that external factor to GDP. This gave us a measure of the volatility of these contributions to GDP. These calculations can be compared to each other and to the real GDP cycle calculated using the same method, in the last row.

Before we go on to interpret the results we should defend our choice of detrending method. Intuitively we used a log-linear trend to filter the data because otherwise we found that the detrending was putting what seemed like cyclical movements into the trend. That could because of heteroscedasticity in the Colombian business cycle. Later on we compare results based on these estimates to heteroscedastic robust measures, and we also provide some evidence that a log-linear trend is justified.

Table 3. Estimated impact elasticities and

contribution on impact to real Colombian GDP of external factors

	Standard deviation of cycle in raw series	Average elasticity in impacting on GDP			Average amplitude of cycle in contribution	Standard deviation of cycle in contribution
	(% of trend)				(pp of GDP cycle)	(pp of GDP cycle)
	1970-2007	1970-89	1990-2007	2007	1970-2007	1970-2007
Price of exports	16.88	0.14	0.19	0.22	5.10	2.75
Price of imports	10.80	-0.15	-0.20	-0.24	2.62	1.73
Capital and financial account					5.99	2.52
World GDP	2.86	0.14	0.19	0.22	0.56	0.63
Terms of trade					5.77	1.88
Real GDP volume per capita					0.41	3.75

Source: Own calculations

Table 3a. Formulas for impact contributions in Table 3

	Contribution formula (derivation, see Appendix 9.3)
Real dollar export prices	$\left[\frac{P_{Xs}E_sX_s}{P_{GDPs}GDP_s}\right]_{s\in(t,t-1)} \Delta \log \frac{P_{Xt}}{P_{USGDPt}}$
Real dollar import prices	$\left[\frac{P_{Ms}E_sM_s}{P_{GDPs}GDP_s}\right]_{s\in(t,t-1)} \Delta \log \frac{P_{Mt}}{P_{USGDPt}}$
Capital and financial account	$\left[\frac{E_tNA_t}{P_{GDPt}GDP_t}\right]_{s\in(t,t-1)} \Delta \log \frac{NA_t}{P_{USGDPt}}$
	$-\left[\frac{E_t}{E_{t-1}}\frac{P_{GDPt-1}GDP_{t-1}}{P_{GDPt}GDP_t}\frac{E_{t-1}NA_{t-1}}{P_{GDPt-1}GDP_{t-1}}\right]_{s\in(t,t-1)} \Delta \log \frac{NA_{t-1}}{P_{USGDPt-1}}$
World GDP	$\left[\frac{P_{Xt}E_tX_t}{P_{GDPt}GDP_t}\right]_{s\in(t,t-1)} \Delta \log (WGDP_t)$
Net terms of trade	$\left[\frac{P_{Xt}E_tX_t}{P_{GDPt}GDP_t}\right]_{s\in(t,t-1)} \Delta \log \frac{P_{Xt}}{P_{USGDPt}}$
	$-\left[\frac{P_{Mt}E_tM_t}{P_{GDPt}GDP_t}\right]_{s\in(t,t-1)} \Delta \log \frac{P_{Mt}}{P_{USGDPt}}$

Note: M_s is import volumes in pesos, NA_t is the stock of net foreign assets (without gold and reserves) in nominal dollars, and $WGDP_t$ is real world GDP in dollars. The contribution of import prices has been multiplied by -1.

Table 3 shows that the raw world price series are very volatile while world GDP is much less so. But what matters is the scale of impacts of these series on Colombian GDP. The second column shows that the impact elasticities of world prices and world GDP are estimated to be fairly small. The reason is simply that Colombia is not yet very open in terms of goods and services trade compared to other countries. However as the opening up of Colombia is an ongoing process, these elasticities will grow over time, implying that the impact of world trade variables on domestic GDP is likely to increase substantially.

The point of calculating elasticities and then contributions allows for the possibility that a very volatile external factor can contribute a lot on impact to real GDP movements even with a small elasticity. In fact this seems to be the case. The standard deviations of the cyclical movements in these contributions in column 6 shows that the volatility of the impact of capital inflows, real dollar export prices and import prices are very large. World GDP movements have the smallest volatility in amplitude. When matched up against the standard deviation of real GDP, all these contributions measure up to sizeable impacts. The impression this gives us is of an economy buffeted by strong external factors on impact. What remains to be seen is whether these impacts are larger than in developed countries with similar export structure, such as Canada, and whether internal mechanisms cushion or amplify them.

3.2 Interrelations between external factors themselves and real GDP

In the previous section we measured the contribution on impact of the external factors on real GDP. It would be interesting to see if those impacts actually translate into movements in GDP during the first year of impact. One way of estimating this is to look at the contemporary correlations between the cyclical component of the contribution on impact of the external factors

against the cycle in real GDP on annual data. We also interested in seeing how the cyclical component of the contribution on impact of our external factors are related among themselves, for example is there is a significant world cycle that links Colombia's export prices, import prices, capital inflows and world GDP in dollar terms.

We carried out these tests on the impact contributions of each of our the external factors, after detrending loglinearly. We first explain the different statistical measures of correlation that we report in this section and also in much of the rest of the paper.

As is common practice, we calculate the bivariate classical correlations. It is useful to have some idea of the significance of these correlations. Sheskin (Sheskin, 2000, chapter 28) estimates that the correlation coefficient will be significantly different from zero if it is less than -0.35 or greater than 0.35 at a 95% level. He also proves a simple formula to calculate a t-statistic for the correlation measures which we also report below our correlations.

We also experimented with some interesting alternatives that adjust for some possible disadvantages with classical correlations.

Our sample is only for 38 years and therefore in principle our measures of correlation may be severely affected by outliers. So we also report a robust measure of correlation. Intuitively, the robust correlation measures places less weight on observations the further they are away from the others (in the dimension of all the series in the group). When both measures of location (mean) and scale (variance and covariance) are jointly estimated in order to minimize the total distance between the weighted data, that estimate is called an M-estimate, and can be thought of as a maximum likelihood estimator of mean and covariance but for the weighting. Here we use a special class of M-estimates, called S-estimates which also jointly estimate a normalisation factor for the determinant of the variance covariance matrix to prevent trivial solutions to the problem. The weighting functions we use are of the bisquare multivariate S-estimate form, and the initial values for our estimations are based on a half-sample subsampling procedure recommended by Maronna, Martin and Yohai (2006) and our whole procedure is summarized in page 199, Chapter 6 of their book. We use Sheskin's formula to calculate t-statistics for these correlations too.

Another problem could be that we are only testing for contemporaneous relationships. What if the correlations occurred with lags of the external factors and current real GDP? We checked for this possibility and found that in the vast majority of cases where there was a correlation with a lag of one or two years it was either smaller in size than the contemporary correlation or less significant. In what follows, where the lagged correlation only is significant, we report it in the text.

The charts in Section 2 suggest that our cycles are widening as the Colombian economy opens up to international markets. In general, Colombian business cycles do not seem to have a fixed amplitude. This creates heteroscedasticity which can impair classical measures of correlation (Forbes and Rigobon, 2002). We adopted two solutions to heteroscedasticity.

First we estimated the concordance between two series using the Kendall tau b statistic (Sheskin, 2000). The Kendall tau b statistic compares the ordinal rankings of two series and estimates how closely they match up, on a scale between 1 and -1, just as with the classical correlation. Providing the same type of heteroscedasticity is present in both series (a good

approximation in our case) this measure should be less distorted by heteroscedasticity than the classical correlations. The measure comes with an asymptotic t-statistic for which we report the probability in Table 4, along with the statistic itself

Second, we estimated Harding and Pagan's measure of concordance, an estimator which is specifically designed for comparing two cyclical series and that is also invariant to heteroscedasticity (Harding and Pagan , 2002). Harding and Pagans' indicator compares two cycles to see if they are in the same phase, or in opposite phases, for each period. Phases are defined by whether the series is moving from a trough to a peak or vice versa and a censoring rule is used to define when we are at a peak or a trough. We used a simple rule that time t is a trough on series y_t if $y_t < y_{t-1}$ and $y_{t+1} > y_t$ and a peak if $y_t > y_{t-1}$ and $y_{t+1} < y_t$. This rule seems perfectly satisfactory on our annual data. For example troughs and peaks always alternate in all cases. Table 6 describes our estimates of the timing of these cycles along with other stylized facts, that are building blocks to calculate to calculate coincidence.

This statistic reports a number in between 1 and 0, with 1 indicating perfect coincidence, and 0 indicating that the two series are in opposite phases. However when the two series are independent the measure will not necessarily be 0.5 in part because of the censoring and in part because we are working with a small sample. Harding and Pagan provide a formula to approximate the reference number for when the two series should be independent and we report that below the measure of coincidence. Our Harding and Pagan estimates are reported in Table 5.

The disadvantage of measures of concordance is of course that with them we are not able to say by how much the shocks are correlated in quantitative terms. We need quantitative information to infer something about the strength of the relationship over the first year. But they should serve to support our classical correlations, which do report that quantitative information.

Having dealt with outlier effects and heteroscedasticity, we are left with two other possible problems namely multicollinearity among the external factors and the possibility that our log-linear detrending was not appropriate. We do not discuss those possibilities here but leave that for the next two sections.

3.2.1 Correlations

Table 4. Estimated correlations between the external factors and real GDP over the cycle (1970-2007)

		Price of exports	Price of imports	Capital and financial account	World GDP	Real GDP volume per capita
Price of imports	Classic correlation	**0.74**				
	tstat	6.51				
	Robust correlation	**0.76**				
	tstat	7.12				
	Kendall's taub	**0.56**				
	prob=0	0.00				
Capital and financial account	Classic correlation	0.26	**0.35**			
	tstat	1.65	2.26			
	Robust correlation	**0.36**	**0.44**			
	tstat	2.32	2.93			
	Kendall's taub	**0.20**	**0.24**			
	prob=0	0.08	0.03			
World GDP	Classic correlation	**0.70**	**0.44**	0.20		
	tstat	5.86	2.96	1.22		
	Robust correlation	**0.69**	**0.47**	0.20		
	tstat	5.70	3.21	1.20		
	Kendall's taub	**0.46**	**0.35**	0.11		
	prob=0	0.00	0.00	0.34		
Real GDP volume per capita	Classic correlation	**0.56**	**0.54**	**0.37**	**0.40**	
	tstat	4.01	3.82	2.42	2.60	
	Robust correlation	**0.57**	**0.59**	**0.36**	**0.33**	
	tstat	4.16	4.44	2.30	2.09	
	Kendall's taub	**0.39**	**0.40**	**0.23**	0.17	
	prob=0	0.00	0.00	0.05	0.13	
Terms of trade	Classic correlation	**0.76**	0.15	-0.02	**0.52**	**0.32**
	tstat	6.87	0.93	-0.13	3.64	2.01
	Robust correlation	**0.71**	0.09	0.11	**0.54**	0.20
	tstat	5.94	0.53	0.66	3.83	1.20
	Kendall's taub	**0.56**	0.12	0.04	**0.33**	**0.20**
	prob=0	0.00	0.28	0.71	0.00	0.08

Notes: Bold indicates 10% level of significance. External factors in terms of impact contributions.

Import price contribution multiplied by -1.

Source: Own calculations.

3.2.2 Coincident indicators

Table 5. Measures of coincidence between the external factors and real GDP

		Price of exports	Price of imports	Capital and financial account	World GDP
Price of imports	Coincident indicator	0.84			
	Reference value	0.51			
Capital and financial account	Coincident indicator	0.68	0.63		
	Reference value	0.56	0.51		
World GDP	Coincident indicator	0.95	0.89	0.68	
	Reference value	0.52	0.50	0.54	
Terms of trade	Coincident indicator	0.84	0.68	0.58	0.79
	Reference value	0.49	0.50	0.49	0.50
Real GDP volume per capita	Coincident indicator	0.87	0.92	0.61	0.92
	Reference value	0.50	0.50	0.50	0.50

Notes: External factors in terms of impact contributions. Import price contribution multiplied by -1.

Source: Own calculations.

Table 6. Stylized facts about the cycles

	No of complete continuous cycles	Mean duration	Mean amplitude	Dates of cycle 1	Dates of cycle 2
Price of exports	1	18.0	5.10	p2p: 1978 to 1996	
Price of imports	2	8.5	2.62	p2p: 1980 to 1989	p2p: 1989 to 1997
Capital and financial account	2	12.5	5.99	t2t: 1977 to 1991	t2t: 1991 to 2002
World GDP	2	10.5	0.56	p2p: 1979 to 1988	
Terms of trade	2	8.5	1.87	p2p: 1978 to 1986	p2p: 1986 to 1995
Real GDP volume per capita	2	8.0	5.77	p2p: 1979 to 1989	p2p: 1989 to 1995

Source: Own calculations.

Looking now at the results, we see that dollar export prices, capital inflows and world GDP are all significantly correlated with real GDP within the first-year of impact. The correlation is weakest in the case of world GDP and strongest in the case of export prices. The Kendall's tau b statistics confirm this finding except in the case of world GDP. The coincident indicators report that all the series including world GDP move in phase with GDP with statistics well above reference values, indicating that it is not an artefact of heteroscedasticity.

It seems then that all of these external factors do not just have strong impacts on real GDP, but also that those impacts translate into sizeable first-year effects. This is even more astonishing in the case of export prices because real GDP volume,

as a measure of the productive contributions of domestic factors only, is designed to abstract from the effects of terms of trade changes through the double deflation procedure. We shall return to this shortly.

In the case of the relative dollar import prices there is a strong positive correlation with real GDP there too. But we cannot interpret this correlation as saying that higher dollar import prices will raise GDP over the cycle, independently of what is happening to the other factors. As we explained in Section 2.2, this positive relationship is really a consequence of the extremely positive strong correlations between dollar export and dollar import prices, and between dollar export prices and the exchange rate. Tables 4 and 5 confirm that the net terms of trade cycle (export prices weighted by export share over import prices weighted by the import share — see Appendix 9.3) is positively correlated with real GDP. On these grounds in what follows for the rest of the paper, we are very careful in reporting and interpreting our estimates of the effect of import prices.

We should also report that the robust correlation between the cycles in real import prices in pesos (deflated by the CPI) and real GDP is negative, as it should be, though not significant. That between the real peso export price cycle and the GDP cycle is also not significant. Clearly then, the exchange rate responses to these shocks are large enough to affect correlations when we translate them into different currency terms.

What can we say about the correlation between the international variables themselves? Most obviously, the cycles in dollar export prices and world GDP are strongly correlated with each other. But more interestingly, the robust correlation between the cycle in capital inflows and the cycle in export prices is positive and significant. And then, simple tests on subsamples show that this correlation seems to be much greater over the second half of the nineties— see Charts 1 and 2. With greater globalization in the future, the comovement between capital inflows and export prices could become even more relevant for Colombia.

On top of this, the estimates also indicate that the cycles in these international series are coincident: the Hardy and Pagan statistics for two out of the three bivariate relations above the reference levels. In conclusion then it seems that these external forces combine when they impact on Colombian GDP. Kaminsky, Reinhart and Végh (2004) reported a similar finding between export prices and domestic monetary policy interest rates for Latin America. We can paraphrase them in saying that when it rains, it pours and when the sun shines, it burns.

That the cycles in these series are related does also mean that the pairwise correlations between each cyclical contribution and real GDP may be distorted by picking up the effect of the other shocks. Although this risk of multicollinearity is unlikely to matter as much as in the case of import prices, it suggests that we need at least to cross check our pairwise estimations with a multivariate estimation of the coefficients of the cycles in the contributions on impact of these external factors on real GDP at an annual frequency. Estimates of these coefficients, as opposed to correlations, can also tell us how large the first-year responses are compared to the impacts and thus if there is any cushioning or instead amplification. This is what we do in the next section.

3.2.3 Some tests of robustness

We conclude this section by checking to see if our results are sensitive to different data series.

Our correlations were based on real GDP volume. But instead we could have tested for the first-year impact of these external factors on real value added national income. At its most simple form, this variable is nominal value-added income divided by the consumer price level. Conceptually it is the consumption purchasing power of real income earned by domestic factors of production. See Cassing (1996) or Duguay (2006).

The reason why we might be interested in doing this is that it is real value-added income and not real GDP that is the income variable in the consolidated budget of the household as non-investment income. And so it is real value-added income and not real GDP that more directly affects consumption and so welfare.

In Appendix 9.5, we present a comparison between the correlations with real GDP and real value-added income and show that the correlations with the latter are smaller and less significant. We do not however think that this is because real value-added income is not the relevant variable in principle. Rather we think that is because the cost of using real value-added income measures is that it brings in measurement error in the CPI of Colombia. The Colombian national accounts authority had never adjusted the aggregate expenditure weights for its CPI index in the 38 years for which we have this sample. The substitution bias that this might create is one source of error. Of course the deflators that are used to calculate real GDP volume estimates might themselves be subject to error. But a visual inspection shows that real value-added income seems excessively volatile, in a way that goes beyond allowing for terms of trade movements. Introducing this possible measurement error will affect our estimates, in the sense of attenuating our correlation estimates. Also in the case of Canada, where we would guess the CPI is better measured, we found stronger correlations when we used real value-added income: see Appendix 9.5.

In principle we could do even better than real value-added income. We could include net repayment of investment income from abroad, which would mean a real national income measure. The national accounts convention is to exclude the income indirectly earned from financial services (FISIM) because of difficulties in allocating that output to disaggregated expenditures. But that does not mean it is badly measured in aggregate, and then perhaps we should include FISIM in our measure of real income. We also tested for national income and GDP with FISIM. However as those measures are only available on a nominal basis, we had to work with real income measures, using CPI deflation. As was with the case with real value-added income, the correlations were weaker and less significant.

We also tested for different measures of net capital inflows other than the capital and financial account to respond to the doubts we raised in Section 2.3. We compared the correlation that we have with net capital inflows against the correlations with capital inflows other than gross FDI, with capital inflows other than net FDI flows. The correlations against the real GDP cycle were only marginally worse when we excluded foreign direct investment, indicating that at least in our sample, there is not very much different about FDI than other capital flows. The correlations with the real GDP cycle and with the

cycle in capital flows plus remittances was much worse than without remittances, indicating that there is no extra information in including remittances, or that the data on remittances is so noisy that any improvement is masked from us. Finally we also experimented with changes in external sovereign debt only, and again the correlation was worse, which might suggest that private sector net inflows affect GDP more. In conclusion we are fairly confident that our measure of capital inflows, apart from being the most straightforward, is the best we could have done. Possibly on a larger sample we would find a significantly different effect for FDI flows. And along the same lines it may also be the case that private sector capital inflows affect GDP more.

3.3 Econometric estimates of a dynamic factor model

The results of the previous section suggested that the external factors were related among themselves. A dynamic factor model builds this multicollinearity into the relationship between the external factors and an endogenous variable and so seems a very appropriate way of exploring this relationship further, following Titelman, Pérez-Caldentey and Minzer (2008). That model is described in our case as

$$\begin{aligned} c_t &= \gamma_1 c_{t-1} + \varepsilon_{1t} \\ y_t &= c_t + \varepsilon_{2t} \\ px_t &= \gamma_2 c_t + \varepsilon_{3t} \\ cc_t &= \gamma_3 c_t + \varepsilon_{4t} \\ wgdp_t &= \gamma_4 c_t + \varepsilon_{5t} \end{aligned}$$

where y_t is the cycle in the real GDP, px_t, cc_t and $wgdp_t$ are the cycles in the impact contributions of real dollar export prices, the capital and financial account and world GDP respectively. The variable c_t is an unobserved state variable which captures the dynamic common factor by which all of these shocks affect GDP, which is identified to be in units of GDP. The shocks ε_{it} for $i = 1, ..., 5$ are all independent white noise terms. We left out real dollar import prices because as we have explained it would enter with a positive sign because of multicollinearity with export prices and the effect of an appreciation in reversing the direction of real peso import prices.

The dynamic factor model permits us to go beyond the pairwise correlations. For example if the coefficient γ_2 is significant then this tells us that export prices are important in affecting this common factor. Remember that our export price series is a contribution and so is in terms of GDP. Therefore, if γ_2 is less than one then the impact of the change in real dollar export prices on real GDP is cushioned within the first year by some internal mechanisms but if γ_2 is greater than one, the effect would be amplified. Identical interpretations apply to the other two external factors.

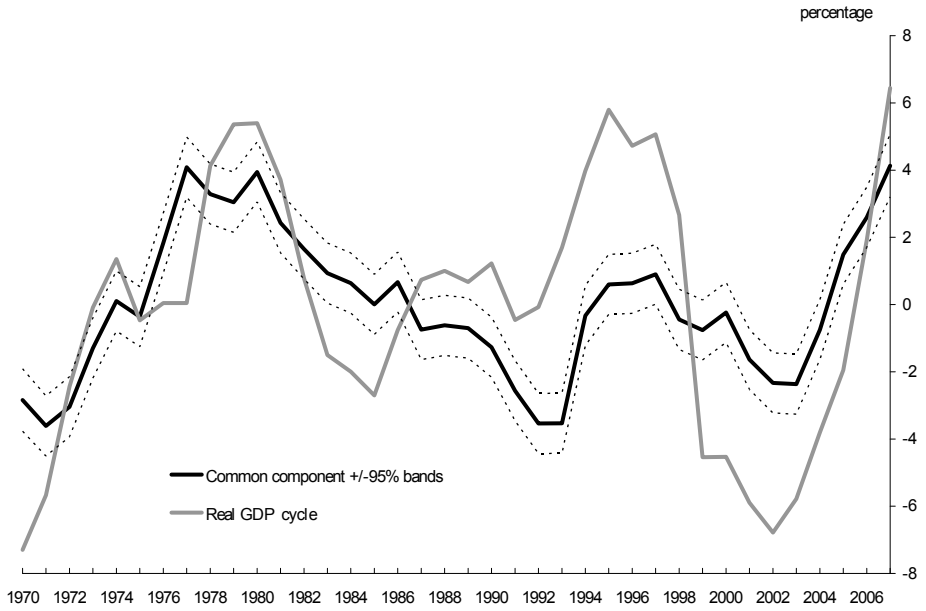
The dynamic factor model was estimated by a maximum likelihood method for the four coefficients, the error variances and the initial value and error covariance of the unobserved state. Table 7 reports the results and Chart 12 plots the estimated common factor against the cycle in real GDP.

Table 7. A dynamic factor model of the external factors and real GDP

Dependent variable:	Price of exports cycle	Capital and Financial Account cycle	World GDP cycle	Real GDP volume cycle	Common state
Exogenous variables:					
Common state	**1.25** 3.76	0.33 1.33	**0.21** 6.40	1.00	
Common state (-1)					**0.83** 0.13
S.E. of regression (%)	0.53	2.39	0.44	3.05	1.30

Note: Maximum likelihood estimates. Z-statistics underneath coefficient estimates. Bold indicates 10% level of significance

Chart 12. The GDP cycle and the common cycle in export prices, world GDP and capital inflows



Source: Own calculations

The estimates of the model as whole seem quite plausible, confirming that these external factors together do play a very important role in affecting real GDP even within the year. Chart 12 shows that a large part of the GDP cycle would seem to be related to them.

We can see that the coefficients in Table 7 on each external factor reveal a very similar pattern to our pairwise correlations, indicating that multicollinearity may not have been a problem. Here export prices are most important in determining the common factor. The world GDP cycle is also important and significant. The capital inflows term is not significant at a high level but is of the right sign and a plausible scale.

The coefficient estimate indicates that the initial impact of the shock in real export prices is amplified within the year. There is some cushioning, especially with capital inflows but also with world GDP. In the case of world GDP that could be because the supply of exports takes time to respond to the demand while for capital inflows that could because the data is noisy (causing an attenuation bias) or that some of the inflow is reinvested abroad and not spent.

Combining the estimates of Table 7 and those of Table 3 we now have a more detailed picture of how these shocks affect Colombian GDP.

Table 8. Summary of impacts and first-year responses (1970-2006)

	Impact	First-year effect			
	Standard deviation of cycle in impact contribution (A)	First-year elasticity estimate (B)	Standard deviation of first-year elasticity estimate (C)	First-year response of real GDP to a 1% shock	
				(B-1.96×C) lower 95% bound	(B+1.96×C) upper 95% bound
Price of exports	2.75	1.25	0.33	0.60	1.90
Capital and financial account	2.52	0.33	0.25	-0.16	0.82
World GDP	0.63	0.21	0.08	0.06	0.36

Source: Own calculations.

The first column is the standard deviation of the impact contribution of each shock in terms of GDP, from Table 3. The next two columns are information from Table 7 on the estimates of the first-year effect of those impact contributions on GDP. The final columns combine both numbers to say by how much a 1% shock in the impact contribution of each series will affect real GDP in the first year, as a 95% range. For example from 2006 to 2007 the real dollar price of exports rose by 2pp above its trend. The table suggests that the effect of this was to raise per capita real GDP by in between 1.2 to 3.8pp above its trend. That might seem like a lot, but then the per capita GDP cycle was estimated to be about 7% about its trend in 2007. The capital account cycle improved by about 3.5pp and that could have affected the GDP cycle by -0.6pp to 2.8pp. The range here is wide because the estimate of the first-year effect is not very precise. Finally our world GDP cycle improved by 1.2 %, which would raise the GDP cycle by somewhere in between 0.1p and 0.3pp.

It is difficult to compare with the findings of others because of differences in method. But there are some other comparable estimates. For example Österholm and Zettelmeyer (2007) estimate that the mode effect of US GDP on Latin American GDP within the year is roughly one for one and Abrego and Österholm (2008) find the effect a bit higher for Colombia, both working with Bayesian VARs. So our estimates of the effect of world GDP seem much to be smaller than these papers.

3.4 Testing for mean reversion

The results of the previous section suggested that important exogenous shocks in especially export prices were not on the whole being cushioned when affecting real GDP. There could be several reasons for this but one important possibility is that movements in these shocks are mostly permanent and not temporary. Aguiar and Gopinath (2007) argue that permanent shocks are relatively more important in emerging market countries because consumption smoothing fails more there. Here we are attempting to test for mean reversion directly on Colombia. This possibility of permanent income shocks also matters to our study because if it were true then our log-linear detrending procedure would be inappropriate.

Estimating what proportion of shocks to a series are permanent as opposed to temporary is an extremely sensitive exercise, as mirrored in the controversy on testing for unit roots. Perhaps one can do little better than making a decision based on a visual inspection of Chart 11. Nevertheless we felt that it is was worthwhile to try and formalise that decision with a test. Our first strategy was to adapt a structural time series model (Harvey, 1990) to the purpose of assessing if our log-linear detrending procedure is valid or not. We base our estimations on the log-linear detrended series, called $x_s^{cycle,ols}$and write a model around that series, which allows for deviations from the log-linear trend. The model in state-space is

$$\begin{aligned} x_t^{cycle,ols} &= \mathbf{z}\alpha_t \\ \boldsymbol{\alpha}_t &= \boldsymbol{\Gamma}_1\boldsymbol{\alpha}_{t-1} + \boldsymbol{\Gamma}_2\boldsymbol{\varepsilon}_t \end{aligned}$$

where unobserved state components are the true cycle, stochastic trend movements and the stochastic trend growth rate deviations from the constant growth rate assumed in log-linear detrending:

$$\boldsymbol{\alpha}_t \equiv \begin{bmatrix} x_t^{cycle} \\ x_t^{trend} \\ g_t \end{bmatrix}.$$

The log-detrended series can deviate from the true cycle if there are stochastic trend movements which the simple detrending has not accounted for. Hence

$$z \equiv \begin{bmatrix} 1 & 1 & 0 \end{bmatrix}.$$

Stochastic trend growth rate movements cumulate onto the stochastic trend level and both the true cycle and the stochastic trend growth rate deviations can follow autoregressive processes. Note that the second state variable (the stochastic trend component of the log-linear detrended series) can be a random walk. Then the transition matrix between those states is

$$\boldsymbol{\Gamma}_1 \equiv \begin{bmatrix} \rho & 0 & 0 \\ 0 & 1 & \tau \\ 0 & 0 & \rho_g \end{bmatrix}.$$

There are pure cyclical shocks and stochastic trend growth rate deviation shocks. Both are white noise,

$$\boldsymbol{\varepsilon}_t \equiv \begin{bmatrix} \varepsilon_t^{cycle} \\ \varepsilon_t^{g\,\mathrm{row}\,th} \end{bmatrix},$$

and have a variance covariance matrix given by

$$\mathbf{Q} \equiv \begin{bmatrix} \sigma^2_{cycle} & 0 \\ 0 & \sigma^2_{g\,\mathrm{row}\,th} \end{bmatrix}.$$

Note that these shocks are independent, a standard assumption in this type of models. The matrix linking these two shocks to the three states is

$$\mathbf{\Gamma}_2 \equiv \begin{bmatrix} 1 & 0 \\ 0 & \tau \\ 0 & 1 \end{bmatrix}.$$

The model admits interesting possibilities which are more general than log-linear detrending. In particular the trend growth rate can deviate persistently from the constant rate we assumed in the rest of the paper. Only if the true variance of the growth rate shocks ($\sigma^2_{g\,\mathrm{row}\,th}$) is close to zero, does this collapse to a log-linear trend. In this way, an estimate of this model can help us infer whether or log-linear detrending was a good approximation.

We seek to find values for the parameters and the initial state values $\boldsymbol{\alpha}_0$ that maximize the loglikelihood. But estimating a model as general as this on a single time series is bound to involve problems of identification. In particular, Monte Carlo experiments have shown that if $\sigma^2_{g\,\mathrm{row}\,th}$ is small, its estimate is found to be further biased towards zero, a phenomenon known as the pile-up problem.

Stock and Watson (1998) suggested a solution to the pile-up problem in a set up which matches our model above. They assume that the parameter τ is inversely proportional to the sample size:

$$\tau = \left(\frac{\lambda}{\text{no. of observations}} \right), \tag{12}$$

and then test for that proportion, called λ, with structural break tests. An asymptotic median function of those test results allows us to impose λ in the relationship 12 when we estimate the parameters of the structural time series model.

The look up tables that they provide are suitable only when a normalisation assumption is also adopted (Stock and Watson, page 8), which in our setup would be

$$\frac{\sigma^2_{cycle}}{\sigma^2_{g\,\mathrm{row}\,th}} = \left(\frac{1-\rho}{1-\rho_g} \right)^2. \tag{13}$$

Assumption 13 is not excessively restrictive for our purposes. For example it does not mean that the variance of the cyclical contribution to the log level of the series will necessarily dominate the contribution of trend shocks. The greater identification from restrictions 12 and 13 acts against the pile-up problem.

To carry out their procedure we first estimate a regression of the growth of each impact contribution series (that is without detrending) on a constant. We estimate this equation by feasible generalized least squares to allow for autocorrelation in the residuals. Then excluding the first and last 15%, we sequentially test the residuals in the rest of the sample for a structural break. We use GLS Chow statistics. The highest value of that statistic, called Quandt's Sup LR statistic (Quandt, 1960), is compared to a lookup Table 3 in Stock and Watson (1998) to imply a λ which is higher, the higher is Sup LR statistic. The λ is used to restrict the ratio of the error variances in estimating the model, according to equation 12. In a second stage, we estimated values of the rest of the parameters as well as initial values of each state variable by maximum likelihood, given the restrictions 12 and 13 and the value of λ.

To compare our structural results against something more simple, we also estimated two models which do not allow for time-varying growth rates in the trends. Both of these models were estimated on log-linear detrended series. To begin we estimated a simple AR(1) process for the log-linear detrended cycle:

$$x_t^{cycle,ols} = c^{ols} + \rho^{ols} x_{t-1}^{cycle,ols} + e_t \text{ with } e_t \sim N\left(0, \sigma_{ols}^2\right),$$

by OLS. We also wanted to be sure that our estimates were not affected by heteroscedasticity and outliers, as could be the case with OLS. So we also estimated a Bayesian AR(1) heteroscedastic model as described in Geweke (2005) and LeSage (2003). That model is summarized as

$$x_t^{cycle,ols} = c + \rho^{bayes} x_{t-1}^{cycle,ols} + e_t \text{ with}$$

$$e_t \sim N\left(0, \sigma^2 V\right),$$

$$V = \text{diag}\left(v_1, \ldots, v_{\text{no. of observations}}\right),$$

$$\rho^{bayes} \sim N\left(c_1, T_1\right),$$

$$c \sim N\left(c_0, T_0\right),$$

$$\frac{1}{\sigma^2} = \Gamma\left(\frac{1}{\sigma_0^2}, T_2\right),$$

$$\frac{r}{v_i} \sim \chi^2\left(r\right) \text{ for } i = 1, \ldots, \text{no. of observations.}$$

and

$$r \sim \Gamma(m, 2).$$

If r is small then we would favour a model with many outliers and heteroscedasticity. The gamma distribution for r has a mean of $m/2$ and a variance of $m/4$, and the inverse chi-squared for $\frac{r}{v_i}$ have a mean of 1 and a variance of $\frac{2}{r}$. So with a prior of $m = 8$ our priors indicate an inverse chi-squared distribution for the v_i which would be far from identically normally distributed and with a long upper tail. Thus extreme observations would be weighted down.

The other priors were diffuse around OLS values:

$$\text{priors: } m = 8,\ c_0 = \left[c^{ols}\right],\ c_1 = \left[\rho^{ols}\right],\ T_0^{-1} = T_1^{-1} = T_2^{-1} = 0,\ \text{and } \frac{1}{\sigma_0^2} = \frac{1}{\sigma_{ols}^2}\ .$$

The model is estimated using Monte Carlo Markov Chain sampling. Stability conditions can be imposed on the AR coefficient using Gibb sampling and a suitable mean acceptance rate applied.

Table 9 reports the results of all three models. Note that real GDP is in per capita terms because they have been some important changes in population growth over the sample.

Table 9. Structural Time Series Model estimations for Colombia

	Price of exports	Capital and financial account	World GDP	Price of imports	Real GDP volume per capita
Standard Error of cyclical shocks (%)	1.72	1.98	0.28	1.09	2.03
Standard Error of growth rate shocks (%)	1.76	2.03	0.55	1.09	3.05
Lambda	0.00	0.00	5.02	0.00	3.93
Variance of growth in non-cyclical component as a proportion of variance in growth rate	0.00	0.00	0.23	0.00	0.02
rho (structural model)	0.80	0.64	0.53	0.39	0.84
rho (ols)	0.79	0.63	1.00	0.77	0.80
median rho (bayesian)	0.79	0.62	0.89	0.85	0.82
Interquartile range rho (bayesian)	0.15	0.19	0.13	0.12	0.11
rhog	0.21	0.37	0.91	0.61	0.25
Number of obs.	38	38	38	38	38

Source: Own calculations.

The general impression is that the external factors are dominated by cyclical rather than non-cyclical movements. In all cases except for world GDP, the ratio of the variance of the non-cyclical component to the growth rate is negligible. In the case of world GDP a ratio of 0.3 does indicate some cause for concern but not enough to lead us to think that our estimates are very flawed.

This does not mean that the trend growth of any our series are found to be completely fixed; the estimations indicate some autocorrelation in the trend growth rate (ρ_g). It is just that shocks to the trend growth rate are not large enough to contribute as much to the overall variance of the series.

The estimated values of the persistence parameter (ρ) are similar to the OLS values and fall within the interquartile range of the Bayesian estimates. In the case of capital inflows and export prices, though they do indicate substantial persistence, they are still consistent with mean reversion. The OLS estimate for world GDP does not indicate mean reversion, but that property reappears in the more general structural time series model estimates once we allow for a stochastic trend.

Note that Colombian real GDP growth is also found to be dominated by cyclical movements. Interestingly its trend growth rate is found to exhibit little persistence even if the external forces have some autocorrelated trend growth rates. This is perhaps some evidence of smoothing at least at this very low frequency.

Another way to estimate how likely our series are to return to their means is to estimate the variance ratios, an idea borrowed from empirical finance literature. If a financial series is i.i.d, then the variance of the k-period return will be k times the variance of the one-period return. The same logic should also apply to the growth rates of our raw series, as if financial markets were trading in an index of export prices, capital inflows, world GDP or real GDP. The idea is to compare the ratio of the variances between the one-year growth rate and the nine-year growth rate, multiplied by nine. If a series is a random walk, and so unlikely to mean revert, then its variance ratio will be one or greater. Values smaller than one indicate mean reversion. We chose a nine-year horizon as that was the shortest horizon for which the ratio becomes less than one for all series.

The advantages of the variance ratio test for us is that the calculation is independent of any detrending procedure or estimated model. To complement the ratio, Lo and MacKinlay (Lo and MacKinlay, 1988) provide a M2 statistic that is designed to cope with heteroscedasticity and is supposed to have some finite sample power and tests the null that the variance ratio is one. Table 10 reports the results.

Table 10. Mean reversion after 9 years compared to 1 year ahead

	Price of exports	Capital and financial account	World GDP	Price of imports	Real GDP volume per capita
Variance ratio	0,69	0,33	0,63	0,94	0,82
M2 statistic	-0,63	-1,31	-0,61	-0,13	-0,40
Number of obs.	29	29	29	29	29

Source: Own calculations

At a 95% level of significance the M2 statistic would report that all four external factors are not different to random walks. But note that in the case of the export prices, the capital and financial account and world GDP, the variance ratios are less than one. Given that we are working with a small sample, and in the light of our other findings, we would rather argue that this table reports some evidence that export prices, capital inflows and world GDP are likely to revert to mean, once we extend to a long enough horizon, here nine years. Capital inflows are the most likely to revert followed by world

GDP and then export prices. Real GDP is less likely to revert than are the external factors, except possibly import prices.

We can now answer the question that we raised in the introduction about the reversibility of shocks. These external factors seem to have a large component of temporary movements, and can therefore be described as transitory in their growth rates although that transition can take many years. Although it is difficult to statistically to distinguish mean reversion from a nonstationary alternative, our findings agree with other investigations of terms of trade shocks or sudden shifts in capital inflows. For example Cuddington (1986) and Suescún (1997) and Zettlemeyer (2007) reach similar conclusions. On the other hand, Cashin, Liang and McDermott (2000) did conclude that shocks to world commodity prices are very long-lasting and variations are dominated by persistent movements. But here we are working with an aggregate export price series, rather than world prices for a few selected items.

An example borrowed from Cuddington (1986) might serve to convince the reader that consumption cannot be responding so strongly to these external conditions only because they have a dominant permanent component. In 1986, the world coffee price rose because of climate changes that damaged production in Brazil. Expert opinion, freely available at the time in Colombia, concluded that the elevated price would only last two years, as it did. For example the Controloría General of Colombia published a special issue on the Coffee Bonanza in its March 1986 edition in which it explained that the bonanza could not last more than three years (Controlaría General de la República, 1986). And if history is the witness, in between the 1950s and the 1986, there had been eight coffee price booms caused by climatic changes in Brazil, all of which were temporary (Suescún, 1997). Yet consumption per capita grew 1 pp faster in 1986 than the average from 1980 to 1985.

If you accept our conclusion that these external forces are dominated by temporary movements, then that rules out one explanation, at least for Colombia, that these shocks are strongly correlated with real GDP because they represent permanent changes in the level of GDP. Indeed Aguiar and Gopinath (2007) who make the claim for emerging market countries that permanent shocks are important are careful not to say that this is because external shocks have permanent components. They suggest that the permanent shocks could be down to domestic policy. In this way, their work could even be consistent with our findings. Our results also represent some good evidence to defend our decision to use log-linear detrending, which in turn should reassure us that our correlations are well measured.

4 Relation with components of real GDP

In the previous sections we investigated the relationships between our shock impact contributions and real GDP. In this section we look at the relationship between these the external factors and the components of GDP, along the dimensions of expenditure, household income and output respectively.

4.1 The expenditure approach

Table 11 describes the correlations between with the expenditure components.

Table 11. Correlations between the external factors and real GDP expenditure components

		Price of exports	Capital and financial account	World GDP
Household consumption volume cycle	Classic correlation	**0.67**	**0.55**	**0.53**
	tstat	5.42	3.98	3.73
	Robust correlation	**0.73**	**0.62**	**0.61**
	tstat	6.45	4.74	4.66
	Kendall's taub	**0.51**	**0.38**	**0.32**
	prob=0	0.00	0.00	0.00
Government consumption volume cycle	Classic correlation	0.02	**0.40**	0.01
	tstat	0.13	2.65	0.04
	Robust correlation	0.13	**0.66**	0.14
	tstat	0.79	5.32	0.87
	Kendall's taub	0.06	**0.31**	0.14
	prob=0	0.60	0.01	0.24
Gross capital formation volume cycle	Classic correlation	**0.37**	**0.70**	**0.30**
	tstat	2.36	5.88	1.87
	Robust correlation	**0.38**	**0.77**	**0.28**
	tstat	2.46	7.27	1.72
	Kendall's taub	**0.27**	**0.53**	**0.21**
	prob=0	0.02	0.00	0.06
Exports cycle	Classic correlation	-0.22	-0.29	0.07
	tstat	-1.36	-0.29	0.07
	Robust correlation	-0.21	**-0.33**	0.11
	tstat	-1.28	-2.08	0.67
	Kendall's taub	**-0.19**	-0.15	-0.02
	prob=0	0.10	0.18	0.88
Imports cycle	Classic correlation	**0.29**	**0.75**	**0.27**
	tstat	1.83	6.82	1.70
	Robust correlation	**0.34**	**0.82**	**0.32**
	tstat	2.19	8.57	2.05
	Kendall's taub	**0.21**	**0.57**	**0.25**
	prob=0	0.06	0.00	0.03
Public investment cycle	Classic correlation	**0.31**	**0.33**	0.16
	tstat	1.90	2.03	0.97
	Robust correlation	**0.32**	**0.59**	-0.01
	tstat	2.01	4.36	-0.08
	Kendall's taub	**0.21**	**0.29**	0.10
	prob=0	0.06	0.01	0.39
Private investment cycle	Classic correlation	0.17	**0.39**	0.05
	tstat	1.00	2.53	0.30
	Robust correlation	0.15	**0.36**	-0.03
	tstat	0.93	2.31	-0.20
	Kendall's taub	0.15	**0.29**	-0.01
	prob=0	0.18	0.01	0.92

Notes: 10% level of significance in bold. All series in per capita terms prior to detrending.

External factors in terms of impact contributions.

Source: Own calculations.

What stands out immediately is that the cycle in household consumption per capita is strongly correlated with all three exogenous forces. All measures of correlation attest to the strength and synchronicity of this relationship.

Investment too is strongly correlated with these impacts. It is apparently less strongly correlated than consumption but investment here includes inventories and so is a very volatile and probably noisy series. For that reason we should see this as strong a correlation as that of consumption. In particular the relationship between investment and the capital account impact contribution stands out. This is one way of looking at the Feldstein Horioka puzzle (Feldstein Horioka, 1980) and

suggests that financial capital is certainly not perfectly mobile across the Colombian border. Bosworth and Collins (Bosworth and Collins, 1999) report that capital inflows affect investment with an elasticity of about a half. Kumar (2007) shows the effect of a one percent rise in the FDI to GDP ratio leads to an increase of a half percentage point in domestic investment. Later on when we look at credit variables, we argue that the response of investment to capital inflows may in part be due to financial accelerator type financial frictions.

Looking further down the table we can see that the investment capital inflow correlation is also present in both public and private components (even if this split is only available in terms of real values and not volumes). There is a good reason to argue that the response of public investment and government spending are each asymmetric over the cycle, because the government finds it much harder to cut its consumption spending during recessions, public investment has to be reduced much more than it was raised in the upswing (Servén, 2008). We cannot test for this, as our detrending procedure imposes symmetry, but we should note that it might distort our findings.

Government consumption is correlated with the capital and financial account, and that relationship is close and in phase. This suggests that fiscal spending on consumption items is historically linked to when finance is available, just as is public investment (Gavin, Hausmann, Perroti and Talvi, 1996). It is likely that this relationship follows with a lag as it takes time for the state to convert incomes into spending. Indeed we did find that the cycle in export prices was significantly correlated with government consumption after two years.

Interestingly the cycle in export volumes is not significantly correlated with either the cycles in real dollar export prices or world GDP. Exports volumes are not the same as real values; to get from values to volumes, the direct of effect of terms of trade changes are removed[2]. They are in peso terms, and the effect of a large peso appreciation during upswings and depreciations during downswings (see Section 4.4 below) could be to cancel out the benefit of dollar export price movements. Yet one would presume that these exporters would buy some part of inputs and also borrow in dollars and so be stimulated by a high dollar output price. And then if the real dollar export price does not promote export production why should it boost household consumption? And then the lack of any relationship between the export volume cycle and the world GDP cycle on one hand and the slight negative correlation between the export volume cycle and the capital and financial account cycle on the other seem even more counter intuitive. For example we know that these exporting sectors receive much foreign direct investment (see Section 4.1). In summary, the export volume correlations constitute a puzzle. We return to this conundrum in Section 4.3 below where we argue that it is due to inelasticities in supply in these sectors.

The import volume cycle is very strongly correlated with the cycles in the capital and financial account, the price of exports and world GDP. We take the first result to imply that spending on imports in Colombia happens when external finance is plentiful. The positive correlations with the world GDP and export price cycles most probably have to do with the short-term behaviour of the real exchange rate (see Section 3.2).

Note that the combined behaviour of exports and imports following export price movements is consistent with a negative

[2]That said, this negative correlation also stands out when we look at real values (deflated by the CPI) instead of volumes.

relationship between the terms of trade and the trade balance. Harberger (1950) and Laursen and Metzler (1950) argued that an exogenous rise in the terms of trade of a small open economy leads to an improvement in its trade balance because its current income would be boosted, and given a marginal propensity to consume less than unity, current consumption increases less than current income, causing private saving to increase. Our negative relationship then denies the Harberger-Laursen-Metzler hypothesis.

But Colombia is not alone in this it seems. In developing countries it is more common to observe a negative relationship between the terms of trade and the trade balance (see or example Backus (1993) and Mendoza (1995)). This failure of the Harberger-Laursen-Metzler effect is explained by a combination of imperfect substitutability between imports and domestic goods in final and intermediate consumption and that the export production response is rigid because of costly factor adjustment in those sectors (J curve effects). In addition there may be crowding out effects exacerbated by financial frictions, both of which hold back export production. We investigate this possibility at a sectoral level in the next section, Section 4.3.

4.2 Relation with household income components

In the previous section we uncovered an extraordinary strong correlation between the household consumption per capita and these external forces. In Colombia consumption tracks income quite closely. That leads us to investigate how household income is affected by these external impulses within the first year. Table 12 contains some answers.

Table 12. Correlations between the external factors and household income

		Price of exports	Capital and financial account	World GDP
Nominal gross household income cycle	Classic correlation	0.24	-0.01	0.12
	tstat	1.44	-0.07	0.72
	Robust correlation	0.22	-0.14	0.08
	tstat	1.34	-0.82	0.46
	Kendall's taub	0.17	0.00	0.02
	prob=0	0.15	0.99	0.91
Compensation of employees cycle	Classic correlation	**0.28**	**0.53**	0.12
	tstat	1.71	3.68	0.70
	Robust correlation	**0.53**	**0.50**	0.19
	tstat	3.74	3.41	1.17
	Kendall's taub	**0.26**	**0.38**	0.02
	prob=0	0.03	0.00	0.84
Gross operating surplus and gross mixed income cycle	Classic correlation	0.13	-0.12	-0.10
	tstat	0.75	-0.71	-0.57
	Robust correlation	0.03	-0.10	-0.12
	tstat	0.19	-0.57	-0.74
	Kendall's taub	0.07	-0.12	-0.08
	prob=0	0.57	0.31	0.49
Property income cycle	Classic correlation	0.27	-0.05	0.18
	tstat	1.66	-0.32	1.11
	Robust correlation	0.17	0.13	0.23
	tstat	1.02	0.79	1.37
	Kendall's taub	0.14	-0.04	0.13
	prob=0	0.22	0.72	0.28
Net transfers from other sectors to households cycle	Classic correlation	-0.10	**-0.60**	0.00
	tstat	-0.61	-4.41	0.01
	Robust correlation	**-0.39**	**-0.75**	-0.15
	tstat	-2.51	-6.80	-0.87
	Kendall's taub	-0.07	**-0.45**	-0.05
	prob=0	0.57	0.00	0.70

Notes: 10% level of significance in bold. All series in per capita terms prior to detrending.

External factors in terms of impact contributions.

Source: Own calculations.

To begin with, we note that aggregate household income is not strongly correlated with our impact contributions. But this might very well be down to aggregation bias; it seems that its most important component, compensation of employees, is very strongly correlated on the robust measure with the impact contributions of capital inflows and export prices. The only other component that appears to bear some relation to the shock impacts is net transfers which is negatively correlated with the capital inflows cycle. But as this is essentially a residual by construction we chose not to place much emphasis on this. If anything, it indicates that another component of household income other than wage compensation is poorly measured and is correlated with capital inflows. That would most likely be gross operating surplus.

We should be careful to point out that as this income breakdown is only available in nominal peso terms, these series

are real incomes deflated by the CPI. If there are errors in the CPI, that would bias our correlations towards zero. See Section 3.2. In addition the income side of the national accounts is probably the least well measured. Nevertheless we would argue that these results give some support for the view that where these shocks are to affect consumers disposable income it is through their salaries. Otherwise they must affect consumption through access to credit (which are not part of these accounts). Both explanations are tested in the following sections.

4.3 Relation with production components

We now turn to look at how sectoral GDPs are affected by the impact contributions of export prices, capital inflows and world GDP. In part this helps us understand why favourable shocks did not seem to affect exports at all, whereas consumption, investment and imports were all strongly affected. But also it should also shed light on the finding of the previous section, that capital inflows affected the wages earned by households. If this were true then we should see that those sectors where most wages are earned are those whose GDP is most closely correlated with these shocks.

Table 13. Correlations between the external factors and sectoral GDP

		Price of exports	Capital and financial account	World GDP	Percentage of wage income earned (1990-2005)	Percentage of total employment (2001-2006)
Real GDP volume agriculture, forestry, fishing, and hunting cycle	Classic correlation	0.26	-0.11	**0.29**	8.3	20.3
	tstat	1.63	-0.66	1.81		
	Robust correlation	**0.36**	-0.26	0.32		
	tstat	2.35	-1.58	1.66		
	Kendall's taub	**0.19**	-0.08	0.12		
	prob=0	0.10	0.51	0.29		
Real GDP volume mining and hydrocarbons cycle	Classic correlation	**-0.62**	**-0.36**	**-0.45**	2.8	1.2
	tstat	-4.76	-2.34	-3.03		
	Robust correlation	**-0.66**	-0.26	**-0.50**		
	tstat	-5.27	-1.64	-3.48		
	Kendall's taub	**-0.44**	**-0.25**	**-0.35**		
	prob=0	0.00	0.03	0.00		
Real GDP volume manufacturing industry cycle	Classic correlation	**0.46**	0.03	**0.55**	14.9	13.7
	tstat	3.08	0.16	3.92		
	Robust correlation	**0.59**	-0.07	**0.52**		
	tstat	3.78	0.08	4.15		
	Kendall's taub	**0.27**	-0.07	**0.22**		
	prob=0	0.02	0.53	0.05		
Real GDP volume electricity, gas and water cycle	Classic correlation	**0.34**	0.21	0.16	2.4	0.4
	tstat	2.15	1.28	0.96		
	Robust correlation	**0.38**	0.15	0.10		
	tstat	2.43	0.90	0.62		
	Kendall's taub	**0.21**	0.16	0.11		
	prob=0	0.06	0.16	0.33		
Real GDP volume construction cycle	Classic correlation	**0.36**	**0.53**	0.20	5.4	4.6
	tstat	2.31	3.75	1.24		
	Robust correlation	**0.35**	**0.52**	0.06		
	tstat	2.23	3.64	0.34		
	Kendall's taub	**0.26**	**0.37**	0.02		
	prob=0	0.02	0.00	0.90		

Notes: 10% level of significance in bold. All series in per capita terms prior to detrending.

External factors in terms of impact contributions.

Source: Own calculations.

		Price of exports	Capital and financial account	World GDP	Percentage of wage income earned (1990-2005)	Percentage of total employment (2001-2006)
Real GDP volume distribution, hotels and catering cycle	Classic correlation	**0.56**	**0.39**	**0.42**	11.9	25.0
	tstat	4.08	2.77	3.67		
	Robust correlation	**0.65**	**0.36**	**0.44**		
	tstat	5.14	2.32	2.98		
	Kendall's taub	**0.40**	**0.27**	**0.28**		
	prob=0	0.00	0.02	0.01		
Real GDP volume transport and communication cycle	Classic correlation	**0.78**	**0.49**	**0.68**	9.6	6.9
	tstat	7.45	3.40	5.63		
	Robust correlation	**0.83**	**0.40**	**0.64**		
	tstat	8.97	2.62	5.04		
	Kendall's taub	**0.59**	**0.37**	**0.44**		
	prob=0	0.00	0.00	0.00		
Real GDP volume financial intermediation, real estate, enterprise and rental services cycle	Classic correlation	**0.27**	**0.64**	0.11	8.8	5.6
	tstat	1.69	5.03	0.64		
	Robust correlation	0.26	**0.71**	0.03		
	tstat	1.63	6.12	0.20		
	Kendall's taub	0.18	**0.41**	**0.21**		
	prob=0	0.11	0.00	0.06		
Real GDP volume activities of social, communal and personal services cycle	Classic correlation	0.24	0.21	0.10	35.9	21.4
	tstat	1.48	1.31	0.61		
	Robust correlation	0.26	**0.32**	0.18		
	tstat	1.62	1.99	1.07		
	Kendall's taub	0.16	0.06	**0.22**		
	prob=0	0.16	0.63	0.05		

Notes: 10% level of significance in bold. All series in per capita terms prior to detrending.

External factors in terms of impact contributions.

Source: Own calculations.

In terms of sectoral real GDP volumes, the results show a marked difference between export-oriented sectors with the inelastic supply on one hand and the other exporting and the nontradable sectors on the other.

First, the cycle in real GDP of the mining and hydrocarbons sector is found to be negatively and significantly correlated with all three shocks. As mining and fuel products take an important share of exports, this is consistent with our earlier finding of a weak negative correlation between the external factors and export volume cycle. We know that mining and hydrocarbons projects have been a major recipient of FDI inflows since 1990, and so this suggests that those capital inflows take a long time to affect the real GDP of this sector. In fact we think that these negative correlations to all the international variables are down to the fact that supply is particularly inelastic in this sector. Production is inelastic because it is intensive in imported capital, requires the exploitation of new fields and depends on transport infrastructure. And then this sector cannot switch direction to produce domestically; its products are almost entirely for exports, and so cannot take advantage of domestic demand to supplement earning while extra capacity is put in place. The only comparable set of estimates of sectoral price elasticity of supply we have been able to find is those by Loza (2001) for Bolivia. He estimates the long-run elasticity of mining and hydrocarbons to be about 0.7, compared to 2.5 for agriculture and 2.2 for manufacturing.

The agricultural GDP cycle is positively correlated with the impact contribution cycles in export prices. The positive correlation makes some sense. After all the supply elasticity of that part of agricultural production that is meant for export should be higher than mining. For example following the rise in the world coffee price over 1976 to 1978, the quantity of green coffee beans produced in Colombia rose by nearly a third in the same period (Food and Agriculture Organization of

the United Nations, 2008). As for the part of agricultural production that is destined for domestic consumption, this sector is certainly likely to be more sensitive to domestic demand than is mining and hydrocarbons. On the other hand the parts of this sector that export are likely to be insensitive to domestic demand: Suescún (1997) also finds that coffee GDP is not very procyclical.

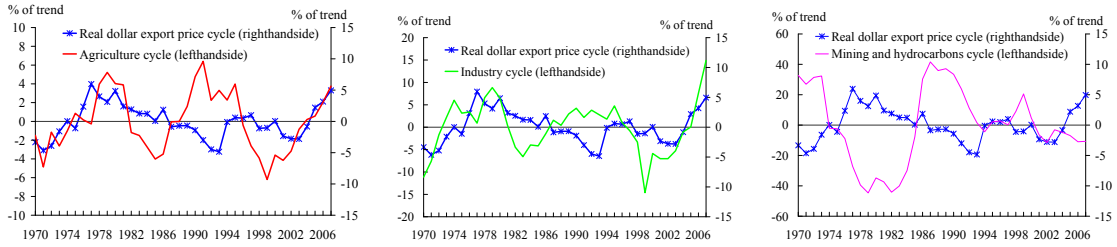
The cycle in real industrial GDP volume is also significantly positively correlated with export prices. Industry, like agriculture, has reasonably elastic supply and has both tradable and nontradable elements Colombian industry exports are concentrated in the US and Venezuela and so the significant positive correlation with world GDP also makes sense. As Venezuela is a close neighbour with similar preferences to Colombia, the elasticity of supply in exporting there should be particularly high.

The lack of correlation with capital inflows cycle and the GDP cycles of these two sectors is as should be expected. The value of FDI inflows going into agriculture is tiny, less than 0.05% of total GDP and only some parts of industry receive FDI inflows and then for particular years, such as 2005. What is surprising though is that the lagged value of the capital inflows cycle is significantly and *negatively* related to the GDP cycles of these two tradable sectors.

Loosely speaking, the greater the domestic market share in the first three tradable sectors, the more that sectors' GDP is correlated with these international cycles. This surprising pattern is reinforced when we look at the non-tradable sectors. The cyclical correlations with the nontradable sectors' GDPs, namely those of construction, distribution, transport, financial and business services and personal services, to these external shocks are in general much more significant and overwhelmingly positive than those of the tradable sectors even within the same year. To bring this out, Chart 13b describes the comovement of three nontradable sectors' cycles with the cycle in export prices, and compares it to the weaker comovement against the tradable sectors cycles in Chart 13a.

Chart 13a. Tradable Sectors' Output

and Real Dollar Export Prices (deviations from trend)

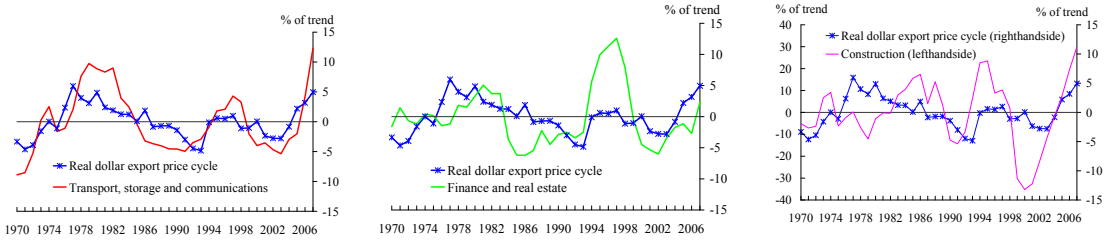


Note: Export price in terms of impact contributions.

Source: DANE and Banco de la República.

Chart 13b. Nontradable Sectors' Output

and Real Dollar Export Prices (deviations from trend)



Note: Export price in terms of impact contributions.

Source: DANE and Banco de la República.

This is astonishing. Surely export price rises and world GDP improvements should first impact on the export orientated sectors and only then feed through onto these more domestically oriented sectors? And then the export prices here are in dollars. We know that peso export prices behave quite differently, and that it makes these responses even more puzzling Also most capital inflows, at least of FDI type, are not directed at the private nontradable sectors. Capital inflows are either supplying government borrowing or financing large non-financial firms in mining and fuels and some important manufacturing concessions.

In particular we can see that the real GDP cycle of the financial, business services and real estate sector is very much affected by cyclical movements in capital inflows with a robust correlation of 0.71. It seems that even if those net financial inflows are for the large part destined directly for other sectors, the real returns to the value added domestic factors in this sector are related closely to cross border financial flows. Note that some of this is removed from GDP by the FISIM adjustment (See Section 3.2). But this sector's earnings are also affected by dollar export prices and world GDP, and more so than the exporting sectors!

These strong cyclical responses of the nontradable sectors are counterparts of our findings on the expenditure side. Along with the domestically oriented parts of agriculture and industry, hotels and catering are all important suppliers of final private consumption. We saw that private consumption is strongly affected by these shocks. Similarly domestic investment goods are supplied for by construction. Finally transport, distribution, financial services and construction are important intermediate suppliers for all types of expenditure. For example public investment is supplied by construction and so our earlier finding that public spending was positively affected by capital inflows has also found its way here in production.

The weakest relationship among the nontradable sectors and the cycles is in the case of personal services. This sector is dominated by public sector production and so its seems odd that it should not be correlated with capital inflows when the cycle in government expenditure is. Looking at graphs of the two, the difference seems to be that the public production cycle is smoother version of government consumption cycle, perhaps reflecting that an important part of government consumption is produced by other sectors and imported from abroad. This is consistent with our finding that the cycle in GDP of this sector is significantly correlated with cycles in export prices and capital inflows but after a lag of two years.

In general then we can conclude that we have discovered an interesting relationship between nontradable sectors output and our external forces but it is not yet clear enough as to cause and effect. We need more evidence. In Table 13 we report the share of total wage income earned and employment in each sector. Shortly we will use this along with another piece of information, the behaviour of financial variables, to try and assess different explanations for these patterns among GDP components.

4.4 Relation with balance sheet variables

In this section we look at the relationship between the external factors and some important balance sheet variables. Table 14 looks at the correlations with the real exchange rate, as an indication of the price of international capital compared to domestic finance. The real exchange rate is measured with the Colombian and US GDP deflators. A rise is a depreciation. Then we also look at the cyclical contribution of two banking variables, net private sector credit by all financial institutions and M3 deposits. Both are measured as the real per capita stock and then detrended. We also look at household savings rate cycle. Our savings rate variable is calculated as an index of the contribution of savings to household income, which is then detrended. This permits us to remove any trend in savings that are due to demographic changes, financial liberalization or to greater trade openness for example, and concentrate on the cyclical movements in household savings.

The last variable in this section is the cycle in the domestic physical capital stock per capita. The series is calculated by aggregating capital stock measures for four different types of capital, dividing by population and then detrending.

A detailed explanation of all these data is presented in Appendix 9.1.

Table 14. Correlations between the external factors and balance sheet variables in Colombia

		Price of exports	Capital and financial account	World GDP
Real exchange rate cycle	Classic correlation	**-0.74**	**-0.36**	**-0.66**
	tstat	-6.56	-2.28	-5.15
	Robust correlation	**-0.77**	**-0.46**	**-0.64**
	tstat	-7.10	-3.08	-4.97
	Kendall's taub	**-0.59**	**-0.28**	**-0.52**
	prob=0	0.00	0.01	0.00
Net private credit real per capita cycle	Classic correlation	**0.40**	**0.55**	0.09
	tstat	2.61	3.86	0.52
	Robust correlation	**0.46**	**0.57**	0.06
	tstat	3.08	4.12	0.33
	Kendall's taub	**0.28**	**0.36**	0.14
	prob=0	0.01	0.00	0.23
M3 real per capita cycle	Classic correlation	**0.39**	**0.66**	0.09
	tstat	2.52	5.20	0.54
	Robust correlation	**0.43**	**0.69**	0.06
	tstat	2.81	5.71	0.34
	Kendall's taub	**0.33**	**0.43**	**0.25**
	prob=0	0.00	0.00	0.03
Savings real per capita cycle	Classic correlation	0.05	**-0.52**	0.00
	tstat	0.31	-3.59	0.03
	Robust correlation	-0.13	**-0.54**	-0.02
	tstat	-0.79	-3.82	-0.15
	Kendall's taub	0.00	**-0.29**	**0.23**
	prob=0	0.99	0.01	0.04
Capital stock per capita cycle	Classic correlation	**0.61**	**0.32**	0.15
	tstat	4.59	2.00	0.90
	Robust correlation	**0.64**	**0.48**	0.19
	tstat	4.98	3.21	1.14
	Kendall's taub	**0.40**	**0.25**	**0.20**
	prob=0	0.00	0.03	0.09

Notes: 10% level of significance in bold. An appreciation is a more negative value of the real exchange rate cycle.

External factors in terms of impact contributions.

Source: Own calculations.

The real exchange rate is very closely related to all the external factors within the first year of impact on real GDP. The correlations are among the highest for any variable reported in this chapter and the Kendall's tau b statistics indicated synchronized movements with all shocks. Of course a correlation does not in general imply a strong elasticity. But in this case it does. A simple OLS regression of the real exchange rate cycle on real dollar export price cycle estimates a short-run elasticity of -1.7, implying that the real exchange rate is very sensitive to our external shocks and that the fluctuations in these external forces can cause substantial misalignments in the nominal exchange rate[3]. This sensitivity has already been noted by Arias and Carasquilla (1996) and Arias and Zuleta (1997) for Colombia and by Athukorala and Rajapatirana (2003) for other countries.

Why should the real exchange rate appreciate following strong capital inflows, high export prices and booming world demand? The explanation seems to be related to the boost in available resources following these favourable developments,

[3]See Section 5 for a description of the equation and a comparison with Canada.

and the differences between tradable and nontradable spending. If the cyclical spending on nontradables is more income elastic than the spending on tradables within the domestic market, and if there are more rigidities in the supply of nontradables, then the relative price for nontradables must rise. The most likely way for this to happen is for the nominal exchange must appreciate (Obstfeld and Rogoff, 1997, Chapter 4). In other words, an appreciation happens during booms in Colombia because a large part of capital inflows are channelled into nontradable spending. If instead the spending was on pure imports, there would be less appreciation.

At first glance this might not seem to be borne out by the Colombian data. In particular it might seem at odds with the fact that import spending, especially on durables, does rise rapidly during booms as seen in Section 4.1. In fact the appreciation is likely to foment import spending during the boom phase; in Section 3.2 we noted that the cyclical movement in appreciation in so strong so as to convert a positively correlated dollar import price cycle into a cycle in peso import price that is negatively correlated. But the real appreciation can be consistent with faster import growth and a widening of the current account deficit, as long as nontradable spending pressure is even greater. This explanation only requires that nontradable spending is more income elastic than is import spending. And it is also crucial that the value of imports sold domestically typically contains a large nontradable margin for distribution and transport and then that there are many complementary services needed to maintain its consumption flow (Burstein, Eichenbaum and Rebelo, 2005).

Although most models assume that the income elasticity of demand for nontradables and tradables are fixed at unity, in an early paper Kravis, Heston and Summers (1983) provided some evidence that the income elasticity of services is greater than one. Nontradable supply in Colombia may reasonably expected to be rigid in the flow of the important services generated from housing and public infrastructures. Looking back to Table 13 we can see that GDP of nontradable consumption sectors (on services) indeed do seem to be more affected by the external impulses than the GDP of tradable consumption producing sectors such as agriculture and industry, suggesting that this nontradable income explanation might fit the Colombian case rather well.

Also in Table 14, it is interesting that the cyclical component of the stocks of real assets and real liabilities of the domestic banking sector are correlated with capital inflows and export prices. The cycle in world GDP is also related after a lag of one year. This is important because in Colombia bank finance (here we also include building societies) matters both for household consumption and firms investment. But not all households and firms have access to the formal financial sector in Colombia and retained income and profits and informal financial suppliers are also crucial. Yet as it is poorer households and smaller firms whose access to the formal financial sector is more limited and so their economic weight is much less than their population share. And even then, the closest opportunity cost that matters to of those who are making spending decision without recourse to the banking sector could still be a bank rate because there is some intermediation with the suppliers of informal credit. That cycles in the banking sector's balance sheets are correlated with the external factors is of great significance in explaining the responsiveness of GDP to these external factors.

The cyclical component of the household savings rate is negatively correlated with capital inflows. This finding is

consistent with other findings for Latin America, such as those reported by Reinhart and Plies (1989) and also Cárdenas and Escobar (1998) just for Colombia. The implication is that the foreign capital inflows are used to finance consumption somehow. Although we do not have correlations with the savings flows of the other sectors (non-bank firms, banks, and the government) we would expect at least that non-financial firms' savings to also be negatively correlated. That would be consistent with the investment correlation. This does not mean that reserve accumulation was not significant nor that there are no capital outflows induced by inflows: it is just that in net, national private savings are found to be negatively related to the global liquidity cycle.

The capital stock cycle is strongly correlated with export prices and capital inflows in the same year. A relationship with the world GDP cycle emerges after one year. This tells us more than the investment correlation of Table 11. It tells us that even the planned productive capacity of installed capital, and not just gross spending, is quite sensitive to these external forces. This seems to be quite at odds with the idea of smoothing out shocks which are not persistent, a point to which we return in Section 6. But it also provides some extra evidence with which to build up and test hypotheses about how exactly these external forces come to affect domestic output so much over the cycle.

4.5 Assessing different explanations of these correlations

We can start by laying out various hypotheses to explain these strong patterns of contemporaneous correlation and synchronisation between the impact contributions of capital inflows, export prices and world GDP on hand against Colombian real GDP and some of its components on the other. These hypotheses are not mutually exclusive and some may have mattered at some times and others at other times. Here we describe what could be happening in upswings but the explanations would work in the opposite direction during slowdowns.

Explanation 1. A first possible channel is direct. During upswings the combination of plentiful finance, higher export prices and greater world demand improve the prospects of exporters who would be most of the firms in mining, and some producers in industry and agriculture, which then spreads out to the rest of the economy. Certainly an important part of capital inflows would be directed at the large firms and multinationals who work in these sectors. This leads to higher salaries in exporting firms and also more demand by these sectors for domestically produced intermediates. Thus the demand boost spills over. Wage incomes rise first in that sector and then in the intermediate sectors that supply them, raising consumption in the whole economy. This all happens within the same year.

Explanation 2. Second it is possible that during global booms, a surge in capital inflows acts to alleviate an external constraint on external financing that in turn cracks the seals on internal financial restrictions.

2a. One way this could happen during global booms is that domestic banks could borrow cheaply from abroad directly at low interest rates and on the basis of those deposits, lend on to firms and households domestically at higher interest rates.

2b. But this could also happen indirectly. Let us say that it is not banks but rather large, multinational firms and

the government who raise capital from abroad when global finance is readily available. That finance is destined for projects within Colombia that are likely to be long term. These projects are also likely to be risky and so borrowers need access to some buffer against contingencies. Against this, these borrowers also know that the source of capital inflows can dry up quickly and may not be available in the future, an argument that has often applied to external fiscal financing in Latin America (Gavin, Hausmann, Perotti, Talvi, 1996) but should also surely apply to the private sector.

It therefore makes sense for the FDI investors to obtain slightly more credit from the international market than is actually needed to be spent at each moment in time. That excess credit should be kept where they can be accessed. A small part of the gross inflows of this sort may be reinvested in liquid assets abroad: that would be consistent with the stylized fact that gross outflows are negatively correlated with the much larger gross inflow. But the lion's share would be deposited within the Colombian financial system, in interest earning monetary assets. If the velocity of circulation of broad money with respect capital inflows is close enough to that of any other domestic income GDP flow, then these capital inflows will generate a large percentage increase in the money stock. For example if a one standard deviation shock to capital inflows is of the scale of 3pp of GDP on impact (Table 3), this would translate into a 3pp increase in money stock with velocity fixed. The deposits of domestic banks swell.

What happens next is similar to the model of banking sector propagation presented in Edwards and Végh (1997). Given that banking is an inherently procyclical business in Colombia as elsewhere, banks immediately start to lend out to even to those domestic sectors that do not have direct access to external finance. Flush with deposits, their savings rate would fall, bringing down the opportunity cost of saving within the country. This spurs on lending and risk taking even outside the banking sector, encouraging spending of retained incomes and activating an informal financial sector.

In either case 2a or 2b, the central bank can try to act against this expansion of credit. It can offer bonds to soak up the liquidity and by doing so raise interest rates. It can also impose reserve requirements or capital controls. If these inflows are large, this may require a very steep rise in nominal policy interest rates, or in the case of reserve requirements raising costs sharply on bank customers. The situation becomes even more complicated if the aim of the central bank is also to prevent any appreciation, for then it would also be actively buying the foreign exchange of exporters and external borrowers.

Explanation 3. This leads to another possible way in which these shocks get transmitted onto spending; that is when monetary policy responds procyclically. In this scenario, the capital inflows and better terms of trade are met with lower not higher real policy interest rates. Naturally domestic demand and inflation rises. The higher inflation lowers the real interest rate even more and stimulates spending further As we have just argued, one reason why monetary policymakers would be reluctant to raise nominal interest rates during the phase of strong capital inflows is when they are also trying to resist a strong appreciation.

Explanation 4. Then it could be fiscal policy that is procyclical. In developing countries like Colombia that are not dependent on foreign aid, the government's revenues are likely to be very cyclical. That could be for various reasons. First the government receives revenue from exporters either via taxes or through franchise agreements. Second when global capital

markets are eager to lend, the government will find it cheaper to maintain its debt, take on new debt and also raise capital through privatisations. Conversely when global markets are closed, their finance drastically curtailed. Finally as the domestic economy is growing strongly, there are more tax revenues and less non-discretionary spending claims. Perry (2008) explains why governments might resist smoothing out their expenditures. It is precisely for these reasons that economists would adjust for the cycle when assessing the sustainability of fiscal policy and in Latin America that cyclical adjustment is often to compensate for temporary swings in export prices and spreads (Izquierdo, Romero and Talvi, 2008). If the response of the government in the favourable upswing is to spend more, invest more and hire more, that fiscal expansion could spark off demand in the rest of the economy. If on the other hand the government acts countercyclically then monetary policy can be less countercyclical in smoothing the demand fluctuations of the private sector.

Using the evidence accumulated in this section we can make some progress in weighting these explanations.

For example explanation 1 might be plausible in the case of the coffee booms in the 1976 and 1986. This is because the coffee industry in Colombia was large but not concentrated in large farms. It was rather composed of many small family-run farms, presumably with a higher propensity to consume other domestic products. But even then, it looks quite unlikely to explain the correlations between these shocks and GDP over the whole period. In our sample, although the share of coffee in GDP reaches a maximum in the sample of 10% in 1978 by 2000 it was less than 2%. And then we should remember that coffee producers had a stabilization scheme in operation during our sample, which saved the income gains during years when the price was high and spent them on supporting the income of coffee growers when prices were low. Finally it seems that the great problem during the coffee booms was rather to do with difficulties in sterilizing the revenues earned from coffee once they re-entered the Colombian monetary system (Cuddington, 1986). This suggests that even when coffee was important, the explanation for why export prices affected GDP so strongly must also depend on some special aspects of banks' behaviour and on constraints on monetary policy.

Another reason to cast doubt on this explanation is in the last but one column of Table 13. There we can see that the share of labour income earned in mining, quarry and hydrocarbons is small. While more of wages (23%) are earned in agriculture and industry, we should adjust for the fact that not all of the firms that produce in agriculture and industry are exporters. Indeed these sectors should be quite heterogenous. The last column of Table 13 shows that the share of employment in agriculture is nearly twice its wage share, indicating that a large part of agricultural production must be small scale and less productive. We would guess that in the more productive, export-orientated firms in these sectors, the share of labour would be much less than a half that of the rest of the sector.

And neither would it be the case that all firms in these three sectors could raise capital from abroad directly, as we argued in Section 4.3. We would guess that the firms in these sectors that borrow from abroad would again be the more productive and therefore those with a smaller share of wage income. Therefore we don't see a link between those sectors that receive foreign financing and those that earn wages, which for us is reason to cast doubt on working capital models of financial imperfections (Neumeyer and Perri, 2005).

Then we would guess that exporting sectors do not use much domestically produced intermediates. Given that their product is for export, the commercialization would be done in the markets. Most of what they use from the nontradable sectors is most likely transport. And then finally note that the key message of Table 13 was that these external factors were more strongly felt on the nontradable sector within the same year. It is hard to fit this results with an explanation that the impulse begins in the exporting sector and spreads elsewhere.

Explanation 2a is likely to be relevant for some but not all of the cycles. For example Caballero and Urrutia (2006) explain that in 1982, just before an external debt crisis, three large private banks were severely exposed to short-term external debt but just before the crisis in 1999, the external debt was only in the form of privatisations, credit to large firms and portfolio investment, not bank lending.

Explanations 3 and 4 might be important. In the case of monetary policy, it is difficult to judge empirically as to when policy has been tight and when it has been loose because many different instruments were used, objectives were sometimes not explicit and inflation is nonstationary over the sample. It cannot be assessed by looking at market interest rates because it is possible that they move independently of policy reflecting the capital inflows. On top of this, we would need to estimate the counterfactual benchmark of what optimal policy should have been to compare actual policy with. With the luxury of hindsight, as we have seen important per capita GDP cycles in Colombia, one could always argue that monetary policy was not countercyclical enough. Kaminsky, Reinhart and Végh (2004) estimate policy rules for a sample of middle income countries, including Colombia, and find that emerging market monetary policy was loose during booms and tight during downturns.

Accepting that this were true, then why? A common explanation for the failure to raise interest rates and prevent booms from building up as a result of favourable international climate is that the inflows of capital were so great that sterilisation became difficult. That is, once the Banco de la República accepted some responsibility for resisting appreciation, or as was often the case historically, organizing a devaluation, it became difficult to do this and also keep some control of inflation and credit. See for example Uribe (1995) and references in Martinez (2008).

Much depends on how much interest rate activism would have been needed. In the face of shocks of such a scale and given serious rigidities and institutional failings elsewhere, it is possible that interest rates would have had to be raised very aggressively during the early phases of a boom and large swings in the real exchange rate would also have to be tolerated in order to limit the effect of these shocks on consumption. Another restriction is in terms of the financial cost of sterilisation. And even if capital controls, reserve requirements and other instruments could be employed to try and maintain control of both objectives (Villar, Salamanca and Murcia, 2005), these measures can create inefficiencies in the financial intermediation which might even then provoke further problems.

No doubt this monetary policy dilemma could have been made easier by a fiscal policy that was countercyclical. Many studies for example Lozano and Toro (2007) or Perry (2008), find that Colombian fiscal policy was instead procyclical for most of this period. Chapter 3 of the Fall World Economic Outlook on Managing Large Capital Inflows (Cardarelli, Elekdag

y Kose, 2007) estimates that a more disciplined fiscal policy during the boom phase helps to limit the hard landing caused by a sudden stop in capital inflows. They also estimate that resisting appreciations and imposing capital controls does little to help.

In summary, an inadequate countercyclicality in monetary and fiscal policy are probably important parts of the explanation for these response of the Colombian business cycle to the external shocks, as suggested by Kaminsky, Reinhart and Végh (2004). But to do this explanation full justice one would have understand and quantify the trade-offs that policymakers face over the cycle, especially given the cyclical tendency of the real exchange rate, which we argued might be down to structural preferences and rigidities in supply in Section 4.4.

We think that the main reason why the policy trade-off is so difficult in Colombia is because of inefficiencies in the financial system. Indeed explanation 2b fits many of the facts remarkably well. Firstly it is consistent with the strong response of banking deposits and private sector credit within the first year. It also explains why the business cycle in nontradable sectors is more strongly correlated with these external forces even during the first year. In particular bank lending for house purchases is likely to stimulate demand for financial services, durable consumption, construction and personal services. Table 13 shows that a large share of labour income is earned in these sectors (about 70%) and so it is easier to understand why total wage income and so total consumption could quickly respond to a boom in these sectors.

In this way the boom within the nontradable sectors could be mutually reinforcing and could even explain the appreciation, if the income elasticity of nontradable consumption demand is relatively higher and nontradables are in more restricted supply. as we argued in Section 4.4.

One might ask, why would banks be so eager to lend on the basis of short-term deposits? One answer would lie partly in some financial market imperfection that makes banks procyclical. Using very different methodologies, Rubio, Ojeda and Montes (2003), Tenjo, Martínez and López (2007), Tenjo, Charry, López and Ramírez (2008), and López, Prada and Rodríguez (2008) all estimate that financial market imperfections play a great part in investment decisions in Colombia using a great variety of different data and different methods. Lopéz (1994) explains the financial imperfections faced by households.

Perhaps it is the imperfections inherent in the business of banking (a banking channel) that are the most important for the transmission of monetary policy in Colombia, and that complicates the transmission of changes in the external environment. The eagerness of banks to lend out during booms could also be because dollar export prices are high when capital inflows are plentiful. Banks then conclude that their exporting depositors will have little problem financing their dollar loans, and the dollar revenues boost domestic lending by the way of a financial accelerator scheme (Bernanke, Gertler and Gilchrist, 1998). Importantly this mechanism would explain the correlation between nontradable sectors' GDP and dollar export prices which posed us a puzzle in Section 4.1.

Another appealing feature of explanation 2b is that it acknowledges that investment in countries like Colombia is much more risky than investments in countries that supply the capital, and therefore why more capital inflows do not necessarily mean faster growth (López, 1999 and Prasad, Rajan and Subramanian, 2007).

Finally, it is difficult, if not impossible, to explain these responses in a model for Colombia without financial frictions (Suescún, 1997), although we acknowledge that much more will have to be done to understand the nature of this inefficiency.

In conclusion then, we have made some important progress in understanding how these external forces are so important for Colombia's GDP cycle. An explanation that seems most consistent with our findings is to do with a predilection for procyclicality in bank lending, which in turn could be related to the existence of deep financial frictions. Another factor could be insufficient countercyclicality in monetary and fiscal policy. We speculated that this might have to do with a tendency for the exchange rate to overshoot during the cycle, which we see as a consequence of the procyclicality in bank lending.

5 Comparison with Canada

Up until now we have found that cyclical movements in dollar export prices, world GDP and capital inflows affect Colombian real GDP on impact and after a year. We traced through the channels by which this might happen and concluded that the effect might be due to a financial system being procyclical and policies not being sufficiently countercyclical. Then it would interesting to compare our findings with a developed country. Canada, being a small open country where natural resource products are a large share of exports and which also receives a fair amount of foreign direct investment (Cross and Ghanem, 2005), seems a good candidate. In this section we reproduce many of our results for Canada. The data set we used is described in the Appendix 9.1, and is designed to be as close to the Colombian data set as possible. Some series were not available for the whole sample.

Our first table, Table 15, is the Canadian equivalent of Table 3 showing our estimates of the impacts of export prices, import prices, capital inflows and world GDP on Canadian real GDP. Remember that these impacts are based on all other variables being fixed, and so are unobservable in the data.

Table 15. Estimated impact elasticities

and cyclical contributions to real Canada GDP of the external factors

	Standard deviation of cycle in raw series (% of trend)	Average elasticity in impacting on GDP			Average amplitude of cycle in (pp of GDP cycle)	Standard deviation of cycle in (pp of GDP cycle)
	1990-2007	1970-89	1990-2007	2007	1990-2007	1990-2007
Price of Exports	12.81	0.25	0.36	0.35	3.19	3.05
Price of Imports	9.70	-0.24	-0.34	-0.33	3.15	1.90
Capital and Financial Account					3.74	1.97
World GDP	2.16	0.25	0.36	0.35	1.00	0.92
Net Terms of Trade					4.35	1.54
Real GDP per capita volume					1.05	3.31

Source: Own calculations.

The most important message from Table 15 is that the impacts of these shocks on Canada are estimated to be as large as in the case of Colombia. In fact the world GDP and export price shocks have larger impacts, because Canada is more open than Colombia to trade. This holds in terms of elasticities as well as in terms of the standard deviation of contributions.

Table 16 now looks at the correlations between these forces and real GDP on one hand, and between themselves on the other.

Table 16. Estimated correlations between the external factors and real GDP for Canada over the cycle (1970-2007)

		Price of Exports	Price of imports	Capital and financial account	World GDP	Real GDP volume per capita
Price of imports	Classic correlation	**0.89**				
	tstat	13.10				
	Robust correlation	**0.89**				
	tstat	11.90				
	Kendall's taub	**0.74**				
	prob=0	0.00				
Capital and financial account	Classic correlation	0.20	**0.42**			
	tstat	1.25	2.78			
	Robust correlation	0.20	**0.57**			
	tstat	1.25	4.15			
	Kendall's taub	0.11	**0.23**			
	prob=0	0.35	0.04			
World GDP	Classic correlation	-0.19	**-0.50**	**-0.45**		
	tstat	-1.13	-3.48	-3.01		
	Robust correlation	-0.10	**-0.46**	**-0.65**		
	tstat	-0.63	-3.08	-5.08		
	Kendall's taub	-0.06	**-0.26**	**-0.37**		
	prob=0	0.63	0.02	0.00		
Real GDP volume per capita	Classic correlation	**0.43**	**0.33**	0.03	**0.38**	
	tstat	2.83	2.10	0.18	2.46	
	Robust correlation	**0.41**	**0.31**	0.01	**0.44**	
	tstat	2.70	1.94	0.03	2.92	
	Kendall's taub	**0.31**	**0.28**	0.14	**0.19**	
	prob=0	0.01	0.01	0.22	0.10	
Terms of trade	Classic correlation	**0.86**	**0.57**	-0.12	0.25	**0.44**
	tstat	10.02	4.12	-0.70	1.56	2.90
	Robust correlation	**0.85**	**0.49**	-0.18	**0.38**	**0.43**
	tstat	9.62	3.35	-1.11	2.49	2.86
	Kendall's taub	**0.72**	**0.45**	-0.07	0.17	**0.29**
	prob=0	0.00	0.00	0.53	0.14	0.01

Notes: 10% level of significance in bold. External factors in terms of impact contributions.

Import price contribution multiplied by -1.

Source: Own calculations

Interestingly the correlations between the export price and real GDP cycles and between the world GDP and real GDP cycles are both positive and significant. The Kendall's tau b statistic confirms that both cycles, especially the export price cycle are synchronized with the real GDP cycle. Superficially this seems similar to Colombia. But as yet we do not know if the same procyclical financial sector mechanism is at work or simply that Canada is a open economy for whom trade matters.

One important difference is that the capital inflows cycle is not as significantly correlated and not as synchronized with the business cycle in Canada as it was in Colombia. This may seem at first surprising because Canada also receives important FDI inflows into its natural resource sector. Revealingly, this correlation is even weaker in terms of real value-added income, as seen in Appendix 9.5. To us, this suggests that Canadians are more likely to immediately invest a larger part of their real value-income earned abroad and hence the real GDP volume correlation becomes insignificant. On this basis, we would not be inclined to argue that capital inflows are weakly exogenous in the Canadian case.

When we look at the relationships between the shocks themselves we find that the export price cycle and the capital inflows cycle are correlated with each other, as they were in the Colombian case, but not as synchronized. The world GDP

cycle, which is essentially US GDP, is not correlated with export prices and is negatively correlated with capital inflows. So this is another difference with Colombia; there may be occasions when US GDP is growing strongly but dollar export prices are not, and this affords Canada some degree of cover. Still on the whole the pattern is remarkably similar to the Colombian case.

As for import prices, the cycle is very similar to export prices and therefore we have to avoid making any interpretations, just as we did with Colombia. We do not report the Harding and Pagan measures of coincidence but we can confirm that they provide very similar findings to the Kendall tau b statistics above. We also estimated our structural time series model for each of these Canadian series (Section 3.4) and found them to be very similar to the Colombian in terms of the degree of mean reversion. For example, as with Colombia, the only series which exhibited a significant variance of the non-cyclical component in the variance of the total growth rate was world GDP, and the ratio was actually higher than Colombia, at 0.5 instead of 0.3. We conclude that our model estimates that US GDP has some stochastic component in its growth rate, and this matters more for Canada. The estimated degrees of persistence in the shocks are also quite similar.

At first glance, the effect of real export prices, world GDP and capital inflows in terms of the size of the impacts contributions on GDP, their comovement, and their degree of mean reversion seem quite similar to the Colombian case. The main difference is in the behaviour of the capital inflows cycle which is no longer positively correlated with the Canadian GDP cycle.

But would we see the same relationships between the expenditure components of real GDP and our impact contributions, over the cycle? Table 17 reports the results, and shows that there are some very important differences.

Table 17. Correlations between the external factors and real GDP expenditure components for Canada

		Price of exports	Capital and financial account	World GDP
Household consumption volume cycle	Classic correlation	**0.56**	0.21	**0.38**
	tstat	4.04	1.28	2.50
	Robust correlation	**0.56**	0.08	**0.41**
	tstat	4.03	0.51	2.69
	Kendall's taub	**0.36**	0.18	**0.29**
	prob=0	0.00	0.11	0.01
Government consumption volume cycle	Classic correlation	**0.65**	**0.45**	-0.21
	tstat	5.12	2.98	-1.26
	Robust correlation	**0.67**	**0.49**	-0.27
	tstat	5.43	3.38	-1.66
	Kendall's taub	**0.43**	**0.31**	-0.12
	prob=0	0.00	0.01	0.31
Gross capital formation volume cycle	Classic correlation	**0.45**	0.19	**0.50**
	tstat	3.05	1.18	3.47
	Robust correlation	**0.55**	0.11	**0.43**
	tstat	3.99	0.65	2.84
	Kendall's taub	**0.38**	0.14	**0.32**
	prob=0	0.00	0.21	0.01
Exports cycle	Classic correlation	**-0.68**	**-0.33**	**0.46**
	tstat	-5.50	-2.10	3.11
	Robust correlation	**-0.71**	**-0.43**	**0.37**
	tstat	-6.12	-2.83	2.40
	Kendall's taub	**-0.46**	**-0.25**	**0.27**
	prob=0	0.00	0.03	0.02
Imports cycle	Classic correlation	0.01	0.15	**0.52**
	tstat	0.07	0.92	3.69
	Robust correlation	-0.05	-0.11	**0.51**
	tstat	-0.31	-0.64	3.51
	Kendall's taub	0.09	0.06	**0.28**
	prob=0	0.42	0.62	0.01
Public investment	Classic correlation	**0.59**	0.05	0.06
	tstat	4.37	0.31	0.37
	Robust correlation	**0.59**	0.15	0.00
	tstat	4.41	0.93	0.00
	Kendall's taub	**0.39**	0.09	0.02
	prob=0	0.00	0.42	0.86
Private investment	Classic correlation	**0.53**	0.12	**0.45**
	tstat	3.76	0.72	3.01
	Robust correlation	**0.66**	**0.38**	0.25
	tstat	5.29	2.47	1.55
	Kendall's taub	**0.43**	0.14	**0.30**
	prob=0	0.00	0.22	0.01

Notes: 10% level of significance in bold. All series in per capita terms prior to detrending.

External factors in terms of impact contributions.

Source: Own calculations.

First household consumption is strongly correlated with the dollar price of exports and world GDP variables but less so with the capital account than was the case with Colombia. Investment volumes are not correlated with any of the variables, very much unlike Colombia. Note however that the real value of private investment (nominal value deflated by the CPI) is correlated with these international cycles, suggesting that while the amount of investment expenditure might be cyclical with these forces, the volume or productive potential is not. Government consumption on the other hand seems related to export price variable unlike Colombia. But just as for Colombia, it is related to the capital account. The export volume cycle

is strongly related to world GDP as is the import volume cycle. Interestingly import volumes are related to export prices, which is consistent with the idea that Canadians spend their income gains on nontradables, which puts less pressure on the exchange rate. Clearly US growth matters for Canadian trade volumes.

In summary then, one of the key differences is that capital inflows are not as correlated with private consumption or investment over the cycle as they were in the Colombian case, suggesting that there is less of a financing constraint for the Canadian private sector. US dollar export price cycles matter for private and public consumption over the cycle. We note that the US dollar and the Canadian dollar export price cycles are strongly correlated (that was not the case for Colombia) meaning that US dollar export price rises actually do translate into local currency gains.

We now turn to the correlations with the real exchange rate, financial variables and the physical capital stock over the cycle in Table 18.

Table 18. Correlations between the external factors and balance sheet variables in Canada

		Price of exports	Capital and financial account	World GDP
Real exchange rate cycle	Classic correlation	**-0.49**	-0.13	-0.08
	tstat	-3.33	-0.79	-0.50
	Robust correlation	**-0.38**	-0.09	-0.14
	tstat	-2.45	-0.57	-0.86
	Kendall's taub	**-0.32**	-0.09	**-0.38**
	prob=0	0.00	0.42	0.00
Net private credit real per capita cycle	Classic correlation	**0.48**	0.05	0.02
	tstat	3.24	0.28	0.13
	Robust correlation	**0.62**	0.08	**0.29**
	tstat	4.80	0.48	1.81
	Kendall's taub	**0.42**	-0.02	**0.39**
	prob=0	0.00	0.90	0.00
M3 real per capita cycle	Classic correlation	**0.72**	0.21	0.14
	tstat	6.28	1.30	0.88
	Robust correlation	**0.69**	0.24	**0.28**
	tstat	5.66	1.46	1.73
	Kendall's taub	**0.59**	0.13	**0.55**
	prob=0	0.00	0.26	0.00
Savings real per capita cycle	Classic correlation	**0.66**	**0.32**	**-0.41**
	tstat	5.27	2.02	-2.67
	Robust correlation	**0.65**	**0.57**	**-0.43**
	tstat	5.17	4.19	-2.83
	Kendall's taub	**0.45**	**0.21**	**0.27**
	prob=0	0.00	0.06	0.02
Capital stock per capita cycle	Classic correlation	**0.67**	0.12	0.19
	tstat	5.48	0.74	1.15
	Robust correlation	**0.62**	0.11	**0.36**
	tstat	4.79	0.64	2.30
	Kendall's taub	**0.45**	0.12	**0.47**
	prob=0	0.00	0.29	0.00

Notes: 10% level of significance in bold.

External factors in terms of impact contributions.

Source: Own calculations.

Just as was the case for Colombia, there is an appreciation in the real exchange rate whenever US dollar export prices are above trend. In the absence of further evidence we can say that this is consistent with consumption being sensitive to

US dollar export prices, and our argument in Section 4.4 that the appreciation was due to a higher income elasticity and rigidities in the supply of nontradables: But we estimate that the sensitivity of the real exchange rate to export prices is much less in the Canadian case. The OLS estimate of the short-run coefficient in a regression of the current export price cycle on the current real exchange rate cycle is -0.7 for Canada compared to -1.7 for Colombia[4]. Not surprisingly the real exchange cycle of Colombia is nearly four times as volatile (judging by the ratio of standard deviations) as Canada in response to a export price cycle with a similar volatility.

Another important difference is that the real exchange rate in Canada is not related to the cycle of capital inflows as it is in Colombia, nor to the world GDP cycle. In fact if there is any relation it is positive. There are two possible reason why the exchange rate is less sensitive to net capital inflows in Canada. First it may be that any inflows in Canada are reinvested abroad or spent relatively more on tradables. Or second net capital inflows in Canada are not as exogenous as in Colombia and reflect the active decisions of Canadians to reinvest some of their export earnings abroad. Evidence of the second possibility is provided by the fact that domestic banks assets and liabilities are not related to capital inflows over the cycle. Neither is household savings here negatively related to capital inflows. Instead they are significantly and positively related to US dollar export prices and world GDP, in contrast to the Colombian case. These results are consistent with Lane and Tornell's comparisons of OECD and Latin American countries, (Lane and Tornell, 1998), suggesting that unlike Colombia, in Canada national income gains from exporting are more likely to be reinvested abroad rather than spent. The capital stock cycle does depend on the US dollar export cycle and the world GDP cycle but not significantly on capital inflows. Again this could be because external income gains are invested, but external finance is not needed to support that investment. We do not have data series on sectoral GDP for Canada, but we would expect that the cycle in nontradable sector output would not be as sensitive to export prices and world GDP as it is in Colombia.

In conclusion, at an aggregate level there would seem to be not that much difference between Canada and Colombia. For example the ratio of standard deviations of detrended consumption to detrended real GDP is 1 in Colombia, compared to 0.94 in Canada. But once we look at the relationship between the external factors and real GDP components and financial variables, we see that there is a great difference in how the two economies react. Although a higher US dollar export price does seem to stimulate both private and public consumption in Canada, more of that income is saved, and possibly saved abroad. That means that the real exchange rate appreciates by less and there is less of a dilemma for monetary policy. It could very well be that Canadian investment is subject to less risk and less lags that Colombian investment, or that Canadian firms can draw on domestic savings to finance that investment. Either way the gains from higher export earnings seem not to be kept within the domestic banking system, and nor is the domestic banking system prone to expand credit, as it is in Colombia.

[4]The regression was with two lags of the real exchange rate. All coefficients were significant and LM tests indicated no serial correlation in either case.

6 Smoothing in the capital stock cycle

It would be useful to explore these differences between Colombia and Canada further. We now compare our correlations on each country's data against what we would expect to see in a model without financial frictions. We can use our model of Section 2.1 to do this. From the solutions of that model, we can see that the variance of capital, the variance of the exogenous shock and the covariance of both are given by

$$\begin{aligned} E\left[\left(\widehat{k}_t\right)^2\right] &= \frac{q^2 E\left[\left(\widehat{z}_t\right)^2\right] + 2q\lambda_1\rho_z E\left[\widehat{k}_t, z_t\right]}{1-\lambda_1^2}, \\ &= \frac{q^2 E\left[\left(\widehat{z}_t\right)^2\right]}{1-\lambda_1^2}\left(1+\frac{2\lambda_1\rho_z}{(1-\lambda_1\rho_z)}\right), \\ &= \frac{q^2 E\left[\left(\widehat{z}_t\right)^2\right]}{1-\lambda_1^2}\left(\frac{1+\lambda_1\rho_z}{1-\lambda_1\rho_z}\right); \end{aligned}$$

$$E\left[\left(\widehat{\eta}_t\right)^2\right] = \left(1-\alpha_1-\alpha_2\right)^2 E\left[\left(\widehat{z}_t\right)^2\right];$$

and

$$\begin{aligned} E\left[\widehat{k}_t, \widehat{\eta}_t\right] &= \left(1-\alpha_1-\alpha_2\right) E\left[\widehat{k}_t, z_t\right], \\ &= \left(1-\alpha_1-\alpha_2\right)\frac{qE\left[\left(\widehat{z}_t\right)^2\right]}{(1-\lambda_1\rho_z)}; \end{aligned}$$

when all series are correctly measured as deviations from a steady state and using

$$E\left[\widehat{k}_t, z_t\right] = \frac{qE\left[\left(\widehat{z}_t\right)^2\right]}{(1-\lambda_1\rho_z)}.$$

The correlation of detrended capital and the detrended shock impact is given by

$$\begin{aligned} &\text{Corr}\left[\widehat{k}_t, \widehat{\eta}_t\right] \\ \equiv\ & \frac{E\left[\widehat{k}_t, \widehat{\eta}_t\right]}{\left(E\left[\left(\widehat{k}_t\right)^2\right]\right)^{0.5}\left(E\left[\left(\widehat{\eta}_t\right)^2\right]\right)^{0.5}}, \\ =\ & \frac{\left(1-\lambda_1^2\right)^{0.5}}{(1-\lambda_1\rho_z)}\left(\frac{1-\lambda_1\rho_z}{1+\lambda_1\rho_z}\right)^{0.5}, \\ =\ & \left(\frac{1-[\lambda_1]^2}{1-[\lambda_1\rho_z]^2}\right)^{0.5}. \end{aligned}$$

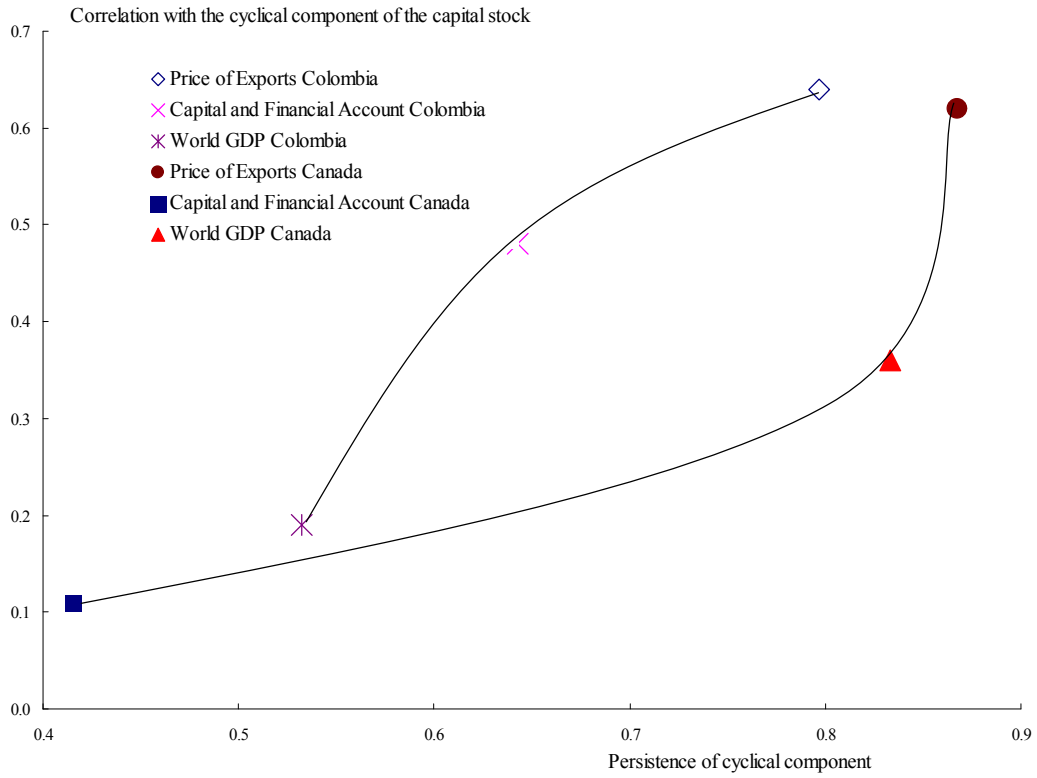
Note first that this correlation is always positive: a surprise increase in technological progress always leads to more capital. Then it is always increasing with the degree of persistence ρ_z, for positive persistence: $\frac{\Delta Corr\left[\widehat{k}_t,\widehat{\eta}_t\right]}{\Delta\rho_z} > 0$. This is due to smoothing: the more persistent the shock, the greater its contribution to permanent income and the more we should see capital rise following its impact so that future consumption will be supported by a greater productive capacity. In contrast, a temporary increase in income will not need so much investment. Furthermore, according to our theory, the slope of the relationship will itself be increasing in the persistence: $\frac{\Delta^2 Corr\left[\widehat{k}_t,\widehat{\eta}_t\right]}{\Delta\rho_z^2} > 0$, and so we should expect that the incentive to smooth decreases disproportionately with the persistence of the shock.

This smoothing result is likely to hold in a wide class of models for a wide class of shocks. The reason is that many, even more complicated, models, capital is a non-jumping, state variable, and so those models will be solved by an autoregressive expression for the dynamics of capital where the autoregressive parameter (λ_1) will be independent of the parameters of the exogenous shock processes. See equation 5.18 of Uhlig (1995) for example.

There is one class of important models where this relationship between the persistence of each external factor and its correlation with the capital stock cycle is unlikely to hold however. These are models where there are significant financial frictions. That would be because under financial frictions the decision to increase or decrease capital would also depend on how much these shocks add to current income and not just on how much they add to future income, as the presence of a strong current income flow lowers monitoring costs for the lender.

How well do our estimations match the theoretical predictions of the model? Chart 14 compares the correlations of each our external shocks with detrended capital stock against the persistence of that cyclical component.

Chart 14. Persistence of shocks and capital stock correlations



Notes: Correlation is the robust measure and persistence is measured by the structural time series model

The relationship predicted by our model holds for Canada, broadly speaking. The less persistent the shock, the less correlated is that shock with the capital stock. For example, US dollar export prices are very persistent, promising more future income, and so are strongly correlated with the cyclical capital. And, crucially, the slope of the relationship is increasing, as predicted by our theory.

Chart 14 also shows that in this latter sense this relationship fails to hold for Colombia. Although the slope is positive, it is now decreasing. In particular, the Colombian capital stock responds too strongly to what we have estimated to be temporary net inflows of external finance. To us, this suggests that there is a very important role for financial frictions in explaining the transmission mechanism in Colombia to external changes which are quite similar to Canada.

7 Conclusions

We can summarise by answering the questions we posed in the introduction.

- How large and how volatile are their impacts on domestic variables?

To answer this question we estimated the impact (the instantaneous effect, all other things being held constant) of cycle in real dollar export prices, the terms of trade, in real world GDP and capital inflows on Colombian real GDP cycle and

found that they are large. Real export price movements especially contribute a lot to the volatility of the Colombian real GDP cycle on impact.

- What is the first-year reaction of domestic macroeconomic variables to these shocks?

To answer this we looked both at different measures of pairwise correlations and also a multivariate model relating these shocks to real GDP. All these variables were strongly correlated and synchronized with the real GDP cycle. We found that real export prices affected GDP tremendously during the first year and not just on impact. In this case there is not internal smoothing then. The first-year effect of capital inflows seemed to be less than its initial impact but was also statistically harder to determine. It could also be without smoothing. The first-year effect of world GDP was estimated to be less than its impact, which itself contributed less to the real GDP cycle than did the other shocks on impact.

- How are the external factors interrelated?

We found some evidence that these external factors were correlated among themselves, although the correlation between capital inflow cycles and export price cycles was more of a recent phenomenon.

- How likely is it that the external factors revert to their mean?

To answer this question we estimated a structural time series model for each variable and found that in nearly all cases the variance in the cyclical component dominated the total variance of the series. This was less true of world GDP.

- On which sectors do they impact?

We found that all these shocks affected household consumption and investment. The cyclical effect on investment was so great that is was passed on to the capital stock. These external cycles affected the wage income of households. Interestingly the GDP of non-tradables sector is procyclical to these shocks in a way that tradable sector output is not. The deposits of Colombian financial institutions were boosted by cyclical movements in all of these forces even within the first year, and this seems to lead them to expand credit. The real exchange rate is very strongly correlated with all these shocks and the elasticity indicates strong appreciations during booms and deep depreciations during recessions.

- Is this what we should expect from a developing country, or from any primary commodity exporter?

We answered this question by comparing Colombia to Canada. On impact the shocks are equally as large on Canada, and with the notable exception of capital inflows, they are about as strongly and as positively correlated with the real GDP cycle as they were in the Colombia case. However at a disaggregated level, important differences begin to emerge. In Canada, banking sector deposits and credit, household saving and real exchange rate appreciations were not positively correlated with the capital inflows over the cycle. And Canadian household savings are positively not negatively correlated with US dollar export price swings.

To sum up, in this paper we have shown how monetary policy in Colombia is set in reaction to powerful exogenous forces. We estimate the monetary policy dilemma is made more difficult by financial frictions that lead the banking sector to overrespond to external financing and external income cycles. The gains from favourable external developments are thus channelled into nontradable spending, whose supply is inelastic, and not enough is reinvested abroad. This creates large appreciations during booms which makes monetary policy decisions difficult. Thus monetary policy in Colombia is often a response to a situation where large, but temporary, cycles in global markets are not cushioned but rather amplified by inefficiencies in the domestic financial sector.

More work will be needed to establish if monetary policy can act against these forces just being more aggressively countercyclical. If not, important accompanying financial stability and fiscal policies will be also needed if these cycles are to be stabilized. We fulfilled our basic objective which was to demonstrate that monetary policy in Colombia is by no means set in a vacuum.

8 References

Abrego, L. and Österholm, P. (2008). "External Linkages and Economic Growth in Colombia: Insights from A Bayesian VAR Model", IMF Working Paper, No. 46, International Monetary Fund (IMF).

Aguiar, M. and Gopinath, G. (2007). "Emerging Market Business Cycles: The Cycle is the Trend", Journal of Political Economy, June, Vol. 115, pp. 69-102.

Arias, A. and Carrasquilla, A. (1996). "Tipo de cambio real en Colombia ¿Qué pasó?" Borradores de Economía, No. 64, Banco de la República.

Arias, A. and Zuleta, H. (1997). "Tasa de cambio real e inversión: La experiencia de 1990-1996", Borradores de Economía, No. 76, Banco de la República.

Athukorala, P. and Rajapatirana, S. (2003). "Capital Inflows and the Real Exchange Rate: A Comparative Study of Asia and Latin America", The World Economy, Vo. 26, No. 4.

Backus, D. (1993). "Interpreting Comovements in the Trade Balance and the terms of Trade", Journal of International Economics, No. 34, pp. 375-387.

Bernanke, B., Gertler, M. and Gilchrist, S. (1998). "The Financial Accelerator in a Quantitative Business Cycle Framework", NBER Technical Working Papers, N ^{o} 6455, National Bureau of Economic Research (NBER).

Borensztein, E., De Gregorio, J. and Lee, W. (1998). "How Does Foreign Direct Investment Affect Economic Growth?" Journal of International Economics, June, Vol. 45, pp. 115–35.

Bosworth, B. and Collins, S. (1999). "Capital Flows to Developing Economies: Implications for Saving and Investment", Brookings Papers on Economic Activity, No. 1, pp. 143-69.

Bound, J., Jaeger, D. and Baker, R. (1993). "The Cure Can Be Worse than the Disease: A Cautionary Tale Regarding

Instrumental Variables", NBER Technical Working Papers, No. 0137, National Bureau of Economic Research (NBER).

Burstein, A., Eichenbaum, M. and Rebelo, S. (2005), "The Importance of Nontradable Goods' Prices in Cyclical Real Exchange Rate Fluctuations", NBER Working Papers, No. 11699, National Bureau of Economic Research (NBER).

Bussolo, M. and Roland, D. (1997). "Colombia and the NAFTA", FEDESARROLLO Working Paper Series, October, No. 2, Fedesarrollo.

Caballero, C. and Urrutia, M. (2006). Historia del sector financiero en Colombia en el siglo XX, Norma.

Calvo, G., Leiderman, L. and Carmen M. Reinhart (1993). "Capital Inflows to Latin America: The Role of External Factors", IMF Staff Papers, March, Vol. 40, No. 1, International Monetary Fund (IMF).

Cardarelli , R., Elekdag, S. and Kose, A. (2007). "Managing large capital inflows", Publication: World Economic Outlook, Chapter 3.

Cárdenas, M. (1997). La tasa de cambio en Colombia. Cuadernos de Fedesarrollo No.1, Fedesarrollo.

Cárdenas, M. and Escobar A. (1998). "Saving determinants in Colombia: 1925-1994", Journal of Development Economics, Vol. 57, pp. 5-44.

Cárdenas, M. (2001). "Economic Growth in Colombia: A Reversal of "fortune?", Working Papers, July, No. 83, Harvard University.

Cárdenas, M. (2005). "Crecimiento Económico en Colombia 1970-2005", Coyuntura Económica, XXXV2.

Cashin, P., Liang, H. and McDermott, C. (2000). "How Persistent Are Shocks to World Commodity Prices?", IMF Staff papers, Vol. 47, International Monetary Fund (IMF).

Cassing, S. (1996). "Correctly Measuring Real Value Added", Review of Income and Wealth, Blackwell Publishing, June, Vol. 42, pp. 195-206.

Contraloría General de la República y Centro de Investigaciones para el Desarrollo (CID) (1988). El Fondo Nacional del Café Evaluación Institucional y Financiera, Ediciones Especiales Contraloría General de la República.

Contraloría General de la República (1986). "La Política Económica y las Perspectivas para 1986", Economía Colombiana, No. 179, pp. 20-29.

Creel, M. (2005). Econometrics, Online economics textbooks, No. emetr10, SUNY-Oswego, Department of Economics.

Cross, P. and Ghanem, Z. (2005). "Canada's natural resources exports", Feature article, Canadian Economic Observer.

Cuddington, J. (1986). "Bonanza de productos básicos, estabilización macroeconómica y reforma comercial en Colombia", Ensayos Sobre Política Económica, diciembre, No. 10, pp. 45-100, Banco de la República.

Cummins, J. and Hubbard, G. (1994). "The Tax Sensitivity of Foreign Direct Investment: Evidence from Firm- Level Panel Data", NBER Working Papers, No. 4703, National Bureau of Economic Research, (NBER).

Davidson, R. and MacKinnon, J. (1993). Estimation and Inference in Econometrics, Oxford, Oxford University Press.

Deardorff, V. and Robert M. (1990). Computational Analysis of Global Trading Arrangements, Ann Arbor: The University of Michigan Press.

Duguay, P. (2006). "Productivity, terms of trade and economic adjustment", Remarks to the Canadian Association for Business Economics, Kingston, Ontario, August.

Edwards, S. and Végh, C. (1997). "Banks and macroeconomic disturbances under predetermined exchange rates", NBER Working Papers No. 5977, National Bureau of Economic Research (NBER).

Edwards, S. (1998). "Capital Flows, Real Exchange Rates, and Capital Controls: Some Latin American Experiences", NBER Working Papers No. 6800, National Bureau of Economic Research (NBER).

Feldstein, M. and Horioka, C. (1980), "Domestic Saving and International Capital Flows", Economic Journal, No. 90, pp, 314-329,

Fernández, C. (2005). "La política monetaria y los ciclos económicos en Colombia en los últimos 35 años", Coyuntura Económica, XXXV-2.

Food and Agriculture Organization of the United Nations, (2008) Prodstat, available at www.faostat.fao.org.

Forbes, K., and Rigobon, R. (2002). "No Contagion, Only Interdependence: Measuring Stock Market Comovements", Journal of Finance, October, American Finance Association, vol. 57(5), pp. 2223-2261.

Gavin, M., Hausmann, R., Perotti, R. and Talvi, E. (1996). "Volatility, Procyclicality, and Limited Creditworthiness", OCE Working Papers Series, No. 326, Inter American Development Bank (IADB).

Geweke, J. (2005). Contemporary Bayesian Econometrics and Statistics, John Wiley and Sons, Ltd: New Jersey.

Harberger, A. (1950). "Currency depreciation, income, and the balance of trade", Journal of Political Economy, No. 58, pp. 47-60

Harding, D. and Pagan, A. (2002). "Dissecting the cycle: a methodological investigation", Journal of Monetary Economics, March, Vol. 49, Issue 2, pp. 365-381.

Hausman, J. (1978). "Specification Tests in Econometrics", Econometrica, No. 46, pp. 1251-1272.

Hausmann, R. and Fernandez, E. (2000). "Foreign Direct Investment: Good Cholesterol?", Research Department Working Paper, March, No. 417, Inter-American Development Bank (IADB).

Harvey, A. (1990). Forecasting, Structural Time Series Models and the Kalman Filter Cambridge University Press.

Hofman, A. (2001). "Long run economic development in Latin America in a comparative perspective: Proximate and ultimate causes", Serie Macroeconomía del desarrollo, diciembre, No. 8., Comisión Eonómica para América Latina y el Caribe (CEPAL).

International Monetary Fund (IMF) (2003). "Foreign Direct Investment in Emerging Market Countries", Report of the Working Group of the Capital Markets Consultative Group (CMCG), September.

Izquierdo, A., Romero, R. and Talvi, E. (2008). "Booms and busts in Latin America: The role of external factors", Workig Paper IADB, February, No. 631, Inter-American Development Bank (IADB).

Junguito, R. and Pizarro, D. (1978). Producción de café en Colombia, Fedesarrollo.

Kaminsky, G., Reinhart, C. and Vegh, C. (2004). "When it Rains, it Pours: Procyclical Capital Flows and Macroeconomic Policies", NBER Working Papers, No. 10780, National Bureau of Economic Research (NBER).

Kravis, I., Heston, A. and Summers, R. (1983). "The Share of Services in Economic Growth" in Global Econometrics: Essays in Honour of Lawrence B Klein, F. G. Hickman, MIT Press Cambridge, pp. 188-218.

Kumar, A. (2007). "Does Foreign Direct Investment Help Emerging Economies?", Economic Letter—Insights from the Federal Reserve Bank of Dallas, January, Vol. 2, No. 1, Federal Reserve Bank of Dallas.

Lane, R. and Tornell, A. (1998). "Why aren't savings rates in Latin America procyclical?", Journal of Development Economics, October, Vol. 57, pp. 185-199.

Laursen, S. and Metzler, A. (1950). "Flexible exchange rates and the theory of employment", Review of Economic and Statistics, No. 32, pp. 281-299.

LeSage, J, (2003). Econometrics toolbox. Available at http://www.spatialeconometrics.

com/.

Lo, A. and Mackinlay, C. (1988): "Stock Market Prices Do Not Follow Random Walks: Evidence from a Simple Specification Test", The Review of Financial Studies, No. 1, pp. 41-66.

López, A. (1994). La Teoría del Ingreso Permanente y las Restricciones de Liquidez en Colombia, in R. Steiner (ed.), Estabilización y Crecimiento, Tercer Mundo-Fedesarrollo.

López, A. (1999). "Large Capital Flows: Causes, Consequences, and Policy Responses", Finance and Development, Vol. 36, No. 3, International Monetary Fund (IMF).

López, M., Prada, J. and Rodríguez, N. (2008). "Financial Accelerator Mechanism in a Small Open Economy", Borradores de Economía, No. 525, Banco de la República.

Loza, G. (2001), "Tipo de Cambio, Exportaciones e Importaciones: El caso de la economía boliviana", Revista de Análisis Económico, Banco Central de Bolivia (BCB).

Lozano, I. and Toro J. (2007). "Fiscal Policy Throughout the Cycle: The Colombian Experience", Borradores de Economía, No. 434, Banco de la República.

Maddala, G. (1999). Introduction to Econometrics, John Wiley and Sons, Ltd: New Jersey.

Maronna, L., Martin, D. and Yohai, V. (2006). Robust Statistics, Theory and Methods, John Wiley and Sons, England.

Martínez, G. (2008). "Anatomía de los ciclos económicos en Colombia 1970-2007", Borradores de Economía, No. 496, Banco de la República.

Mendoza, E. (1995). "The terms of trade, the real exchange rate, and economic fluctuations", International Economic Review, No. 36, pp. 101-137.

Mishkin, F. (2001). "Financial polices and the prevention of financial crises in emerging market economies", Policy Research, October, Working paper No. 2863.

Neumeyer, P. and Perry, F. (2005). "Business cycles in emerging economies: the role of interest rates", Journal of Monetary Economics, No. 52, pp. 345-380.

Obstfeld, M. and Rogoff, K (1997). Foundations of International Macroeconomics. The MIT Press, (chapter 4).

Ocampo, J. A. (2007). "La macroeconomía de la bonanza económica latinoamericana", Revista de la CEPAL, diciembre, No., 93, pp. 7-29.

Österholm, P. and Zettelmeyer, J. (2007). "The Effect of External Conditions on Growth in Latin America", IMF Staff Papers, International Monetary Fund (IMF).

Perry, G., Servén L. and Suescún, R. (2007). Size and Effectiveness of Automatic Fiscal Stabilizers in Latin America" in Fiscal policy, stabilization, and growth: prudence or abstinence? World Bank.

Perry, G. (2008). Fiscal rules and procyclicality, in Fiscal Policy, Stabilization, and Growth: Prudence or Abstinence?, pp. 159-194, Luis Servén (Editor), Guillermo E. Perry (Editor), Rodrigo Suescun (Editor), World Bank.

Prasad, E., Rajan, R. and Subramanian, A. (2007). "Foreign Capital and Economic Growth", Brookings Papers on Economic Activity, Vol.38, pp. 153-230.

Quandt, R. (1960). "Test of the hypothesis that a linear regression system obeys two separate regimes", Journal of the American Statistical, June, Vol. 55, No. 290, pp. 324-330.

Reinhart, C. and Talvi, E. (1998). "Capital flows and saving in Latin America and Asia: a reinterpretation", Journal of Development Economics, October, Vol. 57(1), pp. 45-66.

Reinhart, C. and Plies, W. (1999). "Saving in Latin America and Lessons from Europe: An Overview), MPRA, No. 6987, University Library of Munich.

Restrepo, J. and Rincón, H. (2006). "Identifying Fiscal Policy Shocks in Chile and Colombia", Borradores de Economía, No. 397, Banco de la Republica de Colombia.

Rubio O., Ojeda, J. and Montes, E. (2003). "Deuda externa, inversión y crecimiento en Colombia, 1970-2002", Borradores de Economía, No. 272, Banco de la República.

Servén, L. (2008). Fiscal discipline public investment and growth, in Fiscal Policy, Stabilization, and Growth: Prudence or Abstinence?, pp. 195-224, Luis Servén (Editor), Guillermo E. Perry (Editor), Rodrigo Suescun (Editor)

Sheshkin, D. (2000). The Handbook of Parametric and nonparametric Statistical Procedures. Chapman & Hall/CRC New York.

Steiner, R. (1994). Afluencia de Capitales y Estabilización en América Latina. TM Editores y Fedesarrollo.

Stock, J. and Watson, M. (1998). "Median Unbiased Estimation of a Coefficient Variance in a time-varying Parameter Model", Journal of the American Statistical Association, March, Vo. 93, No. 441, pp. 349-358.

Suescún, R. (1997). "Commodity booms, dutch disease, and real business cycles in a small open economy: the case of coffe in Colombia", Borradores de Economía, No. 73, Banco de la República.

Svensson, L. (2004). "Targeting Rules versus Instrument Rules for Monetary Policy? What Is Wrong with McCallum and Nelson?", unpublished manuscript, August, Princeton University.

Taylor, A., (1998). "Argentina and the World capital market: saving, investment, and international capital mobility in the twentieth century", Journal of Development Economics, Vol. 57, pp. 147-184.

Tenjo, F. (1995). "Restricciones Financieras, Comportamiento de las Empresas Manufactureras y Perspectivas para el Desarrollo del Mercado de Capitales en Colombia", Misión de Estudios para el Mercado de Capitales.

Tenjo, F., Martinez, J. and López, E. (2007). "Los ciclos de la inversión y su financiamiento en Colombia", Borradores de Economía, No. 438, Banco de la República.

Tenjo, F., Charry, L. López, M. and Ramírez, J. (2007) "Acelerador Financiero y Ciclos económicos en Colombia: Un Ejercicio Exploratorio", Borradores de Economía No. 451, Banco de la República.

Titelman, D., Pérez Caldentey, E. and Minzer, R. (2008). "Comparación de la dinámica de los efectos de los choques financieros y los choques de los términos de intercambio en América Latina en el período 1980-2006", Comisión Económica para América Latina y el Caribe (CEPAL), Inédito.

Turner, P. (1995). "Capital Flows in Latin America: a new phase", BIS Economic Papers, May, No. 44, Bank for International Settlements (BIS).

Uhlig, H. (1995). "A Toolkit for Analyzing Nonlinear Dynamic Stochastic Models Easily", Discussion Paper 101, June, The Federal Reserve Bank of Minneapolis.

Uribe, J. (1995). "Flujos de Capital en Colombia: 1978-1994", Borradores de Economía, No. 25, Banco de la República.

Uribe, J. (2007). "Globalization and Colombia´s Policy Framework", LACEA, October.

Urrutia, M. (2002). Una visión alternativa: La política monetaria y cambiaria en la última década, Banco de la República.

Villar, L. and Rincon, H. (2000). "The Colombian economy in the nineties: Capital flows and foreign exchange regimes", Borradores de Economía, No. 149, Banco de la República.

Villar, L. Salamanca, D. and Murcia, A. (2005). "Crédito, Represión financiera y Flujos de Capital en Colombia", Borradores de Economía, No. 322. Banco de la República.

Zettelmeyer, J. (2007). "Growth and Reforms in Latin America: A Survey of Facts and Arguments". IMF Working Paper, No. 06-210, International Monetary Fund (IMF).

9 Appendix:

9.1 Appendix: Data description

A brief description of our data set is as follows.

9.1.1 Data series on the external factors

Colombia The capital and financial account is as measured by the Banco de la República and is the annual net dollar flow. We also need the net foreign asset stock of the capital and financial account. We begin with an initial value which is the net international investment position without reserves or gold in 1970. We then cumulate the capital and financial account flows to this stock.

The import price and export price deflators were calculated from the national accounts in peso terms (by dividing current price values with constant price volumes, see below) and converted into dollars using the average exchange rate for that year. World GDP was constructed from the real and nominal annual GDP of the United States, Venezuela, Ecuador and OECD Europe. The sources for these data were as follows: US GDP (Bureau of Economic Analysis), Ecuador current values (the IMF International Financial Statistics and the Banco Central de Ecuador), Ecuador constant values (World Bank and the IMF World Economic Outlook Database), Venezuela (World Bank and the IMF World Economic Outlook Database), OECD Europe, which is the weighted GDP of 22 European OECD members (OECD Statistics). All series were converted into dollars using PPP exchange rates (from the IMF World Economic Outlook Database) and the real values re-referenced to be same as the nominal in 1994. We also had nominal export shares of these four destinations from the Colombian National Accounts (DANE), which we adjusted to sum up to one each year. Then Colombian real world GDP was then calculated as a Törnqvist index of the real GDP growth rates of each of these exports, using those weights. The nominal world GDP was calculated in a similar fashion.

Canada The capital and financial account is as measured by the IMF IFS, Balance of payments data. The net foreign asset stock was calculated by the same method as for Colombia using IMF IFS. Export and import price deflators were from the national accounts data, see below. World GDP was built up from the real and nominal annual GDP of the United States, Japan, Mexico and OECD Europe, by the same method as Colombia, but in practice US GDP would have been a very good approximation.

9.1.2 National accounts data

Colombia The Colombian national accounts data were all sourced from the DANE. To adjust for changes in methodology and relative prices between the different bases (1970, 1994 and sometimes 2000) we used the growth rates from the earlier

base onto the level data in the later base, and worked backwards. All real series are referenced to be the same as the nominal in 1994, indicating that this the base of our data set. Household consumption was the final consumption of households and NPISH together, as earlier data in the national accounts do not separate the two. All Colombian volume data was converted into per capita terms prior to detrending, using data on population from DANE, because they have been important changes in population growth over the sample.

Private nominal investment was the sum of fixed gross capital formation for financial institutions, non-financial institutions, households and NPISH. The 2007 value is calculated as the difference between nominal investment and public investment. Public investment is calculated from DANE data up until 2006, adjusting for the change in base in 1994. For the 2007 value we used the growth rate of the index of public works, published by DANE, to approximate a growth rate of real public investment for 2007 of 6%. Then we multiplied that by the total investment deflator inflation to get an approximation for public investment growth and so the level in 2007.

Household income and its components (wage remuneration, gross surplus, rent) was calculated across three bases (1970, 1994 and 2000) but the levels were taken to be consistent with the 1994 base. The income and its components includes the income of NPISH. Net transfers was calculated as a residual from household income after subtracting the other components. As the flows could be negative, we converted the series into an index using the same formula as for household savings, see below, prior to detrending.

Canada The Canadian national accounts data on GDP and its components was taken from Datastream and from the OECD. Public and private investment was from Datastream. The population data came from Statistics Canada.

9.1.3 Credit financial variables and the capital stock

Colombia The real exchange rate was calculated as the average nominal exchange over the year, with the relative GDP deflators of Colombia and the US.

The stock of M3 deposits in the banking sector, at the average value during the year, is data published by the Banco de la República. Private sector credit is by all financial institutions and is published by the IMF as the total credit to the private sector . The value reported is the end of year stock, as no annual average is available. We used data from the Banco de la República (panorama bancaria) to fill in missing values.

Savings can be negative, and so cannot be detrended. To overcome this we calculated the cumulated contribution of the real net savings to the level of real household income by the following value-added formula

$$\Delta \ln S_{Ht} = \frac{1}{\left[1 - \frac{C_{Ht}}{Y_{Ht}}\right]_{s\in(t,t-1)}} \Delta \ln Y_{Ht} - \frac{\left[\frac{C_{Ht}}{Y_{Ht}}\right]_{s\in(t,t-1)}}{\left[1 - \frac{C_{Ht}}{Y_{Ht}}\right]_{s\in(t,t-1)}} \Delta \ln C_{Ht}, \;\; S_{Ht=1970} = 100.$$

where S_t is real household savings (disposable income minus consumption) and Y_{Ht} is real household disposable income per capita, both in year t and both using the CPI to deflate. $S_{t=1970} = 100$, where $[x_t]_{s\in(t,t-1)}$ indicates an arithmetic mean of time t and time $t-1$ values of x_t. The log of this index was detrended to obtain a cyclical measure of savings.

The capital stock series was calculated by using a Törnqvist weighted average of the capital stocks of a) housing, b) non-residential buildings, public works and improvements in land, c) transport equipment and d) machinery and equipment with nominal shares as weights. Each stock was calculated separately from the national account series on gross investment flows using depreciation rates of the Bureau of Economic Analysis, adjusted down by a proportion of 0.8 because depreciation was likely to be less in Colombia owing to cheaper labour. Thus the annual depreciation weights were a) housing (1.8%), b) non-residential buildings etc (2%), c) transport equipment (20%) and d) machinery and equipment (10.4%) to one decimal place. The initial capital stocks were adjusted to give a ratio between the initial aggregate capital stock and GDP in 1965 of 1, assuming that in that year capital stocks were in the same proportion as investment flows.

Canada The data for Canada for the real exchange rate and private credit and M3 were as for Colombia, except that we used data from the IMF IFS instead of directly from the national accounts.

In the case of the Canadian capital stock, we only have data on aggregate gross investment flows (real and nominal). We assumed a depreciation rate of 6.3% and an initial capital GDP real ratio of 2.1 in 1969 and calculated the stock by accumulating.

9.2 Appendix: Model

To solve the consumer's problem we form the Lagrangian

$$\begin{aligned}
&\max_{c_t,h_t,a_t} E_t \sum_{s=0}^{\infty} \left(\frac{1}{1+\beta}\right)^{t+s} (c_{t+s})^{-\frac{1}{\sigma}} \\
&-E_t \sum_{s=0}^{\infty} \left(\frac{1}{1+\beta}\right)^{t+s} \lambda_{t+s} \left(c_{t+s} + k_{t+s} - \frac{(1-\delta)}{(1+n)} k_{t+s-1} - (k_{t+s})^{\alpha_1} \left(\frac{k_{t+s-1}}{1+n}\right)^{\alpha_2} (e^{z_{t+s}} \Gamma_{t+s})^{1-\alpha_1-\alpha_2}\right). \qquad (14)
\end{aligned}$$

The first-order and second-order conditions are then

$$\begin{aligned}
\left(\frac{1}{1+\beta}\right)^{t}(c_t)^{-\frac{1}{\sigma}} - \left(\frac{1}{1+\beta}\right)^{t}\lambda_t = 0 \\
-\left(\frac{1}{1+\beta}\right)^{t}\lambda_t + E_t\left(\frac{1}{1+\beta}\right)^{t+1}\frac{\lambda_{t+1}}{(1+n)} \\
+\left(\frac{1}{1+\beta}\right)^{t}\lambda_t\alpha_1\left(k_t\right)^{\alpha_1-1}\left(\frac{k_{t-1}}{1+n}\right)^{\alpha_2}\left(e^{z_t}\Gamma_t\right)^{1-\alpha_1-\alpha_2} \\
+E_t\left(\frac{1}{1+\beta}\right)^{t+1}\lambda_{t+1}\alpha_2\frac{1}{(1+n)}\left(k_{t+1}\right)^{\alpha_1}\left(\frac{k_t}{1+n}\right)^{\alpha_2-1}\left(e^{z_{t+1}}e^{s\mu_g}\right)^{1-\alpha_1-\alpha_2} = 0 \\
c_t = -k_t + \frac{(1-\delta)}{(1+n)}k_{t-1} + \left(k_t\right)^{\alpha_1}\left(\frac{k_{t-1}}{1+n}\right)^{\alpha_2}\left(e^{z_t}e^{s\mu_g}\right)^{1-\alpha_1-\alpha_2} \\
y_t = \left(k_t\right)^{\alpha_1}\left(k_{t-1}\right)^{\alpha_2}\left(e^{z_t}e^{s\mu_g}\right)^{1-\alpha_1-\alpha_2} \\
\text{and } \lim_{T\to\infty}\lambda_{t+T}k_{t+T} = 0,
\end{aligned} \tag{15}$$

We can rewrite these first-order conditions as

$$\begin{aligned}
\left(c_t\right)^{-\frac{1}{\sigma}} = \lambda_t, \\
-1 + \alpha_1\left(k_t\right)^{\alpha_1-1}\left(\frac{k_{t-1}}{1+n}\right)^{\alpha_2}\left(e^{z_t}e^{t\mu_g}\right)^{1-\alpha_1-\alpha_2} \\
+\frac{(1-\delta)}{(1+\beta)(1+n)}E_t\frac{\lambda_{t+1}}{\lambda_t} \\
+\frac{1}{(1+\beta)(1+n)}E_t\frac{\lambda_{t+1}}{\lambda_t}\alpha_2\left(k_{t+1}\right)^{\alpha_1}\left(\frac{k_t}{1+n}\right)^{\alpha_2-1}\left(e^{z_{t+1}}e^{(t+1)\mu_g}\right)^{1-\alpha_1-\alpha_2} = 0 \\
c_t = -k_t + \frac{(1-\delta)}{1+n}k_{t-1} + \left(k_t\right)^{\alpha_1}\left(\frac{k_{t-1}}{1+n}\right)^{\alpha_2}\left(e^{z_t}e^{t\mu_g}\right)^{1-\alpha_1-\alpha_2} \\
\text{and } \lim_{T\to\infty}\lambda_{t+T}k_{t+T} = 0.
\end{aligned}$$

We now rewrite all variables in terms of technological progress, using the notation

$$\widetilde{x}_t \equiv \frac{x_t}{e^{t\mu_g}}.$$

With this transformation, we have two equations

$$\frac{(1-\delta)}{(1+\beta)(1+n)}E_t\left(\frac{\widetilde{c}_{t+1}}{\widetilde{c}_t}e^{\mu_g}\right)^{-\frac{1}{\sigma}}$$
$$+\frac{1}{(1+\beta)(1+n)}\left(\frac{\widetilde{c}_{t+1}}{\widetilde{c}_t}e^{\mu_g}\right)^{-\frac{1}{\sigma}}\alpha_2\left(\widetilde{k}_{t+1}\right)^{\alpha_1}\left(\frac{\widetilde{k}_t e^{-\mu_g}}{1+n}\right)^{\alpha_2-1}(e^{z_{t+1}})^{1-\alpha_1-\alpha_2}$$
$$+\alpha_1\left(\widetilde{k}_t\right)^{\alpha_1-1}\left(\frac{\widetilde{k}_{t-1}e^{-\mu_g}}{1+n}\right)^{\alpha_2}(e^{z_t})^{1-\alpha_1-\alpha_2}-1=0 \tag{16}$$

and

$$\widetilde{c}_t+\widetilde{k}_t-\frac{(1-\delta)}{1+n}\widetilde{k}_{t-1}e^{-\mu_g}-\left(\widetilde{k}_t\right)^{\alpha_1}\left(\frac{\widetilde{k}_{t-1}e^{-\mu_g}}{1+n}\right)^{\alpha_2}(e^{z_t})^{1-\alpha_1-\alpha_2}=0 \tag{17}$$

in two stationary endogenous variables $\widetilde{c}_t$ and $\widetilde{k}_t$.

Note that the steady-state value of these variables is

$$\begin{aligned}\frac{c}{k} &= -1+\frac{(1-\delta)}{1+n}e^{-\mu_g}+\frac{y}{k}\\ &= \frac{y}{k}\left(1-\frac{k}{y}+\frac{(1-\delta)}{1+n}\frac{k}{y}e^{-\mu_g}\right)\end{aligned}$$

and

$$\begin{aligned}\frac{k}{y} &= \frac{\left(1-\frac{c}{y}\right)}{1-\frac{(1-\delta)}{1+n}e^{-\mu_g}}\\ &= \frac{1-\frac{c}{y}}{\delta+n+\mu_g}\end{aligned}$$

where

$$\frac{e^{-\frac{1}{\sigma}\mu_g}}{(1+\beta)(1+n)}=\frac{\frac{k}{y}-\alpha_1}{(1-\delta)\frac{k}{y}+\alpha_2 e^{\mu_g}} \tag{18}$$

and

$$\frac{1}{\frac{y}{c}}-1+\frac{k}{y}=\frac{(1-\delta)}{1+n}e^{-\mu_g}\frac{k}{y}. \tag{19}$$

We now rewrite equations 16 and 17 with all variables as log deviations from their steady-state values

$$\widehat{x}_{t+s}\equiv\ln\frac{\widetilde{x}_{t+s}}{\widetilde{x}_{ss}}$$

to give

$$-\frac{1}{\sigma}\frac{e^{-\frac{1}{\sigma}\mu_g}}{(1+\beta)(1+n)}\left((1-\delta)+\alpha_2\frac{y}{k}e^{\mu_g}\right)(E_t\widehat{c}_{t+1}-\widehat{c}_t)$$
$$+\frac{(1-\delta)}{(1+\beta)(1+n)}e^{-\frac{1}{\sigma}\mu_g}\left(1+\alpha_2\frac{y}{k}e^{\mu_g}\right)\left(\alpha_1\widehat{k}_{t+1}-(1-\alpha_2)\widehat{k}_t+(1-\alpha_1-\alpha_2)E_tz_{t+1}\right)$$
$$-\alpha_1(1-\alpha_1)\frac{y}{k}\widehat{k}_t+\alpha_1(1-\alpha_1-\alpha_2)\frac{y}{k}\widehat{z}_t+\alpha_1\alpha_2\frac{y}{k}\widetilde{k}_{t-1}=0 \tag{20}$$

Using expression 18

we have

$$\left(\frac{k}{y}-\alpha_1\right)\alpha_1\widehat{k}_{t+1}-\left(\left(\frac{k}{y}-\alpha_1\right)(1-\alpha_2)+\alpha_1(1-\alpha_1)\right)\widehat{k}_t+\alpha_1\alpha_2\widehat{k}_{t-1}$$
$$-\frac{1}{\sigma}\left(\frac{k}{y}-\alpha_1\right)E_t\widehat{c}_{t+1}+\frac{1}{\sigma}\left(\frac{k}{y}-\alpha_1\right)\widehat{c}_t$$
$$+\left(\frac{k}{y}-\alpha_1\right)(1-\alpha_1-\alpha_2)E_t\widehat{z}_{t+1}$$
$$+\alpha_1(1-\alpha_1-\alpha_2)\widehat{z}_t=0$$

Similarly equation 17 becomes

$$\widetilde{c}_t+\widetilde{k}_t-\frac{(1-\delta)}{1+n}\widetilde{k}_{t-1}e^{-\mu_g}-\left(\widetilde{k}_t\right)^{\alpha_1}\left(\frac{\widetilde{k}_{t-1}e^{-\mu_g}}{1+n}\right)^{\alpha_2}\left(e^{z_t}\right)^{1-\alpha_1-\alpha_2}=0$$

and then

$$\widehat{c}_t+\frac{y}{c}\left(\frac{k}{y}-\alpha_1\right)\widehat{k}_t-\frac{y}{c}\left(\frac{k}{y}\frac{(1-\delta)}{(1+n)}e^{-\mu_g}+\alpha_2\right)\widehat{k}_{t-1}-\frac{y}{c}(1-\alpha_1-\alpha_2)\widehat{z}_t=0 \tag{21}$$

We solve the model 20 and 21 by writing it in the form

$$0=a\widehat{k}_t+b\widehat{k}_{t-1}+\widehat{c}_t+dz_t \tag{22}$$

$$0=E_t\left(f\widehat{k}_{t+1}+g\widehat{k}_t+h\widehat{k}_{t-1}+j\widehat{c}_{t+1}+k\widehat{c}_t+lz_{t+1}+m\widehat{z}_t\right) \tag{23}$$

$$\widehat{z}_{t+1}=n\widehat{z}_t+\epsilon_{t+1}\text{ with }E_t\epsilon_{t+1}=0 \tag{24}$$

with

$$a=\frac{y}{c}\left(\frac{k}{y}-\alpha_1\right),$$

$$\begin{aligned} b &= -\frac{y}{c}\left(\frac{k}{y}\frac{(1-\delta)}{(1+n)}e^{-\mu_g}+\alpha_2\right) \\ &= -\left(1+\frac{y}{c}\left(\frac{k}{y}-1\right)+\frac{y}{c}\alpha_2\right) \end{aligned}$$

$$d = -\frac{y}{c}\left(1-\alpha_1-\alpha_2\right),$$

$$f = \left(\frac{k}{y}-\alpha_1\right)\alpha_1,$$

$$g = -\left(\left(\frac{k}{y}-\alpha_1\right)\left(1-\alpha_2\right)+\alpha_1\left(1-\alpha_1\right)\right),$$

$$h = \alpha_1\alpha_2,$$

$$j = -\frac{1}{\sigma}\left(\frac{k}{y}-\alpha_1\right),$$

$$k = \frac{1}{\sigma}\left(\frac{k}{y}-\alpha_1\right),$$

$$l = \left(\frac{k}{y}-\alpha_1\right)\left(1-\alpha_1-\alpha_2\right),$$

$$m = \alpha_1\left(1-\alpha_1-\alpha_2\right),$$

and

$$n = \rho_z.$$

and then use a method of undetermined coefficients to determine the parameters λ and q in

$$\widehat{k}_t = \lambda\widehat{k}_{t-1} + qz_t \tag{25}$$

By substituting out for $\widehat{k}_t$ from 25 into 22 and 23, and equating coefficients we know that λ must satisfy

$$\begin{aligned} &\left(f-ja\right)\lambda^2+\left(g-jb-ka\right)\lambda+h-kb=0 \\ &\Rightarrow \Psi\lambda^2-\Gamma\lambda-\Theta=0. \end{aligned} \tag{26}$$

with

$$\begin{aligned} &\Psi \equiv \left(f-ja\right) \\ &= \left(\frac{k}{y}-\alpha_1\right)\alpha_1+\frac{y}{c}\frac{1}{\sigma}\left(\frac{k}{y}-\alpha_1\right)^2 > 0, \end{aligned}$$

$$\Gamma \equiv -\left(g - jb - ka\right)$$
$$= \frac{1}{\sigma}\frac{y}{c}\left(\frac{k}{y} - \alpha_1\right)^2 + \frac{y}{c}\frac{1}{\sigma}\left(\frac{k}{y} - \alpha_1\right)\left(1 + \frac{y}{c}\left(\frac{k}{y} - 1\right) + \frac{y}{c}\alpha_2\right) + \left(\left(\frac{k}{y} - \alpha_1\right)\left(1 - \alpha_2\right) + \alpha_1\left(1 - \alpha_1\right)\right) > 0,$$

and

$$\Theta \equiv h - kb$$
$$= -\frac{y}{c}\frac{1}{\sigma}\left(\frac{k}{y} - \alpha_1\right)\left(1 + \frac{y}{c}\left(\frac{k}{y} - 1\right) + \frac{y}{c}\alpha_2\right) - \alpha_1\alpha_2 < 0.$$

We can solve for λ in the quadratic equation 26. That equation has two roots $\lambda_2 \geq \lambda_1$ such that

$$\lambda_1 + \lambda_2 = \frac{\Gamma}{\Psi} > 0;$$

$$\lambda_1\lambda_2 = -\frac{\Theta}{\Psi} > 0;$$

and

$$\left(\lambda_1 - 1\right)\left(\lambda_2 - 1\right) = \lambda_1\lambda_2 - \left(\lambda_1 + \lambda_2\right) + 1$$
$$= -\left(1 - \alpha_1 - \alpha_2\right)\frac{k}{y}$$
$$< 0$$

Hence we can say that both roots are positive, and one is greater than one and the other less than one. Our solution for capital should be that with the root less than one because that is the only stable solution for capital which is a predetermined variable.

Then we can solve for q as a function of ρ_z :

$$\begin{aligned}
&(f\lambda + g - ja\lambda_1 - jb)\, q + fq\rho_z \\
&-j\,(aq + d)\,\rho_z - k\,(aq + d) + l\rho_z + m = 0 \\
q(\rho_z) &= \frac{jd\rho_z + kd - (l\rho_z + m)}{((f - ja)\,\lambda_1 + g - jb - ka) + (f - ja)\,\rho_z} \\
q(\rho_z) &= \frac{\Psi^{-1}(jd - l)\,\rho_z + \Psi^{-1}(kd - m)}{\rho_z + (\Psi p)^{-1}\,\Theta} \\
&= \frac{\Psi^{-1}(jd - l)\,\rho_z + \Psi^{-1}(kd - m)}{\rho_z - \lambda_2} \\
&= \frac{-\Psi^{-1}(jd - l)\,\rho_z + \Psi^{-1}(jd + m)}{\lambda_2 - \rho_z} \\
&= \frac{(jd - l)}{\Psi}\frac{\left(\frac{(jd+m)}{(jd-l)} - \rho_z\right)}{(\lambda_2 - \rho_z)} > 0
\end{aligned}$$

9.3 Appendix: Construction of contribution series

Using a very similar calculation to that for export prices in Section 2.1 we find the contribution of real dollar import prices to Colombian real GDP is the lefthandside of the following equation:

$$\Delta \log(GDP_t) = -\left[\frac{P_{Mt}E_tM_t}{P_{GDPt}GDP_t}\right]_{s\in(t,t-1)} \Delta \log \frac{P_{Mt}}{P_{USGDPt}}.$$

To aid interpretation we multiply this series by -1.

Combining the expressions for the impact contributions of import and export prices from gives us a measure of the contribution of the net terms of trade

$$\Delta \log(GDP_t) = \left[\frac{P_{Xt}E_tX_t}{P_{GDPt}GDP_t}\right]_{s\in(t,t-1)} \Delta \log \frac{P_{Xt}}{P_{USGDPt}} - \left[\frac{P_{Mt}E_tM_t}{P_{GDPt}GDP_t}\right]_{s\in(t,t-1)} \Delta \log \frac{P_{Mt}}{P_{USGDPt}}.$$

The calculation for the effect of capital inflows is more complicated. We can use the balance of payments identity in pesos to introduce net capital inflows $NKAI_t$ (in nominal dollars) is the stock of net foreign assets (without gold and reserves) NA_t minus its last period value,as:

$$\frac{NA_t}{P_{USGDPt}}\frac{E_tP_{USGDPt}}{P_{GDPt}} - \frac{NA_{t-1}}{P_{USGDPt-1}}\frac{P_{USGDPt-1}}{P_{USGDPt}}\frac{E_tP_{USGDPt}}{P_{GDPt}} + \frac{A_t}{P_{GDPt}} = GDP_t.$$

The contribution of the real dollar net capital inflows to Colombian real GDP growth is

$$\begin{aligned}\Delta \log (GDP_t) &= \left[\frac{E_t NA_t}{P_{GDPt} GDP_t}\right]_{s\in(t,t-1)} \Delta \log \frac{NA_t}{P_{USGDPt}} - \left[\frac{E_t NA_{t-1}}{P_{GDPt} GDP_t}\right]_{s\in(t,t-1)} \Delta \log \frac{NA_{t-1}}{P_{USGDPt-1}} \\ &= \left[\frac{E_t NA_t}{P_{GDPt} GDP_t}\right]_{s\in(t,t-1)} \Delta \log \frac{NA_t}{P_{USGDPt}} \\ &\quad - \left[\frac{E_t}{E_{t-1}} \frac{P_{GDPt-1} GDP_{t-1}}{P_{GDPt} GDP_t} \frac{E_{t-1} NA_{t-1}}{P_{GDPt-1} GDP_{t-1}}\right]_{s\in(t,t-1)} \Delta \log \frac{NA_{t-1}}{P_{USGDPt-1}}.\end{aligned}$$

The calculation for the world GDP variable is described in our Appendix 9.1, but the idea is to summarize the four main destinations for Colombian exports into one hypothetical country and create a real and nominal GDP series for that country. The demand for Colombian imports into this country is assumed to take a Cobb-Douglas form. Therefore we can write the demand function as

$$\frac{P_{Xt} X_t}{P_{WGDPt} WGDP_t} = \left[\frac{P_{Xt} X_t}{P_{WGDPt} WGDP_t}\right]_{s\in(t,t-1)}.$$

The derivative of real world GDP with respect to the real dollar value of Colombian exports (deflated by the World GDP deflator) is

$$\Delta \log (WGDP_t) = \Delta \log \frac{P_{Xt} X_t}{P_{WGDPt}}.$$

The Colombian GDP identity dictates that

$$\frac{P_{Xt}}{P_{WGDPt}} P_{WGDPt} E_t X_t - \frac{P_{Mt}}{P_{WGDPt}} P_{WGDPt} E_t M_t + A_t = P_{GDPt} GDP_t.$$

Hence

$$\Delta \log (GDP_t) = \left[\frac{P_{Xt} E_t X_t}{P_{GDPt} GDP_t}\right]_{s\in(t,t-1)} \Delta \log \frac{P_{Xt} X_t}{P_{WGDPt}}.$$

The contribution of the real world GDP growth to Colombian real value-added income growth is then

$$\Delta \log \left(\frac{P_{GDPt} GDP_t}{P_{CPICOLt}}\right) = \left[\frac{P_{Xt} E_t X_t}{P_{GDPt} GDP_t}\right]_{s\in(t,t-1)} \Delta \log (WGDP_t).$$

9.4 Appendix: Exogeneity tests

In this Appendix we report a statistical test for the exogeneity of capital inflows.

Table 19. Testing the exogeneity of capital inflows

Dependent variable:	Real GDP per capita volume cycle	Real GDP per capita volume cycle
Exogenous variables:		
Constant	0.00 1.54	0.00 1.53
Real GDP volume cycle (-1)	**0.85** 9.50	**0.90** 8.06
Capital and financial account cycle	**0.31** 2.32	**0.10** 0.32
Capital and Financial Account cycle (-1)	-0.19 -1.35	-0.21 -1.50
Price of exports cycle (-1)	**0.60** 3.94	**0.60** 3.93
Price of imports cycle (-1)	**-1.21** -5.04	**-1.18** -4.79
Residual from capital account equation		0.27
LM test for first-order serial correlation (chi squared 1)	0.07	0.06
S.E. of regression (%)	1.55	1.56

Note: 10% level of significance in bold

We carried out the Davidson and MacKinnon (1993) version of the Hausman (1978) exogeneity test for whether the capital inflows cycle were weakly exogenous to real GDP cycle in the estimation of the correlation coefficient between the two. If the residual from an instrumenting equation for capital inflows is not significant we can accept the null that capital inflows is weakly exogenous. That t-statistic is reported in the second column of the table and is not significant. The instrumenting regression for capital inflows was for capital inflows on all the exogenous variables and also using the return on investment grade (Baa) bonds in the US as instrument. These instruments should in principle be correlated with capital flows to Colombia if these flows are a subset of risky investments in the US investment portfolio. In the instrumenting regression, the return on Baa bonds was significant with a probability value of 6%.

9.5 Appendix: Robustness checks

In this section we report the correlations between the external factors and real value-added income for Colombia and Canada.

Table 20. Correlations between the external factors and real value-added income for Colombia

		Price of exports	Capital and financial account	World GDP
Real GDP volume cycle	Classic correlation	**0.56**	**0.37**	**0.40**
	tstat	4.01	2.42	2.60
	Robust correlation	**0.57**	**0.36**	**0.33**
	tstat	4.16	2.30	2.09
	Kendall's taub	**0.39**	**0.23**	0.17
	prob=0	0.00	0.05	0.13
Real value added income cycle	Classic correlation	**0.28**	0.02	0.07
	tstat	1.76	0.12	0.45
	Robust correlation	0.25	-0.07	-0.02
	tstat	1.57	-0.45	-0.15
	Kendall's taub	**0.20**	-0.01	-0.01
	prob=0	0.08	0.94	0.96

Note: 10% level of significance in bold.

Domestic variables in per capita terms before detrending.

External factors in terms of impact contributions.

Source: Own calculations.

Table 21. Correlations between the external factors and real value-added income for Canada

		Price of exports	Capital and financial account	World GDP
Real GDP volume per capita cycle	Classic correlation	**0.43**	0.03	**0.38**
	tstat	2.83	0.18	2.46
	Robust correlation	**0.41**	0.01	**0.44**
	tstat	2.70	0.03	2.92
	Kendall's taub	**0.31**	0.14	**0.19**
	prob=0	0.01	0.22	0.10
Real value added income per capita cycle	Classic correlation	**0.66**	0.02	**0.28**
	tstat	5.21	0.12	1.74
	Robust correlation	**0.61**	-0.03	**0.44**
	tstat	4.58	-0.16	2.97
	Kendall's taub	**0.51**	0.08	**0.23**
	prob=0	0.00	0.48	0.05

Note: 10% level of significance in bold.

Domestic variables in per capita terms before detrending.

External factors in terms of impact contributions.

Source: Own calculations.