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COLOMBIA

Selected Issues

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Approved by the Western Hemisphere Department

December 21, 2007

Contents

I. Achieving a Soft Landing: the Role of Fiscal Policy[1]

A. Introduction

1. **What are the macroeconomic effects of fiscal policy, and how can fiscal policy help achieve a soft landing for an overheated economy?** While a consensus regarding the role and effects of monetary policy has emerged, there is less agreement regarding fiscal policy.[2] A number of central banks have developed large scale models to predict the effects of monetary policy, but, as discussed in several recent papers, these models often cannot adequately replicate the dynamic effects of fiscal policy found in the empirical literature.[3] Conventional models used for monetary policy typically feature agents with infinite planning horizons, and predict that fiscal policy is ineffective in influencing aggregate demand and external current account balances.

2. **Assessing the macroeconomic effects of fiscal policy is relevant for Colombia, given evidence of overheating pressures**. Real GDP growth is estimated at 6.8 percent in 2006, and Fund staff project the same growth for 2007. Average CPI inflation is expected to rise 1 percentage point to 5½ percent in 2007, despite an increase in the Banco de la República's (BdR) policy interest rate by 350 basis points from 6 percent in April 2006 to 9½ percent in November 2007. Overheating pressures are also evident in the increase in the external current account deficit, which is projected to double to about 4 percent of GDP in 2007. The output gap is estimated at about 3 percent as of the second quarter of 2007. While the tightening of monetary policy is expected to help reduce growth in 2008 to about 5 percent, a positive output gap is nevertheless projected to remain in that year.

3. **This paper utilizes an open-economy structural model to assess the extent to which fiscal policy could enhance macroeconomic stability in Colombia.** The model, developed at the International Monetary Fund (IMF), is called the Global Integrated Monetary and Fiscal (GIMF) model (Kumhof and Laxton, 2007a). Ricardian equivalence does not hold in the model as consumers are assumed to have finite lifetimes and lifecycle income. GIMF reflects the latest advances in new open economy macroeconomic theory, and embodies a number of nominal and real rigidities that permit it to make empirically plausible predictions regarding the dynamic effects of fiscal and monetary policy.

4. **The paper provides quantitative assessments of the effects of changes in fiscal policy on key macroeconomic aggregates, such as real activity and the current account, using GIMF**. In addition, the paper assesses how the effects of macroeconomic shocks

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[1] Prepared by Daniel Leigh.

[2] Recent papers on the new consensus in monetary policy include Goodfriend (2007), and Mishkin (2007).

[3] See, for example, Kumhof and Laxton (2007a), and Gali, López-Salido and Valles (2007). Examples of large-scale models used for monetary policy analysis include the Banco de la República's MMT, the IMF's FPAS and GEM, the Federal Reserve's SIGMA, and the ECB's NAWM.

depend on the response of fiscal policy. In particular, the analysis focuses on assessing (i) how a stronger fiscal policy response to the cyclical position can reduce the burden on monetary policy in responding to shocks; (ii) to what extent a stronger response of fiscal policy to the cyclical position can induce an inflation-output volatility tradeoff; and (iii) how the effectiveness of fiscal policy in enhancing macroeconomic stability depends on the response of monetary policy, and on fiscal policy implementation lags.

5. **The remainder of the paper is structured as follows.** Section B presents the key features of the model. Sections C and D report the results, and Section E concludes.

B. Methodology

The model

6. **GIMF is an open economy general equilibrium model developed at the Fund that is equipped for both monetary and fiscal policy analysis**. The model's multiple non-Ricardian features, nominal and real rigidities, monetary policy reaction function, and fiscal policy reaction function yield plausible macroeconomic responses to changes in fiscal and monetary policy.

7. **Ricardian equivalence is assumed not to hold for four reasons**:

- First, the model features overlapping generation agents (OLG) with finite lifetimes. These agents are myopic in the sense that they perceive debt-financed tax cuts as an increase in their human wealth, and attach a low probability to having to pay for them in the future.

- Second, workers have a life-cycle labor productivity pattern that implies a declining rate of productivity as workers age. This feature means that workers discount the effects of future payroll tax increases as the latter are likely to occur when they are older and less productive.

- Third, the model contains liquidity-constrained consumers (LIQ) who do not have access to financial markets to smooth consumption, and change their consumption one-for-one with changes in after-tax income.[4]

- Finally, the model includes payroll and capital income taxes that are distortionary because labor effort and private investment respond to relative price movements that result directly from variations in tax rates.

[4] These consumers do solve an intratemporal optimization problem for choosing consumption and leisure levels. However, without access to financial markets, they cannot smooth consumption in response to temporary changes in disposable income.

8. **Importantly, GIMF relaxes the conventional assumption that all government spending is wasteful and does not contribute to aggregate supply**. Instead, GIMF allows for productive public infrastructure spending that adds to the public capital stock, and enhances the productivity of private factors of production. Real rigidities embedded in the model include consumer habits that induce consumption persistence, investment adjustment costs that induce investment persistence, and import adjustment costs. Nominal rigidities include sticky inflation Phillips curves in each sector of the economy.[5]

9. **The government determines how the fiscal balance-to-GDP ratio responds to business cycle fluctuations using a simple fiscal policy rule**. The rule for the fiscal balance-to-GDP ratio is of the following form:

$$\frac{fbal_t}{gdp_t} = \phi^* + d\left(\frac{\tau_t - \tau_t^*}{gdp_t}\right) \qquad (1)$$

where $\frac{fbal_t}{gdp_t}$ is the fiscal balance-to-GDP ratio. If the response parameter $d = 0$, the fiscal balance is kept equal to ϕ^* at all times, regardless of the economy's cyclical position. For example, if $d = 0$ and the economy experiences a cyclical upswing with actual tax revenue τ_t exceeding steady-state tax revenue $\tau^*{}_t$, the fiscal balance remains unchanged, and the cyclical excess revenue is spent. Such a response corresponds to a "balanced budget" rule and is procyclical. A response of $d < 0$ would also qualify as procyclical. As the response parameter d increases, a greater share of the cyclical excess revenue is saved. When $d = 1$, a 1 percentage point of GDP increase in cyclical tax revenue translates into a 1 percentage point increase in the fiscal balance, a response consistent with a "structural balance" rule. The rule can be implemented by adjusting taxes or spending. A response of $d > 1$ implies that a 1 percentage point of GDP increase in cyclical revenue induces an improvement in the fiscal balance of more than 1 percentage point of GDP, and is, for the purposes of this paper, defined as being countercyclical.

10. **The central bank targets inflation by manipulating the nominal interest rate following a standard inflation forecast-based (IFB) rule**. The specification of this monetary policy rule is consistent with the IFB rule embodied in the BdR's MMT, as described by Gómez, Uribe, and Vargas (2002), and López (2003), and is of the following form:

[5] For further details regarding household preferences and firm technology in the model's traded and non-traded sectors, see Kumhof and Laxton (2007a).

$$i_t = i_{t-1}^{\mu_i} (r_t^* \bar{\pi}_{t+4})^{1-\mu_i} \left(E_t \frac{\bar{\pi}_{t+4}}{\pi_{t+4}^*} \right)^{(1-\mu_i)\mu_\pi} \quad (2)$$

where the gross policy interest rate is i_t, the inflation forecasting horizon is 4 quarters, the inflation target, π^* is for total 4-quarter gross inflation, $\bar{\pi}_{t+4} = \pi_{t+1}\pi_{t+2}\pi_{t+3}\pi_{t+4}$, and E_t denotes expectations based on information available at time t.[6] Coefficient $\mu_i \in [0,1)$ denotes the degree of nominal interest rate inertia. If μ_i=0, equation (2) implies that when the inflation forecast exceeds the target by 1 percentage point, the nominal interest rate increases by 1+μ_π. Monetary policy responds to output, but only to the extent that it is relevant for forecasting inflation. The equilibrium real interest rate r_t^* is endogenous, and is determined by the global market for loanable funds, as well as a country-specific risk premium.

11. **Given the importance of risk premiums in emerging markets, and their possible relationship with fiscal policy, the model includes an endogenous country-specific risk premium**. In particular, the risk premium on the interest paid on domestic debt is denoted ρ_t and enters the model via a risk-adjusted uncovered interest parity (UIP) equation for foreign currency bonds:[7]

$$i_t = i_t^{RW} E_t \varepsilon_{t+1} (1 + \rho_t) \quad (3)$$

where i_t^{RW} is the gross nominal interest rate in the rest of the world, and ε_{t+1} denotes future gross nominal exchange rate depreciation.[8] The domestic risk premium ρ_t is assumed to have the following non-linear form:

$$\rho_t = \delta_1 + \frac{\delta_2}{\left((debt/gdp)^{\max} - (debt_t/gdp_t) \right)^{\delta_3}} \quad (4)$$

If $\delta_2 = 0$, then the risk premium always equals the exogenous level δ_1, regardless of the level of the debt-to-GDP ratio $(debt_t / gdp_t)$. If $\delta_2 > 0$, a decline in government debt reduces the risk premium. As the debt-to-GDP ratio rises towards the level $(debt/gdp)^{\max}$, the risk premium rises at an increasing rate. The assumption of an increasing slope is broadly

[6] The gross rate equals one plus the rate. For example, an inflation rate of 3 percent corresponds to a gross rate of 1.03.

[7] There are two financial assets in the model, private bonds that are traded internationally, and government bonds that are subject to complete domestic bias.

[8] If the risk premium $\rho_t = 0$, an expected depreciation of the domestic currency by 1 percent is, via arbitrage, associated with an increase in the domestic interest rate by about 1 percentage point above the rest-of-the-world interest rate.

consistent with empirical studies that find a positive linear relationship between the *logarithm* of the risk premium and the debt ratio, such as Arora and Cerisola (2001). Such estimates imply that the *level* of the risk premium grows at an increasing rate as the debt ratio rises. The parameter $\delta_3 > 0$ determines the curvature of the risk premium function.[9]

Calibration

12. **The model is calibrated to contain two countries, Colombia and the rest of the world.** Each period corresponds to one quarter. Colombia is assumed to comprise 0.3 percent of world GDP, and to have a steady state inflation rate of 3 percent per year. The rest of the world is assumed to have a steady state inflation rate of 2 percent per year. The steady-state rate of technological progress is assumed to be 2 percent per year, population is assumed to grow at 1 percent per year, and the real interest in the rest of the world is assumed to be 3 percent per year in the initial steady state. The structural parameters regarding household preferences and firm technology are set following Kumhof and Laxton (2007b), who calibrated GIMF for the case of Chile and the rest of the world. In particular, the parameters that govern the degree of household myopia, a key non-Ricardian feature of the model, are calibrated as follows. Households in both Colombia and the rest of the world are assumed to have a planning horizon of 15 years, i.e., a probability of death of 6.7 percent per year, and a decline in lifecycle worker productivity of 5 percent per year. Fifty percent of Colombian households are assumed to be liquidity constrained. This proportion is the same as that assumed for Chile by Kumhof and Laxton (2007b), and is larger than that assumed for the United States by Kumhof and Laxton (2007a), 33 percent. Given that financial development is lower in Colombia than in the United States, a larger share of liquidity constrained households in Colombia seems plausible.[10]

13. **Fiscal parameters, such as the ratios to GDP of government transfers, purchases of goods and services, and public investment are calibrated based on data from the Colombian authorities**. The productivity of public capital is calibrated following Ligthart and Suárez (2005) who present a meta analysis of a large number of studies (for OECD countries including Mexico) on the elasticity of aggregate output with respect to public capital, and estimate this elasticity at 0.14. Accordingly, the model is calibrated so that a 10 percent real increase in public investment is associated with a long-run increase in real GDP net of depreciation of about 1.4 percent. The depreciation of public capital is set at 4 percent per year.

14. **Regarding the parameter that governs the fiscal policy response to the business cycle, *d*, this paper considers a range of values**. In particular, the analysis evaluates

[9] While the risk premium function is assumed to be continuous, a sudden, discontinuous change in the risk premium could be simulated by changing the exogenous component of the premium δ_1.

[10] A fully satisfactory calibration of these parameters would require the model to be estimated.

macroeconomic and external current account volatility for values of *d* ranging from the strongly procyclical response of $d = -0.5$ to the strongly countercyclical response of $d = 4.5$. For the purposes of this paper, the fiscal rule is implemented by adjusting payroll, consumption, and capital income tax rates by the same proportion.

15. **In the absence of business cycle shocks, the fiscal surplus is assumed to equal the value that stabilizes the debt-to-GDP ratio at the projected end-2007 level of 38 percent**. In particular, in the steady state, there is a one-to-one correspondence between the fiscal deficit-to-GDP ratio and the government debt-to-GDP ratio that depends on the rate of nominal GDP growth, i.e.:

$$\left(\frac{fdef}{gdp}\right)^{*} = \frac{NG^{*}}{1+NG^{*}}\left(\frac{debt}{gdp}\right)^{*} \qquad (5)$$

where NG^{*} denotes the steady state nominal growth rate, and *fdef* denotes the fiscal deficit. For example, if the steady state nominal growth rate is 6 percent, and the steady state debt-to-GDP ratio is 38 percent, then the steady state debt-stabilizing fiscal deficit equals 2.2 percent of GDP ($\phi^{*} = -2.2$). A decline in the fiscal deficit by 0.5 percentage points of GDP would be associated with a long-run decline in the debt-to-GDP ratio of 8.8 percentage points.[11]

16. **The monetary policy response function is calibrated in line with previous work on monetary policy in Colombia and other countries.** In particular, the baseline calibration of the inflation response parameter is $\mu_{\pi} = 1.5$. An inflation response of 1.5 is in the range of coefficients found to be "efficient" for Colombia, 1.0–2.0, (in terms of minimizing a weighted function of inflation, output, and interest rate volatility) by Lopez (2003) using stochastic simulations of the BdR's MMT model. For sensitivity analysis, the paper also considers a less aggressive inflation response of $\mu_{\pi} = 0.25$, and a more aggressive response of $\mu_{\pi} = 4$. The nominal interest rate inertia parameter is set at $\mu_{i} = 0.5$, a value consistent with empirical evidence for a number of countries.[12]

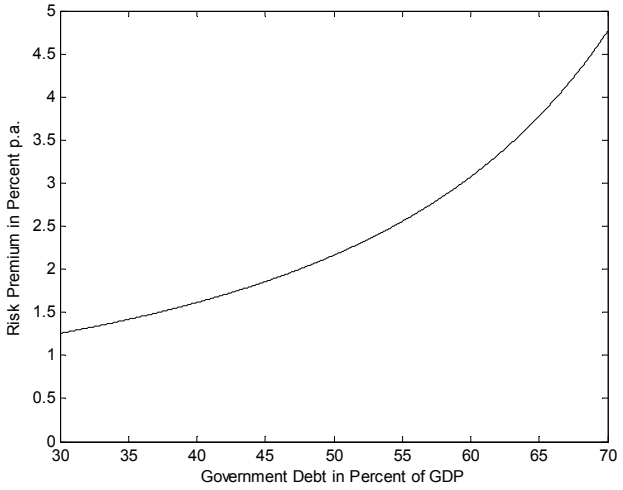
17. **Regarding the elasticity of the domestic risk premium to changes in government debt, calibration is complicated by the scarcity of empirical evidence for emerging market countries**. Based on a sample of data for 16 emerging market including Colombia, Rowland and Torres (2004) find that a 1 percentage point increase in the debt-to-GDP ratio is associated with an increase in the risk premium, proxied by the EMBI spread, of

[11] The long-run decline in the debt-to-GDP ratio of 8.8 is found as follows: 8.8 = 0.5 × (1.06/0.06).

[12] See, for example, Clarida, Gali, and Gertler (1998) who estimate an interest rate inertia parameter of about 0.8 using monthly data for Germany, Japan, and the United States. This value corresponds to about 0.5 at a quarterly frequency ($0.8^3 = 0.51$).

7–8.26 basis points after controlling for a number of other explanatory variables.[13] Guided by this estimate, the baseline calibration of this paper implies that, starting from the end-2007 position, a 1 percentage point increase in the debt-to-GDP ratio raises the risk premium by 8 basis points. For example, raising the debt ratio from the end-2007 expected level of 38 percent of GDP by 5 percentage points to 43 percent of GDP—the end-2006 level—increases the risk premium by about 40 basis points. This calibration is broadly consistent with the observed change in the Colombia EMBI spread from 2006 to 2007.[14] The assumed degree of curvature of the risk premium function is illustrated in Figure 1.

Figure 1. Domestic Risk Premium and the Debt-to-GDP Ratio



C. Results: Macroeconomic Effects of Fiscal Policy Tightening

18. **This section reports the results of a fiscal tightening experiment in which the fiscal balance is improved permanently by 0.5 percentage points of GDP**. In the base case, the government implements the consolidation by cutting public consumption by 0.5 percentage points of GDP, and the sensitivity analysis explores how the results depend on the composition of the adjustment. In each case, the results are reported in terms of the deviation from the baseline, i.e., the steady state that would occur if the fiscal consolidation were not implemented.

[13] See Rowland and Torres (2004), Tables 5.3a and 5.3b.

[14] The Colombia EMBI spread declined from an average level of 196 basis points during 2006 to an average of 159 basis points during January-September 2007, a change of 40 basis points, although a number of factors besides Colombia's debt-to-GDP ratio probably contributed to this change.

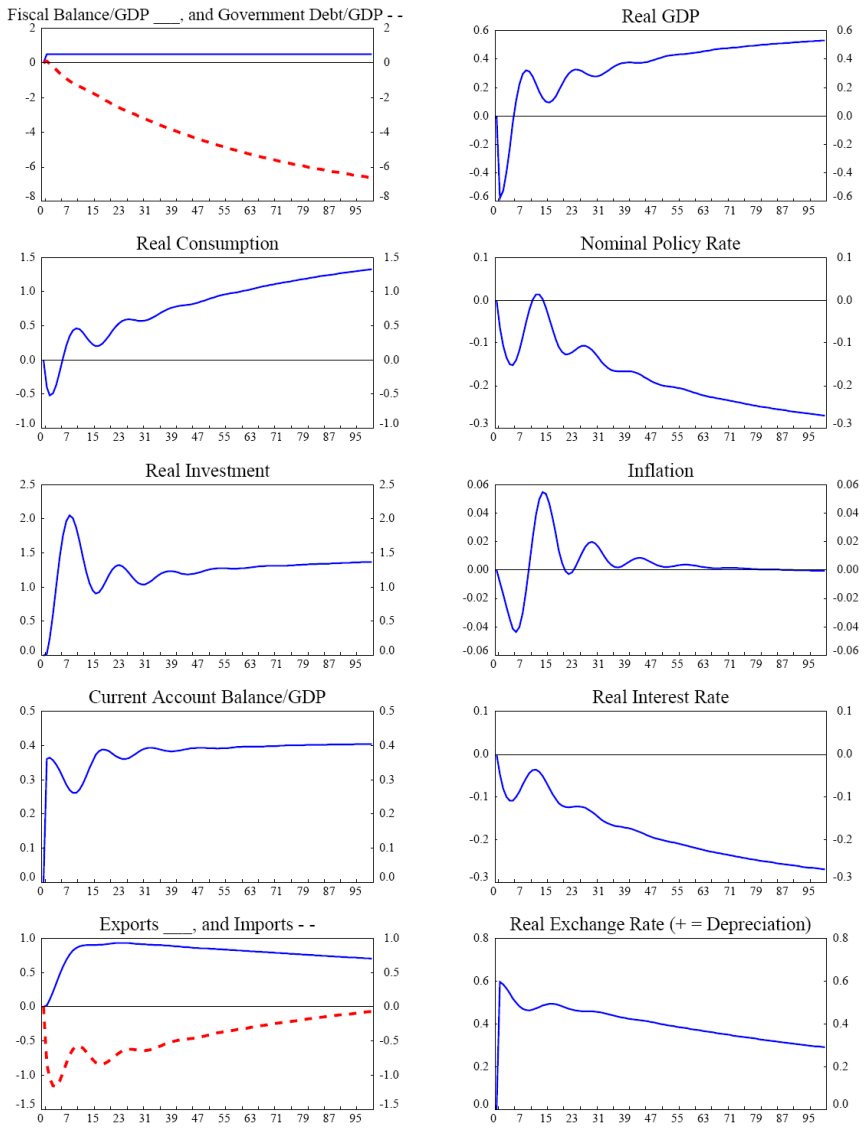
Base case: a cut in government consumption

19. **A fiscal consolidation based on a cut in government consumption is associated with a short-run decline in aggregate demand, but a medium-term increase in GDP**. The baseline experiment implements a permanent 0.5 percentage point cut in the government consumption-to-GDP ratio to improve the fiscal balance permanently by 0.5 percentage points (Figure 2). As debt and the associated cost of interest obligations decline, taxes are reduced to keep the fiscal surplus unchanged. The improvement in the fiscal balance, as well as the reduced interest cost, reduces the government debt-to-GDP ratio by, eventually, 8.8 percentage points.

20. **The cut in government consumption of 0.5 percent of GDP has an immediate effect on aggregate demand, although the effect is short-lived**. In particular, GDP declines by 0.58 percent on impact, a response that implies a short-run multiplier of 1.15. This response is broadly consistent with the effect of government spending shocks estimated for Colombia using a Bayesian VAR approach.[15] Monetary policy responds to the associated decline in expected inflation by reducing interest rates, which stimulates private spending, and contributes to a real depreciation. This monetary policy stimulus reduces the disinflationary effect of the fiscal contraction, while the resulting improvement in net exports increases net foreign assets as overall Colombian savings rise. Consequently, the current account improves by 0.36 percentage points of GDP within the first year, illustrating a strong reversed "twin deficit" phenomenon. Note that in conventional infinite horizon models, the fiscal tightening would have a negligible effect on the current account as the increase in public savings would be offset by lower private savings.

[15] See Chapter II. The response is also consistent with Blanchard and Perotti (2002) who estimate a government spending multiplier between 0.9 and 1.29 using a mixed structural VAR/event study approach for the United States that identifies fiscal shocks based on institutional information (see Table 4 of their paper). While the predictions of GIMF—as calibrated for the purposes of this paper—are in line with empirical studies such as Blanchard and Perotti (2002), they differ from the estimates of some other studies, such as Giavazzi and Pagano (1990) that find negative multipliers for some European countries.

Figure 2. Exogenous Permanent Cut in Public Consumption of 0.5 Percent of GDP
(In Deviation from Steady State Baseline)



21. **Over the medium run, the savings generated by lower government consumption and lower interest payments permit reductions in payroll and capital income taxes**. These tax reductions, and the decline in risk premiums due to the lower debt-to-GDP ratio have positive effects on labor supply, investment, GDP, and consumption.[16] Using the baseline calibration, a permanent improvement of the fiscal balance by 0.5 percent of GDP

[16] Using the additional fiscal space to increase productive public investment rather than to reduce taxes also results in long-run output gains. Results are not shown here, but are available on request.

that reduces the debt-to-GDP ratio by, eventually, 8.8 percentage points raises real GDP in the long-run by 0.56 percent (Figure 2).

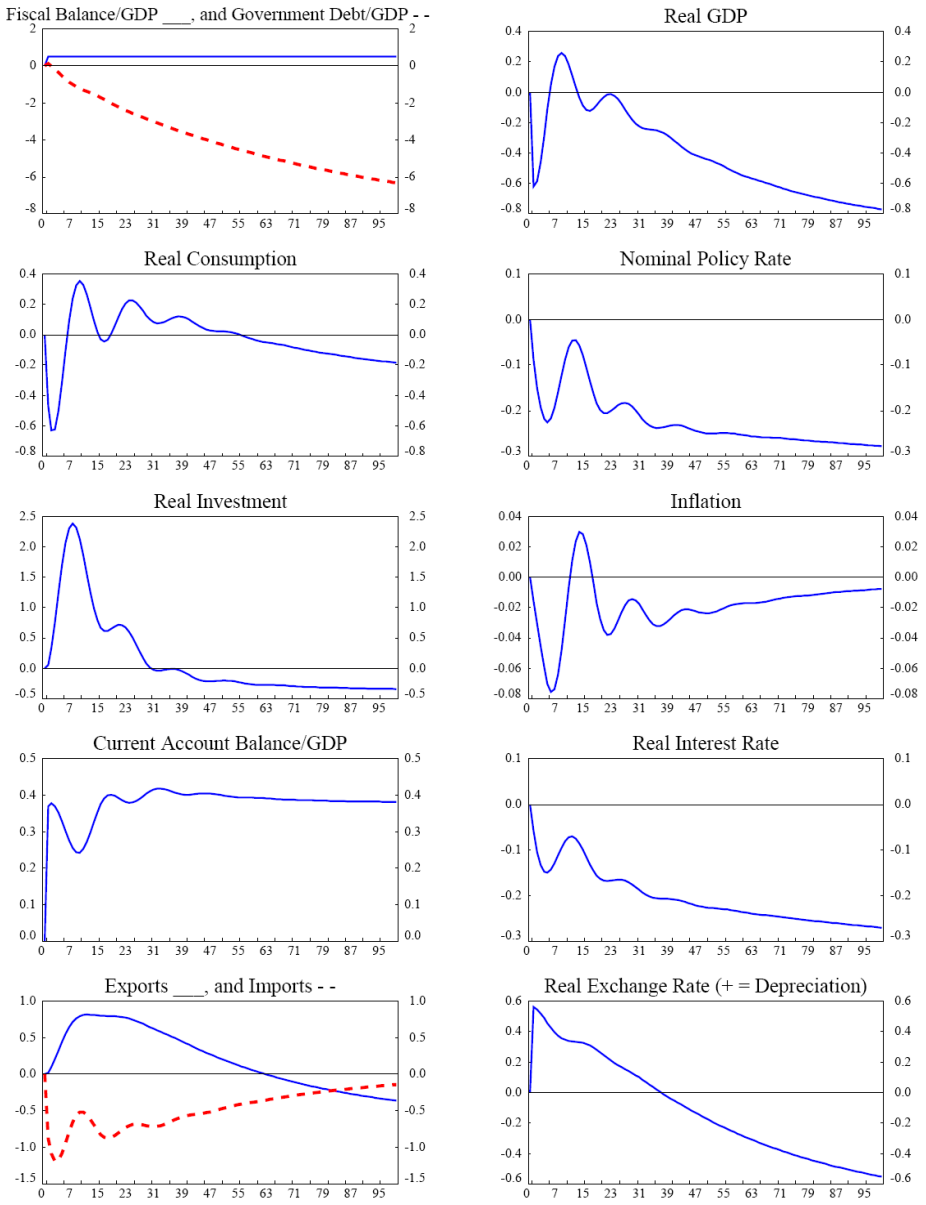
Sensitivity analysis: composition of fiscal tightening

22. **Variations on the baseline experiment reveal that the long-run positive effects of fiscal consolidation depend strongly on the composition of the adjustment**. In particular, implementing the consolidation by cutting productive public investment by 0.5 percentage points of GDP can jeopardize the long-run gains. As Figure 3 reports, a permanent cut in public investment leads to an aggregate demand contraction of 0.62 percent on impact, but GDP now also declines in the long run by 0.86 percent due to a contraction in the economy's supply capacity. If public investment is not productive, however, fiscal adjustment based on cuts in capital expenditure has a broadly similar effect as a reduction in public consumption.

23. **Similarly, the short-run contractionary effects of the consolidation depend on its composition**. When the fiscal consolidation is implemented by raising taxes or cutting transfers, the short-run contraction in GDP is smaller and more gradual than when the burden of tightening falls on government purchases. The difference in magnitude stems from the fact that after-tax disposable income and transfers can be spent by households on both domestic and foreign output, while government purchases have a strong domestic bias. The more gradual effect results from the assumption that households in the model have consumption habits, and respond gradually to a change in after-tax disposable income. In particular, a payroll tax increase of 0.5 percent of GDP is found to lower GDP by 0.39 percent after three quarters, compared to 0.58 percent on impact when public consumption is cut.[17] An increase in consumption taxes has a smaller negative effect, reflecting the broader tax base, with GDP falling by 0.24 percent in the first year following a 0.5 percent-of-GDP increase in consumption taxes. A 0.5 percent of GDP cut in lump-sum transfers leads to a decline in GDP by 0.17 percent within the first year.

[17] The size of the effect of changes in taxes, which implies a multiplier of 0.78 after three quarters, is consistent with the empirical estimates of Blanchard and Perotti (2002) for the United States, who estimate a tax multiplier between 0.78 and 1.3 (see Table 3 of their paper), but is smaller than that of Romer and Romer (2007).

Figure 3. Exogenous Permanent Cut in Public Investment of 0.5 Percent of GDP
(In Deviation from Steady State Baseline)



D. Results: Fiscal Policy and Macroeconomic Stability

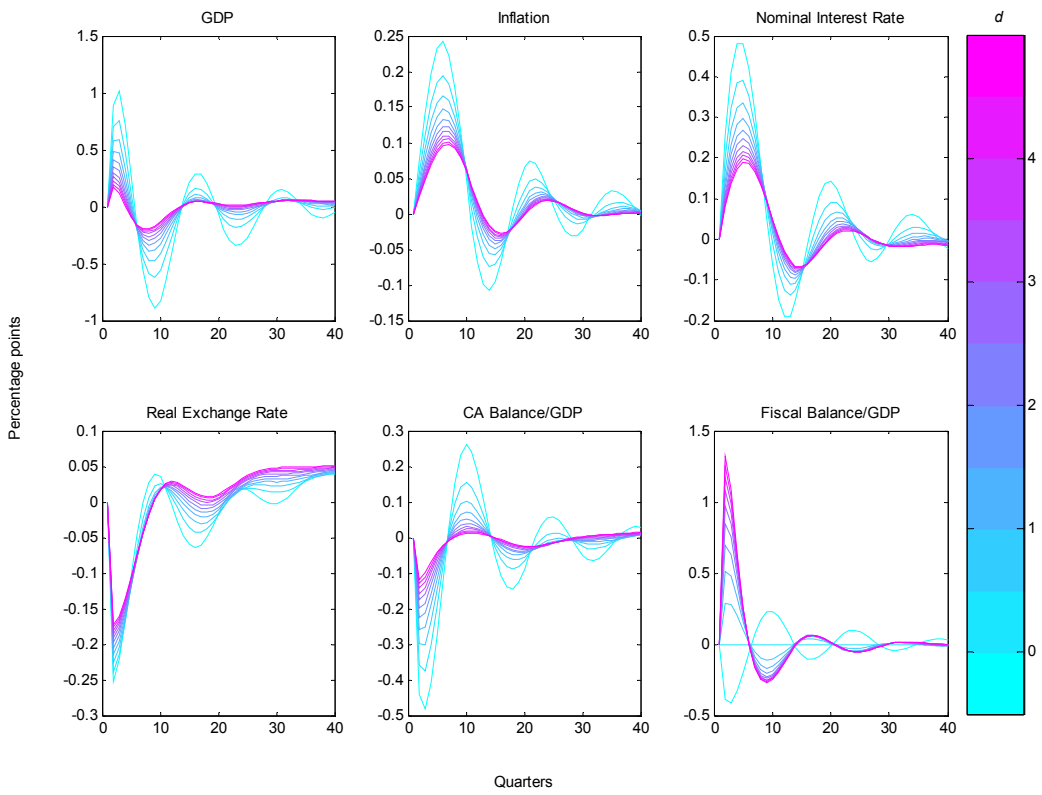
24. **Having discussed the dynamic effects of fiscal policy in the model, this section investigates how the impact of macroeconomic shocks depends on the strength of the fiscal policy response**. In particular, the section quantifies how the effectiveness of fiscal policy in contributing to macroeconomic stability depends on the type of shock, the strength of the monetary policy response, and the length of fiscal policy implementation lags. Regarding the type of shocks considered, the analysis focuses on three types that have different implications for output and inflation: (i) a "demand" shock due to a change in private savings; (ii) a "supply" shock due to a change in firms' markups; and (iii) a risk premium shock.

Demand shock: a reduction in private savings

25. **Following a demand shock due to a reduction in private savings, a stronger response of fiscal policy helps to stabilize both output and inflation, while reducing the burden on monetary policy for stabilizing inflation.** Figure 4 reports the dynamics of GDP, inflation, interest rates, exchange rates, and the current account following a reduction in private savings that is due to an exogenous increase in the consumer rate of time preference.[18] The increase in private spending raises inflation, and results in a deterioration in the external current account balance. Monetary policy tightens in response to the higher inflation, inducing a real appreciation of the currency, and further worsening the current account balance. For each variable, Figure 4 reports how the effects of the shock depend on how cyclical fiscal policy is. A stronger response of the fiscal balance to the cyclical position (a move from a small to a larger d) implies, due to the effect of fiscal policy on aggregate demand, that smaller interest rate increases are required to stabilize inflation. Consequently, the exchange rate appreciates less, and the external current account deteriorates less and then converges more smoothly towards the steady state.

[18] The shock involves a 4 percentage point increase in the consumer rate of time preference, and is assumed to follow an AR(1) process with a persistence coefficient of 0.9, implying a half-life of about 7 quarters.

Figure 4. Private Savings Shock and Strength of Fiscal Policy Response
(Deviation from Steady State Baseline)



Note: darker lines in the figure correspond to a stronger response of the fiscal balance to excess cyclical revenue (larger values of parameter *d*).

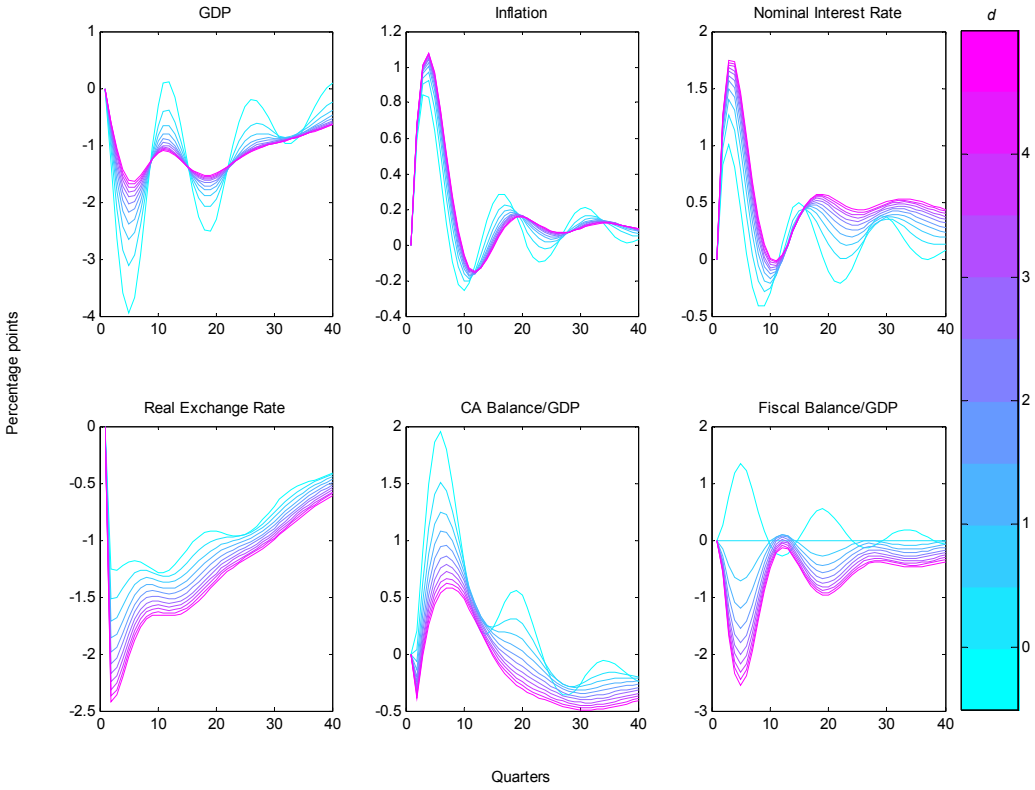
Supply shock: an increase in firms' markups

26. **Following a supply shock due to an increase in markups that shifts inflation and output in opposite directions, a stronger fiscal policy response to the cyclical position induces a modest inflation-output volatility tradeoff**. Figure 5 reports the dynamics of GDP, inflation, interest rates, exchange rates, and the current account following a temporary increase in firms' markups. The source of the markup shock is assumed to be an increase in the degree of market power of firms in the distribution sector, which results in a restriction of activity, and an increase in firms' prices.[19] The decline in real demand for goods and services in response to the markup shock implies an increase in private savings, and an improvement in the external current account balance. At the same time, monetary policy tightens in response to the inflationary effect of the markup shock. A stronger response of the fiscal

[19] The supply shock involves a 5 percentage point increase in the markup of prices over marginal cost in the distribution sector, and is assumed to follow an AR(1) process with a persistence parameter of 0.9, implying a half-life of about 7 quarters.

balance to the cyclical position (a move from a smaller to a larger *d*) implies a larger fiscal loosening, which moderates the decline in output, but slightly raises inflation. However, the output-inflation volatility tradeoff associated with a stronger fiscal policy response is modest under the baseline calibration of the model. In addition, a stronger easing in fiscal policy during the downturn moderates the improvement in the current account balance.

Figure 5. Markup Shock and Strength of Fiscal Policy Response
(Deviation from Steady State Baseline)



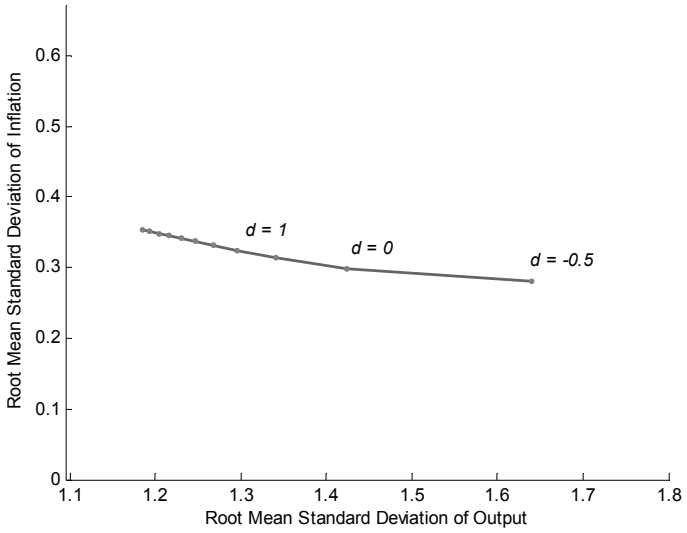
Note: darker lines in the figure correspond to a stronger response of the fiscal balance to excess cyclical revenue (larger values of parameter *d*).

27. **To quantify the inflation-output volatility tradeoff, an efficiency frontier is constructed**. The efficiency frontier identifies the policies that minimize a weighted average of inflation and output volatility given the model and shock structure. The weighted average, denoted ℓ, takes the following form:

$$\ell = \sigma(inflation) + \lambda\sigma(gdp) \qquad (6)$$

where σ denotes the root mean squared deviation about the steady state, and λ is the weight on output. Figure 6 shows the efficiency frontier in inflation-output volatility space, where moving "southwest" implies a decline in both inflation and output volatility.[20] The slope of the efficiency frontier indicates that, for the range of fiscal response parameters considered ($d \in [-0.5,4.5]$), a 1 percent decline in output volatility is associated with an increase in inflation volatility of about 0.2 percent. Note that in the case of the demand shock, a stronger fiscal policy response (a move from a low value of *d* to a large value of *d*) would, in Figure 6, imply moving "southwest" reducing both output volatility and inflation volatility.

Figure 6. Efficiency Frontier: Markup Shock

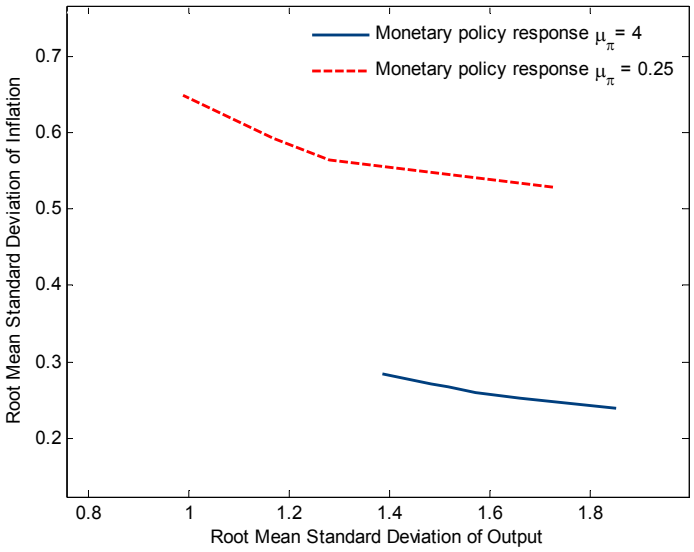


28. **However, the inflation-output volatility tradeoff is sensitive to the strength of the monetary policy response to inflation expectations**. In particular, a weaker monetary policy response to inflation expectations substantially increases the inflationary consequences of an accommodative fiscal response to the supply shock. To illustrate this point, the supply shock experiment is repeated with two alternative monetary policy rules: (i) a weak monetary policy response corresponding to a value of $\mu_\pi = 0.25$ in the policy rule; and (ii) a more aggressive monetary policy response corresponding to $\mu_\pi = 4$. As Figure 7 reports, the efficiency frontier is twice as steep with the weak monetary policy response, a result that underlines the importance of a strong commitment by the central bank

[20] The efficiency frontier is constructed as follows: (i) the markup shock is simulated multiple times, each time with an alternative fiscal rule parameter *d*; (ii) for a given value of λ, the policy rule (and associated inflation-output volatility pair) that minimizes the function ℓ is identified; and (iii) step (ii) is repeated for a range of λ values (from 0 to 30 in steps of 0.0001).

to stabilizing inflation expectations. In addition, for any given fiscal policy response, a weaker monetary policy response implies a higher level of inflation volatility.

Figure 7. Efficiency Frontier for Different Monetary Policy Response Parameters

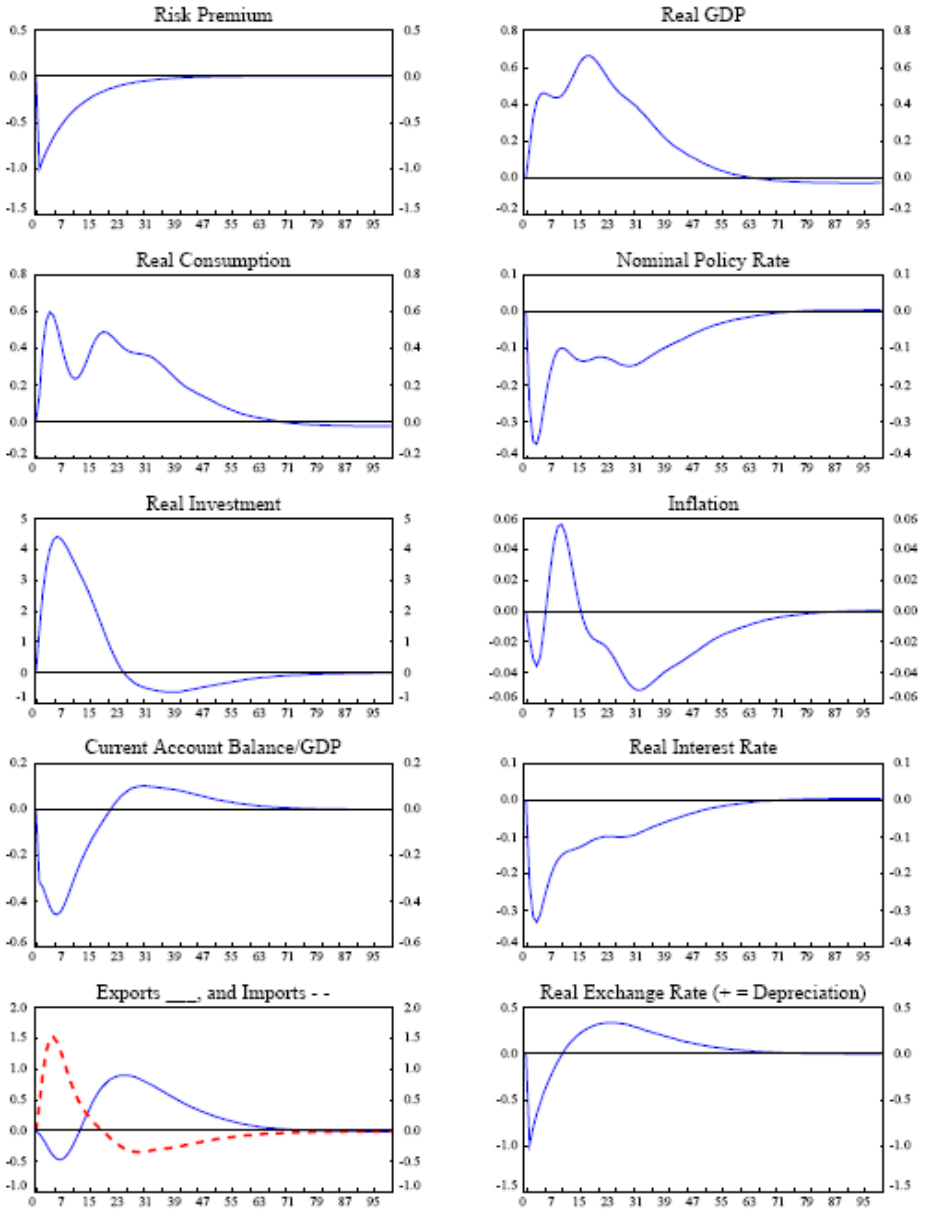


Risk premium shock

29. **An exogenous fall in the risk premium induces a real appreciation, an increase in investment and consumption, and a deterioration in the external current account balance**. The experiment involves an exogenous 100 basis-point fall in the exogenous risk premium component δ_1, and is assumed to follow an AR(1) process with a persistence parameter of 0.9. Figure 8 reports the dynamic responses of key macroeconomic variables with no change in the fiscal balance ($d = 0$). In particular, the decline in the risk premium ρ_t implies an increase in the risk-adjusted return on Colombian bonds $\frac{i_t}{(1+\rho_t)}$, which, via arbitrage Equation (3), raises demand for Colombian assets and induces a domestic currency appreciation. The lower risk premium also lowers the interest rate on borrowing from the rest of the world, which stimulates consumption, both of domestic and of foreign output. In addition, the lower risk premium reduces the cost of capital, and raises the profitability of private capital, which stimulates investment. Due to quadratic investment adjustment costs, the response of investment is hump-shaped. Overall, the rise in private spending demand worsens the external current account balance. Over the medium run, stabilizing net foreign liabilities requires an improvement in the trade balance, an adjustment that implies an exchange rate depreciation. The initial appreciation also has a disinflationary effect, which prompts an easing in monetary policy. The disinflationary pressure is in part off-set by

inflationary pressures associated with the increase in aggregate demand, and the overall response of inflation is therefore modest.

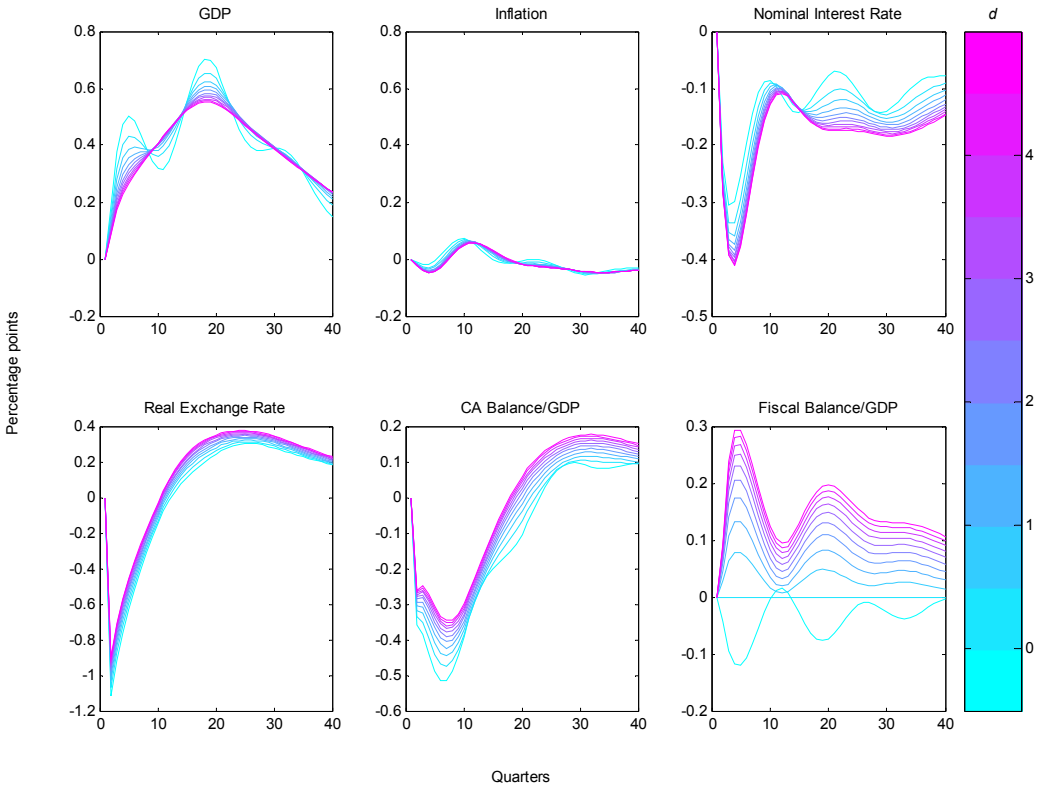
Figure 8. Temporary Fall in Risk Premium by 100 Basis Points
(In Deviation from Steady State Baseline)



30. **Faced with the risk premium shock, and the associated expansion in activity, a stronger fiscal policy response dampens the deterioration in the external current account balance, and stabilizes output.** As Figure 9 reports, a stronger response of the fiscal balance to the increase in fiscal revenue (a move from a smaller to a larger *d*)

moderates the increase in output, and slightly lowers inflation. In addition, the tighter fiscal position moderates the exchange rate appreciation, and reduces the deterioration in the external current account balance.

Figure 9. Risk Premium Shock and Strength of Fiscal Policy Response
(Deviation from Steady State Baseline



Note: darker lines in the figure correspond to a stronger response of the fiscal balance to excess cyclical revenue (larger values of parameter *d*).

Sensitivity analysis: length of fiscal policy implementation lags

31. **The capacity of fiscal policy to contribute to macroeconomic stability depends on the speed with which it can respond**. To illustrate this point, the fiscal response function in Equation (1) is altered to incorporate adjustment lags as follows:

$$\frac{fbal_t}{gdp_t} = \phi^* + d\left(\frac{\tau_{t-L} - \tau^*_{t-L}}{gdp_{t-L}}\right) \qquad (7)$$

where L denotes the implementation lag in quarters. The fiscal surplus now responds with a lag of L quarters to changes in cyclical revenue. The results (not shown, but available on request) suggest that, for implementation lags of 1 or 2 quarters, a countercyclical fiscal

policy continues to enhance macroeconomic stability, although by less than in the absence of implementation lags. However, when the fiscal response is delayed by 3 quarters or more, an aggressive response to the cyclical position ($d > 1$) can be counter-productive, and destabilize output.

E. Conclusions

32. **This paper quantifies the dynamic effects of fiscal policy using a structural model, GIMF, and finds that while fiscal consolidation retards aggregate demand in the short run, it can also yield long-run output gains**. The short-run slowdown is smaller when the consolidation is based on transfer cuts than when the fiscal tightening involves cuts in government purchases, and when the central bank responds strongly to the associate easing of inflation pressures. In particular, the contraction of output within one year following a 0.5 percent-of-GDP increase in the fiscal surplus is estimated to reduce GDP by 0.17–0.62 percent within one year, depending on the composition of the fiscal tightening. The long-run gains accrue due to lower risk premiums that crowd in private activity, and are particularly strong if the savings from lower debt-interest payments are used to lower distortionary taxes or to increase productive public investment. The long-run output gains from a permanent improvement in the fiscal balance by 0.5 percentage points of GDP is estimated at 0.56 percent of GDP when the consolidation is based on cuts in government consumption. However, a fiscal consolidation based on productive public investment cuts alone can jeopardize such long-run gains, and reduce long-run output.

33. **The paper also finds that fiscal policy can substantially contribute to a smooth landing for an overheated economy**. In addition to stabilizing output and inflation, a stronger response of the fiscal balance to excess cyclical revenue reduces the burden on the central bank of raising interest rates and lessens the associated degree of exchange rate appreciation. The stronger response of the fiscal balance also contributes to a more moderate deterioration in the external current account balance during expansions in domestic demand. A stronger fiscal response also moderates the deterioration in the current account balance in response to a fall in risk premiums, highlighting the stabilizing role fiscal policy can play following external shocks.

34. **Moreover, the analysis finds that the success of fiscal policy in enhancing macroeconomic stability depends on the type of shock, the response of monetary policy, and the length of fiscal policy implementation lags**. In particular, while a stronger fiscal policy response can lower both output and inflation volatility during aggregate demand shocks, a supply shock introduces an inflation-output volatility tradeoff. This tradeoff is modest if monetary policy is strongly committed to stabilizing inflation expectations. Regarding fiscal policy implementation lags, the analysis suggests that with lags of up to 2 quarters, less procyclical policy still enhances macroeconomic stability. However, an aggressive countercyclical response that is delayed by 3 quarters or more can be counter-productive, and destabilize output.

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II. External Linkages and Economic Growth in Colombia: Insights from a Bayesian VAR Model[21]

A. Introduction

1. **Colombia's economic growth has risen markedly in recent years**. Real GDP growth averaged less than 3 percent over 1991–2003, but accelerated to 5½ percent in 2004–06. Growth in the year ending June 2007 was close to 8 percent, a pace that had not been observed in Colombia since the late 1970s. This improved performance has taken place against a backdrop of important economic reforms (see IMF, 2006), a markedly improved domestic security situation, and very favorable external conditions, with strong global growth, better terms of trade, abundant international liquidity, and low interest rates.

2. **An important question is to what extent economic growth has been driven by external factors *vis-à-vis* domestic ones, and how sensitive growth is to changes in external conditions**. This paper uses a Bayesian VAR (BVAR) model to address these issues. The model is estimated using a recently developed methodology by Villani (2005) which allows for the specification of informative steady-state priors for the variables used in the model. This approach has been found, *inter alia*, to improve the forecasting performance of empirical models.

3. **This paper builds on the efforts of Österholm and Zettelmeyer (2007) in quantifying the role of external factors in Latin American growth**. We extend their framework by explicitly incorporating domestic factors that are thought to have played a key role in Colombia's growth experience. In including such domestic factors, we focus on variables that are believed to respond to economic policy decisions, such as fiscal and monetary policy variables. With this in mind, the model also attempts to capture changes in Colombia's investment climate, which may be related, *inter alia,* to changes in the domestic policy environment.

4. **Impulse response functions and variance decomposition analysis are undertaken to show how domestic and external factors affect growth**. The paper also examines how much of the recent growth surge was due to external factors. In order to assess this, a historical decomposition using the method of Adolfson and others (2007) is conducted.

5. **The paper also presents forecasts of Colombian growth for the near term.** Since BVARs help reduce the problem of overparameterization that traditional VAR models can suffer they typically provide better forecasting performance. The paper accordingly investigates the forecasting performance of the BVAR model in an out-of-sample exercise, compared to alternative models. Finally, in a forward-looking exercise, an assessment is

[21] Prepared by Lisandro Abrego and Pär Österholm.

undertaken of the growth implications of (i) expected changes in external conditions in 2008 and (ii) a less-benign external environment than presently expected.

6. **The paper is organized as follows**. Section B presents the basic structure of the model, and Section C describes its empirical implementation. Section D discusses the estimation results, including impulse response functions, variance decompositions, historical decompositions, out-of-sample forecasting assessments, and results from the conditional forecasting exercise. Finally, Section E summarizes and offers some concluding remarks.

B. The Model

7. **The Bayesian VAR model allows the incorporation of informative steady-state priors**. The model is estimated using a recently developed methodology by Villani (2005). Adolfson *et al*. (2005), Österholm (2007), and Österholm and Zettelmeyer (2007) contain empirical examples.

8. The model is given by

$$\mathbf{G}(L)(\mathbf{x}_t - \boldsymbol{\psi}) = \boldsymbol{\eta}_t \qquad (1)$$

where $\mathbf{G}(L) = \mathbf{I} - \mathbf{G}_1 L - \ldots - \mathbf{G}_p L^p$ is a lag polynomial of order p, $\mathbf{x}_t$ is an nx1 vector of stationary macroeconomic variables and $\boldsymbol{\eta}_t$ is an nx1 vector of *iid* error terms fulfilling $E(\boldsymbol{\eta}_t) = \mathbf{0}$ and $E(\boldsymbol{\eta}_t \boldsymbol{\eta}_t') = \boldsymbol{\Sigma}$. This model, while non-linear in its parameters, has the feature that $\boldsymbol{\psi}$ provides the steady state. It is typically the case that the forecaster has a reasonably accurate view of the parameters of $\boldsymbol{\psi}$ and an informative prior distribution can accordingly be specified.

9. **Priors on the parameters of the model are as follows**: the prior on $\boldsymbol{\Sigma}$ is given by $p(\boldsymbol{\Sigma}) \propto |\boldsymbol{\Sigma}|^{-(n+1)/2}$, the prior on $vec(\mathbf{G})$ – where $\mathbf{G} = (\mathbf{G}_1 \quad \ldots \quad \mathbf{G}_p)'$ – is given by $vec(\mathbf{G}) \sim N_{pn^2}(\boldsymbol{\theta}_{\mathbf{G}}, \boldsymbol{\Omega}_{\mathbf{G}})$ and, finally, the prior on $\boldsymbol{\psi}$ is given by $\boldsymbol{\psi} \sim N_n(\boldsymbol{\theta}_{\boldsymbol{\psi}}, \boldsymbol{\Omega}_{\boldsymbol{\psi}})$. This choice of priors implies that the prior on $\boldsymbol{\Sigma}$ is non-informative; the priors on the vectors of dynamic coefficients $vec(\mathbf{G})$ and the steady state parameters $\boldsymbol{\psi}$ will, on the other hand, generally be informative. The priors on $\boldsymbol{\psi}$ are discussed in more detail below.[22]

[22] For the priors governing the dynamics of the model, we employ a modified version of the Minnesota prior (Litterman, 1986). The prior mean on the first own lag is set to 0.9 if a variable is modelled in levels and 0 if it is in growth rates; all other coefficients in $\mathbf{G}$ have a prior mean of zero. The reason for the modification of the traditional Minnesota prior is that a prior mean on the first own lag equal to 1 is theoretically inconsistent with the mean-adjusted model, since a random walk does not have a well-specified unconditional mean.

C. Empirical Implementation

10. **Variables capturing both domestic and external drivers of growth were included in the model.** With the variables included in the model given by $\mathbf{x}_t$, we let

$$\mathbf{x}_t = \left(\Delta y_t^{world} \quad i_t^{US} \quad EMBI_t \quad HY_t \quad FDI_t \quad \Delta g_t \quad \Delta y_t \quad i_t\right)', \qquad (2)$$

where y_t^{world}, the logarithm of world real GDP (excluding Colombia); i_t^{US}, the nominal three-month U.S. treasury bill rate; $EMBI_t$, the JP Morgan emerging market bond index spread for Latin America (excluding Colombia); and HY_t, the high-yield corporate bond spread in the United States (aiming to capture general investor risk aversion), constitute the external block. The domestic block is made up of FDI_t, foreign direct investment as a share of GDP (assumed to have an effect on Colombian GDP in itself but also thought to proxy the investment climate in Colombia); g_t, the logarithm of real government spending; y_t, the logarithm of Colombia's real GDP; and i_t, the nominal bank lending rate in Colombia. The data are shown in Figure 1.

11. **Steady-state priors are based on a combination of theory, empirical estimates used in the literature, and the data itself**. The priors used for each variable are shown in Table 1. The prior for world GDP growth was based on medium-term projections from the Fall 2007 World *Economic Outlook* (WEO). The choice of prior for the U.S. three-month Treasury bill rate is based on combining an inflation target of around 2 percent with the Fisher hypothesis, where the equilibrium real interest rate is also assumed to be approximately 2 percent. These values are in line with values suggested by Taylor (1993) and Clarida, Gali, and Gertler (1998). For the EMBI and high-yield bond spread, we adopted the priors of Österholm and Zettelmeyer (2007). For the steady state prior for FDI, neither theory nor the literature provide strong guidance; in this light, a relatively wide distribution—which largely seems in line with the data—was accordingly specified. For Colombian government spending and GDP growth, the priors were based not only on historical performance, but on econometric studies of the impact of economic reforms on long-run GDP growth in Latin America (see, for example, Loayza and others, 2004; or the survey by Zettelmeyer, 2006). Finally, the prior on the lending rate is reasonably wide, which reflects the wide degree of uncertainty regarding the nexus between nominal interest rate changes and output during the sample period.[23] Setting lag length to $p = 2$, we estimate the model using data from 1995Q2 to 2007Q2.

[23] It can be noted that the prior for this variable is centered on a number that exceeds the sum of the steady state GDP growth rate and an inflation target of, say, 3-4 percent. However, given that the variable we use is a lending rate, intermediation costs and a risk premium need to be added to that sum in order to arrive at a more relevant steady-state value.

Figure 1. Data

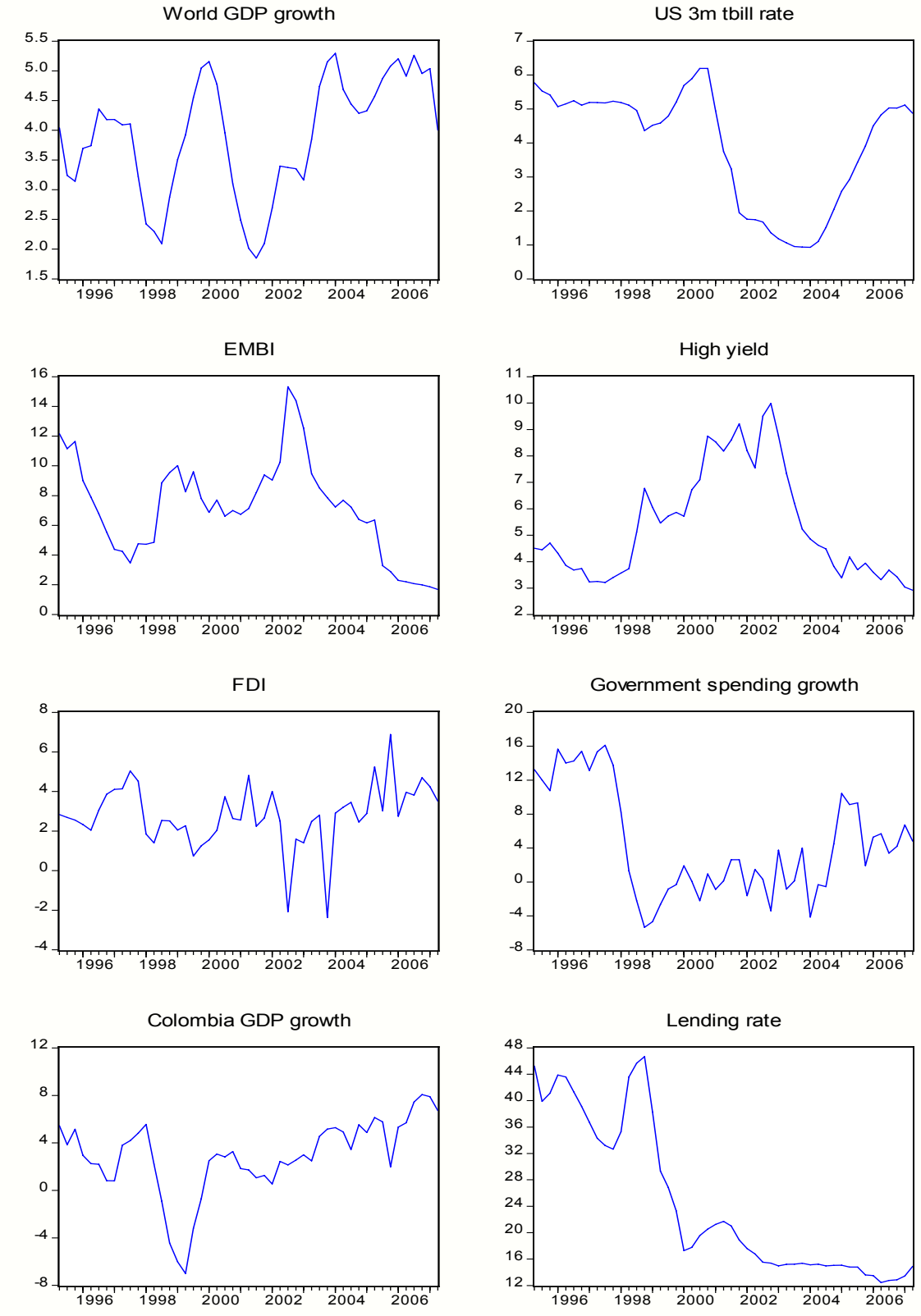


Table 1. 95 Percent Prior Probability Intervals For Parameters Determining Steady-State Values

	95 percent prior probability interval
Δy_t^{world}	(3.75, 4.75)
i_t^{US}	(3.00, 5.00)
$EMBI_t$	(2.00, 5.00)
HY_t	(3.00, 6.00)
FDI_t	(3.00, 5.00)
Δg_t	(4.25, 5.25)
Δy_t	(4.25, 5.25)
i_t	(8.00, 16.00)

D. Results

Impulse responses and variance decomposition[24]

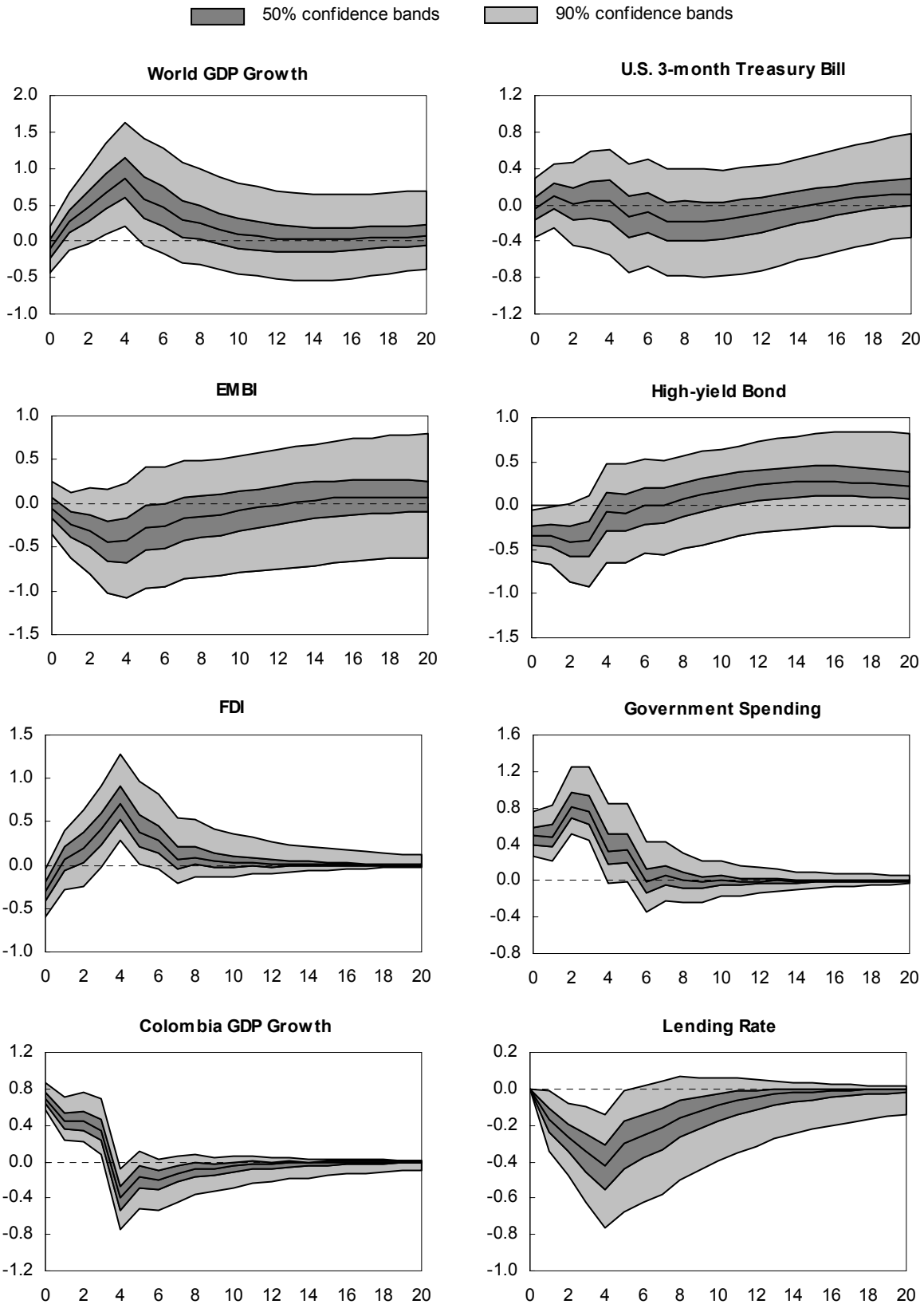
12. **The generation of impulse response functions follows standard practice**. Impulse responses for Colombian GDP reflect one standard-deviation shocks.[25] A standard Cholesky decomposition of the variance-covariance matrix was used to identify independent standard normal shocks $\boldsymbol{\varepsilon}_t$ based on the estimated reduced form shocks; that is, the relationships $\boldsymbol{\Sigma} = \mathbf{PP}'$ and $\boldsymbol{\varepsilon}_t = \mathbf{P}^{-1}\boldsymbol{\eta}_t$, with the variables ordered as in $\mathbf{x}_t$ in equation (2), were used.

13. **Virtually all impulse responses for Colombian growth show the expected sign over relevant time horizons** (Figure 2). Exceptions are the responses on impact to global growth and FDI, which, however, turn positive after the first quarter. For most shocks, the response of Colombian growth is also significant at short horizons, except for the shocks to the U.S. treasury bill rate and EMBI spread which both are fairly imprecisely measured.

[24] The discussion in this section focuses on results for Colombian GDP growth. The full set of impulse response functions and variance decomposition results are presented in Tables A1 and A2 in the Appendix.

[25] A one-standard deviation shock is equivalent to 0.32 percentage points for global growth, 30 basis points for the U.S. treasury bill rate, 147 basis points for the EMBI spread, 43 basis points for the high yield bond spread, 1.25 percentage points for FDI, 2.09 percentage point for public spending growth, 0.70 percentage points for Colombian GDP growth and 165 basis points for the domestic interest rate.

Figure 2. Impulse Response Functions for Colombia GDP Growth



14. **Colombian growth is fairly sensitive to global growth.** The impulse response function implies that if global growth has fallen by one percentage point four quarters after the shock, Colombian GDP growth has at the same time fallen roughly by 1.4 percentage points. Note that in the model the impact of global growth is transmitted both through the traditional trade channel and via changes in external financial conditions. As can be seen in Figure A1 in the Appendix, shocks to global growth also generate substantial changes in the EMBI and high-yield bond spreads, which in turn have an effect on Colombian growth.

15. **The response to global growth shocks is stronger than that estimated by Österholm and Zettelmeyer (2007) for an aggregate of six Latin American countries** (Table 2). These authors' estimates imply roughly a one-for-one relationship between domestic growth and global growth at the same time horizon. The stronger response of the Colombian economy could reflect its higher degree of trade openness (for most of the sample period), combined with a fair degree of sensitivity to changes in external financial conditions. It should be noted, however, that the two models are not fully comparable, as the set of variables they include is not the same.[26]

Table 2. Sensitivity of Domestic Growth to Key External Variables in Österholm and Zettelmeyer (2007) 1/

	World GDP growth		EMBI		High-yield bond	
	Maximum effect	Period for maximum effect	Maximum effect	Period for maximum effect	Maximum effect	Period for maximum effect
Argentina	1.88	5	-0.82	4	-2.76	3
Brazil	1.15	4	-0.38	4	-0.61	3
Chile	1.44	5	0.53	4	-0.39	4
Colombia	1.70	3	-0.29	3	-0.94	2
Mexico	0.54	4	-0.51	4	-0.88	3
Peru	1.15	1	-0.19	1	-0.47	4

1/ Effects based on calculation where the increase in world GDP growth is one percentage point at its peak (which is after three quarters). The effect for the EMBI on Chile is perverse with an increase in GDP growth.

16. **While more moderate than the effect of global growth, the impact of shocks to external financial conditions is generally substantial**. An increase of 100 basis points in the EMBI spread would lower Colombian GDP growth by roughly 0.3 percentage points after the first year. For the high yield spread, a 100 basis point shock would cause Colombian GDP growth to fall by approximately 0.2 percentage points. The effect is substantially larger at shorter horizons, though. In contrast, a shock to the U.S. interest rate has a small impact on Colombian growth. Note also that the response of the domestic lending rate to shocks to the

[26] Österholm and Zettelmeyer do not include domestic variables in their model, while including a commodity-price variable.

U.S. rate is statistically insignificant, suggesting that monetary policy in Colombia is independent of U.S. monetary policy.

17. **Growth is moderately sensitive to changes in domestic variables.** A one percentage point increase in the ratio of FDI to GDP (a proxy for the investment climate) would raise Colombian GDP growth by roughly 0.56 percentage point after one year. Fiscal policy also affects markedly GDP growth in a Keynesian fashion, that is, expansionary fiscal policy has a positive effect on growth in the short run—the estimated impulse response implies that a 1 percent increase in public spending raises GDP growth by 0.36 percentage points.[27] Finally, monetary policy also has a substantial effect on GDP growth—an increase of 100 basis points in the lending rate reduces GDP growth by close to 0.3 percentage point after one year.

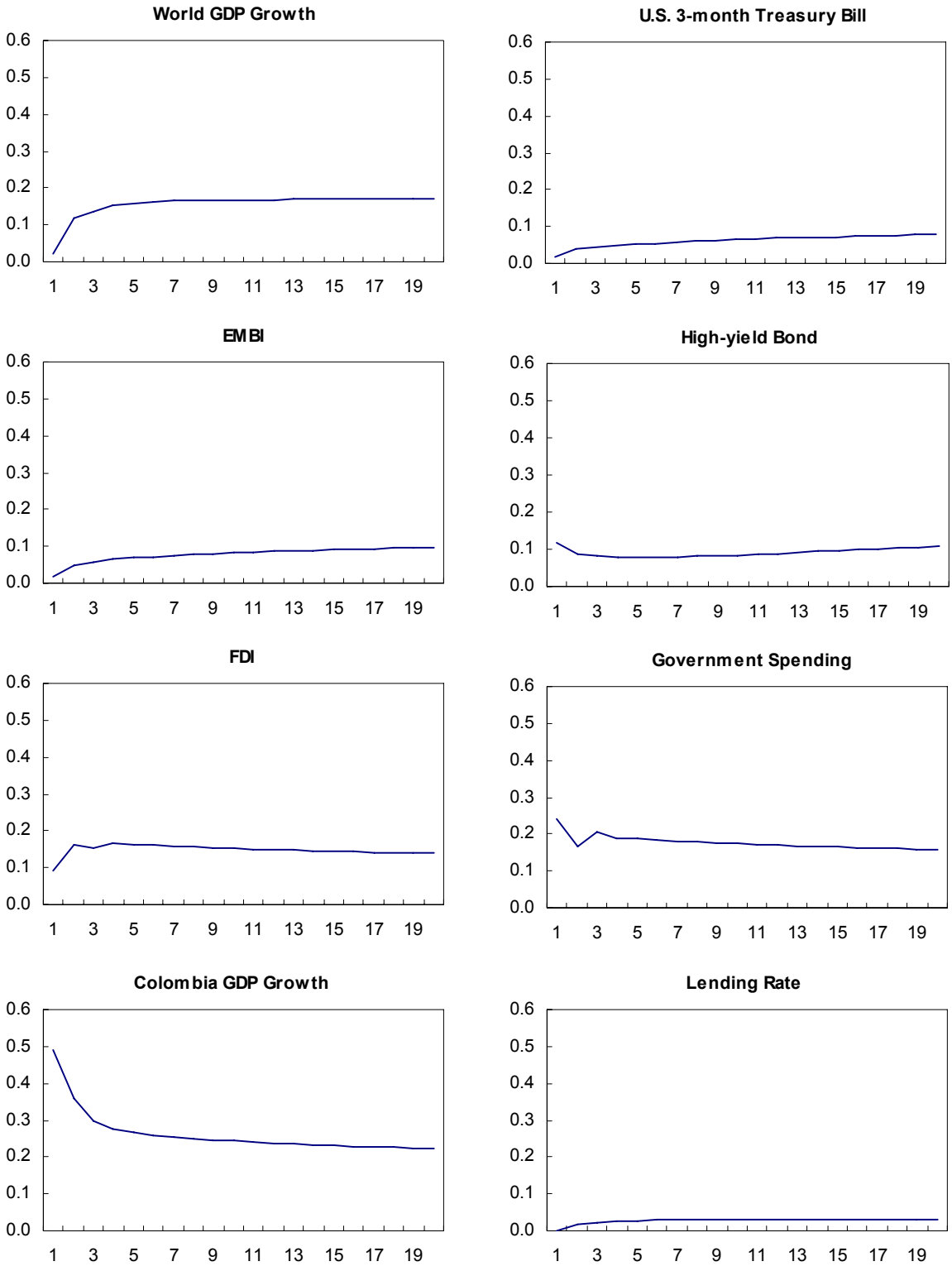
18. **The model explains a very large share of the forecast error variance of Colombian GDP growth**. The variance explained by own shocks is only a touch more than 20 percent (at the 20 quarter horizon), which is a fairly low proportion for a VAR.

19. **The variance decomposition reveals that both foreign and domestic factors matter to economic growth in Colombia, with the contribution from the latter being higher** (Figure 3). It should be noted, however, that breaking down the contribution to growth into domestic and foreign factors is not straightforward. It is possible that some variables—notably the investment climate variable and government spending—reflect also the influence of foreign factors, which would naturally overstate the role of domestic factors.[28] The model results suggest that external factors account for about 40 percent and domestic factors 60 percent. World GDP growth, government spending and FDI are—apart from own shocks—the most important factors, explaining about 17, 16, and 14 percent, respectively, at the 20-quarter horizon. Other external factors play a more modest role, with the U.S. interest rate, the EMBI spread, and the high yield bond spread each accounting for around 10 percent. The contribution from domestic monetary policy is even smaller, with the lending rate explaining only 3 percent of Colombian growth.

[27] This response is broadly consistent with that from the Global Integrated Monetary and Fiscal (GIMF) model for Colombia. See Chapter 1.

[28] For example, changes in the terms of trade could affect such variables. However, a version of the model including the terms of trade produced virtually the same results as our preferred specification. In particular, the domestic growth response to terms-of-trade shocks was not statistically different from zero, while the variance decomposition assigned a very minor role to that variable as a contributor to growth. Since FDI in the mineral sectors (oil and mining) could also respond to changes in the terms of trade, a model specification with the investment climate variable including only non-mineral FDI was also run. This, however, generated only very minor changes in the results.

Figure 3. Variance Decomposition for Colombia GDP Growth



Historical decomposition

20. **To investigate to what extent external factors have contributed to the recent surge in economic growth, a historical growth decomposition is conducted for the 2004–07 period**. The approach by Adolfson and others (2007) is followed to perform this exercise. Based on this approach, actual growth outcomes and the endogenous forecasts are initially compared for the period selected. This comparison indicates that actual growth was generally stronger than predicted by the model over 2004–06 (Figure 4). The implication is that some combination of favorable shocks hit the economy during that period. The estimates of the role of foreign factors in this period are derived from the model's forecast of Colombian GDP growth if only foreign shocks would have hit the economy after 2004Q2. A similar exercise is performed to estimate the role of monetary and fiscal policy shocks and of changes in the investment climate. Note that the various shocks have been identified by the model *ex post.*

21. **The model suggests that the foreign shocks were not particularly favorable in 2004 and 2005** (Figure 4, Table 3). Not until late 2006 were the foreign shocks positive for Colombian GDP growth. This might seem somewhat surprising, as most economists would agree that external conditions were favorable in 2004–05. However, it should be kept in mind that the model's endogenous forecast of the external environment was also quite optimistic.

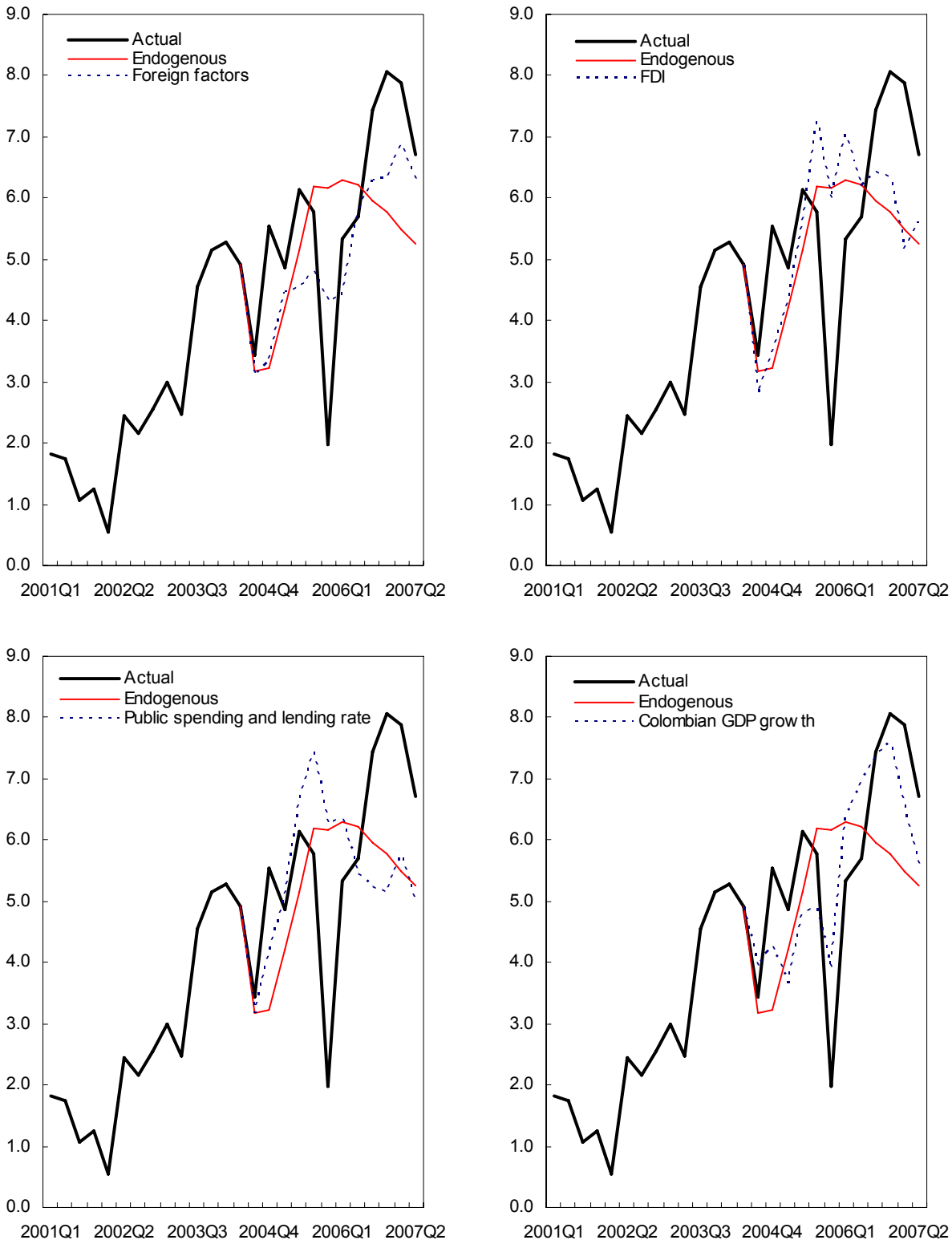
22. **The model indicates that changes in the investment climate have been consistently positive during this period, providing a stimulus to the Colombian economy**. This is consistent with the improvement in the domestic security situation and in economic policies that took place in Colombia during this period.

Table 3. Decomposition of Growth, 2004-07
(In Percent)

	Foreign factors	FDI	Public spending and lending rate	Colombian GDP growth 1/	Total
2004 2/	0.5	-5.4	36.2	68.7	100.0
2005 3/	-122.0	48.0	125.6	-151.5	-100.0
2006	-61.9	77.2	-90.0	174.7	100.0
2007 4/	63.3	1.6	-0.1	35.2	100.0

1/ Own shock.
2/ Second half of the year.
3/ A negative entry in the "Total" column means that actual growth was below the endogenous forecast.
4/ First half of the year.

Figure 4. Foreign and Domestic Factors in 2004-07 Growth



23. **The fiscal and monetary policy shocks are found to have largely the opposite pattern of the foreign shocks**. They were positive at the beginning of the period under consideration but appear to have been less favorable from early 2006. Finally, for completeness, the last chart of Figure 4 and the penultimate column of Table 3 show the effect of only adding the shocks to Colombian GDP growth. This largely shows the opposite pattern to the macroeconomic policy shocks.

Out-of-sample forecasting: a comparison

24. **The out-of-sample forecasting performance of the BVAR model with informative priors is compared to that of a conventional BVAR and to a naïve forecast**. The conventional BVAR is given by

$$\mathbf{G}(L)\mathbf{x}_t = \mathbf{\Phi} + \boldsymbol{\eta}_t \qquad (3)$$

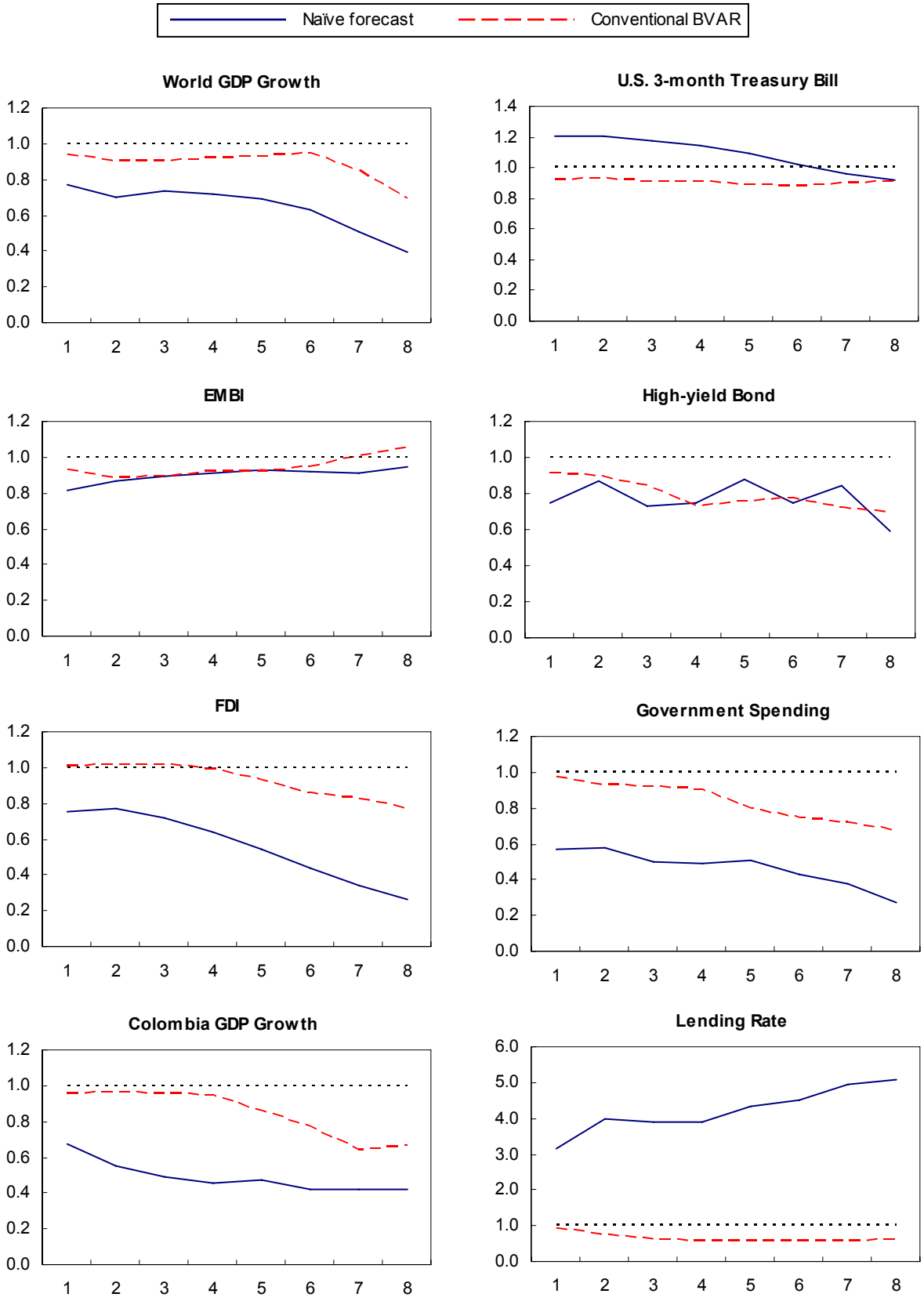
where $\mathbf{G}(L)$, $\mathbf{x}_t$ and $\boldsymbol{\eta}_t$ all are defined as in equations (1) and (2). Comparing the model in equation (3) to that in equation (1), it should be noted that it is typically difficult to specify a prior distribution for $\mathbf{\Phi}$ as it does not have an economically intuitive interpretation. The solution to this problem is generally to employ a non-informative prior for $\mathbf{\Phi}$ and we will follow this convention; the priors for $\mathbf{\Sigma}$ and $\mathbf{G}(L)$ are unchanged relative to the ones for the mean-adjusted BVAR.

25. **The out-of-sample forecast exercise follows standard practice**: the two BVAR models are initially estimated using data from 1995Q2 to 2002Q4 and used to generate forecasts to 2004Q4, that is, eight quarters ahead.[29] The forecasts from the two BVAR models and the naïve forecast are then compared to the actual values and errors are recorded. We then extend that sample one period, re-estimate the models and generate new forecasts eight periods ahead and so on. The last evaluation is conducted on a model estimated from 1995Q2 to 2007Q1 and only forecasted one period ahead.

26. **The mean-adjusted model almost always outperforms the other models**. The root mean square error (RMSE) is used to compare the forecasting performance of the models (Figure 5). A relative RSME smaller than one means that the mean-adjusted BVAR forecasts better than the alternative model at a given forecasting horizon. Only for the lending rate is the mean-adjusted model consistently outperformed by a naïve forecast. This is not completely surprising, though—it is well known that it is very hard to beat naïve forecasts for

[29] In the exercise using the two BVAR models, for every draw from the posterior distribution of parameters a sequence of shocks is drawn and used to generate future data. This leads to as many paths for each variable as we have iterations in the Gibbs sampling algorithm. For each of the two models, a central forecast is then generated as the median forecast based on the forecast density at each horizon. These central forecasts are used for the point forecast comparison.

Figure 5. Forecasting Performance of Alternative Models (Relative Mean Square Errors)



nominal interest rates since they are extremely persistent and are frequently modeled as unit-root processes (see, for example, Campbell and Shiller, 1991). Moreover, looking at the lending rate over the sample for which the out-of-sample exercise was conducted, it can be noted that it was virtually flat. This largely explains the extremely good results for the naïve forecast.

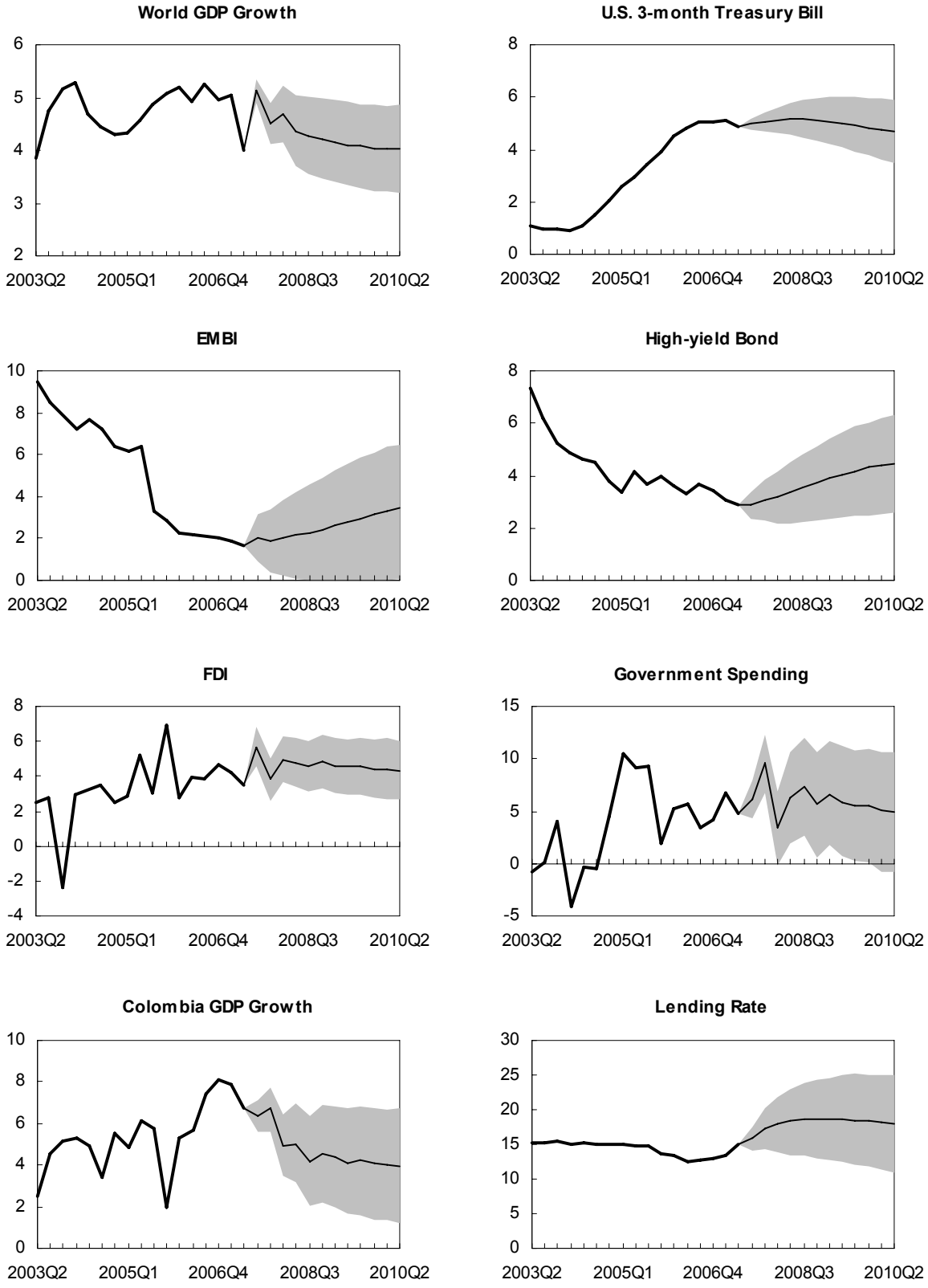
Unconditional and conditional forecasts

27. **Both unconditional (endogenous) and conditional forecasts of Colombian growth through 2010 are generated using the BVAR model**. The unconditional forecast is fully model-based, while the conditional forecast is derived from imposing a path on selected variables. We carry out two conditional forecasts. The first imposes a path on those variables for which standard projections are available, namely, world growth (from the Fall 2007 WEO) and the U.S. interest rate (from the IMF's Western Hemisphere Department but consistent with WEO projections). The second conditional forecast is based on a hypothetical, although arguably plausible, scenario where global growth is lower than projected in the Fall 2007 WEO.

28. **The endogenous and WEO-based conditional forecasts produce somewhat different results (Figures 6–7), although both are broadly consistent with current projections of Colombian GDP growth**. Under the fully endogenous forecast, economic growth decelerates to around 4½ percent by end-2008 and stabilizes at about 4 percent in 2009. The WEO-based conditional forecast, on the other hand, generates growth of about 5¼ percent in by the end of 2008 and 4¾ percent in late 2009. These predictions are broadly in line with projections in the Fall 2007 WEO. The stronger average growth under the conditional forecast is due largely to WEO projections of world GDP growth being higher than in the endogenous forecasts. As seen in the previous section, global growth has a strong effect on Colombian GDP growth in the model.

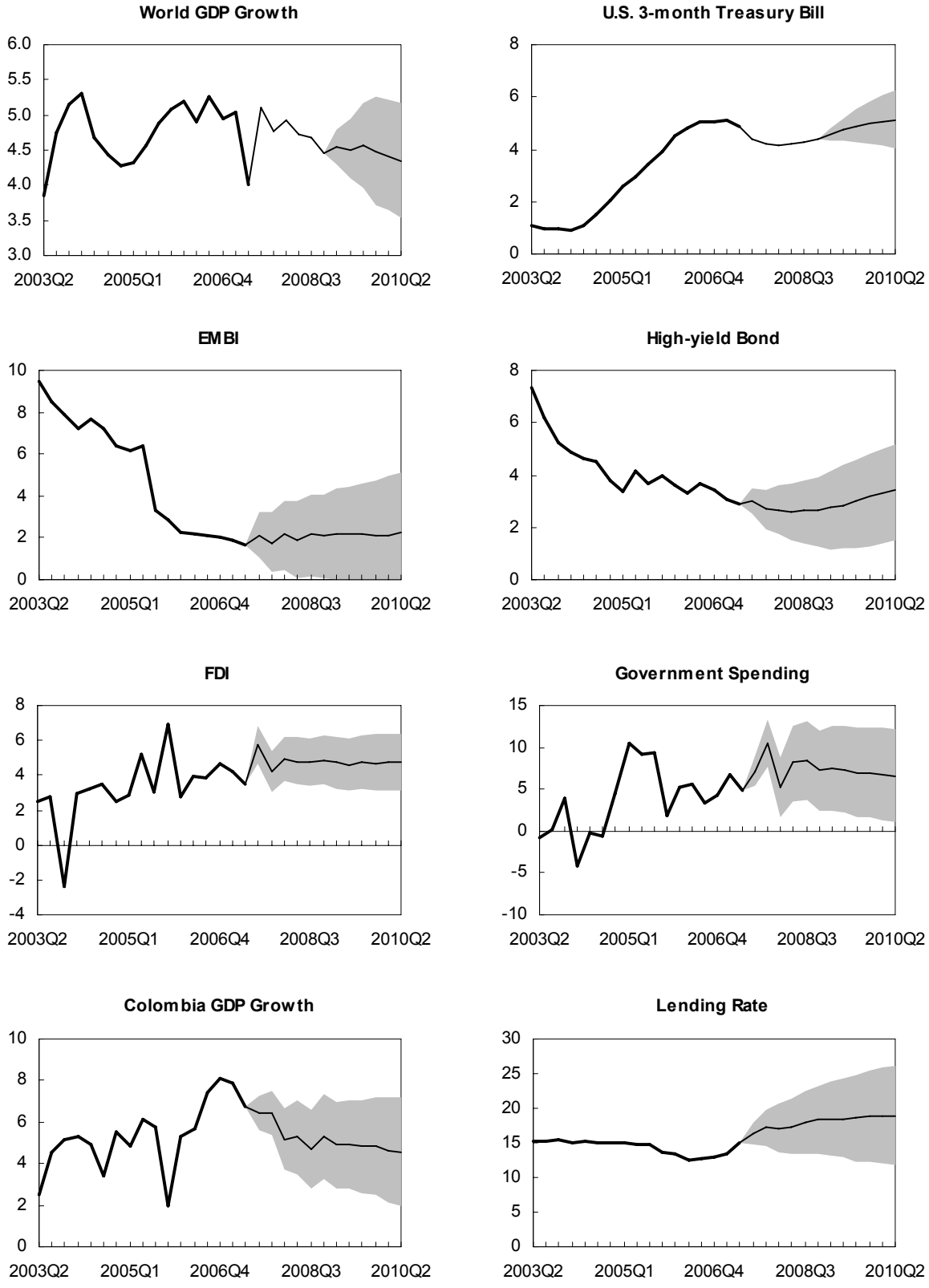
29. **The downside conditional forecast produces a substantial deceleration of growth in Colombia, although growth remains positive in all periods**. This forecast assumes that global growth in each quarter of 2008 is lower by 1 percentage point on an annualized basis relative to the Fall 2007 WEO and that the U.S. three-month treasury bill rate decrease in response to this slowdown. As can be seen in Figure 8, this produces a substantial decrease in Colombian GDP growth, which reaches a low of 3 percent in late 2008Q3 (compared to 4¾ percent growth under the WEO-based conditional forecast). Note that under this scenario the EMBI spread—which has not been conditioned upon—increases a fair amount. This outcome is highly plausible in light of the strong historical correlation between U.S. downturns and global risk appetite. After the sharp decline in Colombian GDP growth, though, the recovery is predicted to be fairly rapid, with growth reaching the same level as in the WEO-based forecast by the end of 2009.

Figure 6. Unconditional Forecast 1/



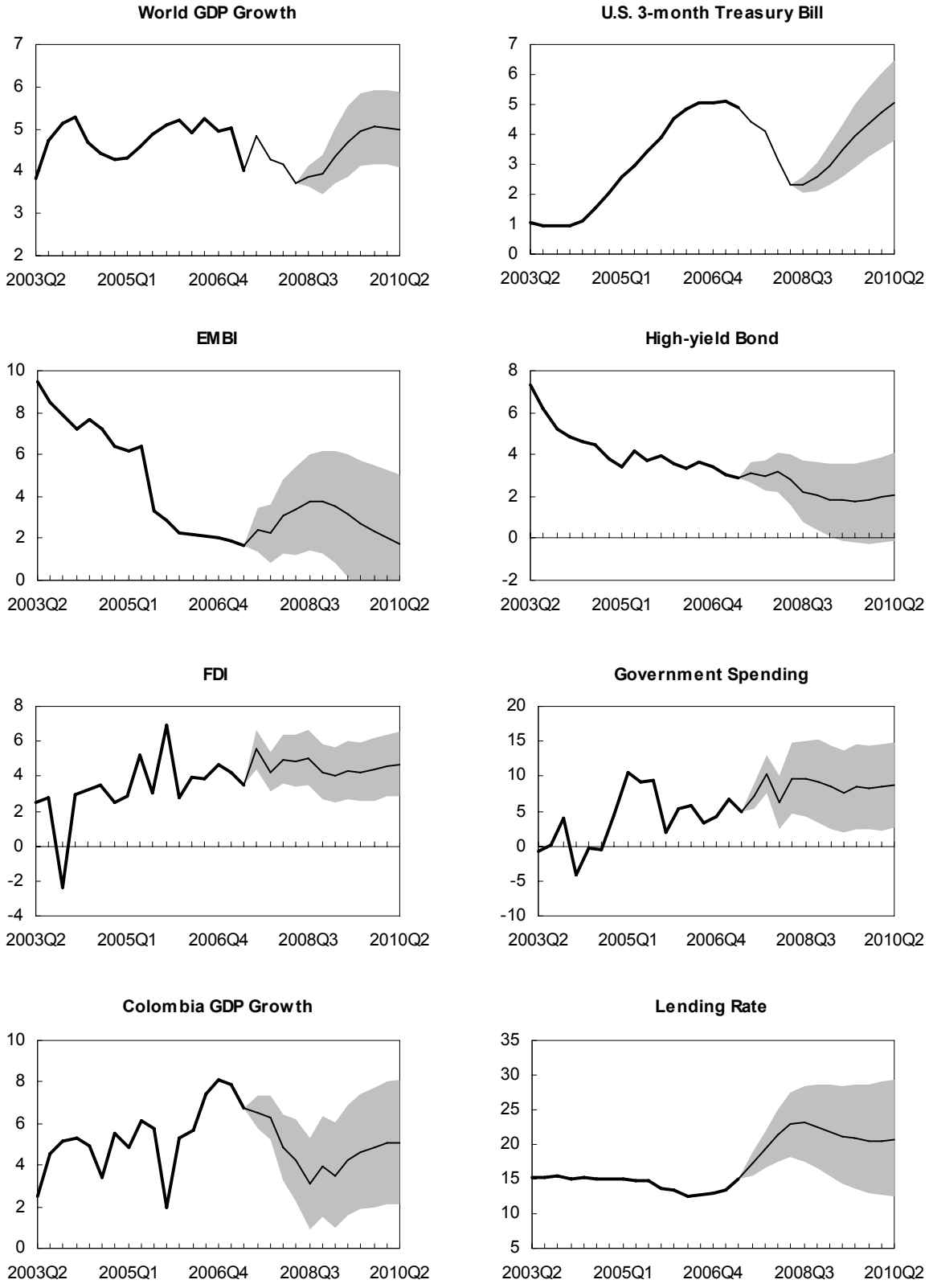
1/ 50% confidence bands.

Figure 7. WEO-Based Conditional Forecast 1/



1/ 50% confidence bands.

Figure 8. Conditional Forecast Based on Hypothetical Shock to Global Growth 1/



1/ 50% confidence bands.

30. **Summing up, the model supports the view that Colombian growth is fairly sensitive to changes in global growth**. Under the scenario of a less auspicious global environment, growth would decline to 3 percent, 1¾ percentage points below the baseline forecast. This suggests that Colombia responds more sharply than other Latin American countries to global downturns. At the same time, the extent of the downturn under the less favorable global scenario described here would fall well short of a full-blown recession, and would be a mild decline in growth by historical standards.

E. Summary and Final Remarks

31. **Colombia's economic growth is explained mostly by domestic factors, although the contribution from external factors is substantial**. Variance decomposition from the BVAR model indicates that domestic factors account for about 60 percent of growth, with the remainder explained by external developments. Among the domestic factors, the investment climate and fiscal policy play a prominent role, while the contribution from monetary policy has been small. Global economic growth is by far the most important external factor behind Colombian growth. External financial conditions, as measured by the U.S. interest rate and the EMBI and high-yield bond spreads, account each only for a modest share of domestic growth.

32. **Growth is moderately sensitive to changes in domestic macroeconomic policies and highly sensitive to global growth shocks.** The impulse response functions indicate that monetary and fiscal policy shocks each have a moderate impact on domestic growth, while the effect of global growth is considerably stronger. Changes in the investment climate also affect growth in a moderate fashion.

33. **The model's conditional and unconditional growth forecasts are broadly in line with WEO projections**. They imply a deceleration of economic growth to 4–5 percent in 2008-10, from close to 7 percent in 2006-07 levels. Also, the model shows that a moderate deceleration in global growth would lead to a significant slowdown of domestic growth, followed by a relatively rapid recovery. However, domestic growth would remain positive and would fall well short of a recession, suggesting domestic resilience to a global downturn.

34. **Beyond the results of the model, a number of other considerations may affect the nexus between Colombian growth and the external environment**. As indicated above, it is very difficult to completely separate the roles of domestic and foreign factors, and it is possible that factors classified as domestic in the model include the effects of external developments. On the other hand, the influence of external factors could be overstated, because the variance decomposition and impulse response functions are estimated on the basis of data including the1990s. Thus, they may not fully capture the effects of the structural reforms implemented since the early 2000s in Colombia. These reforms—which have significantly strengthened the economic policy framework and likely enhanced the economy's flexibility—may have made Colombia less sensitive to foreign developments.

Moreover, there are other factors that would help cushion the effects of a negative external shock (for example, the high level of international reserves and a flexible exchange rate regime) that the model may not capture appropriately. At the same time, however, greater integration into the world economy in recent years, notably from a financial standpoint, may have made the Colombian economy more sensitive to external developments. In this context, and given the highly favorable external conditions of the last few years, the presumption that the resilience of the Colombian economy to external shocks may have been enhanced in recent years, while entirely plausible, remains to be tested.

APPENDIX

Table A1. RMSE for Mean-adjusted BVAR

	Δy_t^{world}	FDI_t	i_t^{US}	$EMBI_t$	HY_t	Δg_t	Δy_t	i_t
1	0.279	0.251	1.440	0.548	1.795	2.588	1.204	1.773
2	0.431	0.508	2.441	1.022	1.904	3.938	1.590	3.063
3	0.698	0.712	3.012	1.413	1.725	4.781	2.010	3.933
4	0.889	0.851	3.536	1.749	1.670	5.999	2.379	4.640
5	0.968	0.903	3.907	1.980	1.886	5.791	2.315	5.380
6	0.898	0.883	4.093	2.190	2.010	5.091	1.964	6.222
7	0.679	0.804	4.428	2.380	1.916	4.194	1.677	7.025
8	0.495	0.710	4.872	2.713	1.832	3.257	1.823	7.867

Note: RMSEs for variables in first differences are given for four-quarter ended values.

Table A2. RMSEs for Traditional BVAR

	Δy_t^{world}	FDI_t	i_t^{US}	$EMBI_t$	HY_t	Δg_t	Δy_t	i_t
1	0.297	0.249	1.564	0.592	1.970	2.657	1.258	1.959
2	0.478	0.499	2.638	1.150	2.117	4.235	1.653	4.127
3	0.776	0.700	3.320	1.574	2.054	5.197	2.100	6.496
4	0.966	0.861	3.906	1.903	2.295	6.637	2.514	8.326
5	1.041	0.976	4.374	2.150	2.490	7.275	2.685	9.648
6	0.950	1.028	4.674	2.319	2.608	6.830	2.551	10.845
7	0.800	0.977	4.947	2.372	2.656	5.818	2.632	12.058
8	0.713	0.926	5.328	2.585	2.650	4.819	2.747	13.037

Note: RMSEs for variables in first differences are given for four-quarter ended values.

Table A3. RMSEs for Naïve Forecast

	Δy_t^{world}	FDI_t	i_t^{US}	$EMBI_t$	HY_t	Δg_t	Δy_t	i_t
1	0.364	0.333	1.199	0.670	2.387	4.557	1.796	0.559
2	0.614	0.659	2.023	1.176	2.181	6.789	2.868	0.768
3	0.945	0.994	2.567	1.585	2.374	9.532	4.068	1.012
4	1.245	1.330	3.094	1.911	2.243	12.329	5.242	1.185
5	1.396	1.673	3.587	2.139	2.146	11.453	4.879	1.240
6	1.425	2.016	4.021	2.379	2.703	11.831	4.669	1.376
7	1.327	2.355	4.633	2.615	2.279	11.162	4.020	1.420
8	1.265	2.683	5.284	2.873	3.114	12.161	4.337	1.544

Note: RMSEs for variables in first differences are given for four-quarter ended values.

Figure A1. Impulse Response Functions

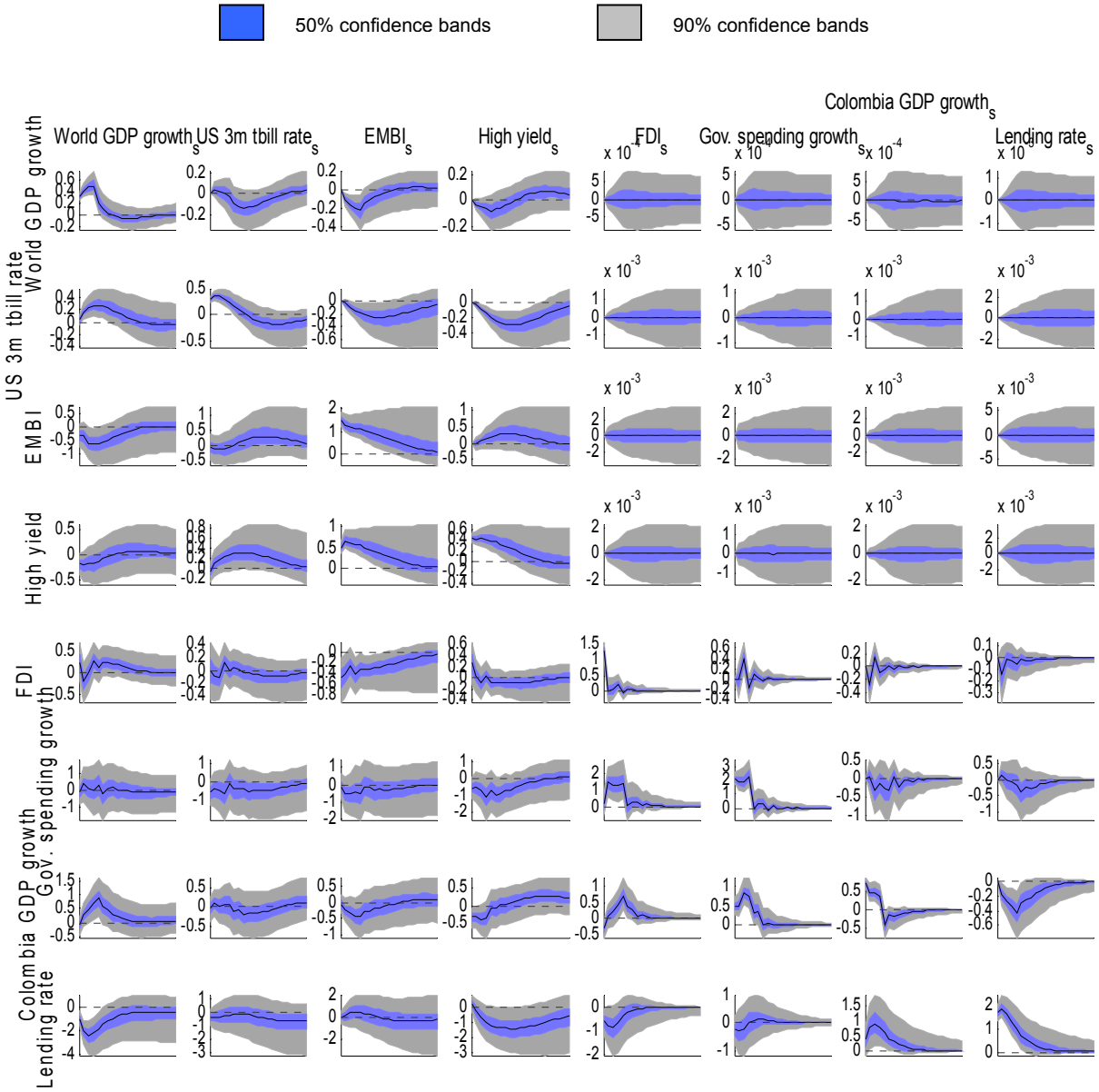
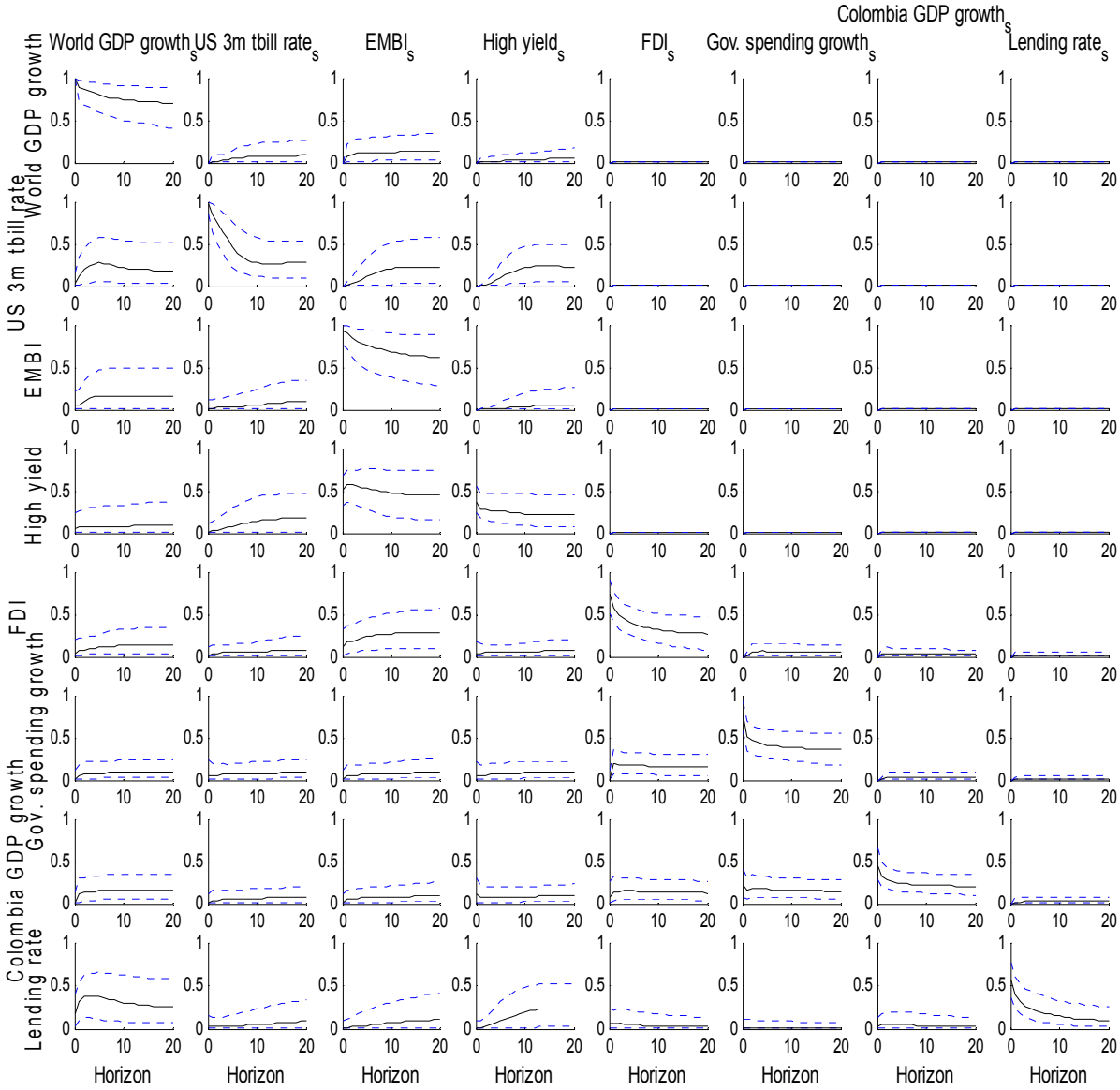


Figure A2. Variance Decomposition



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III. Is Central Bank Intervention Effective Under Inflation Targeting Regimes? The Case of Colombia[30]

A. Introduction

1. **A decade after many emerging market countries battled currency crises, they now face the challenge of adjusting to rapidly appreciating currencies.** To protect the competitiveness of their tradable sectors, many central banks have tried to resist domestic currency appreciation by intervening heavily in currency markets, typically through the accumulation of international reserves. At the same time, many of these same countries have adopted inflation targeting regimes to anchor inflation expectations, most often using short-term interest rates as their main operating target. Controlling inflation—while at the same time limiting currency appreciation—has posed a policy dilemma for many emerging market countries in the last five years (see IMF, 2007a, 2007b, 2007c).

2. **In light of these developments, identifying the effectiveness of intervention and the circumstances under which it can be useful has key policy implications.** Given the lower degree of international substitutability of emerging market assets, and the large size of interventions relative to currency market turnover in these countries, in principle intervention should have a sizeable effect on exchange rates. In this light, it often appears to be attractive tool to respond to surges in capital flows.[31] Moreover, widespread central bank intervention reflects the predominant view among policymakers that intervention is a useful policy tool to influence real exchange rates (Neely, 2007). Indeed, according to a recent BIS study in 2005, 85 percent of those interviewed characterized their interventions as being effective most of the time (Mihaljek, 2004).

3. **While there is an extensive literature on foreign exchange intervention for advanced economies, much less is known about its effectiveness as an independent policy tool in emerging markets.** A major hurdle for doing research in emerging market economies has been the lack of official, high frequency data on central bank intervention operations (because of valuation changes, this cannot be inferred simply from changes in reserves). Moreover, it is often not possible to know, a priori, whether the authorities accumulate reserves with the intent of affecting the exchange rate, or for other reasons, such as self-insurance against external financial shocks.

4. **In this paper, we assess the impact of sterilized intervention operations on the level and volatility of the nominal exchange rate in Colombia from December 2004 to April 2007.** During most of this period, the central bank engaged in frequent—and at times

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[30] Prepared by Herman Kamil.

[31] It is also possible that central banks in emerging market countries have a better grasp of aggregate market conditions than domestic market participants, especially in those cases where local markets are not very sophisticated and remain highly segmented (see Canales-Kriljenko, 2003).

sizable—discretionary purchases of foreign exchange, with the intended effect of depreciating the domestic currency. The paper focuses on two central questions: (i) How effective was central bank intervention in stemming domestic currency appreciation in Colombia? (ii) What constraints—if any—did the inflation targeting regime pose on the central bank's ability to influence the currency?

5. **To answer these questions, we use a new dataset with official statistics on daily foreign exchange intervention by the Central Bank of Colombia (Banco de la República, BdR).**[32] During the period under study, all official discretionary intervention operations were conducted in the spot market, and were automatically sterilized to achieve the operating target of monetary policy, the short-term interest rate. These intervention operations were not publicly announced.[33] A key advantage of the intervention data used in this study is its accuracy: it includes discretionary purchases of dollars by the BdR that were made with the explicit intention to depreciate the value of the domestic currency vis-à-vis the dollar. As such, it excludes changes in reserves for reasons other than—but not related to—influencing the exchange rate.[34] This allows a clean identification of the impact of central bank intervention on the exchange rate.

6. **Besides the availability of a unique dataset, Colombia offers an ideal case to study the effects of central bank intervention in foreign exchange rate markets for at least three reasons.** First, Colombia has faced strong exchange rate appreciation pressures. Between December 2006 and May 2007, for example, Colombia ranked as the country with the *highest* nominal domestic currency appreciation in the world—both vis-à-vis the U.S. dollar and in nominal effective terms.[35] Second, and as shown in Figure 1 below, the period under study is punctuated by frequent, and at times large, discretionary purchases of foreign exchange to resist foreign currency appreciation. During the periods of discretionary intervention, BdR activity took place on almost 80 percent of business days and the scale of official intervention was significant relative to the daily turnover in the market, reaching 50 percent in some days. Through discretionary intervention operations, the BdR accumulated approximately 11 billion dollars, almost doubling the amount outstanding in

[32] Data were kindly provided by the Banco de la República. Historical data on official intervention is not available to the public at a daily frequency, and the BdR only publishes the aggregate monthly amount of its net purchases of dollars, ten days after the end of each month. For that reason, the use of the daily data in this paper is subject to confidentiality agreements. Table A1 in the Appendix provides descriptive information about the central bank's intervention operations examined in Section E.

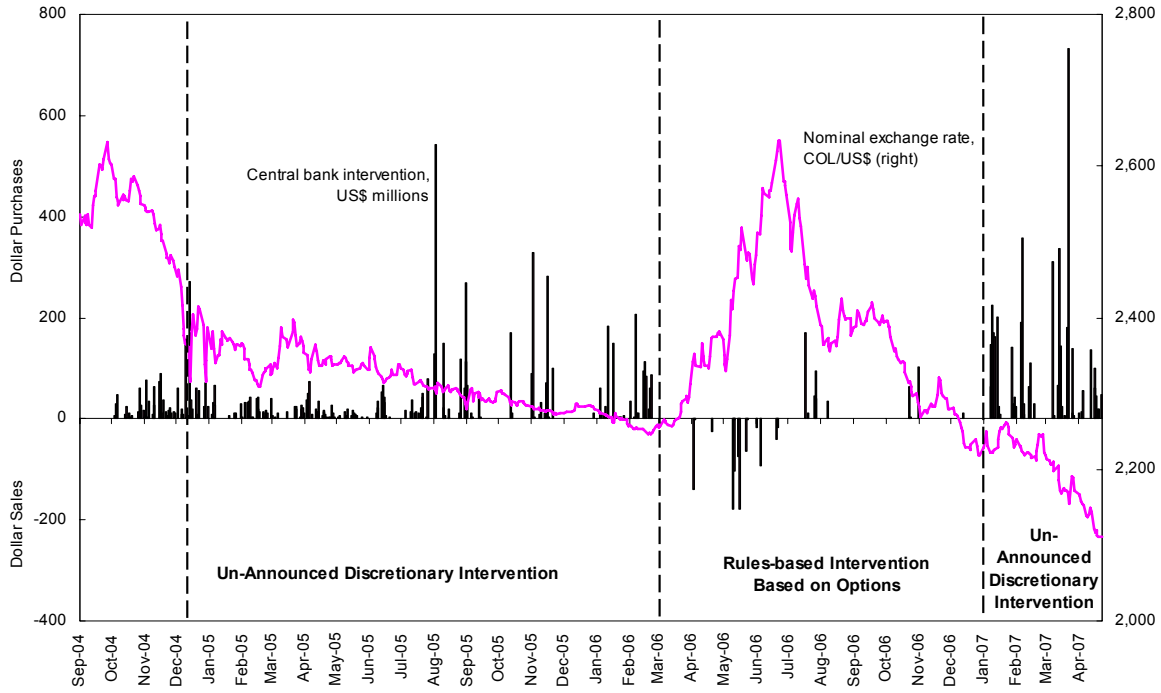
[33] Nor did the Central Bank officially confirm or deny reports in the financial press or wire services regarding its presence in the FX market.

[34] These include valuation effects, capitalization of interest gains, portfolio adjustment operations, or other foreign exchange transactions not aimed at influencing the exchange (such as the trading of foreign exchange to meet the needs of the central government).

[35] Apart from a weak U.S. dollar, much of the peso's strength is driven by economic fundamentals, such as the improvement in the security situation and strong inflows of foreign direct investment.

December 2004. As a share of short-term debt, reserves rose from 92 percent to 172 percent between December 2004 and April 2007.

Figure 1. Central Bank Intervention Operations and Movements in the Nominal Exchange Rate



Source: Banco de la República.

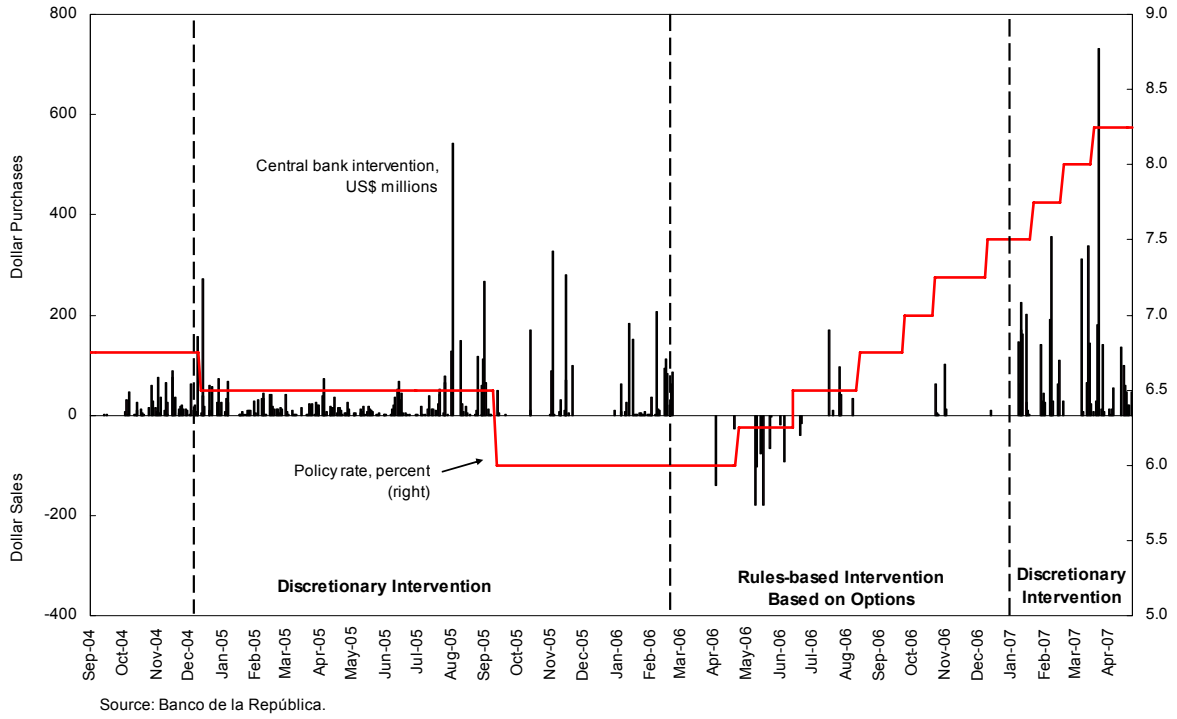
7. **Finally, Colombia is also an interesting case study because the two periods of discretionary intervention considered here are associated with two very different stances for monetary policy (Figure 2).**[36] The first period, spanning from December 2004 to March 2006, was characterized by constant or falling interest rates and a loosening of monetary policy. The second discretionary intervention episode, from January to April 2007, was characterized by a tightening of monetary policy and an increase in nominal interest rates to reduce inflationary pressures.[37] This provides an ideal setting to analyze the interplay between monetary policy and exchange rate policy decisions under inflation-targeting regimes. In particular, it provides an opportunity to test the hypothesis that discretionary

[36] The BdR adopted an Inflation Targeting (IT) scheme with a floating exchange rate in October 1999, after abandoning the crawling exchange rate band system in place since 1994. The IT strategy used the short-term repo interest rate as the main instrument of monetary policy. See Vargas (2005) for a detailed account of monetary policy since 1999.

[37] From March 2006 until mid-January 2007, the government stopped discretionary purchases and only intervened in the foreign exchange (FX) market though FX options to smooth exchange rate volatility. The timing and amounts of these interventions were largely predetermined and known by market participants. A detailed description of the operational aspects, as well as an assessment on the efficacy of the options system, can be found in Uribe and Toro (2004).

intervention to stem domestic currency appreciation is more effective when there is consistency between monetary and exchange rate policy goals.

Figure 2. Central Bank Intervention and Movements in the Reference Rate



Source: Banco de la República.

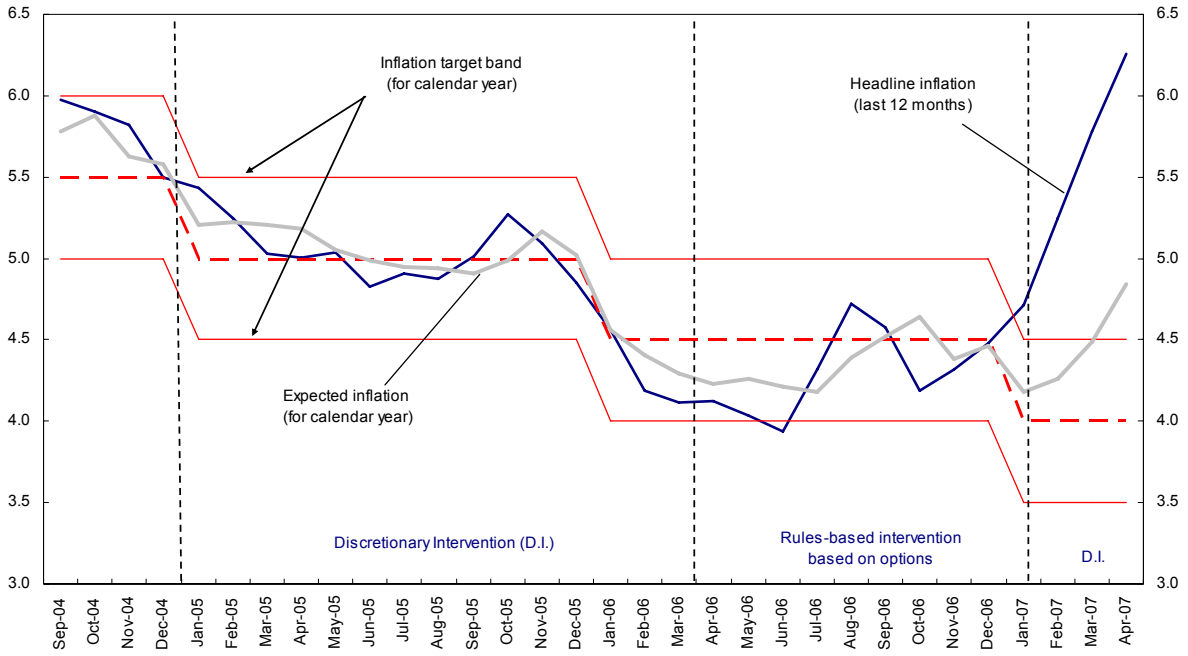
8. **The paper's results suggest that the effects of BdR intervention varied sharply across the two periods.** During the first period of unannounced, discretionary intervention (December 2004–March 2006), BdR foreign currency purchases had a statistically significant, positive impact on the exchange rate level. i.e., higher intervention led to a more depreciated exchange rate. However, while discretionary intervention contributed toward moderating the appreciation trend, its effect was economically small and short-lived. As such, substantial amounts of sterilized intervention were required to have a quantitatively important impact on the nominal exchange rate.

9. **During the second period (January–April 2007), however, BdR intervention did not influence the level of the exchange rate, even in the short term.** In practice, intervention operations aimed at depreciating the currency were dwarfed by offsetting movements in the EMBI spread and the market's reaction to higher than expected GDP and inflation announcements. Thus, during this period, sterilized intervention did not provide an independent channel for monetary policy, and may have also contributed to an increase in market uncertainty.

10. **The results suggest that coherence between the intervention policy and inflation objectives was a critical factor in determining the success of discretionary intervention.**

During the first period, there was no contradiction between monetary and exchange rate policies. Purchases of international reserves were made in the context of a negative output gap and an expansionary monetary policy (that is, decreasing policy rates). For this reason, inflation expectations were not adversely affected by the intervention in the FX market, and the BdR achieved the inflation targets with remarkable precision (Figure 3). In this way, FX intervention and monetary policy maintained target consistency, which helped to increase both the effectiveness of intervention and the credibility of inflation targets (Figure 4).[38]

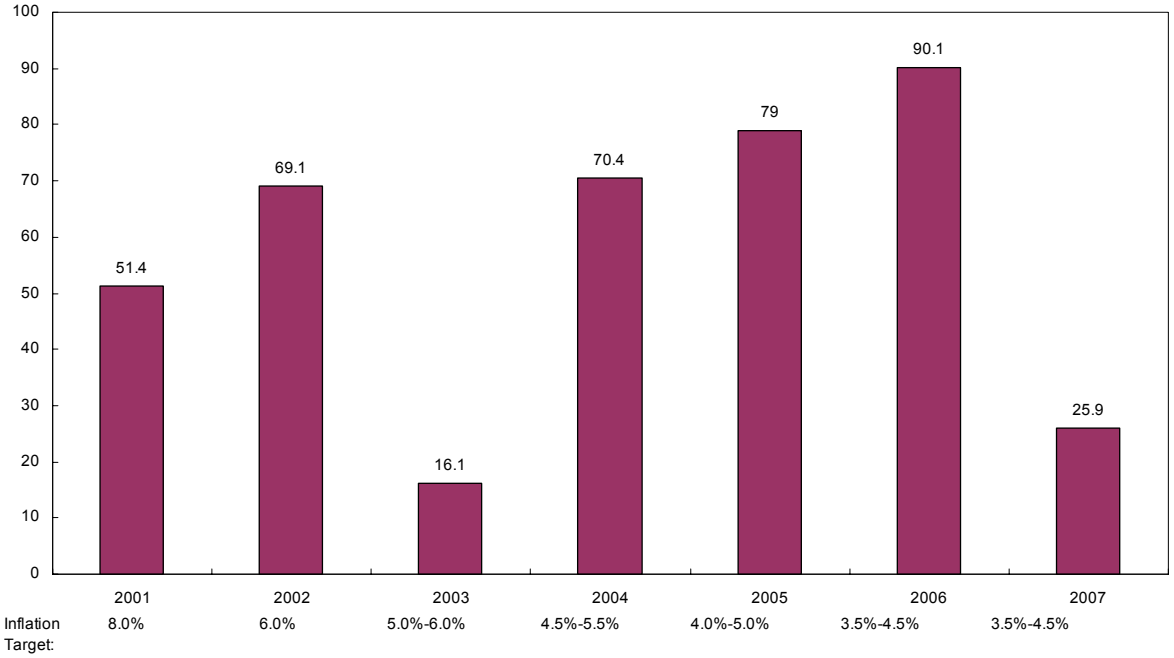
Figure 3. Evolution of Inflation and Inflation Expectations vis-à-vis the Inflation Target



Sources: Banco de la República; and author's calculations.

[38] Toro and Julio (2006) provide additional support for this conclusion.

Figure 4. Credibility of the Inflation Target
(Survey done on April of each year)



Source: Banco de la República.

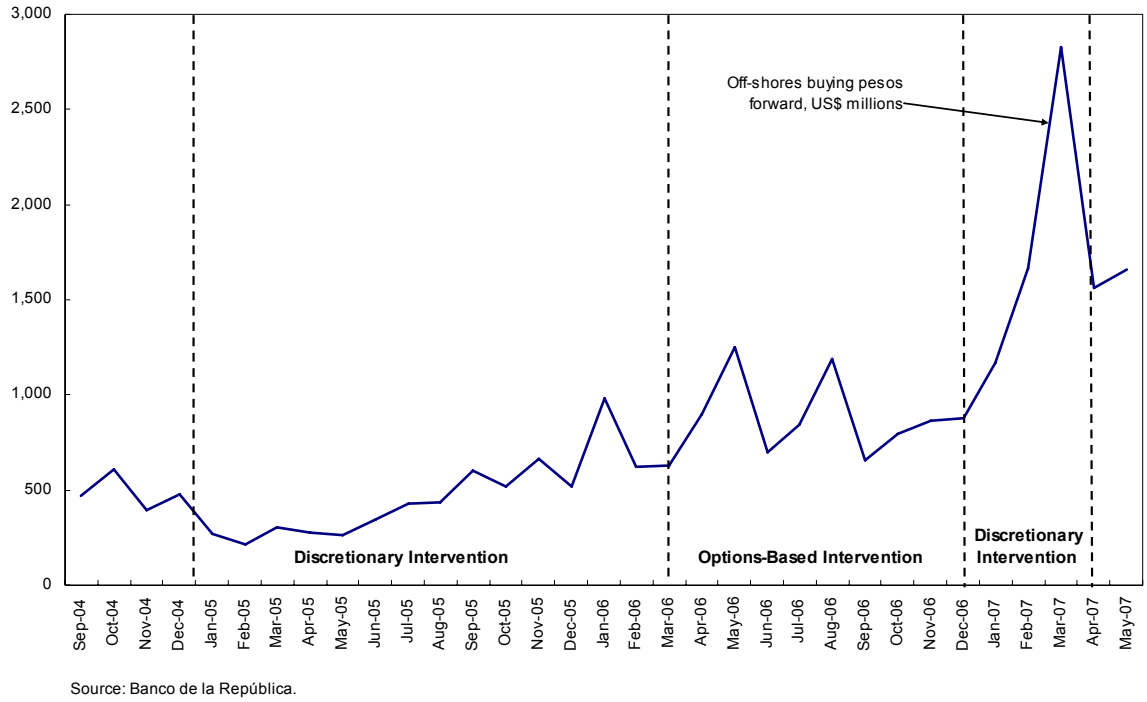
11. **During the second period, however, there was tension between monetary and exchange rate policy goals**. To stem the appreciation of the peso, the BdR intervened aggressively, accumulating US$4.5 billion (38 percent of monetary base) in the first four months of 2007. At the same time, to cope with an overheating economy and inflation pressures, it steadily increased its policy interest rate. But this had the consequence of attracting more capital inflows, thereby exacerbating appreciation pressures. Markets thus perceived that the policy of large-scale foreign currency purchases was unsustainable and inconsistent with meeting the BdR's inflation target, which may have contributed to inflation expectations being above the inflation target ceiling (see Figure 3).[39] Foreign investors, realizing that the central bank would eventually focus on taming inflation (and eventually let the exchange rate appreciate), took unprecedented amounts of short dollar positions at short maturities in the on-shore forward market (see Figure 5).

12. **The rapid increase in inflation in early 2007—caused in part by supply shocks—may have made it difficult to detect this incompatibility between these goals.** Inflation in Colombia was rising in early 2007, also due to shocks to food prices. When inflation is rising, it may not always be clear that the cause is excess demand or a temporary supply shock. If it is a supply shock, then intervention may not be perceived as incompatible with

[39] Other factors include the steep rise in food prices and cross-border demand from Venezuela.

achieving the inflation target. Economic agents, however, appeared to have believed that excess demand pressures were present, given the increase in inflationary expectations. In any event, after inflation and exchange rate data clearly confirmed the incompatibility of such discretionary intervention, the authorities ceased intervening in early May 2007.[40]

Figure 5. Traded Value in Currency Derivatives Between Local Colombian Banks and Off-Shore Entities



Source: Banco de la República.

13. **These results have important implications for policy design.** The Colombian case suggests that successful intervention may be particularly difficult for an inflation targeter, as the commitment to an inflation target limits the scope for allowing lower interest rates, and low upward exchange rate flexibility provides incentives for carry trade and leveraged bets on the currency through derivatives markets. Thus, while a government committed to reducing the value of the currency in theory has a large supply of "ammunition" (i.e., printing money to buy reserves), the inflation objective can in practice become a binding constraint that limits its ability to do so.[41]

[40] Subsequent analysis by the central bank has also noted the incompatibility of discretionary intervention at this stage of the cycle (BdR, 2007). Since May, the central bank's involvement in the FX market has been limited to controlling exchange rate volatility through the options mechanism.

[41] In contrast to a defense of the value of the domestic currency, where the stock of available reserves constrains the cumulative amount of intervention.

14. **The rest of the paper is organized as follows.** Section B provides a literature review, while Section C delineates the empirical strategy. Section D explores the motivations for the central bank to intervene in the foreign exchange market and presents the main results. Section E discusses the limits to sterilization and the role of derivatives markets in blunting intervention operations. Section F concludes.

B. Literature Review

15. **There is a large literature exploring the efficacy of sterilized intervention policy in developed economies.**[42] Overall, the evidence suggests that sterilized interventions by industrial countries have, at times, effectively influenced currency values.[43] However, these effects are typically statistically significant but economically small. The literature for advanced economies concludes that intervention systematically moves the spot exchange rate only if it is publicly announced, coordinated across countries, and consistent with the underlying stance of fiscal and monetary policy. A number of papers have additionally examined the influence of intervention operations on daily exchange rate volatility and generally find evidence that intervention increases volatility. That is, for the major currencies, evidence that sterilized intervention *dampens* volatility is weak.[44]

16. **The literature on the effectiveness of intervention in emerging markets is still sparse, in large part because governments have been reluctant to provide official data on their operations.** Few empirical papers analyze central bank intervention at daily frequencies in developing countries, and existing studies generally find mixed results on its effectiveness.[45] Domac and Mendoza (2002) conclude, in the context of Mexico and Turkey in the period 2001–02, that central bank foreign exchange sales (but not purchases) were generally effective in influencing the exchange rate in both countries. Disyatat and Galati (2007) also find weak evidence that intervention is effective in the Czech Republic. In contrast, Tapia and Tokman (2004) found that actual intervention appeared to have a generally insignificant effect on contemporaneous exchange rate movements.[46] Guimarães and Karacadag (2004) find that in Mexico, foreign exchange sales had a small impact on the

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[42] Edison (1993) surveys the literature from the 1980s through early 1990s; Sarno and Taylor (2001) provide a more recent survey of theory and empirical evidence.

[43] Domínguez and Frankel (1993a) and Domínguez (2003a) provide empirical evidence in this regard. For Japan, Ito (2002) found that large and infrequent intervention had quantitatively small but statistically significant effects on the dollar-yen nominal exchange rate.

[44] Domínguez (2006) and Edison, Cashin, and Liang (2006) have found that intervention increases exchange rate volatility, in contrast with claims by central banks that intervention does not increase (or is not associated with an increase in) volatility (Neely, 2007).

[45] Disyatat and Galati (2007) provide a comprehensive review of the existing literature on the effectiveness of intervention in emerging market countries.

[46] However, public announcements of potential interventions had significant effects on the level and trend of the exchange rate in Chile.

exchange rate level, but not in Turkey.[47] With respect to the impact of intervention on exchange rate volatility, Domac and Mendoza (2002) find that intervention reduced exchange rate volatility in both countries. In contrast, Guimarães and Karacadag (2004) find that intervention tends to increase exchange rate volatility.[48]

17. **Recent cross-country empirical evidence, using monthly changes in gross reserves as a proxy for intervention operations, suggests intervention is unlikely to be effective in dealing with capital flows.** Using a sample of emerging markets and small advanced countries, IMF (2007a) finds that resisting nominal exchange rate appreciation through sterilized intervention is likely to be ineffective when capital flows are persistent. Looking at the experience of five managed-floating countries—India, Indonesia, Korea, the Philippines, and Thailand—over the period 2000–07, IMF (2007b) finds limited evidence of systematic links between exchange rates and intervention. The authors also find mild evidence that intervention may be associated with lower exchange rate volatility.

C. Empirical Strategy

18. **Assessing the effectiveness of intervention is complicated by two empirical challenges.** First, it is not possible to directly observe the counterfactual—i.e., what would have been the exchange rate movement if intervention *had not* occurred, in days when the authorities did in fact intervene.[49] Second, disentangling the causal effect of intervention is further complicated by the fact that the decision (and amount) of intervention may be endogenous to past exchange rate movements. That is, the central bank is more likely to buy foreign currency when the domestic currency is strengthening. Failing to account for the simultaneity of exchange rate and intervention is likely to bias towards finding no impact of intervention on the exchange rate.

19. **To overcome this identification problem, we use a two-stage instrumental variable model based on estimates of BdR's reaction function.[50]** For each period of discretionary intervention, we estimate a foreign exchange intervention function for the amount of intervention. We then use the predicted values from the first stage as an instrument

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[47] Given policy objectives, however, such findings do not necessarily indicate the failure of intervention. For example, the bulk of intervention undertaken in Mexico during the sample period was aimed at accumulating reserves, rather than influencing the exchange rate.

[48] Mandeng (2003) and Ramirez (2004) analyze the experience of options-based foreign exchange intervention in Colombia. The authors find that these have only been moderately successful in reducing exchange rate volatility.

[49] In other words, simultaneous observation of foreign exchange purchases and domestic currency appreciation cannot be interpreted as evidence that intervention was ineffective. For instance, in the absence of intervention, the exchange rate might have followed a more appreciated path.

[50] The same methodology is used in Guimarães and Karacadag (2004) and Disyatat and Galati (2007).

for actual interventions, in a reduced-form model of exchange rate returns allowing for GARCH effects in the conditional variance.

20. **In the first-stage, we describe the foreign exchange intervention policy as a dynamic censored regression (Tobit) model of the following form[51]:**

$$INT_t = \max\left(0\,,\, \gamma_0 + \gamma_1 INT_{t-1} + \gamma_2\left(\ln s_{t-1} - \ln s_{t-1}^T\right) + \gamma_3\left(\sigma_{t-1} - \sigma\right)\right) + \varepsilon_t \qquad (1)$$

where *INT* denotes the amount of dollar purchases and s_t is the nominal exchange rate (expressed in terms of local currency per U.S. dollar, such that a positive change is a depreciation of the Colombian peso). Our model links the amount of intervention to the deviation of the current exchange rate and conditional volatility from their respective target values. s^T is the (time-dependent) 'target' nominal exchange rate, to be defined below. σ is the average conditional variance, i.e., the unconditional variance, so that the regressor $\left(\sigma_t - \sigma\right)$ reflects the deviation of current conditional volatility from average volatility. In addition, and because interventions usually come in clusters, we include the lagged dependent variable as a regressor to account for persistence effects.

21. **We model the target exchange rate as the weighted average of two past representative exchange rates.** These comprise the exchange rate level in the previous day and its backward looking moving average. Thus, deviations from the target (in percentage terms) are given by:

$$\left(\ln s_t - \ln s_t^T\right) = \gamma_{21}\left(\ln s_t - \ln s_{t-1}\right) + \gamma_{22}\left(\ln s_t - \sum_{j=1}^{22}\frac{s_{t-j}}{22}\right) \qquad (2)$$

22. **We thus allow interventions to be motivated by two components: a very short-term one (daily fluctuations in the exchange rate), and a moving average component.** The latter can be thought of as representing past levels of the exchange rate.[52] This enables us to test whether the central bank systematically "leaned against the wind" and tried to smooth deviations from the past-month moving average.[53]

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[51] Edison (1993) and Almekinders (1995) survey empirical work on the determinants of intervention.

[52] This is not to say that the latter is considered to be at a desirable level in the previous month.

[53] This target has been commonly modeled as a moving average of the exchange rate in the past, where the order of the moving average representation varies across studies. In the case of Colombia, we set it to a 22-day backward moving average, which is close to the trigger used in operations with options under the rules based intervention for reducing volatility. Under this rule, the Central Bank auctions options to sell (buy) foreign exchange for up to 180 million when the peso depreciates (appreciates) by more than 2 percent from its 20-day moving average.

23. **In the second stage, we estimate a GARCH (1,1) model of the peso-dollar exchange rate return that is estimated with the following general specification.**[54]

$$\Delta(\ln s_t) = \mu + \gamma_1 \Delta(\ln s_{t-1}) + \beta_1 \overline{INT}_t + \beta_2 \left(i - r^*\right)_t + \beta_3 \Delta\left(EMBI\ spread\right)_t + \sum_{i=1}^{3} \delta_i UNEXP_{it} + \sum_{i=1}^{4} \lambda_i D_{it} + \delta_5\ PostH_t + \varepsilon_t \quad (3)$$

$$\varepsilon_t \left| \Omega_{t-1} \sim \mathrm{N}\left(0, \sigma_t^2\right) \right. \quad (4)$$

$$\sigma_t^2 = \alpha_0 + \alpha_1 \sigma_{t-1}^2 + \alpha_2 \varepsilon_{t-1}^2 + \alpha_3\ INT_t + \alpha_4 \left(i - r^*\right)_t + \alpha_5 \Delta\left(EMBI\ spread\right)_t + \sum_{i=1}^{3} \delta_i \left|UNEXP_{it}\right| + \sum_{i=1}^{4} \delta_i D_{it} + \delta_5\ PostH_t + \varepsilon_t \quad (5)$$

where: $\Delta(\ln s)$ is the daily percentage change in the nominal exchange rate; $\overline{INT}$ is the indicator of central bank intervention in the FX market, as explained above; $\left(i - r^*\right)$ is the interest rate differential between the domestic interbank rate and the US Fed's fund rate, in percent per year; $EMBI\ spread$ is the yield spread on a sovereign foreign currency bond over a comparable U.S. treasury bond in percent per year;[55] $UNEXP_i$ captures the impact of the unexpected component of public releases of macroeconomic information (i= real GDP growth, policy rate and inflation),[56] D_{it} are day of the week dummy variables (for example, $D_{1t} = 1$ for Mondays, where Friday is the omitted category); $PostH_t$ is a holiday dummy variable that is equal to one on the day following the market being closed for any reason other than a weekend; and ε_t is the unexpected return which is used to model the conditional volatility of the exchange rate in the volatility equation (3). Finally, σ_t^2 is the conditional

[54] Table A2 in the Appendix reports various descriptive statistics on the unconditional distribution of exchange rate returns. All the series appear to have non-normal distributions, with significant linear and non-linear serial correlations, especially during the first period. We thus follow Baillie and Bollerslev (1989) and Domínguez (1998) and use a univariate generalized autoregressive conditional heteroskedasticity (GARCH) model for our analysis.

[55] This is measured in first differences to achieve stationarity.

[56] To help distinguish the effect of intervention from the arrival of other relevant information, we constructed a new dataset for Colombia on news about macroeconomic variables announcements and policy decisions (as discussed below).

variance and allows for the possibility of time-varying conditional volatility and clustering. The conditional distribution of the disturbance term is normal with variance σ^2.

24. **Several features of the specification are worth noting.** Equation (3) of the empirical model (the "mean" equation) analyzes changes in the exchange rate return (depreciation or appreciation against the dollar) as a function of intervention, controlling for other factors affecting exchange rates at a daily frequency. Our **main** focus is on the estimate of β_1, the contemporaneous impact of intervention on the exchange rate. If central bank intervention is effective, then purchases of the domestic currency $(INT > 0)$ will depreciate the currency $(\Delta(\ln s) > 0)$ and so β_1, the parameter of interest, will be positive.

25. **We control for other factors affecting exchange rates at a daily frequency.** The interest differential aims to capture the possible impact of monetary policy actions and local money market conditions on the exchange rate. This is especially important during the first period, when the central bank was easing monetary policy.[57] Yield spreads on sovereign external debt over a comparable U.S. treasury bond are included as a measure of country risk and foreign investor sentiment, which are possibly key determinants of demand for local currency.

26. **Control variables used in the estimation also include those that capture the effect of news about macroeconomic or policy developments that may arrive on the same day on which intervention is carried out.**[58] When government agencies announce data measurements or policy decisions—GDP growth, inflation, benchmark interest rates, etc.—economic agents learn about the current value of fundamentals, and also revise their expectations of future fundamentals. "News" is the information contained in the announcement—the difference between the announced level of the economic variable and the market's expectation.[59]

D. Summary of Results

Central bank reaction function

27. **Results for the first period of intervention are consistent with the hypothesis that the BdR attempted to "lean against the wind," i.e., slow or reverse the trend of**

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[57] The distinction between un-sterilized and sterilized intervention is important: changes in the monetary stance would naturally affect the exchange rate, so it would not be surprising to find that un-sterilized intervention is effective.

[58] Of the 43 different macro announcement dates that we have in the sample (with associated survey expectations), 58 percent of them coincided with central bank intervention.

[59] Market expectation is measured as the median forecast of that value culled from opinion surveys conducted during the days preceding the announcements by Bloomberg News.

appreciation (see Table 1).[60] The negative coefficient conforms to our priors, and unofficial central bank statements, that an important motivation for the interventions during the first period was a desire to correct the deviation of the exchange rate from the (moving) target value. The point estimate implies that in response to a 1 percent deviation of the exchange rate with respect to target, the central bank is inclined to lean against the wind, purchasing on average US$17.2 million U.S. dollars to slow the appreciation.

Table 1. Determinants of Central Bank's Daily Discretionary Intervention in FX Spot Market
(Marginal Effect Estimates from Tobit Model)

	First Period September 2004-March 2006	Second Period November 2006-April 2007
γ_1 (Lagged Dependent Variable)	0.13	0.78 ***
	(0.12)	(0.19)
Exchange Rate Acceleration		
γ_2 (Exchange Rate change, in precentage) (t-1)	-13.10 **	-109.67 **
	(5.97)	(53.70)
Deviation of Exchange Rate Level		
γ_3 (Percentage Deviation from *Target*) (t-1)	-17.73 ***	-13.94
	(4.42)	(25.31)
Deviation of Conditional Volatility		
γ_4 (Deviation from Long Term Variance) (t-1)	-48.36 *	174.42
	(28.11)	(376.93)
Diagnostics		
McKelvey and Zavoina's R2:	0.11	0.14
Prob > LR	0.00	0.03
Included observations	295	72
Censored Observations (in percent)	15.2	39.7

Source: Author's calculations.

Note: This table reports estimation of a Tobit model for equation (1) in the text. The dependent variable is the amount of dollars purchased (in millions) to influence the value of the currency. Estimated coefficients are the marginal effects of a unit change in the explanatory variables, evaluated at sample means. Asterisks denote significance of coefficients, with ***, ** and * indicating significance at the 1%, 5% and 10% level, respectively.

28. **We also find during this period that the central bank did not intervene in response to a rise in market uncertainty.** If anything, there is strong evidence that intervention during the first period was associated with a dampening of volatility. This pattern is consistent with the idea that the authorities engage in intervention to guide the

[60] Since the motivation for BdR intervention was not announced, the policy criterion 'leaning against the wind' is only indicative of actual policy intentions.

exchange rate towards a target value (leaning against the wind), but not to lower market volatility (calming disorderly markets).[61]

29. **The results suggest that during the second period, however, the Colombian authorities appeared to intervene solely in response to an acceleration of the speed of peso appreciation.** The coefficient for the reaction on the short-term change in the spot exchange rate has the right sign and is statistically significant, suggesting that in 2007, the BdR reacts systematically to previous day exchange rate changes in deciding to intervene. The estimate of γ_{21} implies a large response by the BdR to changes in the exchange rate: a 1 percent appreciation would result in a 110 million dollar purchase the following day. In the second period, however, we find no evidence of a systematic link between intervention and excess volatility.

30. **During the second period, foreign exchange interventions became highly correlated over time**. The results suggest that once intervention was carried out one day, another intervention of similar magnitude was likely to take place in the following day.[62] In fact, our results indicate that intervention on a given day is an excellent predictor of intervention the following day. This provides important insights into why intervention was ineffective in that period: as it became more predictable, it may have reduced the ability to surprise the market. In effect, market participants may have been better able to anticipate the central bank's operations, especially considering the high frequency of intervention and that all interventions were carried out in the same direction.[63]

Effects on exchange rates

31. **The estimates in Table 2 suggest that intervention during the first discretionary period had a moderately sizable effect on the exchange rate, in the direction intended by the authorities.**[64] [65] The coefficient for the spot rate on current intervention is statistically significant. The coefficient for contemporaneous intervention, 1.067, implies that

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[61] This is consistent with the notion that the central bank uses other mechanical rules of intervention—based on options—to smooth exchange rate volatility.

[62] Dynamic considerations did not play an important role in determining the intervention strategy used by the BdR in the first period.

[63] The model seems to capture only a small fraction of the variance of the intervention variable, as suggested by the R-square statistic. This may suggest that other variables not captured in the model—like political factors—were also important. See Vargas (2005) for a discussion on the political economy issues related to intervention.

[64] These results are consistent with Toro and Julio (2006), who use ultra-high frequency data to analyze the impact of intervention on exchange rate dynamics between 2004 and 2006.

[65] Maximum likelihood estimation was carried out using the Berndt-Hall-Hall-Hausmann algorithm using *Eviews* 5.1 package. In all cases, the skewness and kurtosis of the standardized regression residuals indicate that the assumption of conditional normality in equation (2) does not hold. Therefore, robust standard errors using the method described in Bollerslev and Wooldridge (1992) were reported.

$100 million of purchases of U.S. dollars is associated (on average) with a 1.07 percent depreciation of the peso vis-à-vis the dollar. The response for Colombia is larger than most results in the literature, but closer to the calibrated impact of a 1.6 percent appreciation from a US$100 million of purchase of U.S. dollars in Domínguez and Frankel (1993a).

Table 2. GARCH Model for Daily Nominal Exchange Rate Returns: Instrumental Variable Estimation
(Mean Returns Equation)

	First Period December 2004-March 2006	Second Period January 2007-April 2007
(Lagged Dependent Variable)	0.210 ***	0.146
	(0.07)	(0.10)
Intervention Indicator		
(Predicted Amount of Dollar Purchases, in millions US$) (t)	1.067 ***	0.054
	(0.29)	(0.08)
β_2 (Overnight Interest Differential)	-0.003	-0.039
	(0.01)	(0.03)
β_3 (Change in EMBI Sovereign Spread)	1.261 ***	2.133 ***
	(0.20)	(0.56)
Unexpected Component of Macro Announcements (Actual minus Market Expectation)		
δ_1 (GDP)	0.578 **	-0.330 ***
	(0.27)	(0.06)
δ_3 (Policy Rate)	0.328	-0.003
	(1.12)	(0.45)
δ_4 (Inflation)	0.398 **	-0.373 ***
	(0.16)	(0.09)
Fixed Effects for Days-of-the Week and Post-Holiday Trading Days	Yes	Yes
Diagnostics		
Log *L*	-61.068	-35.447
R-Squared	0.299	0.118
Included observations	295	72

Source: Author's calculations.

Note: This table reports estimation of the Mean Equation of the GARCH(1,1) model in equation (3)-(5) in the text. The dependent variable is the daily rate of change of the nominal exchange rate, in percent. Asterisks denote significance of coefficients, with ***, ** and * indicating significance at the 1%, 5% and 10% level, respectively.

32. **Most of the effects of an intervention on the exchange rate in the first period occurred during the day in which it was conducted, with a smaller impact on subsequent days.** In Table 3, we disaggregate the overall effect of intervention on exchange rates into specific effects on the first and subsequent days. The first day of official intervention is the most effective in moving the exchange rate, while the effects in successive days were more limited. Intervention operations did not have a lasting impact on exchange rate dynamics: almost 70 percent of the contemporaneous effect is reversed in two days.

Table 3. GARCH Model for Daily Nominal Exchange Rate Returns: First and Subsequent Days Estimates

(Mean Returns Equation)

	First Period December 2004-March 2006	Second Period January 2007-April 2007
Exchange Rate Level (mean) Equation		
(Lagged Dependent Variable)	0.260 ***	0.164 *
	(0.08)	(0.09)
Contemporaneous Effect		
β_1 (Central Bank Intervention) (t)	0.839 **	0.078
	(0.38)	(0.10)
Persistence Effects		
β_1 (Central Bank Intervention) (t-1)	0.226	-0.026
	(0.25)	(0.05)
β_2 (Central Bank Intervention) (t-2)	-0.558 ***	0.046
	(0.16)	(0.04)
β_3 (Central Bank Intervention) (t-3)	0.077	0.005
	(0.13)	(0.05)
β_4 (Central Bank Intervention) (t-4)	0.089	-0.096
	(0.18)	(0.04) **
Conditional Variance Equation		
α_0 (GARCH Term)	0.535 ***	0.561 ***
	(0.10)	(0.17)
α_1 (Squared Innovation)	0.212 ***	0.080
	(0.08)	(0.08)
Contemporaneous Intervention		
α_1 (Amount of Purchases) (t)	-0.006	0.007
	(0.01)	(0.09)
Persistence Effects		
α_2 (Central Bank Intervention) (t-1)	-0.003	-0.002
	(0.02)	(0.08)
α_3 (Central Bank Intervention) (t-2)	-0.012	-0.012
	(0.02)	(0.02)
α_4 (Central Bank Intervention) (t-3)	-0.008	-0.011
	(0.01)	(0.02)
α_5 (Central Bank Intervention) (t-4)	-0.017 ***	-0.007
	(0.00)	(0.01)
Diagnostics		
Log L	-72.176	-30.704
R-Squared	0.229	0.141
Included observations	295	76
Diagnostics		
Log *L*	-61.068	-35.447
R-Squared	0.299	0.118
Included observations	295	72

Source: Author's calculations.

Note: This table reports estimation of the Mean Equation and Conditional Variance Equation of the GARCH(1,1) model in equation (3)-(5) in the text, augmented with four lags of central bank purchases of dollars as regressors. Asterisks denote significance of coefficients, with ***, ** and * indicating significance at the 1%, 5% and 10% level, respectively.

33. **The results also suggest that sterilized intervention operations were ineffective in influencing exchange rates during the second period.** Results in Tables 2 and 3 indicate that intervention operations aimed at depreciating the currency had no statistically significant effect on the level of the exchange rate, at any horizon.

34. **Exchange rates appear to be responsive to announcements of economic news.** Two results stand out. First, news on GDP and inflation announcements had a significant impact on exchange rate dynamics, suggesting that fundamentals also drive the exchange rate at higher frequencies.[66] Second, the effect of these announcements was exactly the opposite across periods (Table 2). During the first period, higher-than-expected inflation or GDP growth were on average associated with a depreciation of the peso. For the second period, however, the sign on the inflation and GDP surprise variables is negative and statistically significant, indicating that higher-than-expected inflation results in an immediate currency appreciation (a reduction in the nominal exchange rate). The point estimates are not small: for example, if GDP comes out 1 percentage point above expectations (year-on-year growth) during the second period, the estimated effect was to appreciate the peso by 0.33 percent daily.[67]

35. **The differing reaction of markets to macroeconomic news releases provides new insights into the effectiveness of intervention.** The fact that the peso consistently and significantly appreciated in response to unexpectedly high GDP growth and inflation, suggests that the markets apparently believed that—consistent with the predictions of the Taylor rule model—the central bank was likely to react to the announcements by increasing interest rates. That is, the announcement of a higher output gap induced traders to revise their expectations of future interest rates upwards. The prospect of an increase in domestic interest rates, in turn, made Colombian assets more attractive, inducing an immediate dollar depreciation (peso appreciation) to equilibrate the asset market. This provides insights into the reasons why intervention was ultimately not effective: markets expected that monetary policy would remain committed to the goal of reducing inflation, even if that meant increasing interest rates and thus undoing intervention efforts.

36. **Also of interest is how central bank intervention affects exchange rate volatility.** Volatility often reflects, among other things, uncertainty in economic policies and other fundamental determinants of exchange rates, which the market may be struggling to price accurately. As indicated by Domínguez (1998), central bank intervention is expected to reduce volatility as long as intervention is both credible and unambiguous. The results of

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[66] The systematic relationship between the surprise component of macroeconomic releases and one-day exchange rate changes is noteworthy, given that the literature has pointed out that this connection is weak and hard to detect (Edison, 1997).

[67] The coefficient estimates in Table 2 can be interpreted as the effect of one percent surprise in the macroeconomic release on the exchange rate value of the dollar, in basis points.

Table 4 are consistent with this hypothesis. During the first period, BdR intervention had a powerful stabilizing effect on the exchange rate. Controlling for other factors affecting short-term exchange rate volatility, the results indicate that during the first period, BdR intervention dampened the volatility of exchange rate returns. This empirical finding is noteworthy, given that it is at odds with most of the intervention literature for developed economies. In contrast, during the second period, persistent, large-scale intervention led to increases in exchange rate volatility (especially in March and April of 2007), which suggests that official intervention may have added to market uncertainty during this period.

Table 4. GARCH Model for Daily Nominal Exchange Rate Returns: Instrumental Variable Estimation
(Conditional Variance Equation)

	First Period December 2004-March 2006	Second Period January 2007-April 2007
α_0 (GARCH Term)	0.546	0.549
	(0.12) ***	(0.19) ***
α_1 (Squared Innovation)	0.223	0.082
	(0.09) **	(0.10)
Intervention Indicator		
β_1 (Amount of dollar purchases, in millions US$) (t)	-0.031	0.004
	(0.00) ***	(0.03)
Controls		
α_3 (Overnight Interest Differential)	-0.003	-0.005
	(0.00)	(0.01)
α_4 (Change in EMBI Sovereign Spread)	0.182	-0.004
	(0.08) **	(0.22)
Unexpected Component of Macro Announcements		
(Actual minus Market Expectation)		
δ_1 (GDP)	-0.094	-0.056
	(0.05) *	(0.03) *
δ_3 (Policy Rate)	0.791	-0.267
	(0.73)	(0.19)
δ_4 (Inflation)	-0.135	-0.130
	(0.08) *	(0.05) ***

Source: Author's calculations.

Note: This table reports estimation of the Conditional Variance Equation of the GARCH(1,1) model in equation (3)-(5) in the text. The dependent variable is the conditional volatility of the rate of change of the nominal exchange rate, in percent. Asterisks denote significance of coefficients, with ***, ** and * indicating significance at the 1%, 5% and 10% level, respectively.

E. Limits to Sterilization and the Importance of Derivatives Markets in Blunting Foreign Exchange Operations

37. **Colombia's experience also highlights the practical limits to sterilization of reserve accumulation when the macroeconomic cycle calls for tightening monetary policy.** In 2007, the capacity of the central bank to sterilize intervention diminished over time, as its holdings of government securities dwindled and the central bank shifted from providing liquidity to being a net borrower vis-à-vis the financial sector. A net creditor position is regarded as more desirable for reasons of monetary control: in practice, a central bank is better positioned to move short-term interest rates if it is a net lender of liquidity to the financial sector.

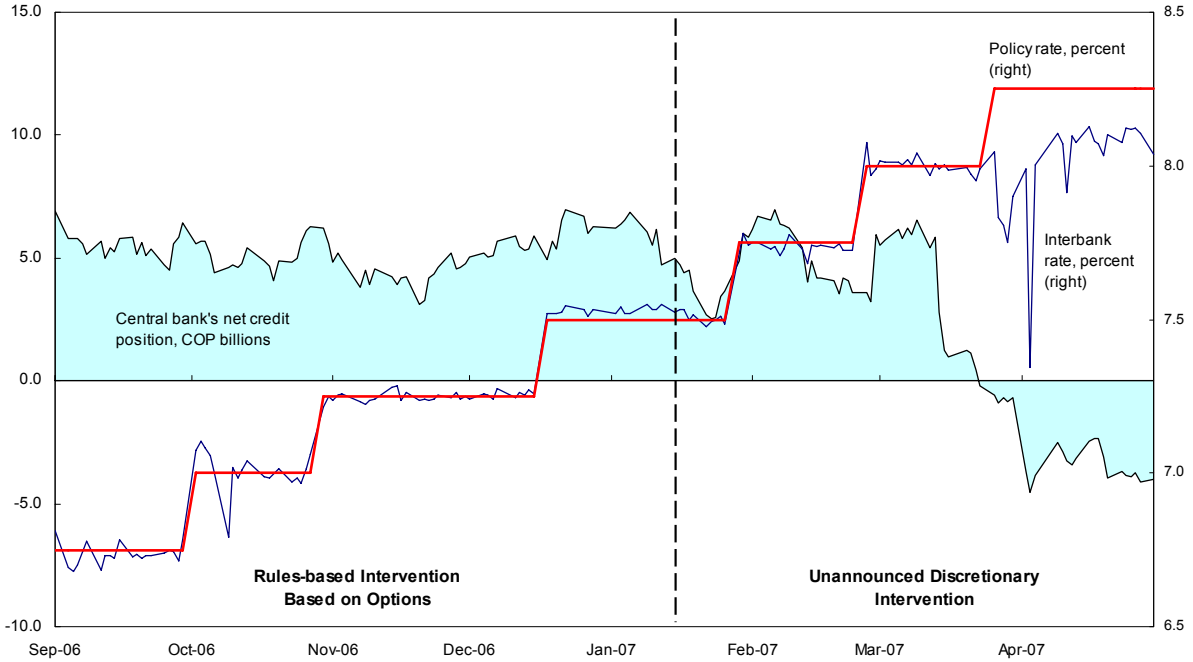
38. **With the BdR undertaking large-scale intervention in the first months of the year, it quickly reduced its stock of treasury bills and was soon close to a position where it would no longer be a net creditor to the financial system.**[68] The latter made it more difficult to control interbank rates and thus stifled the transmission channel of monetary policy.[69] This is evident in the behavior of policy and inter-bank interest rates in Figure 6. While the average interbank rate tracked very closely the reference rate until the end of March 2007, the relationship weakened after that (see Figure 6).[70]

[68] While in theory the BdR could have found additional sources of financing (e.g., a special allotment of treasury bills or issuance of its own long-term bond), in practice this may have not been conceived of as an option by market participants, as evidenced by the behavior of financial markets as the BdR moved to a net debtor position.

[69] Interestingly, this possibility was correctly anticipated in Vargas (2005).

[70] The massive injection of liquidity due to foreign currency purchases became apparent in the money market in April, as the interbank interest rate drifted below and away from the central bank's lending rate.

Figure 6. Net Creditor Position of the Central Bank vis a vis the Financial Sector and Behavior of Interest Rates

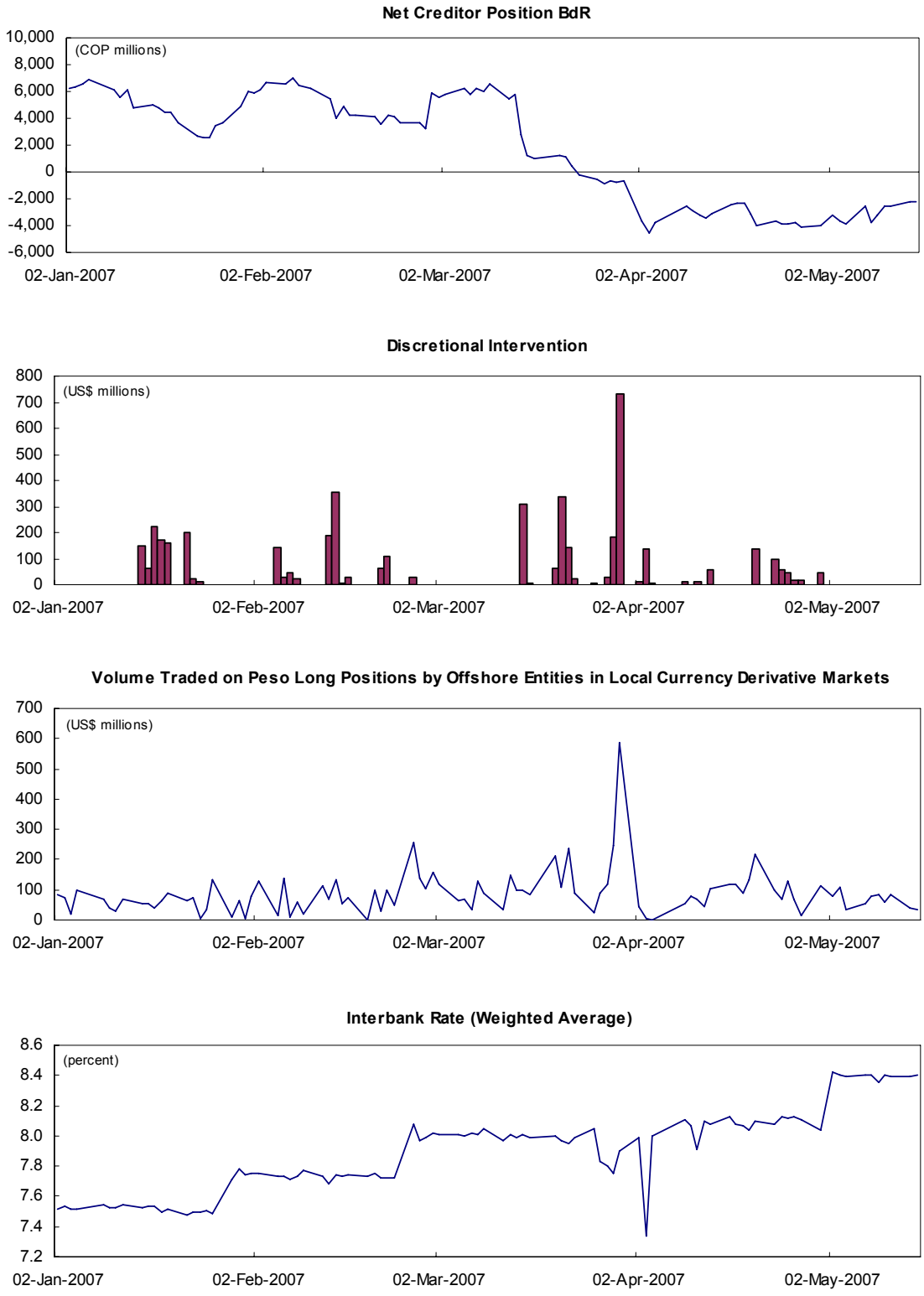


Source: Banco de la República.

39. **As the BdR soon approached a position in which it would become a net debtor, financial markets may have perceived that the scope for additional intervention would be coming to an end.** Investors knew that if the BdR became a net debtor of the banking system, this would greatly weaken their ability to conduct monetary policy, other things remaining equal. Under this scenario, the authorities would be forced to discontinue intervening, and the nominal exchange rate would appreciate on impact. This opened the door to massive one-way bets against the BdR by offshore entities, who built large long positions in pesos through the onshore forward market.[71] Quite clearly, the sudden burst of derivatives trading that occurred at the end of March 2007 (see Figure 7) pushed the BdR into a net debtor position and laid the groundwork for the demise of intervention efforts a month later.

[71] In turn, BdR intervention in FX markets made the Colombian carry trade more attractive, as intervention provided a counter party willing to take the long U.S. dollar risk. Kamil and Reveiz (2007) explain the mechanics underlying these carry trade operations, and discuss its policy implications.

Figure 7. Derivative Markets Can Blunt Central Bank Intervention Operations When Policies Are Inconsistent



Source: Banco de la República.

40. **The results thus suggest that inflation targeting regimes may still be vulnerable to speculative attacks—but attacks that *appreciate* the currency.** One of the major advantages of inflation targeting is often claimed to be that it does not leave an economy vulnerable to a speculative attack. The logic is that a run on reserves can be averted because the central bank can simply let the exchange rate go. In this paper we show that, if the policymaker is fully committed to the inflation target but at the same time intervenes aggressively to stop an appreciation in a manner that is not sustainable, this assertion is not generally valid. The case of Colombia shows that inflation targeting regimes can indeed experience speculative attacks—in this case, against the dollar.

41. **There are several noteworthy characteristics of the Colombian experience of this "speculative attack" that may be instructive for other emerging market countries.**[72] First, they occur when the central bank is trying to prevent an appreciation of the currency, rather than a depreciation. Second, such attacks may occur not in the spot market, but rather in the derivatives market, by off-shores entities leveraging massive bets on the appreciation of the peso.[73] Finally, the ability of the authorities to resist the attack is not determined by the level of reserves, as in the first-generation crisis models (indeed, they accumulate international reserves). Rather, there is a run is on the central bank's net creditor position vis-à-vis the financial system.[74]

42. **Overall, the Colombian experience shows that onshore derivatives trading can blunt foreign exchange intervention operations if forward markets are used actively as a substitute for portfolio investment.** A sterilized intervention that goes against the perception of the majority of market agents has little possibility of success, and could actually lead to greater exchange rate volatility or financial instability as foreign investors engage in one-way bets on domestic currency appreciation.

F. Conclusions

43. **How effective is central bank intervention in influencing the nominal exchange rate in emerging markets?** This is a key question for economic policy today, as many emerging market economies have intervened heavily in FX markets, accumulating reserves

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[72] These special features sets them apart from traditional first-generation currency crisis models (Krugman, 1979).

[73] It is important to note that the strength of such a "speculative attack" depends on how attractive the country is as a destination for carry trade vis-à-vis other emerging market countries at that point in time. In the case of Colombia in 2007, conditions were very favorable for such inflows, with correspondingly large effects.

[74] Much of the literature emphasizes that the high quasi-fiscal costs of intervention is what ultimately limits sterilization efforts. In Calvo (1991) and Calvo, Leiderman and Reinhart (1993), for example, it is argued that resisting currency appreciation keeps domestic money market interest rates high, attracting more inflows and thus continuously increasing the need for sterilization. Eventually, the cost of sterilization rises to unsustainably high levels and must be abandoned.

on a massive scale in a deliberate attempt to limit the extent of exchange rate appreciation. While there is an extensive literature on this subject for advanced economies—with mixed results—much less is known about its effectiveness as an independent policy tool in emerging markets. This paper attempts to add to this literature by examining Colombia's experience with central bank foreign exchange intervention between 2004 and 2007. During most of this period, the BdR engaged in large-scale, discretionary purchases of foreign exchange to resist the appreciation of the domestic currency, making it an interesting case study for assessing the efficacy of such efforts.

44. **Our results suggest that the effectiveness of BdR intervention was substantially different across the two periods of discretionary intervention.** During the first period of unannounced, discretionary intervention (December 2004–March 2006), we find statistically significant evidence that intervention affected the level of the exchange rate in the intended direction. Moreover, foreign exchange intervention moderated the appreciation of the peso vis-à-vis the U.S. dollar without undermining the central bank's ability to meet the inflation target. During the first intervention episode, macroeconomic objectives were well aligned, and foreign currency purchases credibly signaled an easing of monetary policy. Thus, Colombia's experience is indicative of the fact that an IT regime can be credible and effective even though the exchange rate regime is not an entirely clean float.

45. **The Colombia experience in the first half of 2007, however, illustrates the limits of intervention as an independent policy instrument.** During the second period of discretionary intervention, there was no detectable impact on exchange rate markets, as it was ineffective in moving the exchange rate in the desired direction. During this period, the BdR was torn between a concern for price stability, on the one hand, and a concern over the rapid pace of appreciation of the exchange rate, on the other. In this environment, markets perceived the BdR as pursuing two mutually inconsistent goals. The ineffectiveness and inconsistency of intervention thus became mutually reinforcing. We show that in this case, central bank intervention can be destabilizing, either by increasing uncertainty (i.e., increasing exchange rate volatility) or causing traders to speculate against the central bank (by increasing leveraged long peso positions in derivative markets).

46. **We find strong support for the notion that intervention cannot systematically influence the level of the exchange rate when it creates conflicts with other goals of monetary policy that the public perceives as overriding.** Paradoxically, it was the BdR's perceived strong commitment to inflation that undermined its ability to influence the exchange rate: the market most likely believed the central bank would never subordinate its inflation objective to concerns about the exchange rate. In this context, the derivatives market appears to have played an important role in exploiting any inconsistencies in the objectives of monetary policy.

47. **Additional research on the effects of intervention would be useful.** Better data availability (especially at daily frequencies) and continued research into the motives,

strategies, and channels for conducting foreign exchange market operations intervention in emerging markets countries could help provide more guidance on the appropriateness or effectiveness of intervention strategies.

APPENDIX

Table A1. Summary Statistics on Daily Central Bank Intervention in the Foreign Exchange Market

	Regimes of Un-Announced Discretionary Intervention	
	First Period	Second Period
	Dec 2004-Mar 2006	Jan 2007-Apr 2007
Frequency		
Number of trading days	296	73
Number of intervention days	251	44
Frequency of central bank intervention (in percent) 1/	84.8	60.3
Intensity		
Average value of intervention (in US$ millions) 2/	31	103
Maximum daily intervention (in US$ millions)	542	733
Average relative value of intervention (in % of mkt. turnover) 2/	5.2	10.7
Maximum relative value of intervention (in percent)	40.9	48.6
Duration		
Longest intervention spell (in business days) 3/	36	9

Sources: Author's calculations based on data provided by the Banco de la República.

Note: Purchases are in millions of U.S. dollars. The first period goes from December 20, 2004 to March 1, 2006. The second period starts on January 15, 2007 and ends on April 30, 2007.

1/ Number of days in which central bank intervened, as a fraction of total trading days.

2/ Average magnitudes calculated over days on which intervention occurred.

3/ The longest continuous stretch of central bank intervention within each sub-period.

Table A2. Summary Statistics on the Unconditional Distribution of Daily Exchange Rate Returns

	Regimes of Un-Announced Discretionary Intervention	
	First Period	Second Period
	December 2004-March 2006	January 2007-April 2007
Daily exchange rate statistics		
Mean (percent)	-0.03	0.01
Variance (percent)	0.17	0.07
Skewness 1/	0.82	0.04
Kurtosis	9.11	-0.02
$Q_{\Delta s}(20)$ 2/	76.60	23.86
$Q_{\Delta s2}(20)$	349.20	16.34

Sources: Author's calculations based on data provided by the Banco de la República.

1/ The kurtosis statistic is normalized so that a value of zero corresponds to the normal distribution

2/ $Q_{\Delta s}(20)$ and $Q_{\Delta s2}(20)$ are Ljung-Box tests tests for high-order serial correlation for the returns and square returns up to the 20th lag, respectively.

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