IMF Working Paper

External Linkages and Economic Growth
in Colombia: Insights from A Bayesian
VAR Model

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External Linkages and Economic Growth in Colombia:
Insights from A Bayesian VAR Model[*]

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Abstract

This Working Paper should not be reported as representing the views of the IMF.
The views expressed in this Working Paper are those of the author(s) and do not necessarily represent those of the IMF or IMF policy. Working Papers describe research in progress by the author(s) and are published to elicit comments and to further debate.

This paper investigates the sensitivity of Colombian GDP growth to the surrounding macroeconomic environment. We estimate a Bayesian VAR model with informative steady-state priors for the Colombian economy using quarterly data from 1995 to 2007. A variance decomposition shows that world GDP growth and government spending are the most important factors, explaining roughly 17 and 16 percent of the variance in Colombian GDP growth respectively. The model, which is shown to forecast well out-of-sample, can also be used to analyse alternative scenarios. Generating both endogenous and conditional forecasts, we show that the impact on Colombian GDP growth of a substantial downturn in world GDP growth would be non-negligible but still a mild decline by historical standards.

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I. INTRODUCTION

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. Both domestic and external factors are believed to have played a role in this improved performance. On the domestic side, Colombia has implemented in recent years important economic reforms that have strengthened the policy framework (IMF, 2006), whereas the security situation has improved markedly. These factors have helped enhance the domestic business environment, and contributed to the sharp increase in private investment that has underpinned the recent growth surge.[1] On the external side, Colombia has benefited from very favorable conditions, characterized by strong global growth, improving terms of trade, abundant international liquidity, and low interest rates.

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 (2008) which allows for the specification of informative steady-state priors for the variables used. A BVAR model with informative steady-state priors substantially reduces the problem of degrees of freedom arising from the generous parameterization that tends to characterize conventional VAR models. The approach has been found, inter alia, to improve forecasting performance compared to other empirical models.

This paper builds on the efforts of Österholm and Zettelmeyer (2008) 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. The focus is on variables that reflect 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. 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 owes to external factors by performing a historical decomposition using the method of Adolfson *et al*. (2007). In addition, we compare the out-of-sample forecasting performance of the BVAR model to that of alternative models. Finally, in a forward-looking exercise, an assessment is undertaken of the growth implications of *(i)* expected changes in external conditions in 2008 and *(ii)* a less-benign external environment than presently expected.

The rest of this paper is organized as follows. Section 2 briefly presents the basic structure of the model, and Section 3 describes its empirical implementation. Section 4 discusses the estimation

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[1] Private investment rose from 9 percent of GDP in 2002 to 19 percent of GDP in 2006.

results, including impulse response functions, variance decompositions, historical decompositions, out-of-sample forecasting assessments and results from the conditional forecasting exercise. Finally, Section 5 concludes.

II. THE MODEL

In this paper we will rely on a VAR model for our analysis of Colombian GDP growth. VAR models have several advantages; for example, they impose very few restrictions on the dynamics of the system and are considered to perform reasonably well in forecasting. However, the generous parameterization of most VAR models can—in particular in combination with small samples—lead to a deterioration in forecasting performance. Employing parsimonious model specifications is one way to address this issue. However, that also means that interpretability is sacrificed to a greater or lesser extent, as the number of questions that can be addressed becomes limited. An alternative approach is to rely on Bayesian VAR modelling, which reduces the degrees-of-freedom problem by introducing relevant prior information. In general, this leads to a substantial improvement in forecasting performance over classical VARs. We will therefore employ a Bayesian VAR for our analysis.

The model we employ is a particular specification of a Bayesian VAR model, recently developed by Villani (2008). The methodology takes its starting point in the observation that the forecaster often has potentially valuable information regarding the steady-state values of some variables. Villani suggests an innovative solution to bringing that information to bear in the estimation by allowing for an informative prior to be placed on the steady state of the process. The idea is that this information will make forecasts converge to a level that the forecaster judges reasonable. If the forecaster is correct, this should improve the forecasting performance of the model, particularly at longer horizons, and some research shows that this tends to be the case; see, for example, Adolfson *et al*. (2007), Österholm (2008) and Österholm and Zettelmeyer (2008).

The model is given by

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

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 $\mathbf{\eta}_t$ is an nx1 vector of *iid* error terms fulfilling $E(\mathbf{\eta}_t) = \mathbf{0}$ and $E(\mathbf{\eta}_t \mathbf{\eta}_t') = \mathbf{\Sigma}$. This model has the feature that $\mathbf{\psi}$ provides the steady state. It is typically the case that the forecaster has a reasonably accurate view of the parameters of $\mathbf{\psi}$ and an informative prior distribution can accordingly be specified.

Priors on the parameters of the model are as follows: The prior on $\mathbf{\Sigma}$ is given by $p(\mathbf{\Sigma}) \propto |\mathbf{\Sigma}|^{-(n+1)/2}$, the prior on $vec(\mathbf{G})$ – where $\mathbf{G} = (\mathbf{G}_1 \quad \ldots \quad \mathbf{G}_p)'$ – is given by

$vec(\mathbf{G}) \sim N_{pn^2}(\mathbf{\theta_G}, \mathbf{\Omega_G})$ and, finally, the prior on $\mathbf{\psi}$ is given by $\mathbf{\psi} \sim N_n(\mathbf{\theta_\psi}, \mathbf{\Omega_\psi})$. This choice of priors implies that the prior on $\mathbf{\Sigma}$ is non-informative; the priors on the vectors of dynamic coefficients $vec(\mathbf{G})$ and the steady state parameters $\mathbf{\psi}$ will, on the other hand, generally be informative. The priors on $\mathbf{\psi}$ are discussed in more detail below.[2]

III. EMPIRICAL IMPLEMENTATION

Variables capturing both domestic and external determinants of growth were included in the model. The two blocks consists of four variables each; denoting the vector of variables by $\mathbf{x}_t$, we set

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

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.

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 two percent with the Fisher hypothesis, where the equilibrium real interest rate is also assumed to be approximately two percent. These values are in line with values suggested by Taylor (1993) and Clarida *et al.* (1998). For the EMBI and high-yield bond spread, we adopted the priors of Österholm and Zettelmeyer (2008). 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

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[2] 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.
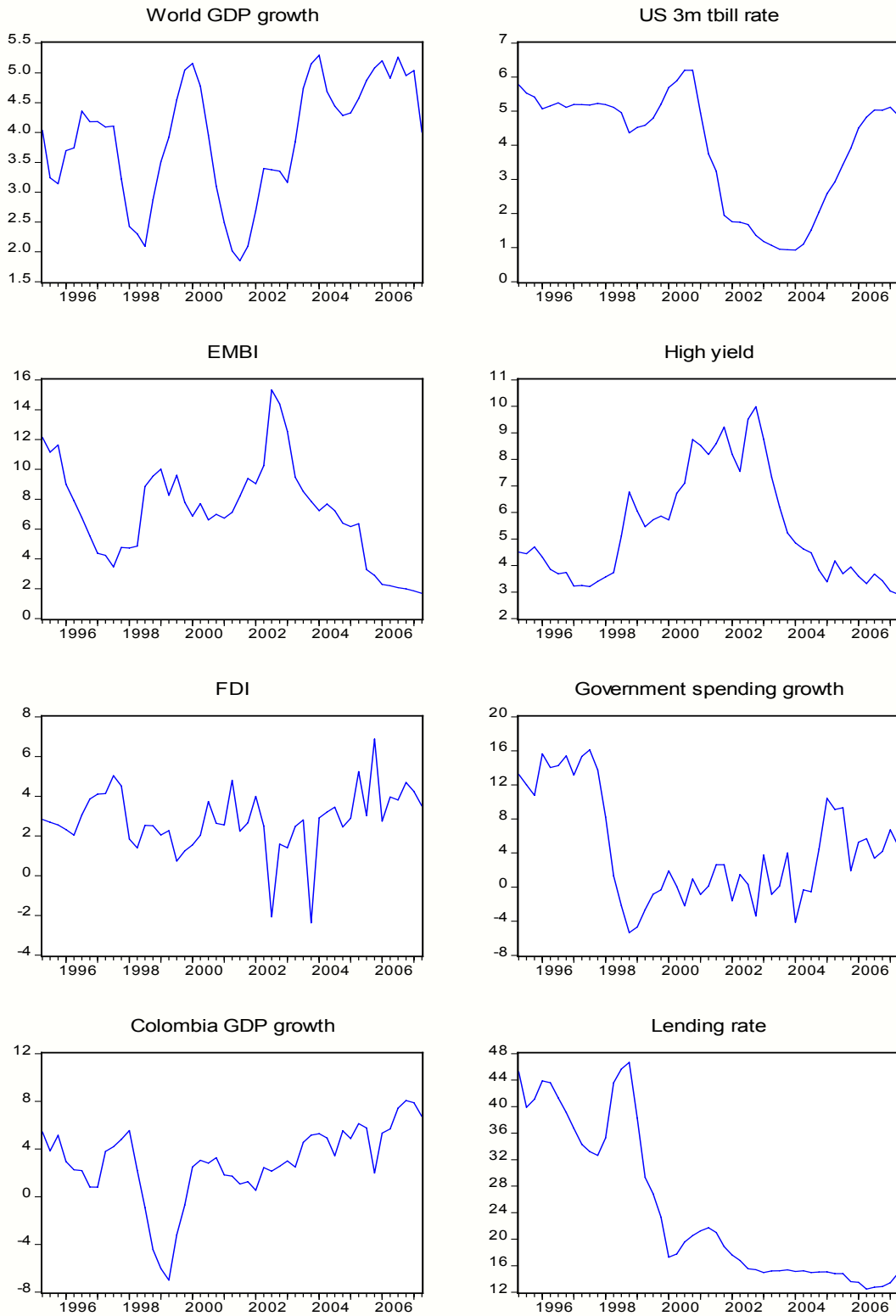
Figure 1. Data

Table 1. 95 Percent Prior 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)

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 *et al*. (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.[3] Setting lag length to $p = 2$, we estimate the model using quarterly data from 1995Q2 to 2007Q2.

IV. RESULTS

A. Impulse Responses and Variance Decomposition

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 Figures A1 and A2 in the Appendix. The generation of impulse response functions follows standard practice. Impulse responses for Colombian GDP reflect one standard-deviation shocks.[4] A standard Cholesky decomposition of the variance-covariance matrix was used to identify independent standard normal shocks ε_t based on the estimated reduced form shocks; that is, the relationships $\Sigma = PP'$ and $\varepsilon_t = P^{-1}\eta_t$, with the variables ordered as in x_t in equation (2), were used.

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[3] 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.

[4] 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.

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.

Colombian growth is fairly sensitive to global growth.[5] 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.

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

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 one percent increase in public spending raises GDP growth by 0.36 percentage points. 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.

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[5] The response to global growth shocks is stronger than that estimated by Österholm and Zettelmeyer (2008) for an aggregate of six Latin American countries. 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; Österholm and Zettelmeyer do not include domestic variables in their model, while including a commodity-price variable.

Figure 2. Impulse Response Functions for Colombia GDP Growth
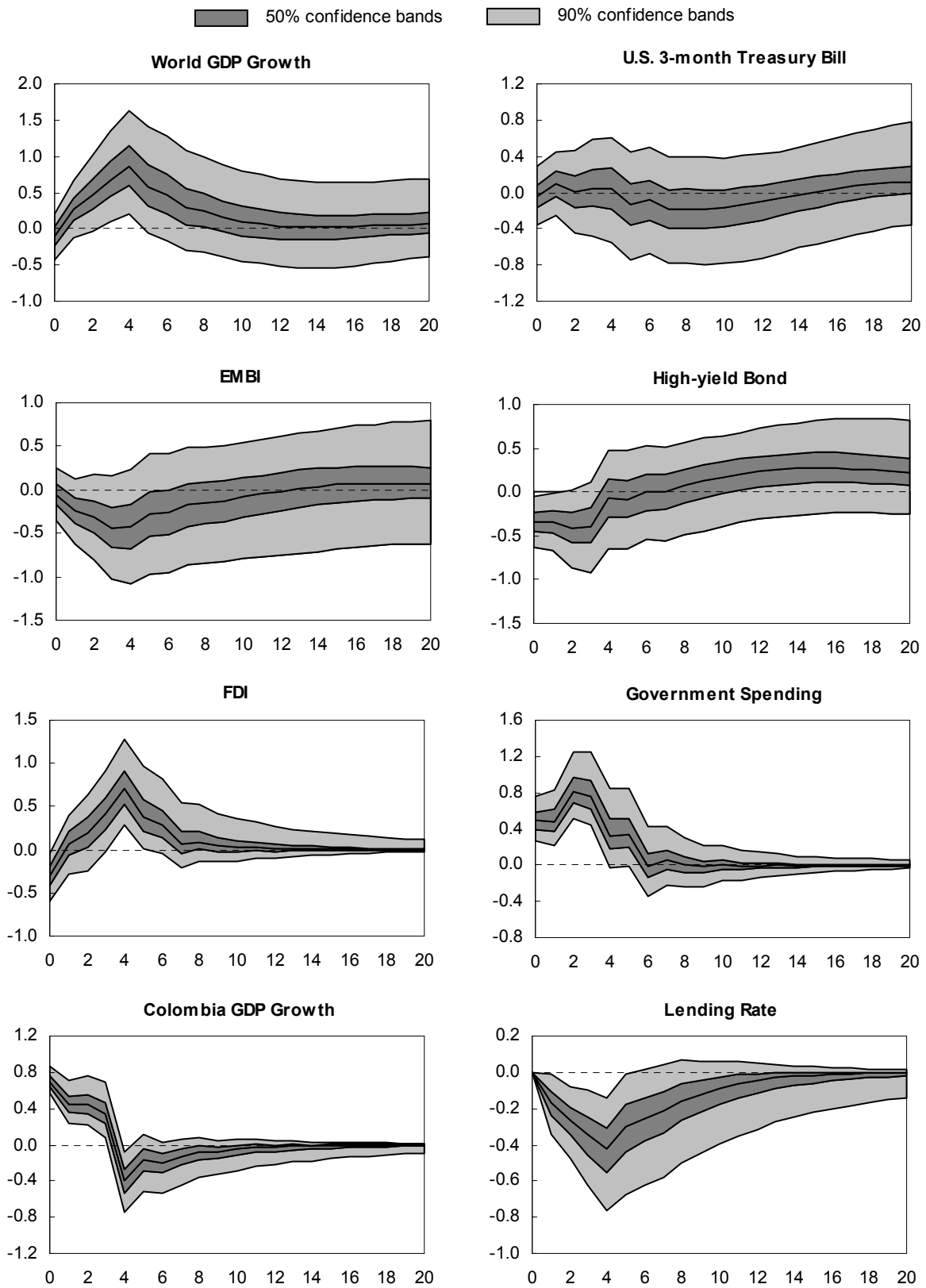
Turning to the variance decomposition in Figure 3, it can initally be noted that the model explains a very large share of the forecast error variance of Colombian GDP growth. The variance explained by own shocks is only a touch more than 20 percent (at the 20 quarter horizon), which is a fairly low proportion for a VAR. The variance decomposition also reveals that both foreign and domestic factors are important to economic growth in Colombia, with the contribution from the latter being higher. 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.[6] 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 three percent of Colombian growth.

B. Historical Decomposition

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 *et al*. (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. As can be seen from Figure 4, this comparison indicates that actual growth was generally stronger than predicted by the model over 2004 to 2006. 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 also 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*.

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[6] 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
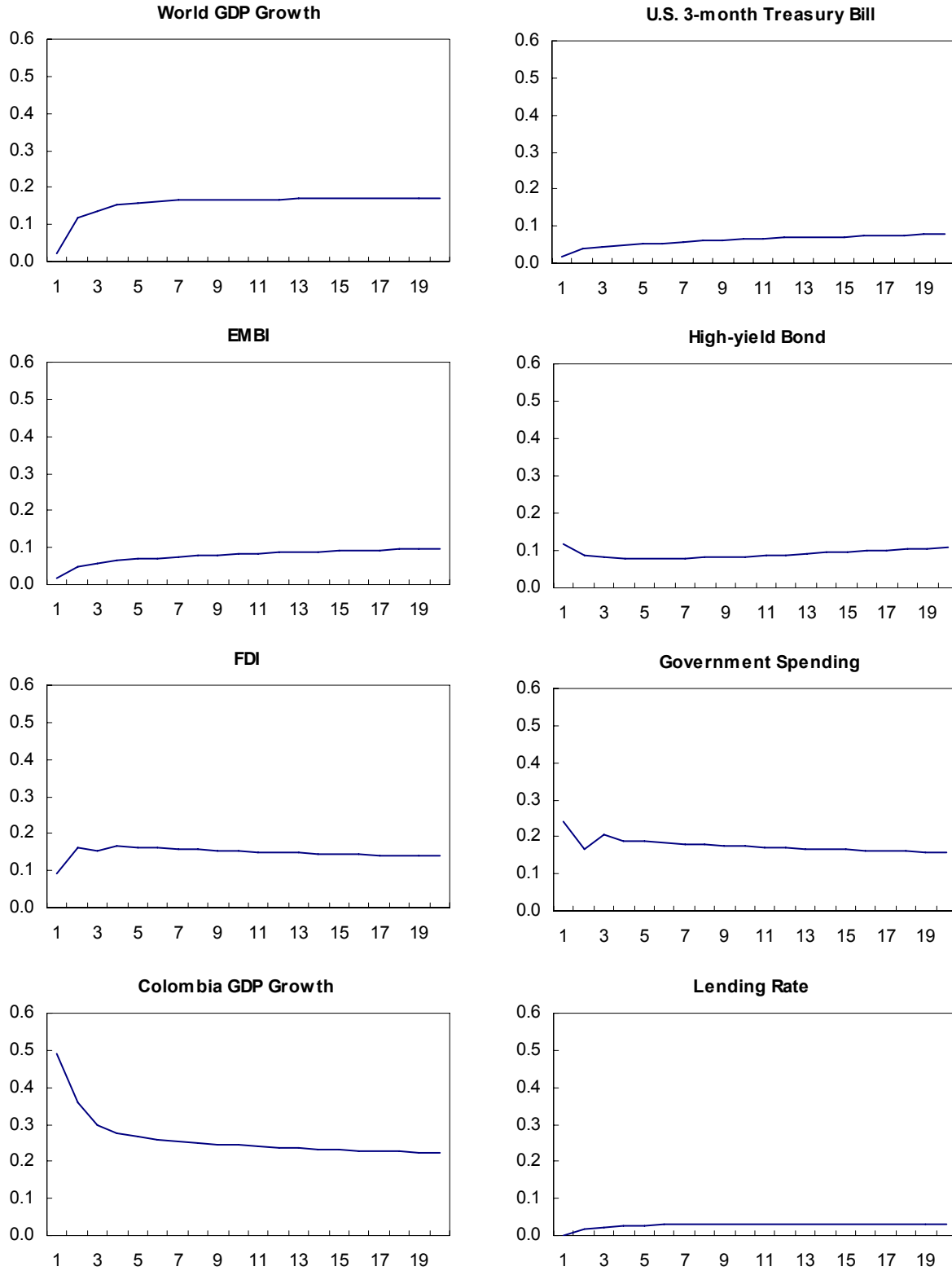
World GDP Growth

U.S. 3-month Treasury Bill

EMBI

High-yield Bond

FDI
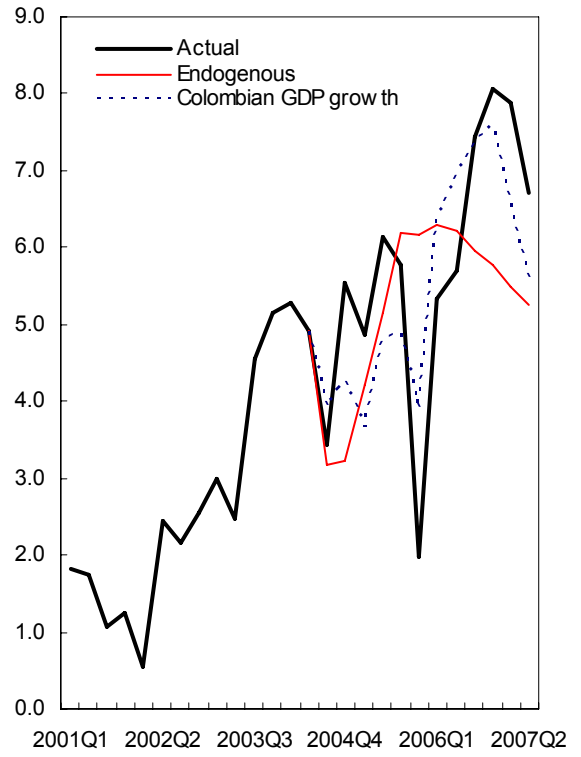
Government Spending

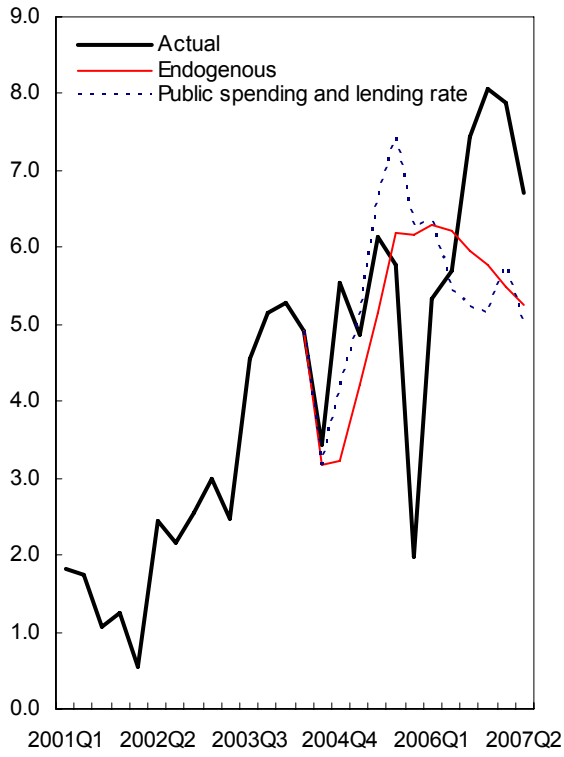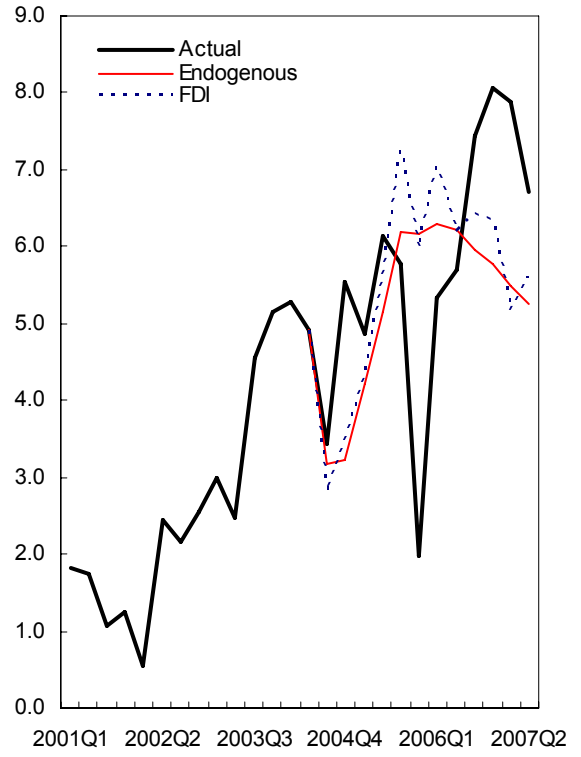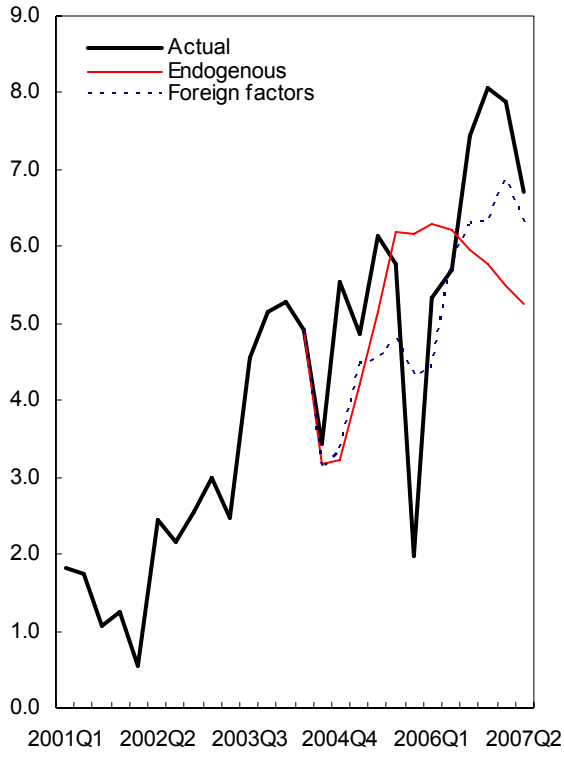**Colombia GDP Growth**

Lending Rate

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

As can be seen from the top left panel, the model suggests that the foreign shocks were not particularly favorable in 2004 and 2005. 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. Turning to the effect of FDI shocks—shown in the top right panel—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.

The fiscal and monetary policy shocks are found to have largely the opposite pattern of the foreign shocks, as can be seen in the lower left panel. 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 shows the effect of only adding the shocks to Colombian GDP growth. This largely shows the opposite pattern to the macroeconomic policy shocks.

C. Out-of-Sample Forecasting: A Comparison

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

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

where $\mathbf{G}(L)$, $\mathbf{x}_t$ and $\mathbf{\eta}_t$ 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 typically is 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.

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.[7] 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

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[7] 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.

evaluation is conducted on a model estimated from 1995Q2 to 2007Q1 and only forecasted one period ahead.

The root mean square error (RMSE) is used to compare the forecasting performance of the models. A relative RSME smaller than one means that the mean-adjusted BVAR forecasts better than the alternative model at a given forecasting horizon. As can be seen if Figure 5, the mean-adjusted model almost always outperforms the other models. 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 a naïve forecasts for 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.

D. Unconditional and Conditional Forecasts

Having established that the forecasting performance of the mean-adjusted BVAR model is good, we next generate unconditional (endogenous) and conditional forecasts of Colombian growth through 2010. The unconditional forecast is fully model-based, while the conditional forecast is derived from imposing paths on selected variables. We carry out two conditional forecasts. The first imposes paths on those variables for which standard projections are available, namely, world growth (from the IMF's Fall 2007 World Economic Outlook [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.

The endogenous and WEO-based conditional forecasts—shown in Figures 6 and 7—produce somewhat different results. 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.

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

| Naïve forecast | Conventional BVAR |

World GDP Growth

U.S. 3-month Treasury Bill

EMBI

High-yield Bond

FDI

Government Spending

Colombia GDP Growth

Lending Rate
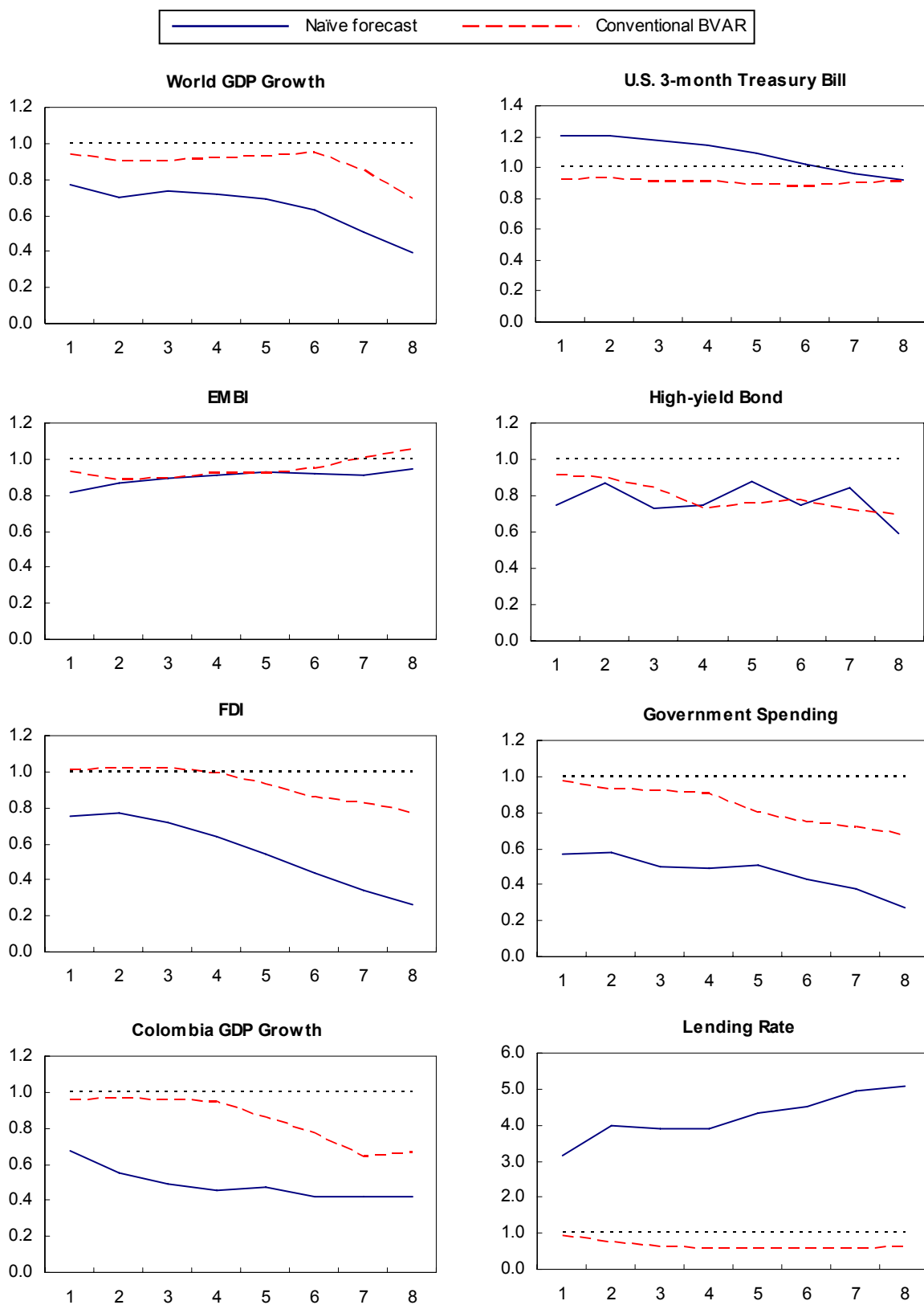
Figure 6. Unconditional Forecast 1/

World GDP Growth

U.S. 3-month Treasury Bill

EMBI

High-yield Bond

FDI

Governm ent Spending

Colombia GDP Growth

Lending Rate
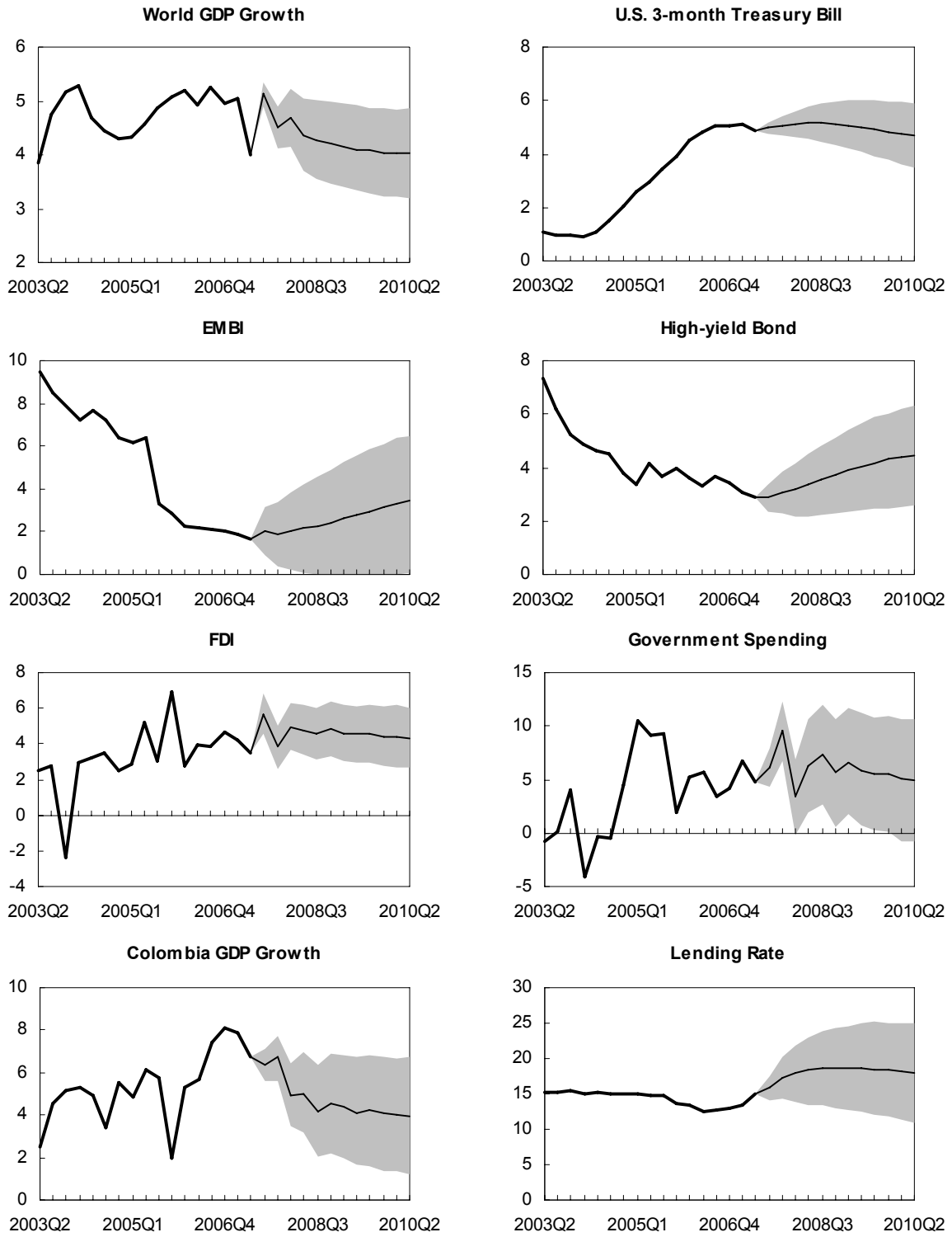
1/ 50% confidence bands.

Figure 7. WEO-Based Conditional Forecast 1/

World GDP Growth

U.S. 3-month Treasury Bill

EMBI

High-yield Bond

FDI

Government Spending

Colombia GDP Growth

Lending Rate
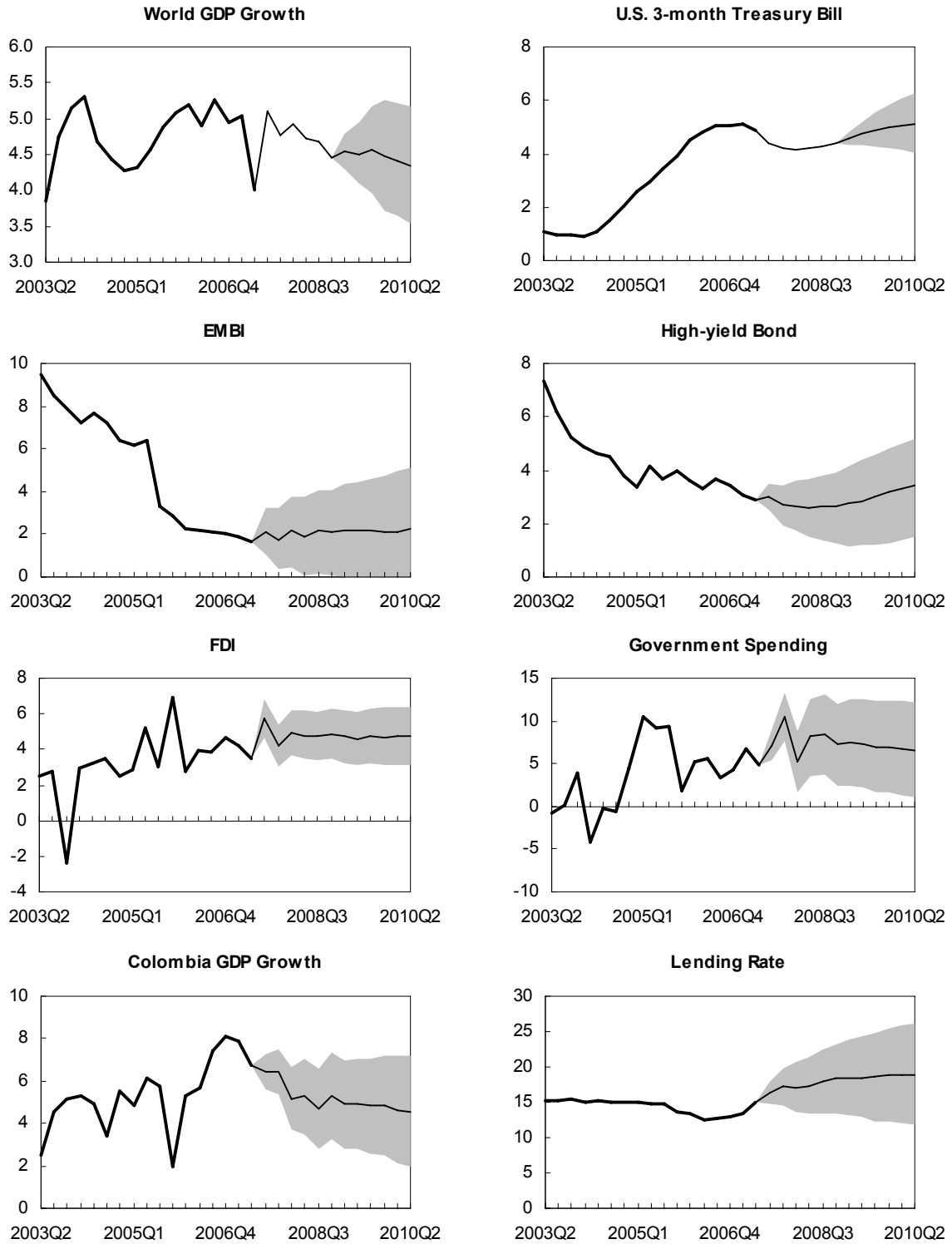
1/ 50% confidence bands.

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

World GDP Growth

U.S. 3-month Treasury Bill

EMBI

High-yield Bond

FDI

Government Spending

Colombia GDP Growth

Lending Rate
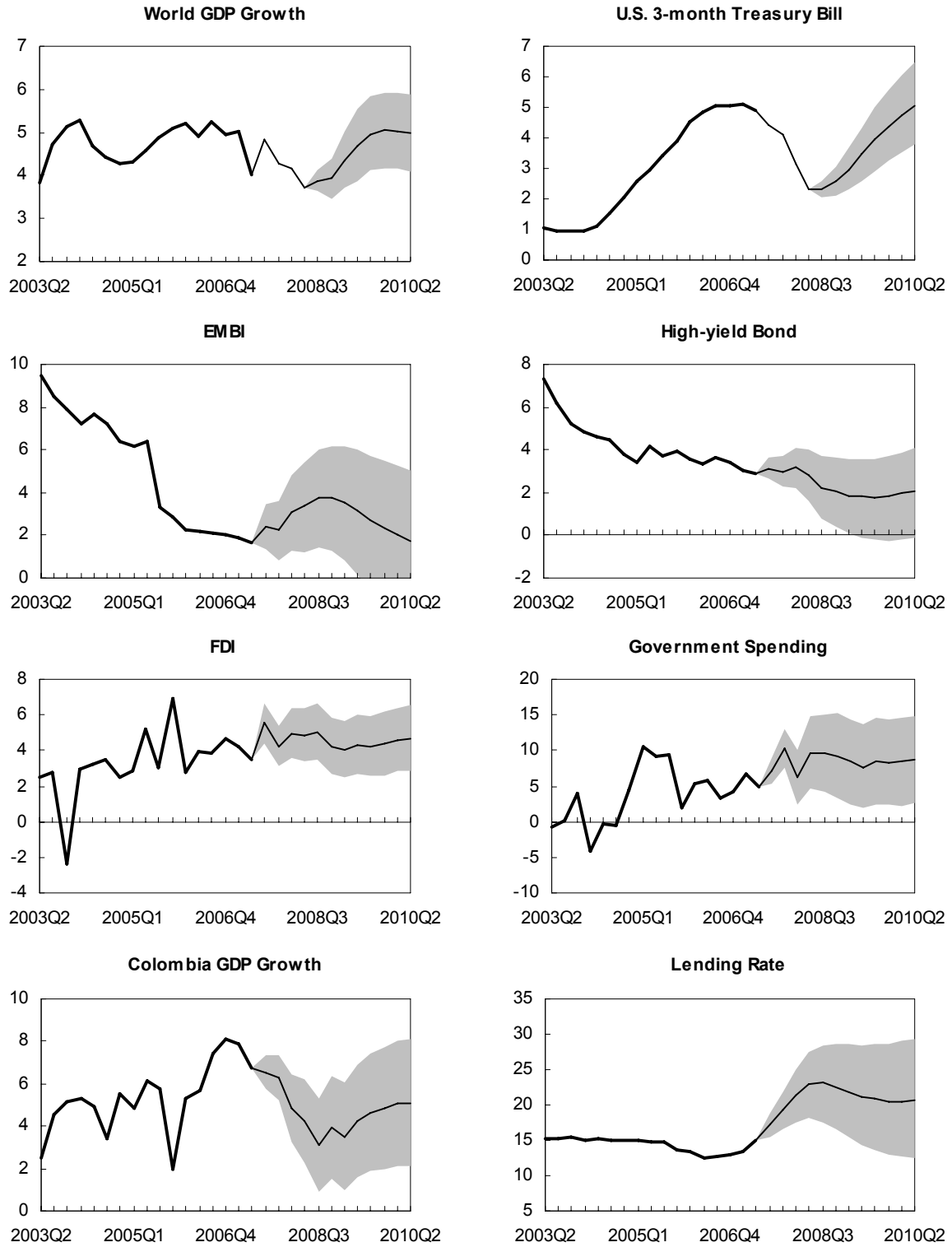
1/ 50% confidence bands.

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.

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.

V. CONCLUSIONS

This paper has investigated the importance of shocks to a number of macroeconomic variables for Colombian GDP growth. A 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 the variation in domestic growth. 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.

The model's conditional and unconditional growth forecasts are broadly in line with other forecasts, such as those from the IMF's WEO, and 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.

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 some 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 the 1990s. 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, 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. RMSE 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. RMSE 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
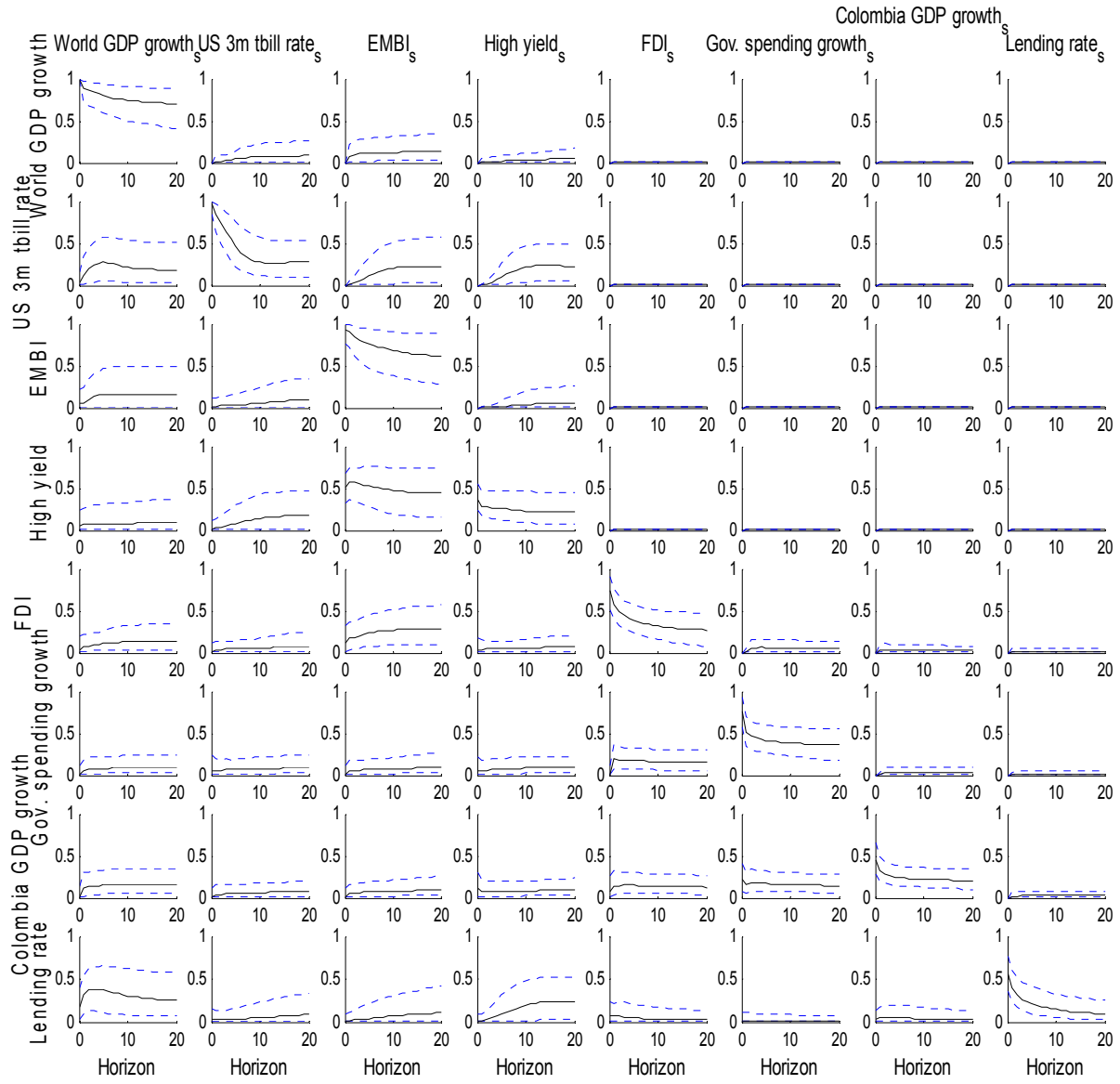
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