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The Effect of External Conditions on Growth in Latin America

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This paper investigates the sensitivity of Latin American GDP growth to external developments using a Bayesian vector-autoregressive model with informative steady-state priors. The model is estimated using quarterly data from 1994 to 2007 on key external and Latin American variables. It finds that 50 to 60 percent of the variation in Latin American GDP growth is accounted for by external shocks. Conditional forecasts for a variety of external scenarios suggest that Latin American growth is robust to moderate declines in commodity prices and external growth, but sensitive to more extreme shocks, particularly a combined external slowdown and tightening of world financial conditions. [JEL F37, F43]
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Following the economic crises of the late 1990s and the early years of this decade, Latin America has enjoyed an extraordinary recovery. From 2004 to 2007, the region grew at an average rate of over 5 percent, making this period the longest and most vigorous expansion since the late 1970s.

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Furthermore, public and private overconsumption, which have tended to accompany similar expansions in the past, have been largely absent. Inflation has generally been low and falling, public debt has declined, and primary fiscal balances and external current accounts reached record surpluses in 2006. Some strains and policy slippages—inflation pressures, and a decline in the fiscal surplus—began to emerge in 2007, but compared with its historical record, the macroeconomic position of Latin America remain strong (IMF, 2006, 2007).

Though improved macroeconomic policy frameworks no doubt deserve some credit, Latin America watchers are quick to point out that the region's extraordinary improvement in macroeconomic fundamentals has occurred in the context of an external environment that has been just as extraordinary, with high world growth, ample private financing, historically low emerging market risk premia, and high commodity prices (Calvo and Talvi, 2007; Talvi, 2007). This leads to the main questions of this paper. Can Latin America's current growth be expected to continue if external conditions deteriorate? What impact would external shocks—both real and financial—have on Latin America's growth performance? More specifically, how is the ongoing slowdown in U.S. growth, and tightening in credit conditions of lower-rated borrowers, likely to affect Latin America?

This paper addresses these questions using a novel technique, namely, a Bayesian vector-autoregressive (BVAR) model with "informative priors" on *steady-state* values. As is standard in BVAR models, we place priors on the dynamic behavior of the model as a step toward addressing the loss in estimation precision caused by the generous parameterization of VARs. In addition, however, our approach exploits outside information about the steady state of variables such as GDP growth. Incorporating such information into the model estimation makes it more likely that forecasts will converge to levels judged sensible by the forecaster; this should improve out-of-sample forecasting performance (see, for example, Villani, 2005; and Adolfson and others, 2007). The efficiency gain is likely to be especially important for the questions addressed in this paper, because structural changes in Latin America between the mid-1980s and the mid-1990s—external opening, liberalization, and stabilization from hyperinflation in several large countries—restrict the useable sample to about a dozen years. Indeed, our model is shown to outperform both a classical VAR and a conventional BVAR in terms of forecasting performance at most horizons.

The main results are as follows:

- External shocks—financing shocks, external growth shocks, and commodity price shocks—explain more than half of the forecast error variance of the growth rate of an aggregate Latin American output index at standard medium-term horizons. Of these shocks, financing shocks turn out to be the most important, explaining over half of the contribution of external shocks.

- The impulse responses in the model deliver some rules of thumb on the dynamic impact of various external shocks on Latin American growth. In particular, the overall impact of a world shock on Latin America is roughly one-for-one over time. One-standard-deviation shocks for commodity prices and the Latin American Emerging Market Bond Index (EMBI)—namely, changes of about 5.5 percent and 110 basis points, respectively, within one-quarter—are both estimated to lead to a change in Latin American growth of around 0.4 percentage point. The effect of a standard deviation shock in the U.S. high-yield bond spread (67 basis points) is estimated to be even higher (0.7 percentage point).
- Conditional forecast exercises suggest that Latin American growth would be fairly resilient to a moderate slowing of external growth as envisaged in the IMF's Fall 2007 *World Economic Outlook* (WEO) projection. The reason is that even with such a slowing, Latin America's external environment would still remain relatively favorable—sustained, in particular, by continuing high commodity prices and relatively low external financing premia. However, this could change if the U.S. economy enters a recession in 2008. The combination of a 2008 U.S. recession and a credit crunch in advanced financial markets—captured in our model by a rise in the U.S. high-yield bond spread to over 700 basis points—could reduce Latin American growth by as much as 2 percentage points below the baseline forecast.

Importantly, these results reflect the average behavior of Latin American economies over the 1994–2007 sample period. In the meantime, many Latin American economies may have undergone structural changes—most dramatically, a large reduction in currency mismatches. Consequently, the results may overstate Latin America's current vulnerability to external shocks, particularly financing shocks. This said, our conditional forecasting framework helps address this problem by allowing us to impose specific paths of variables such as the Latin American EMBI if we have reason to think that these may behave differently in the future compared with what would have been typical in the past. The comparison of these conditional forecasts with forecasts that allow the Latin American EMBI to respond endogenously gives a sense of the sensitivity of growth forecasts to alternative assumptions about financial transmission channels.

This paper contributes to a large and diverse literature on the effect of external factors on growth in Latin America (see Cuevas, Messmacher, and Werner, 2003; Canova, 2005; Kose and Rebucci, 2005; and IMF, 2007, Chapter 4; and see Roache, 2007, for a survey). The paper is most closely related to a recent study by Izquierdo, Romero, and Talvi (2008), who also examine the effects of financial, commodity price, and external growth shocks on Latin American growth at the business cycle frequency. However, the empirical methodologies and focus of the two papers are different, with Izquierdo, Romero, and Talvi interested mainly in the role of external factors in the most recent expansion, but we are interested in assessing the robustness of the expansion to a number of adverse external scenarios.

I. The Model

Methodology

Although VAR models are a common tool in empirical macroeconomics—used both in forecasting and for analyzing the dynamic impact of shocks to the economy—they suffer from some drawbacks. One problem is their heavy parameterization, which, in combination with small or moderate samples, can result in poor forecasting performance, particularly at longer horizons, because the levels at which forecasts converge are a function of the estimated parameters of the model. As a potential solution to this problem, Villani (2005) suggests a BVAR approach with an "informative prior" on the steady state of the process.

To see the benefits of this approach, consider first the standard BVAR model:

$$\mathbf{G}(L)\mathbf{x}_t = \boldsymbol{\mu} + \boldsymbol{\eta}_t, \tag{1}$$

where $\mathbf{G}(L)=\mathbf{I}-\mathbf{G}_1L-\cdots-\mathbf{G}_pL^p$ is a lag polynomial of order p, $\mathbf{x}_t$ is an $n \times 1$ vector of stationary macroeconomic variables and $\boldsymbol{\eta}_t$ is an $n \times 1$ vector of i.i.d. error terms fulfilling $E(\boldsymbol{\eta}_t)=0$ and $E(\boldsymbol{\eta}_t\boldsymbol{\eta}_t')=\boldsymbol{\Sigma}$. It is typically difficult to specify a prior distribution for $\boldsymbol{\mu}$ in Equation (1) and the solution has therefore often been to employ a noninformative prior for these parameters. However, the difficulty of specifying a prior for $\boldsymbol{\mu}$ is related to the chosen specification. Consider the alternative parameterization of the model suggested by Villani:

$$\mathbf{G}(L)(\mathbf{x}_t - \boldsymbol{\psi}) = \boldsymbol{\eta}_t, \tag{2}$$

where $\mathbf{G}(L)$, $\mathbf{x}_t$ and $\boldsymbol{\eta}_t$ all are defined as above. This model—although nonlinear in its parameters—has the feature that $\boldsymbol{\psi}$ immediately gives us the steady state of the series in the system. Hence, it is often the case that the forecaster has an opinion regarding the parameters of $\boldsymbol{\psi}$ and an informative prior distribution can accordingly be specified.

In this paper, we follow Villani (2005) in estimating model (2) with the prior on $\boldsymbol{\Sigma}$ given by $p(\boldsymbol{\Sigma}) \propto |\boldsymbol{\Sigma}|^{-(n+1)/2}$, the prior on $vec(\mathbf{G})$—where $\mathbf{G}=(\mathbf{G}_1 \ldots \mathbf{G}_p)'$—given by $vec(\mathbf{G}) \sim N_{pn^2}(\boldsymbol{\theta}_\mathbf{G}, \boldsymbol{\Omega}_\mathbf{G})$ and the prior on $\boldsymbol{\psi}$ given by $\boldsymbol{\psi} \sim N_n(\boldsymbol{\theta}_{\boldsymbol{\psi}}, \boldsymbol{\Omega}_{\boldsymbol{\psi}})$. That is, the prior on $\boldsymbol{\Sigma}$ is noninformative, but the priors on the vectors of dynamic coefficients $vec(\mathbf{G})$ and steady-state parameters $\boldsymbol{\psi}$—which are characterized by normal distributions centered on particular values—will generally be informative. We will return to and discuss the parameters of these priors below. The priors are then combined with the data through the likelihood function. The conditional posterior distributions of the model are derived in Villani (2005) and the numerical evaluation is conducted using the Gibbs sampler with the number of draws set to 10,000.[1]

[1]See, for example, Tierny (1994). The chain is serially dependent but there has been no thinning of it.

Empirical Implementation

External conditions that might be relevant for Latin America comprise (at a minimum) three sets of factors: external demand, commodity prices, and global financial conditions. In our model, external demand is proxied by GDP growth of Latin America's trading partners, weighted using export shares. We refer to this index as world GDP growth; note, however, that the weights are different from the usual PPP-GDP-based weights (in particular, U.S. growth is weighted with about 0.55 rather than its weight of about 0.2 in the world economy). Commodity prices are captured using a net export share-weighted index; and external financial conditions using U.S. Treasury bill rates, and the high-yield corporate bond spread in the United States.[2] As a measure of Latin American growth, a weighted index for Argentina, Brazil, Chile, Colombia, Mexico, and Peru—referred to as the "LA6" in the remainder of this section—was used.[3] In addition, the model included the Latin America subcomponent of JPMorgan's emerging market bond index, which is influenced both by external financing conditions and domestic fundamentals in Latin America.[4] Hence:

$$\mathbf{x}_t = \left(\Delta y_t^{world} \quad i_t^{US} \quad HY_t \quad \Delta y_t \quad \Delta c_t \quad EMBI_t \right)', \tag{3}$$

where y_t^{world} is the logarithm of export-share weighted world GDP; i_t^{US}, the three-month treasury bill rate; HY_t, the high-yield corporate bond spread in the United States; y_t, the logarithm of aggregate real GDP for the LA6 countries; c_t, a (net) export commodity price index for these countries; and $EMBI_t$, the JPMorgan emerging market bond index spread for Latin America.[5]

World growth and U.S. financial variables are treated as block exogenous with respect to the Latin American variables.[6] The model was estimated on

[2]The U.S. high-yield bond spread is sometimes interpreted as reflecting risk aversion; see Levy Yeyati and González Rozada (2005). An alternative measure, the Chicago Board of Trade Volatility Index (VIX), yields very similar results (not reported but available upon request).

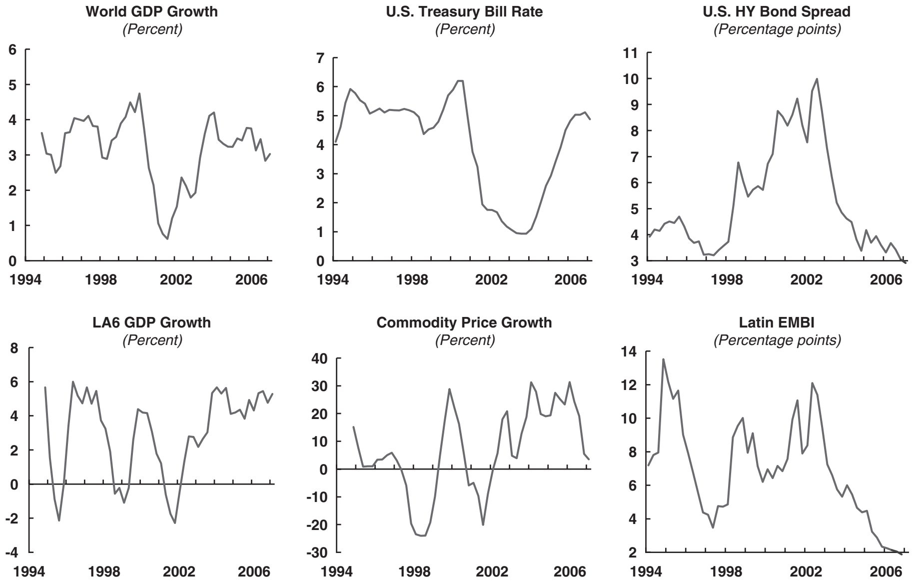
[3]This represents the largest economies in the region (except for Venezuela, which was excluded from the index because of its different economic structure), accounting for almost 90 percent of Latin American output.

[4]A real effective exchange rate index for the region was initially also included, but had no effect on the results.

[5]We tested for unit roots using the Augmented Dickey-Fuller (ADF) test (Said and Dickey, 1984) and KPSS test (Kwiatkowski and others, 1992); see Table A1. For the log commodity price index, both tests support the presence of a unit root in levels, while for the other variables the evidence for a unit root in levels is mixed (in particular, stationarity in levels cannot be rejected using the KPSS test). We hence take model commodity prices, world GDP, and Latin American GDP in first differences. The remaining variables are modeled in levels.

[6]This is achieved using an additional "hyper-parameter", which is used to shrink the parameters on y_t, c_t and $EMBI_t$ in the equations for y_t^{world} and i_t^{US} and HY_t to zero; see Villani and Warne (2003). Intuitively, this modeling approach amounts to imposing a tight prior

Figure 1. Data



Sources: See Appendix.

Note: Growth rates are given as percentage changes with respect to the same quarter in the preceding year.

quarterly data, from 1994:Q2 to 2007:Q2, after defining prior distributions for both the *vec*(**G**) and $\boldsymbol{\psi}$ parameter vectors. Figure 1 shows our data (see the Appendix for sources).

Slightly modified "Minnesota priors" (Litterman, 1986) were used for the dynamic coefficients, *vec*(**G**). Based on the assumption that a univariate random walk with drift is a good starting point for modeling GDP and commodity prices in levels (see Table A1), prior means on the first own lag for variables modeled in first differences were set equal to zero. Accordingly, the prior means for all higher order lags and for all cross-coefficients—that is, coefficients relating a variable to another variable in the system—were also set to zero.[7] However, prior means on the first own lag of variables modeled in levels were set to 0.9. The reason for this is that a traditional Minnesota prior—that is, a prior mean on the first own lag equal to 1—is theoretically inconsistent with the mean-adjusted model (2), as a random walk does not have a well-specified unconditional mean.

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distribution centered on zero for the parameters in question. This is somewhat less restrictive than imposing exogeneity directly, because it would allow an estimated nonzero posterior in the event that the data strongly disagree with our prior.

[7]Lag length was set as 2 or 4. This did not make much difference. Below, results with lag length 2 are reported.

Table 1. Steady-State Prior and Posterior Distributions

	95 Percent Probability Interval	
	Prior[1]	Posterior
World GDP growth	(3.0, 4.3)	(3.1, 3.7)
U.S. treasury bill rate	(3.0, 5.0)	(3.6, 4.9)
U.S. high-yield bond spread	(3.0, 6.0)	(3.7, 5.4)
LA6 GDP growth	(3.5, 5.0)	(3.5, 4.6)
Commodity price growth	(−2.0, 4.0)	(−0.9, 3.9)
Latin EMBI	(2.0, 5.0)	(2.3, 4.6)

Source: Authors' estimations.

Note: Units are percentage points for Latin American EMBI and U.S. high-yield bond spread, and in percent for all other variables.

[1]Refers to a normal distribution.

Steady-state priors are shown in Table 1 (first column). They can be justified as follows:

- Priors for world growth were based on medium-term projections from the IMF's WEO.
- Following standard convention, the prior for the U.S. three-month Treasury bill rate was based on a U.S. inflation target and an equilibrium real interest rate of approximately 2 percent each. These values are in line with Taylor (1993) and Clarida, Gali, and Gertler (1998).
- The steady-state prior for Latin American growth, centered on 4.25 percent, was based on econometric studies of the impact of economic reforms on long-run growth in Latin America (see Loayza, Fajnzylber, and Calderon, 2004; and see Zettelmeyer, 2006, for a survey).
- For the U.S. high-yield bond and EMBI spreads, we did not have guidance from either theory or the previous literature. Consequently, we did not impose strong priors, and instead defined wide distributions in line with the observed behavior of these variables since the late 1980s and early 1990s, respectively—that is, based on a somewhat longer sample period than the one used for estimation.
- Commodity prices are assumed to be reasonably well described by a random walk with a small drift component. The steady-state growth rate in commodity prices is accordingly centered on 1 percent and is not particularly wide despite the historically high variability of commodity prices.

The table shows that the estimated posterior distributions are within, and usually narrower than, the assumed prior intervals. We also confirmed that the short-run *dynamics* of the model were not affected by the steady-state priors chosen.[8] Hence, the assumed steady-state priors do not prejudge the model's short-run forecasts.

II. Results

Impulse Response Functions and Variance Decompositions

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, we used 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 Equations (3) and (4). Hence, world GDP growth is assumed to be contemporaneously independent of all shocks except its own; U.S. interest rates are assumed to contemporaneously depend only on world GDP shocks; and so on.[9]

Figure 2 shows the response of LA6 growth to various shocks; the full set of impulse response functions appears in the Appendix.[10] The magnitude of standard deviation shocks is as follows: about 0.37 percentage point for world growth, 28 basis points for U.S. Treasury bill rate, 67 basis points for the U.S. high-yield bond spread, 5.5 percent for commodity prices, and 110 basis points for the Latin American EMBI. These shocks are estimated to have the following effects on Latin American growth:

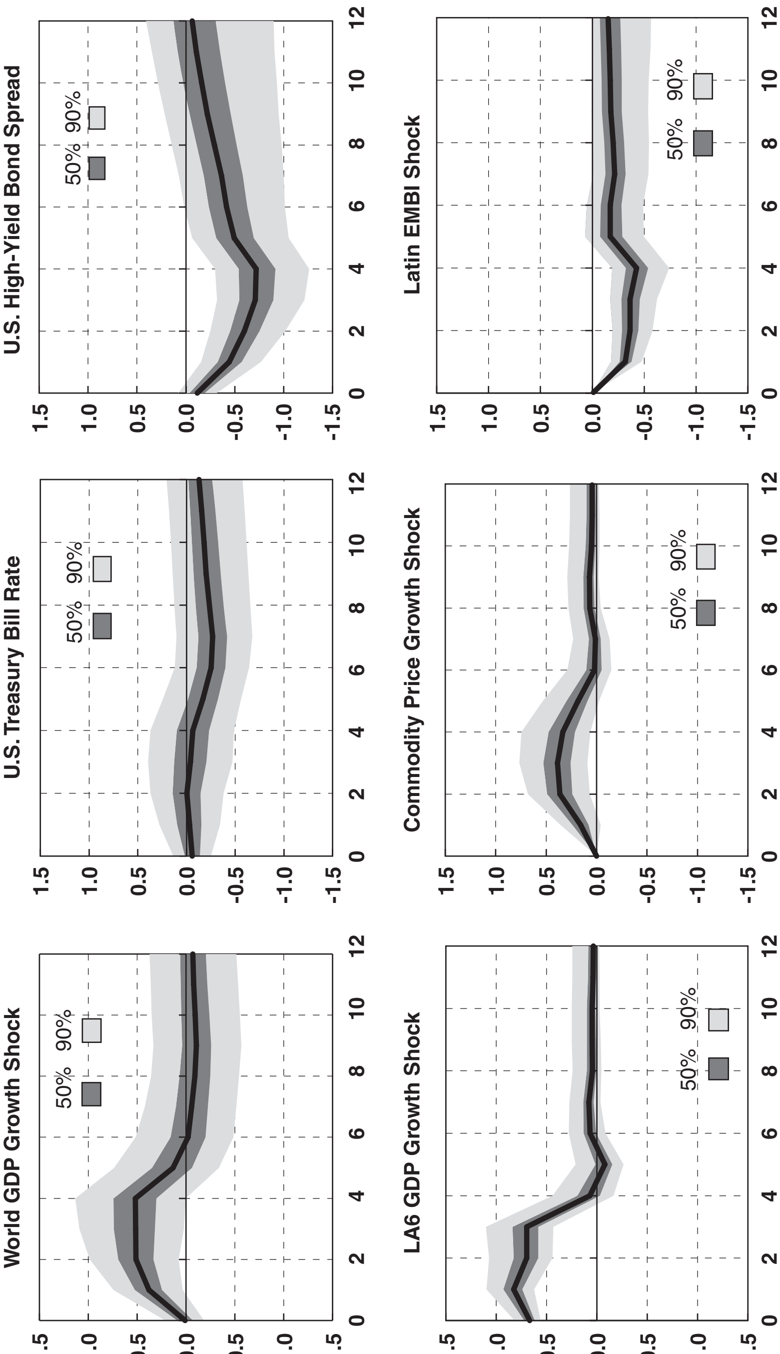
- Increases in world growth are passed on to Latin America about one-for-one: a 0.37 percent world growth shock leads to an increase in (four-quarter) Latin American growth by about 0.52 percentage point after four quarters. This is similar to the impulse response of world growth with respect to its own shock, which also reaches a maximum of about 0.44 (though it gets there faster; see Figure 1).
- The reaction of Latin American growth to U.S. interest rates is more muted; a hike leads to a reduction in growth, but the effect is reasonably small.

[8]Noninformative priors on the constant $\boldsymbol{\mu}$, which allow the data to influence the steady-state parameters to a larger extent, produced qualitatively similar but less precise results.

[9]Note that the ordering allows commodity prices to be contemporaneously affected by Latin American GDP shocks but not vice versa. The argument for this ordering is that GDP is a sticky variable while commodity prices are not. This said, it is also unlikely that Latin American GDP contemporaneously affects commodity prices, and our results did not change if we reversed the ordering of these two variables.

[10]These appear sensible (see Figure A1). A world growth shock leads to an increase in U.S. short-term interest rates over two to three quarters and a decline in high-yield bond spread. A U.S. interest rate hike leads to lower world growth after a few quarters, as well as an increase in the high-yield bond spread. A shock to the latter leads to a dip in world growth and a gradual easing of U.S. interest rates. It also leads to a sharp and immediate jump in the Latin American EMBI, of a slightly larger magnitude as the high-yield bond spread shock itself. Note that the nine impulse response functions in the upper right quadrant of Figure A1 are flat, reflecting block exogeneity of world/U.S. variables.

Figure 2. Response of LA6 GDP Growth with Respect to One Standard Deviation External Shocks
(Percent change from four quarters earlier; shown over 12-quarter horizon)

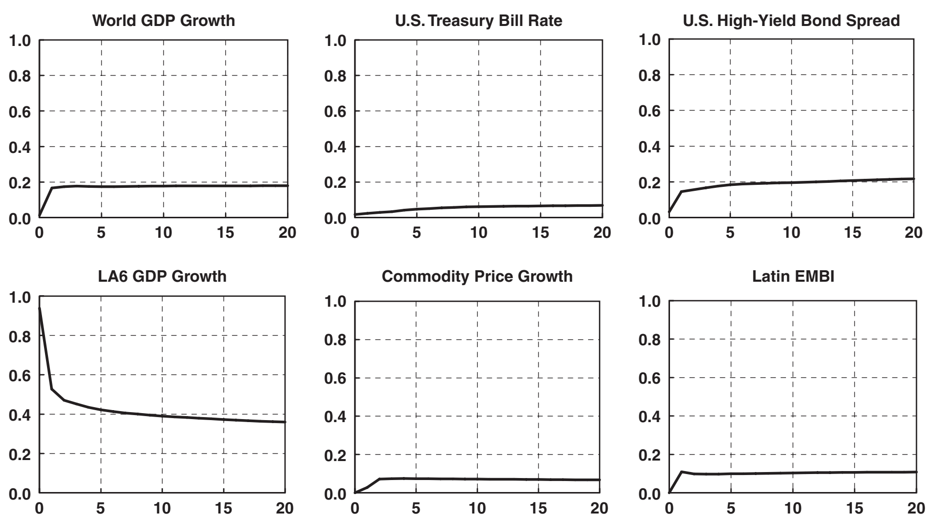


Source: Authors' estimations.

- In contrast, a standard deviation (67 basis points) rise in the U.S. high-yield bond spread, interpreted as reflecting a retreat of investors from risk, has a very strong effect, leading to a decline of four-quarter growth in Latin America by about 0.7 percentage point after three quarters. Note that the U.S. high-yield bond spread also appears to have strong effects on the Latin American EMBI as well as an effect on world growth (or, more strongly on U.S. growth); both of these channels could play a role in transmitting the shock.
- A standard deviation commodity shock—which in this sample is a change of almost 5.5 percent in a quarter, illustrating how volatile Latin American commodity prices have been—leads to a change in four-quarter Latin American growth of about 0.4 percentage point after three quarters.
- Finally, a 110-basis point rise in the Latin American EMBI is associated with a drop in four-quarter growth by 0.4 percent after four quarters.

Figure 3 shows the variance decompositions for LA6 growth, see the Appendix for the full system). More than half of the medium-term (10–20 quarter horizons) forecast error variance of Latin American GDP growth is explained by external factors: approximately 18 percent by world growth shocks, 6 percent by commodity prices, and a remarkable 34 percent by U.S. financial conditions (the combined influence of U.S. short-term interest rates and the U.S. high-yield bond spread).

Figure 3. Variance Decomposition from Mean-Adjusted BVAR Model
(Shown over 20-quarter forecasting horizon)



Source: Authors' estimations.

Out-of-Sample Forecasts

In addition to the impulse responses and variance decompositions just shown, we will be analyzing the effect of external conditions on Latin America using conditional forecasts (see below). It hence makes sense to ask first how the model performs as a forecasting tool relative to other models that use the same variables. We do this by comparing the out-of-sample forecasting performance from our mean-adjusted BVAR with two benchmarks: a conventional BVAR with diffuse priors on the steady-state values, and a classical (non-Bayesian) VAR.[11] In addition, we compared the model's out-of-sample forecasts with forecasts published by the IMF's WEO at roughly the same time.

Forecasts from the two BVAR models are generated in a straightforward manner. 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 (namely, 10,000). 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 compared with each other and to the point forecast from the classical VAR.

We initially estimate all models—the two BVAR models and the classical VAR—using data from 1994:Q2 to 2001:Q2. Using these estimates, we generate forecasts to 2004:Q2, that is, for all quarterly horizons h between 1 and 12. We then extend that sample one period, re-estimate the models and generate new forecasts 12 periods ahead, and so on. Once the estimation sample reaches 2004:Q2, we forecast over consecutively shorter periods, because the actual data that we need to compare the forecasts with ends in 2007:Q2. The last evaluation is conducted on models estimated from 1994:Q2 to 2007:Q1 and forecast only one period ahead. This yields $N_{12}=13$ forecasts at the 12-quarter horizon, $N_{11}=14$ forecasts at the 11-quarter horizon, and so on, and $N_1=24$ forecasts at the one-quarter horizon.

The forecasting performance of the three VAR models is then compared using the horizon h root mean square error (RMSE), given by

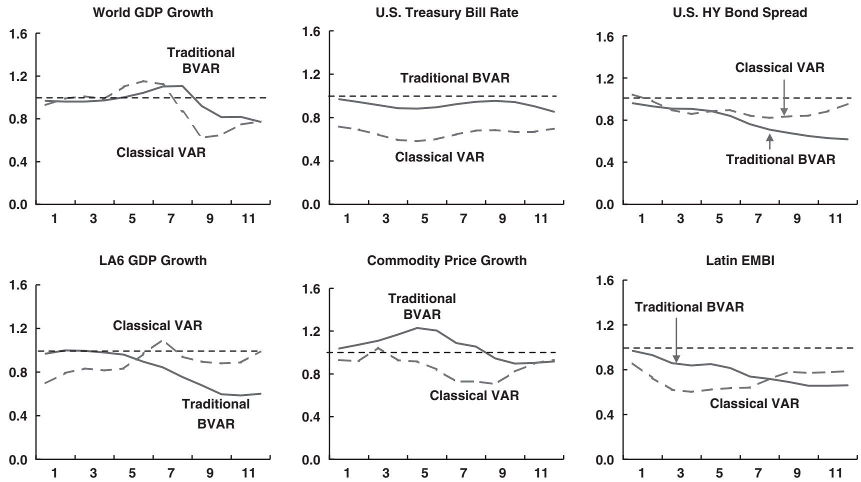
$$RMSE_h = \sqrt{N_h^{-1}\sum_{t=1}^{N_h}\left(x_{t+h} - \hat{x}_{t+h,t}\right)^2}, \tag{4}$$

where x_{t+h} is the actual value of variable x at time $t+h$ and $\hat{x}_{t+h,t}$ is an h step ahead forecast of x generated at time t. The *relative* RMSE at horizon h is defined as

$$RR_h = \frac{RMSE_{ma,h}}{RMSE_{alternative,h}}, \tag{5}$$

[11]The classical VAR is estimated using OLS. In this case, because no restrictions have been imposed on the model, OLS is equivalent to maximum likelihood.

Figure 4. Forecasting Performance of Mean-Adjusted BVAR Model Compared with Traditional BVAR and Classical VAR
(Relative root mean square errors; shown over 12-quarter forecasting horizon)



Source: Authors' estimations.

where $RMSE_{ma,h}$ is the RMSE of the mean-adjusted model at horizon h and $RMSE_{alternative,h}$ is the corresponding RMSE for the traditional BVAR or classical VAR.

Figure 4 shows the relative RMSE at horizons 1–12 for all variables in the system and both alternative models.[12] A number smaller than one indicates that our model outperforms the alternative at a particular forecasting horizon. Furthermore, a higher value for "traditional BVAR" compared with "classical VAR" means that the traditional BVAR does better than the classical VAR.

Figure 4 shows (unsurprisingly) that the mean-adjusted BVAR model decisively outperforms the classical VAR; the relative RMSE against the classical VAR is almost always smaller than unity. It also shows that the mean-adjusted BVAR generally performs better than the traditional BVAR. For four out of six variables, it produces smaller root mean squared errors at all horizons. In the other two cases—forecasts for world growth and commodities—the comparison depends on the horizon, with little difference in performance at the short end (1–3 quarter), somewhat better performance of the traditional BVAR at medium horizons (4–8 quarter); and better performance of the mean-adjusted BVAR at longer horizons. The latter likely reflects the role of steady-state priors, which help the forecasts converge to a sensible level.

[12]For variables expressed in first differences, RMSEs were calculated for forecast growth rates with respect to the same quarter in the previous year.

Table 2. LA6 GDP Growth: Comparison of Model-Based and WEO Forecasts
(In percent)

	2002	2003	2004	2005	2006	2007
Actuals, based on:						
Data in Spring WEO of year after forecast	0.3	2.0	5.4	4.1	5.2	4.9[1]
Most recent data (used in model estimation)	0.3	2.7	5.6	4.2	4.9	4.9[1]
Forecasts of:						
Fall 2002 WEO	−0.5	3.0				
Model; data through 2002:Q2	0.5	4.7				
Spring 2003 WEO		2.7	3.8			
Model; data through 2002:Q4		2.2	3.5			
Fall 2003 WEO		2.2	3.4			
Model; data through 2003:Q2		2.8	5.1			
Spring 2004 WEO			3.8	3.7		
Model; data through 2003:Q4			6.0	6.5		
Fall 2004 WEO			4.5	3.6		
Model; data through 2004:Q2			5.8	6.3		
Spring 2005 WEO				4.2	3.6	
Model; data through 2004:Q4				5.2	4.4	
Fall 2005 WEO				4.0	3.8	
Model; data through 2005:Q2				4.6	4.5	
Spring 2006 WEO					4.3	3.6
Model; data through 2005:Q4					4.1	5.1
Fall 2006 WEO					4.6	4.2
Model; data through 2006:Q2					4.9	5.0
Spring 2007 WEO						4.8
Model; data through 2006:Q4						4.3

Source: Authors' estimations; and IMF, *World Economic Outlook* (WEO).
[1]Preliminary.

We next compare the forecasting performance of the mean-adjusted BVAR model with the IMF's WEO forecasts published by the IMF (Table 2). Following the WEO, we focus the comparison on forecasts of annual average growth rates (derived from the model's quarterly forecasts) over a two-year horizon. We compare forecasts based on roughly similar information periods. Hence, Spring WEO forecasts (published in April of each year) are compared with model forecasts based on data through the fourth quarter of the previous year, but Fall WEO forecasts (typically published in September) are compared with model forecasts based on data through the second quarter of the ongoing year. This gives the WEO forecasts an informational advantage, because these are typically influenced by news in the first and third quarters, respectively, but the model estimates are not. (Of course, the WEO forecasts also have an informational advantage because they are based on many different data series, in addition to the six that we use in our models.) We focus on forecasts for the 2002–07 period, to allow the model a reasonably long estimation sample before comparing it with the WEO.

The "actuals" that we compare both forecasts with are slightly different. The model's out-of-sample forecasts are compared with the latest available GDP growth data, which are also used to estimate the model; but the WEO forecasts are compared with data published at the time (in practice, we use the "actuals" published in the Spring WEO in the year following the time of the forecast). This is because we cannot expect WEO forecasts to anticipate revisions in GDP that are reflected in the data series used to estimate the model.[13]

As in the previous comparison, the forecasts shown in Table 2 can be used to estimate root mean squared errors. Because we are limiting the comparison with the one and two-year forecasting horizons, we only compute two RMSEs for each set of forecasts. For the one-year horizon (meaning the current year for the Spring WEO forecasts), the model, perhaps surprisingly, does slightly better than the WEO: the RMSE is 0.8 percentage point for the WEO and only 0.5 for the model. At the two-year horizon, the WEO's RMSE is 1.1, but the model RMSE is 1.2. These are very small differences. Overall, the forecasts of the model appear to be about as good as those of the WEO, in spite of the WEO's much richer information basis.

It is instructive to examine where the model and WEO forecasts differ. Although the comparison period is obviously too short to draw firm conclusions, it appears that the model is more sensitive than the WEO in picking up turning points, but sometimes exaggerates the cyclical change. The model did much better than the WEO in predicting the strength of the 2004 recovery based on information through mid-2003. However, it predicted the recovery to strengthen further in 2005, which was not the case. Similarly, the model, in response presumably to lower U.S. growth in the second half of 2006, predicted a moderate slowing in Latin American growth in 2007. In the event, Latin American growth did not slow in 2007 relative to 2006, driven by buoyant domestic demand, and the higher persistence of the WEO forecast turned out to be an advantage in this case.

[13]GDP numbers are generally revised with some lag. For a discussion regarding real-time data issues, see, for example, Croushore and Stark (2002) and Orphanides and van Norden (2002).

Conditional Forecasts and Scenario Analysis

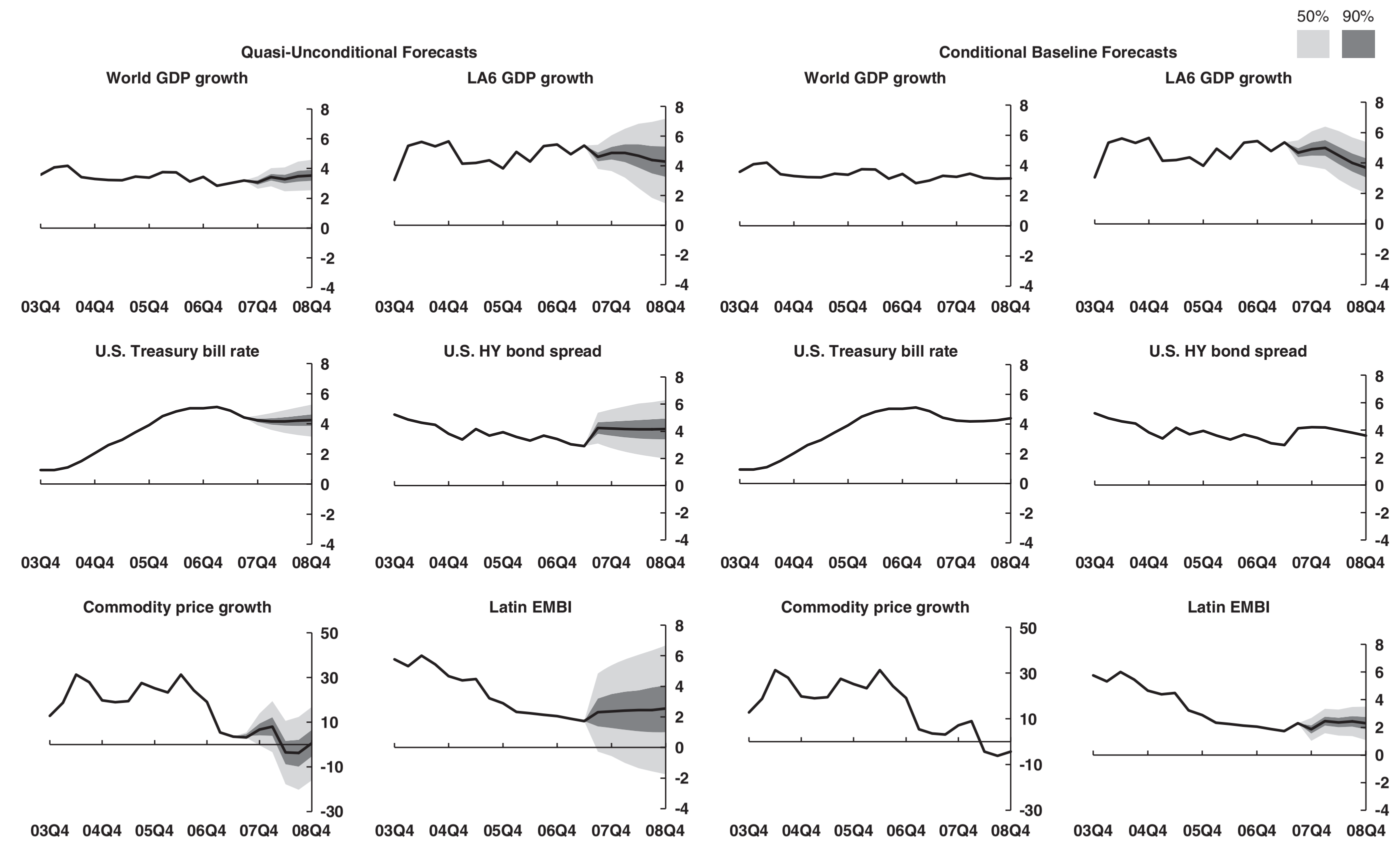
In addition to producing unconditional (or "endogenous") forecasts, as discussed so far, the mean-adjusted BVAR model turns out to be a convenient machinery for *conditional* forecasts, that is, forecasts based on assumptions about the future paths of some of the endogenous variables.[14] Conditional forecasts can serve two purposes. First, they are a way of incorporating extra-model information—"judgment," in Svensson's (2005) terminology—into the forecasting process. For example, assumptions about world growth or about the future path of commodity prices could be fed into the model. To the extent that these are based on information outside the model (such as commodity price forecasts based on futures prices), this might improve overall forecasting performance. Second, conditional forecasts can be used for scenario analysis, that is, to examine how growth would respond to specific external events. It is in this sense that conditional forecasts will be used extensively in this section.

We generate conditional forecasts as follows (see Österholm (2006) for details). As described in the previous section, we are interested in generating a distribution of future paths of the endogenous variables. To generate each path, we require the historical data, a draw from the posterior distribution of parameters, and a sequence of orthogonal shocks $(\boldsymbol{\varepsilon}_{T+1}, \ldots, \boldsymbol{\varepsilon}_{T+H})$. These shocks are then used together with the definition $\boldsymbol{\varepsilon}_t = \mathbf{P}^{-1}\boldsymbol{\eta}_t$ to generate the reduced-form shocks and hence—given history and the realization of the parameters—the future data. The only difference between the unconditional and conditional forecasting exercises is that in the unconditional case, the entire vector $\boldsymbol{\varepsilon}_{T+h}$ is generated randomly at each horizon, through independent draws from a normal distribution. In contrast, in the conditional case, only the orthogonal shocks belonging to a subset of the endogenous variables are created randomly; the shocks of the conditioning variables are implied by the assumed conditioning path. For a given set of randomly generated orthogonal shocks of the variables that have not been conditioned upon and a given path of the conditioning variables, the implicit shocks of the conditioning variables and the forecasts for all variables are generated sequentially, one horizon at a time.

Figure 5 shows two conditional forecasts based on the model estimated through the second quarter of 2007. First a "quasi-unconditional" forecast which conditions only on the realizations of financial and commodity price variables in Q3—which by now are observable—and an estimate for Q3 external growth, and after that projects all variables endogenously. Second, a "baseline" conditional forecast based on world growth and commodity price paths projected by the October 2007 WEO, as well as interest rate paths consistent with that outlook. In particular, following a weak fourth quarter,

[14]This exact imposition of particular paths has been called "hard conditions:" see Waggoner and Zha (1999). It is a common approach in the VAR literature; examples include Sims (1982) and Leeper and Zha (2003).

Figure 5. Quasi-Unconditional vs. Conditional Baseline Forecasts



Source: Authors' estimations.

Note: Units are percentage points for Latin EMBI and U.S. high-yield bond spread; and percent for all other variables.

output in the United States is assumed to gradually recover in 2008 in the conditional baseline scenario, leading to a moderate increase in short-term interest rates, and a moderate decline in the high-yield bond spread from levels observed at the beginning of the fourth quarter. In the figure, theses conditioning paths are recognizable by the fact that they do not have a probability "fans" around them.

As can be seen from the figure, the conditioning paths turn out to be close to the "quasi-unconditional" forecasts for most variables. The largest difference is with respect to external demand growth, where the quasi-unconditional forecast envisages a modest rebound in 2008, to 3.5 percent growth on average, but the WEO forecast implies a slight decline. Hence, the comparison of the quasi-unconditional and conditional baseline forecasts gives a sense of the effects of the moderate slowing of the world economy—without a further deterioration of financial conditions—on Latin America. The main result is that Latin America would slow only slightly, by about 0.3 percent on average in 2008 relative to the quasi-unconditional forecast, and by about 0.6 percent relative to the expected 2007 outturn. The conditional point forecast for average annual growth in 2008 is 4.4, about in line with the October 2007 WEO projection for the LA6 countries (4.2).

We next examine how this conditional forecast changes in a number of scenarios, which represent particular risks to the external environment that are suspected to have an impact on Latin American growth. Appendix Table A2 summarizes these scenarios and compares them to the "quasi-unconditional" forecast and the conditional baseline forecast.

A U.S. recession and credit crunch

The most obvious external risk looming over Latin America today is the possibility that a deepening U.S. housing crisis may trigger a U.S. recession in 2008, as consumer confidence collapses and financial market turbulence begins to affect corporate credit conditions. For illustrative purposes, we assume a scenario in which U.S. growth declines sharply in the fourth quarter of 2007 and remains around zero in the first half of 2008, before beginning a slow recovery in the second half. Average annual growth in 2008 would be reduced from just under 2 percent in the baseline to about 0.8. The Federal Reserve is assumed to cut interest rates aggressively to prevent a deeper and longer downturn, leading to a decline in U.S. Treasury bill rate to about 2 percent by the end of the second quarter. At the same time, corporate credit is likely to decline, and credit spreads for sub-investment-grade borrower would likely rise sharply, to over 700 basis points, in line with previous U.S. recessions.

Slower U.S. growth and tighter credit market conditions are likely to spill over to industrial growth outside the United States. In line with Bayoumi and Swiston (2007), for each one point reduction in U.S. growth we assume a reduction of about 0.4 to 0.5 percent in the growth of major non-U.S. importers of Latin American goods. Given the high weight of the United

States in Latin American exports, this implies an overall reduction of export demand by about 0.8 percentage point below baseline, on average, in 2008.

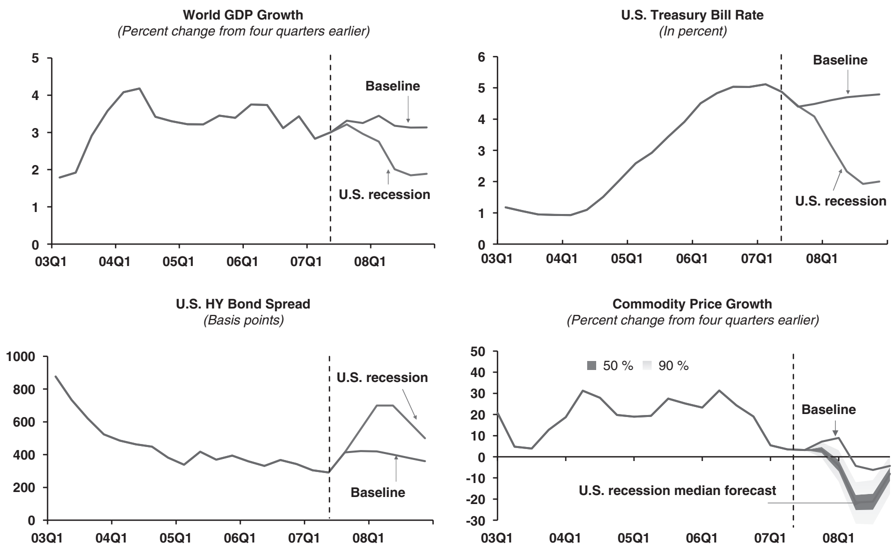
We make no assumption about the price path of commodities; that is, commodity prices are left endogenous. Not surprisingly, the model predicts that they would fall in reaction to the assumed U.S. and world slowdown, by about 22 percent by mid-2008, before recovering slightly (see Table A2).

Finally, regarding the Latin EMBI, we make two alternative assumptions:

- One option is to simply leave the EMBI endogenous. Because the typical response of the EMBI to changes in the high-yield bond spread during this period was at least one-for-one during the 1994–2007 estimation period (see impulse responses in Figure A2), this implies a very sharp rise, from about 230 basis points on average in the third quarter to 670 basis points by the first quarter of 2008.
- Alternatively, one can assume a path for the EMBI in line with the much more muted reactions of the EMBI to changes in the high-yield bond spread observed in the last months. In this case, the EMBI would rise by only about half the amount of the endogenous rise, to 370 basis points by the first quarter.

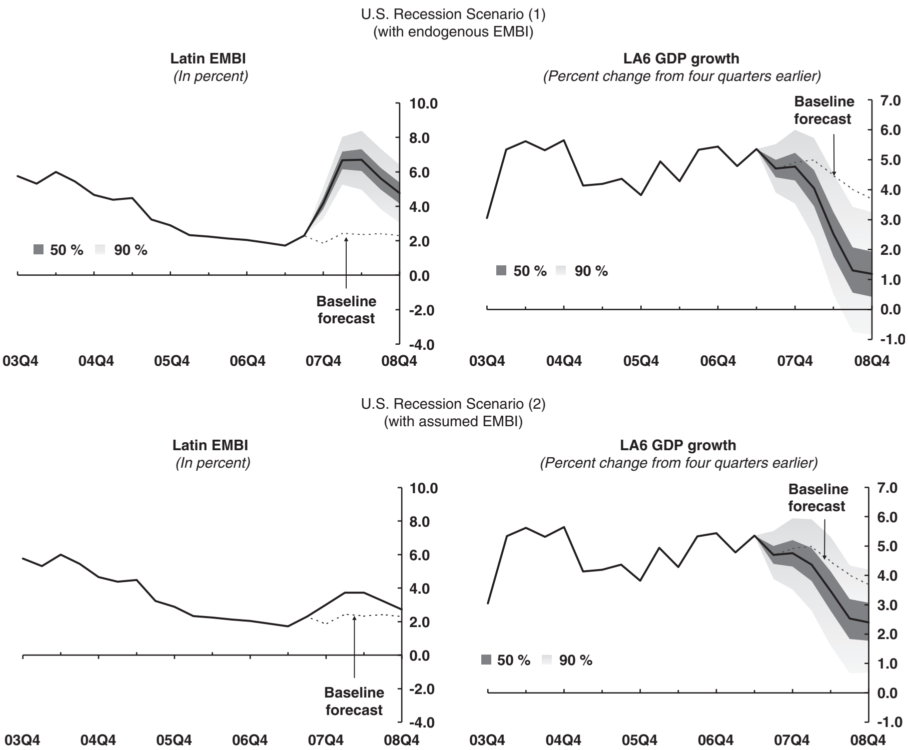
Figure 6 and Table A2 summarize the conditioning paths and compare them to the baseline paths, but Figure 7 shows the results.

Figure 6. Conditioning Paths for Baseline and U.S. Recession Scenario



Source: Authors' estimations.

Figure 7. Effects of a U.S. Recession and Credit Crunch



Source: Authors' estimations.

Not surprisingly, the magnitude of the predicted slowdown depends on the behavior of the Latin EMBI—that is, on the extent of financial contagion.

- If this follows the average pattern during the sample period, the predicted effect of a 2008 U.S. recession and credit crunch is large, with about zero growth during the first half of 2008 relative to the second half of 2007, just short of a recession. The 2008 average growth falls by 2.1 percentage points relative to baseline, to 2.3 percent.
- If external financing premia in Latin America were to continue their partial decoupling from U.S. financial markets, the model predicts a milder slowdown, to about 3.2 percent in 2008, or about 1.2 points relative to baseline.

Note that in either case, the predicted fall of Latin American output relative to the baseline (1.2 to 2.1 percent) exceeds the assumed fall in external demand (0.8). The reason for this is that the scenario consists of a *combined* demand and financial shock, given the assumed sharp rise of the U.S. high-yield bond spread. Even in the more muted scenario, the financial transmission channel has not been shut down completely, and the commodity price channel is also at work in both variants of the scenario.

Declines in commodity prices

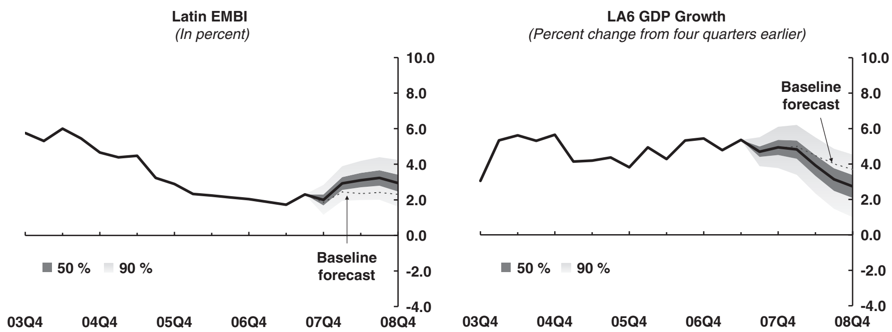
As discussed, declining commodity prices constitute one channel through which a slowdown in external growth could hurt Latin America. It is also interesting to see how much a commodity price fall of about the same magnitude would slow Latin American growth if it occurred in isolation. This can be done by modifying the baseline scenario to include a fall in commodity prices by 20 percent over three quarters, beginning in the last quarter of 2007 (see Table A2). All other baseline paths are retained, and the EMBI is allowed to adjust endogenously.

The model predicts that a 20 percent fall in commodities prices in late 2007 and early 2008 would lead to noticeably lower, but still robust, 2008 growth in Latin America (see Figure 8 and Table A2). Annual average growth is reduced to 3.7 percent. This partly reflects the direct effect of commodity prices on growth, but also higher external risk premia, with the EMBI rising endogenously by about 60 to 80 basis points above baseline (see Figure 8).

An emerging market financing shock

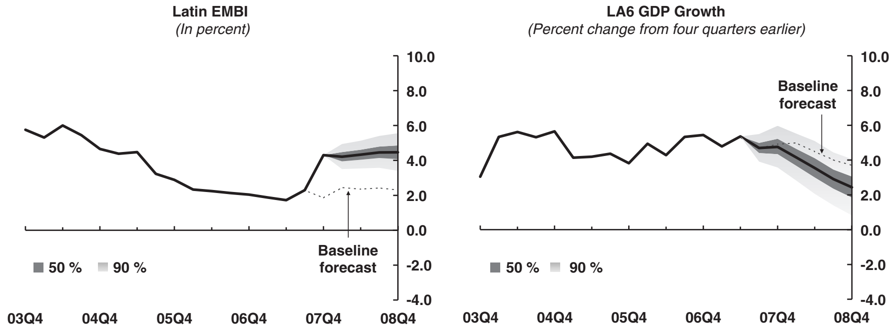
Finally, a scenario illustrating much tighter emerging market financing conditions was considered, in the form of a 200-basis-point shock to the Latin EMBI spread and a 100-basis-point increase in the U.S. high-yield bond spread—perhaps triggered by an emerging market crisis outside Latin America, with a limited spillover effect to U.S. high-yield credit markets. To isolate the effects of a ''pure'' emerging market financing shock, we retain baseline assumptions for world growth, commodity prices, and U.S. Treasury bill rates. The shock to the EMBI spread and the U.S. high-yield

Figure 8. Effects of a Decline in Commodity Prices



Source: Authors' estimations.

Figure 9. Effects of Emerging Market Financing Shock



Source: Authors' estimations.

bond spread is assumed to occur in the fourth quarter, after which these variables are allowed to be endogenous.

The model suggests that a financing shock of this kind would significantly reduce growth in Latin America, though by less than the combined U.S. recession/credit crunch scenario considered earlier (Figure 9). The 2008 growth is predicted to fall to about 3.3 percent on an annual average basis, about 1 percent below baseline.

III. Conclusion

This paper presented a mean-adjusted BVAR model of growth in Latin America for both forecasting and scenario analysis. The model outperforms plausible competitors—a classical VAR and a conventional BVAR—as a forecasting tool, and seems to perform approximately as well as the IMF's WEO forecasts. Using impulse responses and conditional forecasts, we evaluated the sensitivity of Latin American growth to a variety of shocks, including a slowdown in external demand, a U.S. credit crunch affecting high-yield borrowers, commodity price shocks, and an emerging market financing shock.

The main result is that while Latin American growth appears to be fairly robust to a variety of moderate shocks—including a moderate slowdown in U.S./world growth, and a 20 percent reduction in commodity prices, a combined recession and credit crunch in the United States—as currently (late 2007) feared for 2008—could have a severe impact. The scenario analyses undertaken in this paper suggest that the magnitude of the spillover from a U.S. recession to Latin America will depend mainly on two factors:

- First, the extent to which a U.S. recession leads to a decline in commodity prices. In our model, commodity prices are an important channel for transmission of external demand shocks, with a U.S. recession and credit crunch leading to a decline of Latin American commodity export prices by 20 to 25 percent. This, in turn, affects Latin American growth both directly and through tighter external financing conditions.

- Second, whether financial transmission channels continue to be as critical as they were in the 1990s and at the beginning of this decade (the sample period for which our model is estimated). During these periods, a tightening of credit conditions facing sub-investment-grade corporate borrowers in the United States led to an at least one-for-one increase in Latin American external borrowing costs. However, this may not be true today, as public and private sectors in Latin America have become more resilient as a result of better-anchored inflation expectations and less reliance on foreign currency and short-term debt. Indeed, because the U.S. subprime crisis emerged in full force in July 2007, the reaction of the Latin EMBI to changes in the U.S. high-yield bond spread has been comparatively muted.

Depending in particular on the strength of the financial transmission channel, our results suggest that a U.S. recession, involving a reduction of U.S. growth by about 1.2 percent below baseline in 2008, would lead to a baseline reduction in Latin American growth between around 1 and over 2 percent. The latter would imply a fall of Latin American growth to nearly zero the first half of 2008.

What would it take to reduce regional vulnerabilities further? The model estimated in this paper provides evidence for the importance of financial shocks—which account for more than 60 percent of the contribution of external factors to the variance of Latin American growth—as well as the role of financial channels in magnifying "real" shocks, such as commodity price shocks. It also indicates that commodity prices remain an important determinant of short-term fluctuations. This points to policies that lower public debt, make budgets more flexible, strengthen financial systems, diversify export structures, and reduce fiscal dependence on commodity revenues.

APPENDIX

Data Sources

World GDP: Haver Analytics and WEO database (export weighted index created using export shares of the LA6 countries to the rest of the world, export shares taken from the IMF's Direction of Trade Statistics).

Latin American (LA6) GDP: Haver Analytics, weighted using WEO PPP-GDP weights.

U.S. three-month Treasury bill rate and U.S. CPI: Haver Analytics.

U.S. high-yield corporate bond spread: Bloomberg.

Latin Emerging Market Bond Index Spread (EMBI): JPMorgan

Commodity price indices: Calculated based on UNCOMTRADE trade share and IMF commodity price data.

Unit Root Tests

Unit root tests were conducted for both the level and first differenced series, using the standard ADF test (null hypothesis: presence of a unit root in the time series), and the KPSS test (null hypothesis: absence of a unit root in the time series). The results are shown in Table A1.

Impulse Responses and Variance Decompositions

See Figures A1 and A2.

Scenario Analysis

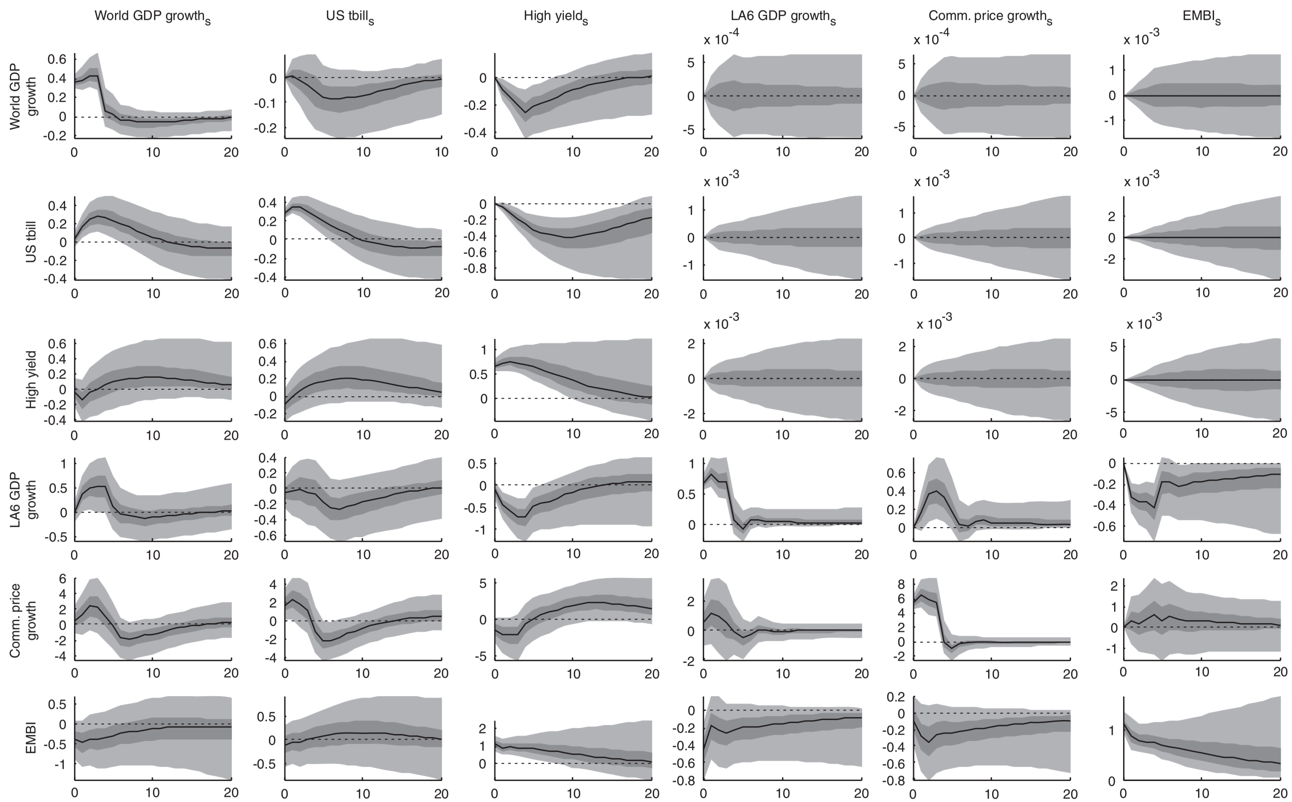
See Table A2.

Table A1. Unit Root Tests

Variable	Level		First Difference	
	ADF	KPSS	ADF	KPSS
y_t^{world}	−2.05	0.138	−5.499**	0.13
i_t^{US}	−2.067	0.403	−3.339**	0.134
HY_t	−1.055	0.205	−5.542**	0.251
y_t	−1.668	0.143	−3.656**	0.265
c_t	−0.332	0.229**	−4.828**	0.46
$EMBI_t$	−1.506	0.406	−6.857**	0.093

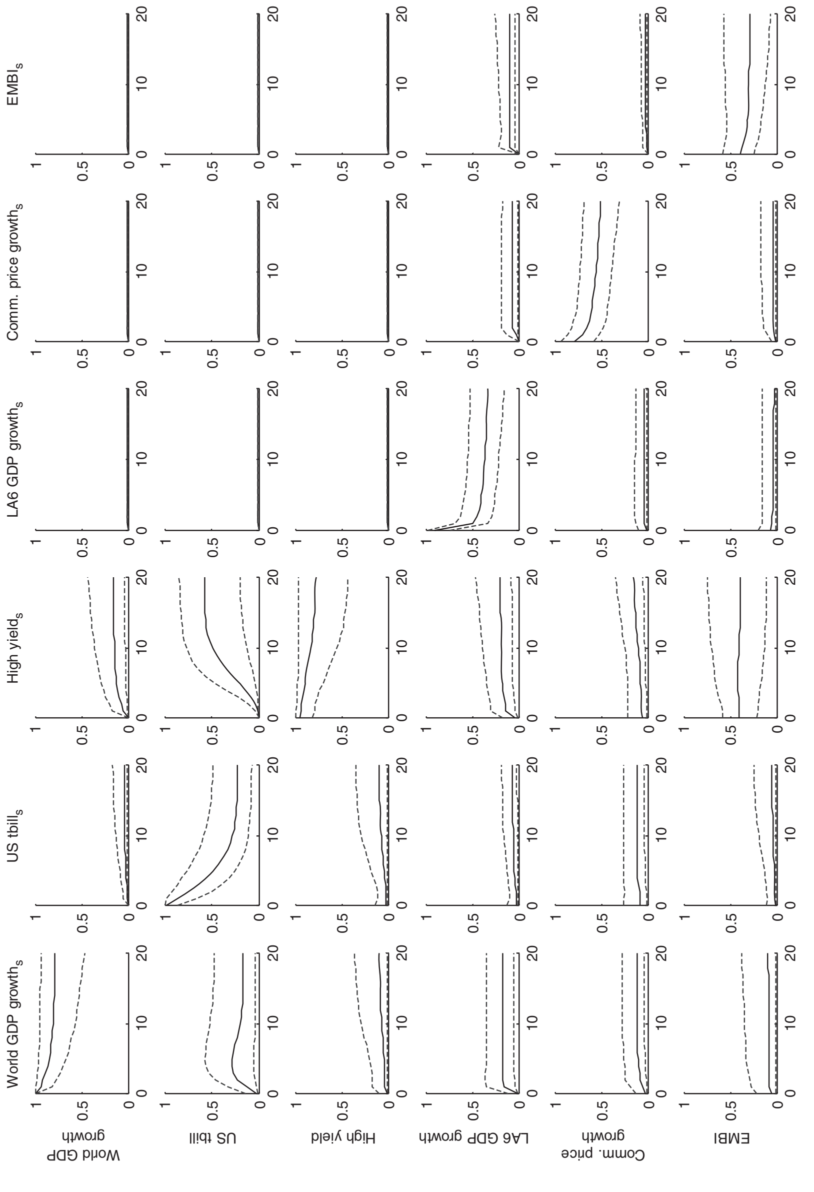
Source: Authors' estimations.
*Indicates rejection at the 5 percent level.
**Indicates rejection of the unit root null hypothesis at the 1 percent level.

Figure A1. Impulse Response Functions with Respect to One Standard Deviation Shocks
(In percent; shown over 20-quarter horizon)



Source: Authors' estimations.
Note: Shocks are in columns, responding variables are in rows.

Figure A2. Variance Decompositions
(Shown over 20-quarter horizon)



Source: Authors' estimations.
Note: Shocks are in columns, variables are in rows.

Table A2. LA6 Growth Forecasts Under Alternative Assumptions (Model Including World Growth)

(Year-on-year percentage changes unless otherwise noted)

Scenario and Variable	2007 Q1	2007 Q2	2007 Q3	2007 Q4	2008 Q1	2008 Q2	2008 Q3	2008 Q4	2007 Average	2008 Average
Quasi-unconditional forecast										
World GDP growth	2.8	3.0	**3.2**	*3.1*	*3.4*	*3.3*	*3.5*	*3.5*	*3.1*	*3.5*
U.S. Treasury bill rate (points)	5.1	4.9	**4.4**	*4.2*	*4.2*	*4.2*	*4.2*	*4.2*	*4.7*	*4.2*
U.S. high-yield bond spread (points)	3.0	2.9	**4.1**	*4.3*	*4.2*	*4.2*	*4.2*	*4.2*	*3.6*	*4.2*
Commodity price growth	5.4	3.5	**3.2**	*6.7*	*8.1*	*−3.6*	*−3.7*	*0.6*	*4.8*	*0.2*
Latin EMBI spread (points)	1.9	1.7	**2.3**	*2.0*	*2.3*	*2.4*	*2.4*	*2.4*	*2.0*	*2.4*
LA6 GDP	4.8	5.4	*4.6*	*4.9*	*4.9*	*4.7*	*4.4*	*4.3*	*5.0*	*4.7*
Baseline scenario										
World GDP growth	2.8	3.0	**3.2**	**3.0**	**3.1**	**2.8**	**2.7**	**2.8**	**3.1**	**2.9**
U.S. Treasury bill rate (points)	5.1	4.9	**4.4**	**4.2**	**4.2**	**4.2**	**4.3**	**4.4**	**4.7**	**4.3**
U.S. high-yield bond spread (points)	3.0	2.9	**4.1**	**4.2**	**4.2**	**4.0**	**3.8**	**3.6**	**3.6**	**3.9**
Commodity price growth	5.4	3.5	**3.2**	**7.2**	**8.9**	**−4.4**	**−6.3**	**−4.3**	**4.9**	**−1.6**
Latin EMBI spread (points)	1.9	1.7	**2.3**	*1.8*	*2.4*	*2.4*	*2.4*	*2.3*	*1.9*	*2.4*
LA6 GDP	4.8	5.4	*4.7*	*4.9*	*5.0*	*4.5*	*4.0*	*3.7*	*5.1*	*4.4*
U.S. recession and credit crunch (1) (with endogenous Latin EMBI)										
World GDP growth	2.8	3.0	**3.2**	**3.0**	**2.8**	**2.0**	**1.9**	**1.9**	**3.0**	**2.1**
U.S. Treasury bill rate (points)	5.1	4.9	**4.4**	**4.1**	**3.2**	**2.3**	**1.9**	**2.0**	**4.6**	**2.4**
U.S. high-yield bond spread (points)	3.0	2.9	**4.1**	**5.6**	**7.0**	**7.0**	**6.0**	**5.0**	**3.9**	**6.3**
Commodity price growth	5.4	3.5	**3.2**	*3.3*	*−4.2*	*−21.6*	*−21.2*	*−8.1*	*3.9*	*−12.9*
Latin EMBI spread (points)	1.9	1.7	**2.3**	*4.2*	*6.7*	*6.7*	*5.6*	*4.8*	*2.5*	*5.9*
LA6 GDP	4.8	5.4	*4.7*	*4.8*	*4.0*	*2.5*	*1.3*	*1.2*	*5.0*	*2.3*
U.S. recession and credit crunch (2) (assuming some decoupling of Latin EMBI)										
World GDP growth	2.8	3.0	**3.2**	**3.0**	**2.8**	**2.0**	**1.9**	**1.9**	**3.0**	**2.1**
U.S. Treasury bill rate (points)	5.1	4.9	**4.4**	**4.1**	**3.2**	**2.3**	**1.9**	**2.0**	**4.6**	**2.4**
U.S. high-yield bond spread (points)	3.0	2.9	**4.1**	**5.6**	**7.0**	**7.0**	**6.0**	**5.0**	**3.9**	**6.3**
Commodity price growth	5.4	3.5	**3.2**	*3.2*	*−4.7*	*−22.4*	*−22.1*	*−9.5*	*3.9*	*−13.7*

Table A2 ***(concluded)***

	2007				2008				2007	2008
Scenario and Variable	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Average	Average
Latin EMBI spread (points)	1.9	1.7	**2.3**	**3.0**	**3.7**	**3.7**	**3.2**	**2.7**	**2.2**	**3.4**
LA6 GDP	4.8	5.4	*4.7*	*4.8*	*4.4*	*3.5*	*2.5*	*2.4*	*5.0*	*3.2*
Commodity price decline without slowing external growth										
World GDP growth	2.8	3.0	**3.2**	**3.0**	**3.1**	**2.8**	**2.7**	**2.8**	**3.1**	**2.9**
U.S. Treasury bill rate (points)	5.1	4.9	**4.4**	**4.2**	**4.2**	**4.2**	**4.3**	**4.4**	**4.7**	**4.3**
U.S. high-yield bond spread (points)	3.0	2.9	**4.1**	**4.2**	**4.2**	**4.0**	**3.8**	**3.6**	**3.6**	**3.9**
Commodity price growth	5.4	3.5	**3.2**	**0.4**	**−3.9**	**−20.1**	**−20.5**	**−8.1**	**3.2**	**−12.5**
Latin EMBI spread (points)	1.9	1.7	**2.3**	*2.0*	*2.9*	*3.1*	*3.2*	*2.9*	*2.0*	*3.0*
LA6 GDP	4.8	5.4	*4.7*	*4.9*	*4.8*	*3.9*	*3.1*	*2.7*	*5.1*	*3.7*
Emerging market confidence shock without slowing external growth										
World GDP growth	2.8	3.0	**3.2**	**3.0**	**3.1**	**2.8**	**2.7**	**2.8**	**3.1**	**2.9**
U.S. Treasury bill rate (points)	5.1	4.9	**4.4**	**4.2**	**4.2**	**4.2**	**4.3**	**4.4**	**4.7**	**4.3**
U.S. high-yield bond spread (points)	3.0	2.9	**4.1**	*5.1*	*5.1*	*5.1*	*5.1*	*5.1*	**3.8**	**5.1**
Commodity price growth	5.4	3.5	**3.2**	**7.2**	**8.9**	**−4.4**	**−6.3**	**−4.3**	**4.9**	**−1.6**
Latin EMBI spread (points)	1.9	1.7	**2.3**	*4.3*	*4.2*	*4.3*	*4.5*	*4.5*	*2.6*	*4.4*
LA6 GDP	4.8	5.4	*4.7*	*4.7*	*4.1*	*3.5*	*2.8*	*2.5*	*5.0*	*3.3*
Memorandum										
U.S. GDP, baseline scenario	1.5	1.9	**2.2**	**2.0**	**2.3**	**1.8**	**1.7**	**2.0**	**1.9**	**1.9**
(quarter-on-quarter path)	0.15	0.94	**0.56**	**0.36**	**0.41**	**0.41**	**0.53**	**0.61**		
U.S. GDP, recession scenario	1.5	1.9	**2.1**	**1.7**	**1.5**	**0.5**	**0.3**	**0.8**	**1.8**	**0.8**
(quarter-on-quarter path)	0.15	0.94	**0.52**	**0.07**	**−0.03**	**−0.03**	**0.32**	**0.50**		

Source: Authors' estimations.

Note: Normal font denotes realizations; bold denotes conditioning paths (for example, from the WEO); and italic denotes model forecasts.

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