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The Effect of External Conditions on Growth in Latin America

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The Effect of External Conditions on Growth in Latin America

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Abstract

This paper investigates the sensitivity of Latin American GDP growth to external developments using a Bayesian VAR model with informative steady-state priors. The model is estimated on quarterly data from 1994 to 2006 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 U.S. or world growth, but sensitive to more extreme shocks, particularly a combined external slowdown and tightening of world financial conditions.

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Contents

I. INTRODUCTION

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 2006, the region grew at an average rate of over 5 percent, making this period the most vigorous three-year expansion since the late 1970s. What makes this expansion all the more remarkable is the absence of the usual signs of public or private overconsumption, which have tended to accompany similar expansions in the past. Inflation has been low and falling, and although imports and public spending are by now growing quickly, public debt has declined, and primary fiscal balances and external current accounts reached record surpluses in 2006.

Though improved macroeconomic policy frameworks no doubt deserve some credit (IMF, 2006a), Latin America watchers are quick to point to 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.[2] This leads to the main question 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?

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, Adolfson *et al*., 2005, and Villani, 2005). 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 variance of the growth rate of an aggregate

[2] See, for example, Talvi (2006, 2007) and Calvo and Talvi (2007).

Latin American output index at standard medium term horizons (depending on the model, the number varies between 50 and 60 percent). 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 or U.S. growth shock on Latin America is roughly one-for-one over time. One-standard-deviation shocks for commodity prices and the Latin EMBI—namely, changes of about 5 percent and 115 basis points, respectively, within one quarter—are estimated to lead to a change in Latin American growth of around 0.4 to 0.5 percentage point. The effect of a standard deviation shock in the U.S. high-yield bond spread (90 basis points) is estimated to be even higher (0.9 percentage point).

- Notwithstanding these relatively large effects, conditional forecast exercises suggest that Latin American growth would be fairly resilient to plausible risks to the external environment—see, for example, the IMF's April 2007 *World Economic Outlook*—including a moderate slowing of U.S. and world growth, and a decline in commodity export prices of around 20 percent. The reason is that even with such moderate shocks, Latin America's external environment would still remain relatively favorable. A significant slowing of Latin American growth would require a stronger set of shocks—such as a combined world growth slowdown and much higher financing premia—which appear unlikely, at least for now.

Importantly, these results reflect the average behavior of Latin American economies over the 1994-2006 sample period. In the meantime, many Latin American economies have undergone structural changes—most dramatically, a large reduction in currency mismatches. Consequently, the result of our model may overstate Latin America's current vulnerability to external shocks, particularly external financing shocks.

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), Izquierdo, Romero and Talvi (2007), and IMF (2007, Chapter 4) for some recent contributions; and Roache (2007) for a survey. We differ in three respects: first, in using a novel methodology, as described above and in more detail in section 2; second, in that we simultaneously analyze the effects of financial, commodity price, and external growth shocks;[3] and third, in using conditional forecasts to illustrate the impact of a variety of external risks on the Latin American outlook.

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[3] With the notable exception of Izquierdo, Romero and Talvi (2007), the literature tends to look at subsets of these shocks, focusing mostly on U.S. growth and monetary policy shocks.

In Section 2, we present the model, discussing first the methodological framework and then its empirical implementation, including the assumed steady state priors. Section 3 evaluates the model in the usual way, showing impulse responses and variance decomposition, and comparing its out of sample forecasting performance with those of other, more traditional approaches. Finally, in Section 4 we use the model to forecast based on current (end-2006) information. We begin with a set of unconditional forecasts and then study a variety of "scenarios" by conditioning the forecast on assumptions about the path of external variables.

II. The Model

A. Methodology

While 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, since 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 Bayesian VAR approach with an "informative prior" on the steady state of the process.

To see the benefits of this approach, consider first the standard Bayesian VAR model

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

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 $\boldsymbol{\eta}_t$ is an nx1 vector of *iid* error terms fulfilling $E(\boldsymbol{\eta}_t) = \mathbf{0}$ and $E(\boldsymbol{\eta}_t \boldsymbol{\eta}_t') = \boldsymbol{\Sigma}$. 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 non-informative 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—while non-linear 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 $\boldsymbol{\Sigma}$ is given by $p(\boldsymbol{\Sigma}) \propto |\boldsymbol{\Sigma}|^{-(n+1)/2}$, the prior on $vec(\mathbf{G})$—where $\mathbf{G} = (\mathbf{G}_1 \quad \ldots \quad \mathbf{G}_p)'$—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 non-informative, while 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.[4]

B. 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 main specification of the model, these factors are proxied by world GDP growth, a trade-weighted index of commodity prices that are relevant for Latin America, U.S. treasury bill rates and the high-yield corporate bond spread in the United States to capture investor risk aversion.[5] In another version, focused on linkages between the U.S. and Latin America, we replaced world growth by U.S. growth and inflation. 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.[6] In addition, the model included the Latin America subcomponent of JP Morgan's emerging market bond index, which is influenced both by external financing conditions and domestic fundamentals in Latin America.[7] Hence, either:

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

or

$$\mathbf{x}_t = (\Delta y_t^{US} \quad \pi_t^{US} \quad i_t^{US} \quad HY_t \quad \Delta y_t \quad \Delta c_t \quad EMBI_t)' \tag{4}$$

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

[5] Using the Chicago Board of Trade "Volatility Index" (VIX), yields very similar results to the high-yield corporate bond spread. Results are not reported but are available upon request.

[6] 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. In Figure A3 in the Appendix we report some results from applying our model to the individual countries making up the LA6 index.

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

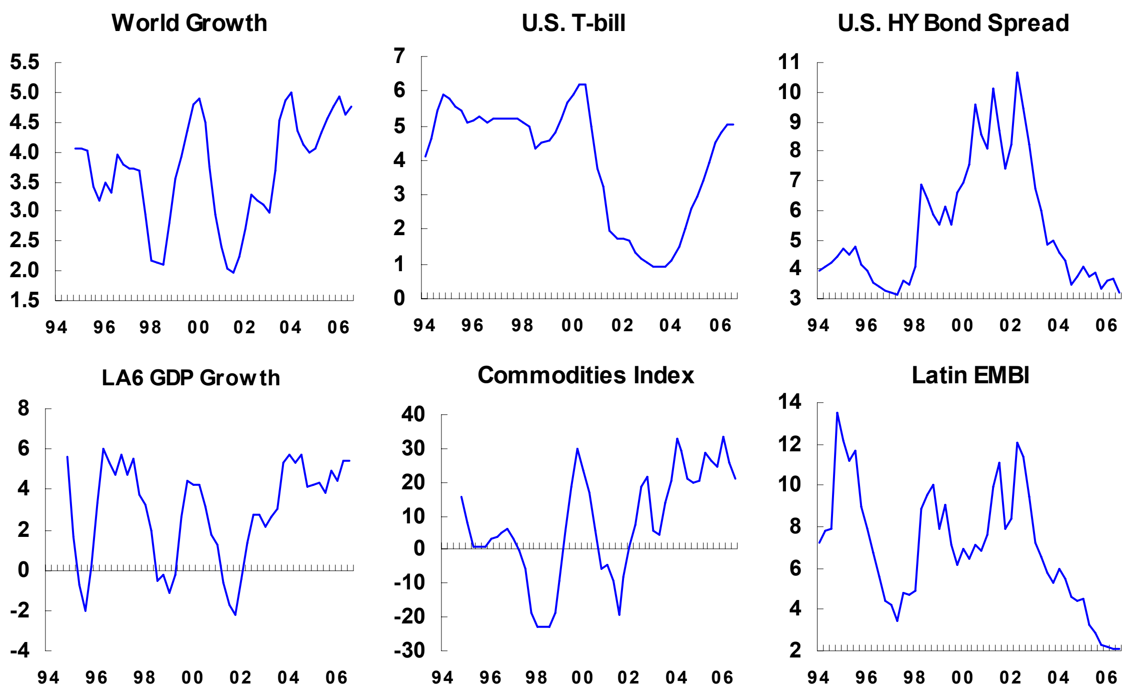
where y_t^{world} is the logarithm of world GDP (excluding Latin America) in fixed prices, y_t^{US} is the logarithm of U.S. GDP, π_t^{US} is U.S. CPI inflation, i_t^{US} is the three-month treasury bill rate, HY_t is the high-yield corporate bond spread in the United States, y_t the logarithm of aggregate real GDP for the LA6 countries, c_t a (net) export commodity price index for these countries, and $EMBI_t$ is the JP Morgan emerging market bond index spread for Latin America.[8]

The world or US variables in the two models are treated as block exogenous with respect to the Latin American variables.[9] The models were estimated on quarterly data, from 1994Q2 to 2006Q4, after defining prior distributions for both the $vec(\mathbf{G})$ and $vec(\boldsymbol{\psi})$ parameter vectors. Figure 1 shows our data (see Appendix for sources).

[8] We tested for unit roots using the Augmented Dickey-Fuller (ADF) test (Said and Dickey, 1984) and KPSS test (Kwiatkowski *et al*., 1992); see Table A1 in the Appendix. For log world GDP and 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 (or US) GDP and—for consistency with our treatment of world/US GDP— Latin American GDP in first differences. The remaining variables are modeled in levels.

[9] 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}, y_t^{US}, π_t^{US}, i_t^{US} and HY_t to zero; see Villani and Warne (2003), Intuitively, this modeling approach amounts to imposing a tight prior distribution centered on zero for the parameters in question. This is somewhat less restrictive than imposing exogeneity directly, since it would allow an estimated nonzero posterior in the event that the data strongly disagree with our prior.

Figure 1. Data



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

Slightly modified "Minnesota priors" (Litterman, 1986) were used for the dynamic coefficients, $vec(\mathbf{G})$. 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, Appendix), 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 the another variable in the system—were also set to zero. 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.

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

- Priors for world and U.S. GDP growth were based on medium-term projections from the IMF's *World Economic Outlook.*

- Steady state priors for the U.S. T-Bill rate and CPI inflation followed standard conventions. The choice of prior for the US 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 also is assumed to be approximately two percent. These values are in line with the numbers in Taylor (1993) and Clarida *et al*. (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 (2005), and Zettelmeyer (2006) for a survey.

- For the U.S. high yield bond and EMBI spreads, we did not have strong guidance from either theory or the literature. We defined relatively wide distributions in line with the observed behavior of the variable 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 one percent and is not particularly wide despite the historically high variability of commodity prices.

The table shows that posterior and prior distributions are generally close, indicating that the assumed prior intervals were judged reasonable by the data. We also confirmed that the short run *dynamics* of the model were not affected by the steady-state priors chosen.[10] Hence, the assumed steady state priors do not prejudge the model's short-run forecasts.

Table 1. Steady State Prior and Posterior Distributions

	prior 1/	posterior 2/
World growth	(3.75, 4.75)	(3.4, 4.1)
U.S. growth	(2.0, 4.0)	(2.8, 3.9)
U.S. inflation	(1.0, 3.0)	(2.0, 2.8)
U.S. T-Bill rate	(3.0, 5.0)	(3.5, 5.0)
U.S. HY spread	(3.0, 6.0)	(3.8, 5.9)
Commodity prices	(-2.0, 4.0)	(-1.4, 4.4)
LA6 growth	(3.5, 5.0)	(3.4, 4.8)
Latin EMBI spread	(2.0, 5.0)	(2.1, 4.9)

1/ Probability intervals refer to a normal distribution.
2/ Except for U.S. growth and U.S. inflation, posterior estimates are based on model including world growth.

[10] Non-informative priors on the constant $\boldsymbol{\mu}$, which allow the data to influence the steady state parameters to a larger extent, produced qualitatively similar results.

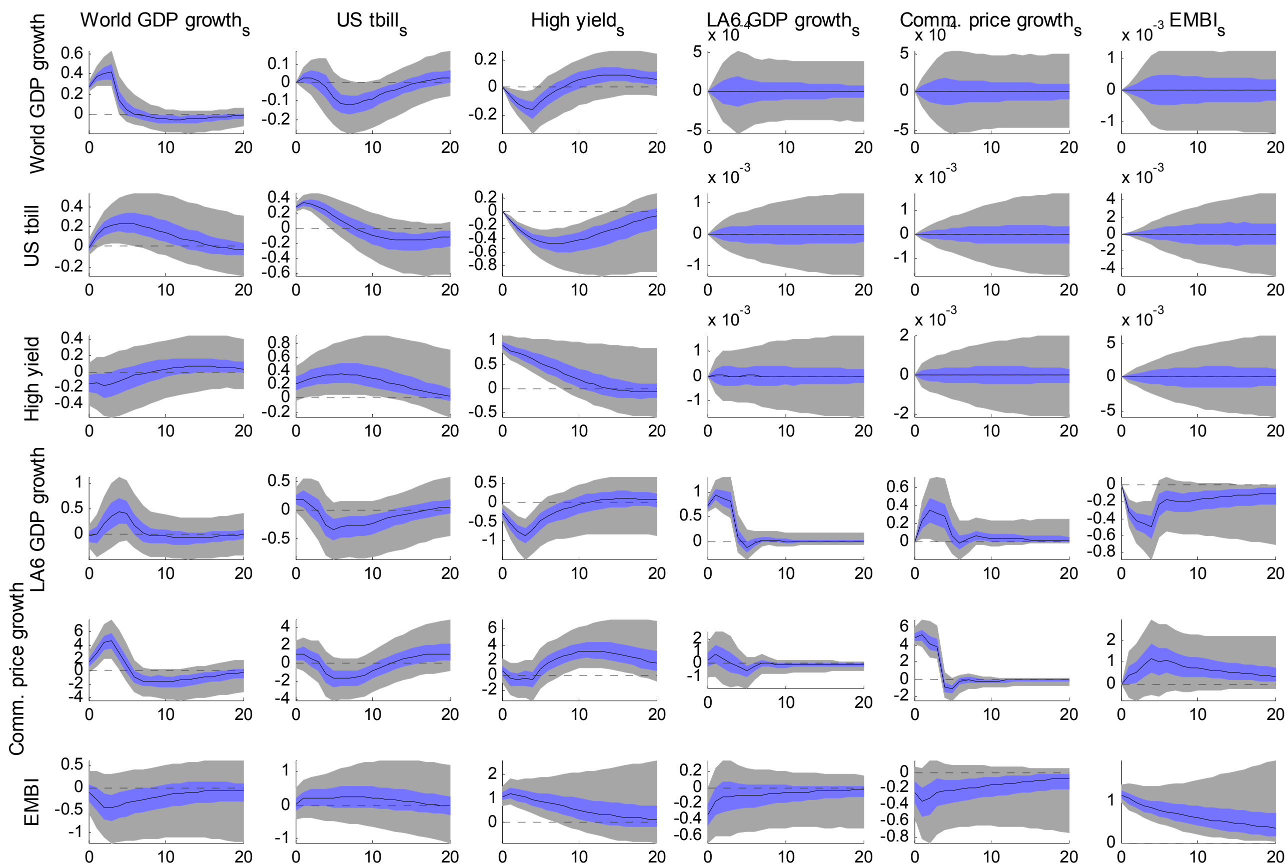
III. Results

A. 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 (or U.S. 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 (or only U.S. GDP shocks and U.S. inflation, in the second version of the model); and so on.

Figure 2 shows the impulse response functions that are generated for the model in equation (3) based on this recursive structure and the estimated parameters (see the Appendix for the results for the second model, that is, equation (4), as well as results for individual countries). As usual, the rows show the response of each variable to a standard deviation shock to the variable described in the column heading. Note that the nine impulse response functions in the upper right quadrant are flat, reflecting block exogeneity of world/U.S. variables (that is, no feedback effects from Latin America-specific variables to world growth and U.S. financial conditions). The magnitude of standard deviation shocks is as follows: about 0.28 percentage point for world growth, 27 basis points for U.S. T-bill rates, 90 basis points for the U.S. high yield bond spread, 5 percent for commodity prices, and 115 basis points for the Latin EMBI.

Figure 2. Impulse Response Functions from Mean-Adjusted Bayesian VAR, 1994Q2–2006Q4



Note: Impulse response functions are plotted for horizons one to twenty quarters. Colored bands are 50 and 90 percent confidence bands.

Before examining the dynamic behavior of Latin American growth, one can check the impulse responses of the world/U.S. variables to obtain some reassurance that the independent shocks have a sensible economic interpretation. A world growth shock leads to an increase in U.S. short term interest rates over two to three quarters (this effect is even stronger in the second version of the model, see Appendix) and a decline in high yield bond spreads. In the second version of the model, it is also shown to lead to an increase in inflation; hence, world growth shocks seem to reflect aggregate demand shocks. A U.S. interest rate hike leads to lower world/U.S. growth after four to six quarters, as well as to an immediate jump in the high yield bond spread. A shock to the latter, finally, 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 EMBI, of about the same magnitude as the high yield bond spread shock itself.

Consider now the estimated effect of external shocks on Latin American growth, as follows:

- Increases in world growth are passed on to Latin America about one-for-one: a 0.3 percent world growth shock leads to an increase in (four-quarter) Latin American growth by about 0.4 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 0.4 (though it gets there faster, see Figure 1).

- The reaction of Latin American growth to U.S. interest rates is more muted. It has the expected sign after about three to four quarters (with a hike leading to a reduction in growth) but the effect is small and barely statistically significant.

- In contrast, a standard deviation (90-basis-point), 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 0.9 percentage point after three quarters. Note that the U.S. high yield bond spread also appears to have strong effects on the Latin 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.

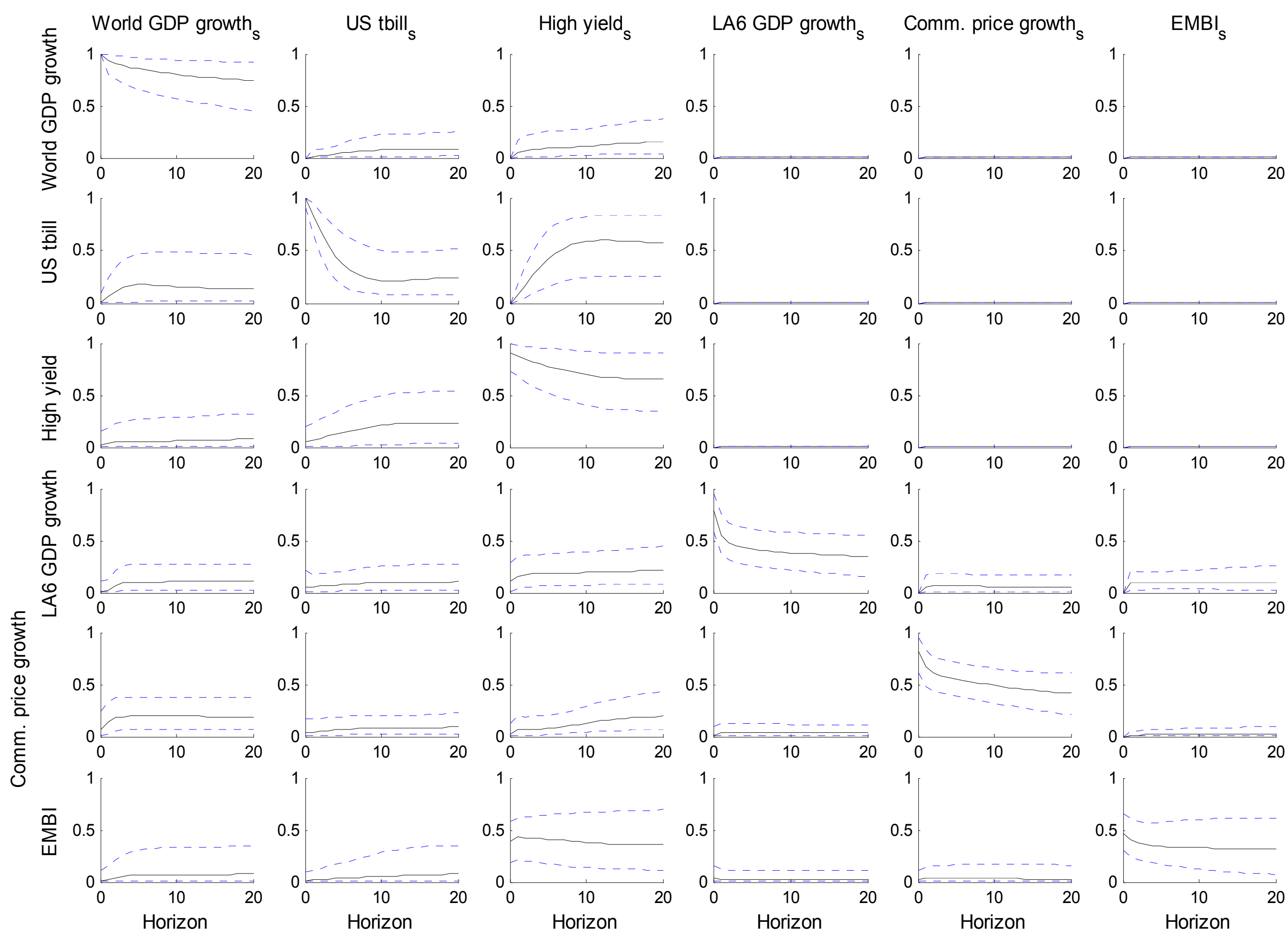
- A standard deviation commodity shock—which in this sample is a change of almost 5 percent in a quarter, illustrating how volatile Latin American commodity prices have been—leads to a change in four-quarter Latin American growth of about ⅓ percentage point after two quarters.

- Finally, a 115-basis point rise in the Latin EMBI is associated with a drop in four-quarter growth by 0.5 percent after four quarters.

The alternative model, which includes U.S. growth and inflation instead of world growth, has very similar effects for the commodities and EMBI shocks, while the reaction to a shock to the U.S. high yield bond spread is slightly more muted, with LA6 growth decreasing by about 0.8 percentage point after three quarters (see Figure A1, Appendix). (A possible reason is that in the model with world growth, the U.S. high yield bond spread might be picking up some of the effect of U.S. growth shocks on the region). U.S. growth shocks—which have standard deviation of around 0.5 percentage points as U.S. growth is more volatile than world growth—appear to lead to a faster and slightly larger reaction than world growth shocks; this is also more precisely estimated in the sense that the standard error bands are tighter. A standard deviation U.S. growth shock results in an increase of four-quarter Latin American growth by about 0.6 points. Since the U.S. growth shock leads to a total increase in U.S. growth of about 0.55 percentage point after three quarters, this implies that the overall average reaction of Latin American growth to U.S. growth is again about one-for-one.

Figure 3 shows the variance decompositions for the model using world GDP growth. The fourth row implies that more than half of the medium-term (10-20 quarter horizon) variance of Latin American GDP growth is explained by external factors: approximately 12 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).[11]

Figure 3. Variance Decompositions from Mean-Adjusted Bayesian VAR, 1994Q2–2006Q4



[11] If the model with U.S. growth and inflation is used (see Appendix, Figure A2), the influence of external factors rises to about 57 percent. 16 percent corresponds to U.S. growth and 5 percent to commodity prices, while U.S. financial conditions account for 27 percent of the variance in this model; the latter rises to 36 percent if the contribution of U.S. inflation is included in this category.

B. 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 without priors on the steady state values, and a classical (non-Bayesian) VAR.[12] In addition, we compared the model's out-of-sample forecasts to forecasts published by the IMF's *World Economic Outlook* (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 to 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 1994Q2 to 1999Q4. Using these estimates, we generate forecasts to 2002Q4, that is, for all quarterly horizons *h* between one and twelve. We then extend that sample one period, re-estimate the models and generate new forecasts twelve periods ahead and so on. Once the estimation sample reaches 2003Q4, we forecast over consecutively shorter periods, since the actual data that we need to compare the forecasts with ends in 2006Q4. The last evaluation is conducted on models estimated from 1994Q2 to 2006Q3 and forecast only one period ahead. This yields $N_{12} = 16$ forecasts at the twelve quarter horizon, $N_{11} = 17$ forecasts at the eleven quarter horizon, etc., and $N_1 = 27$ 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

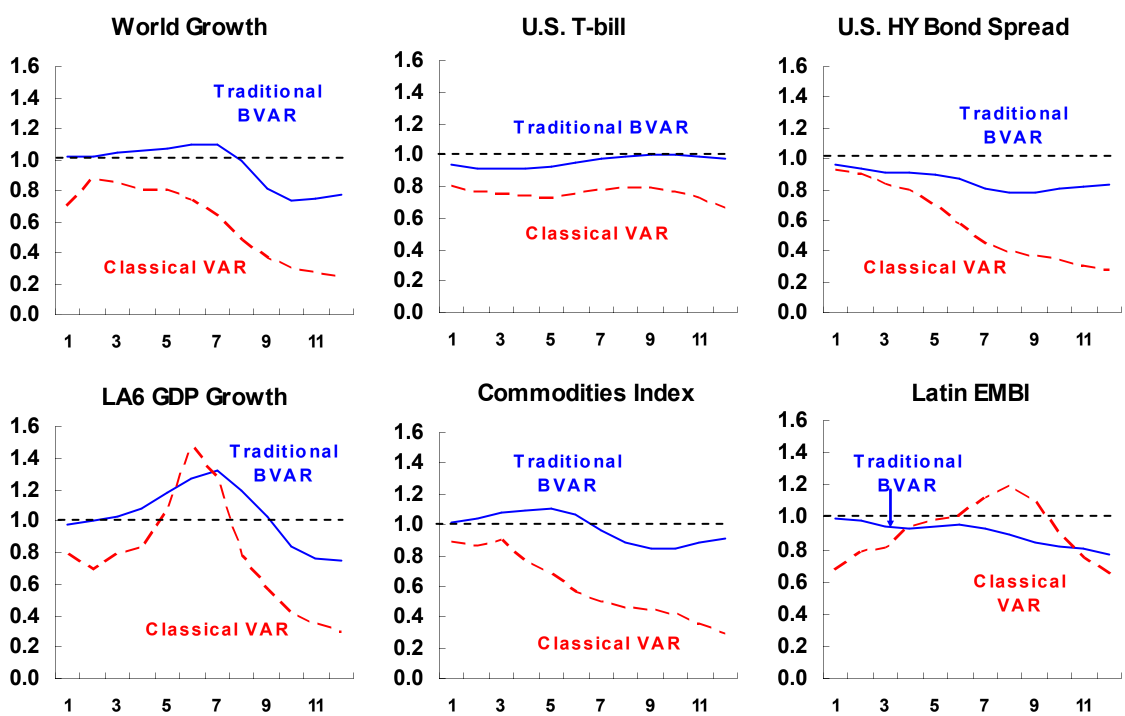
[12] The classical VAR is estimated using OLS. In this case, since no restrictions have been imposed on the model, OLS is equivalent to maximum likelihood.

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

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 one to twelve for all variables in the system and both alternative models.[13] A number of less than one indicates that our model outperforms the alternatives at a particular forecasting horizon. Furthermore, a higher value for "traditional BVAR" compared to "classical VAR" means that the traditional BVAR does better than the classical VAR.

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



Source: Authors' calculations.

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

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

traditional BVAR. For three out of six variables, it produces smaller root mean squared errors at all horizons. In the other three cases—forecasts for world growth, LA6 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 reflects the role of steady-state priors, which help to make forecasts converge to a sensible level.

We next compare the forecasting performance of the mean-adjusted BVAR model with the IMF's WEO forecasts published by the International Monetary Fund (Table 2). Following the WEO, we focus the comparison on forecasts of annual 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, while 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, since these are typically influenced by news in the first and third quarters, respectively, while 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 or seven that we use in our models.)

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 is also used to estimate the model; while 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.[14]

As in the previous comparison, the forecasts shown in Table 2 can be used to estimate root mean squared errors. Since we are limiting the comparison to 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 RMSE is 1.1 percentage points for the WEO and 1.4 for the model. Hence, at this horizon, the WEO provides the more accurate forecast. At the two year horizon, this result is reversed: the WEO RMSE is 2.6, while the model RMSE is only 2.1. Hence, the vastly richer informational basis of the WEO forecasts appears to be an advantage only in the short run.[15] These findings are in

[14] 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).

[15] When the WEO forecasts are compared with the final data rather than the "real time" data, the WEO still outperforms the model at (and only at) the one year horizon, albeit by a smaller margin.

line with other studies arguing that the benefits of more judgmental procedures largely can be found at the shorter horizons; see, for example, Lawrence *et al*. (1986) and McNees (1990).

Table 2. LA6 GDP Growth: Comparison of model-based and WEO forecasts
(in percent)

	2000	2001	2002	2003	2004	2005	2006
Actuals							
based on Spring WEO of year after forecast	4.3	0.4	0.3	2.0	5.4	4.1	5.2
based on model data	4.0	0.2	0.4	2.7	5.6	4.2	5.1
Forecasts of:							
Spring 2000 WEO	4.1	4.9					
Model; data through 1999Q4	4.5	3.8					
Fall 2000 WEO	4.4	4.6					
Model; data through 2000Q2	3.1	2.0					
Spring 2001 WEO		3.7	4.5				
Model; data through 2000Q4		0.9	1.8				
Fall 2001 WEO		1.4	3.6				
Model; data through 2001Q2		1.8	4.3				
Spring 2002 WEO			0.6	3.9			
Model; data through 2001Q4			-3.9	3.1			
Fall 2002 WEO			-0.5	3.0			
Model; data through 2002 Q2			0.8	5.0			
Spring 2003 WEO				2.7	3.8		
Model; data through 2002Q4				3.4	3.3		
Fall 2003 WEO				2.2	3.4		
Model; data through 2003 Q2				2.5	5.4		
Spring 2004 WEO					3.8	3.7	
Model; data through 2003Q4					7.2	6.0	
Fall 2004 WEO					4.5	3.6	
Model; data through 2004 Q2					5.9	5.9	
Spring 2005 WEO						4.2	3.6
Model; data through 2004Q4						5.6	4.1
Fall 2005 WEO						4.0	3.8
Model; data through 2005 Q2						4.5	4.7
Spring 2006 WEO							4.3
Model; data through 2005Q4							4.8
Fall 2006 WEO							4.6
Model; data through 2006 Q2							4.9

It is also instructive to examine some of the specific forecast errors underlying these results. In the table, cell borders have been drawn around instances in which the there were large discrepancies between the model based and WEO forecasts. The unshaded cells contain cases in which the model significantly outperformed the WEO. All of these have to do with turning points. The model did much better than the WEO in picking up the slowing of Latin American growth in 2001, based only on data through mid 2000. Similarly, the model correctly predicted the strength of the 2004 recovery based on information through mid 2003. The WEO missed these turning points, predicting solid growth for 2001 in the Fall of 2000 and even in the Spring of 2001, while underestimating the strength of the 2004 rebound. However, the model has sometimes tended to extrapolate trends immediately following turning points, predicting an excessive collapse for 2002 and an excessive recovery for 2004 based on end-2001 and end-2003 information, respectively (see shaded cells). In these cases, the model appears to have reacted too sensitively to changes in the short run dynamics. These errors are avoided by the more sluggish WEO forecasts, leading to better forecasting performance in the very short run.

C. Conditional Forecasts and Scenario Analysis

In addition to producing unconditional (or "endogenous") forecasts, 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.[16] 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 rich 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 the endogenous variables are created randomly, while the

[16] 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).

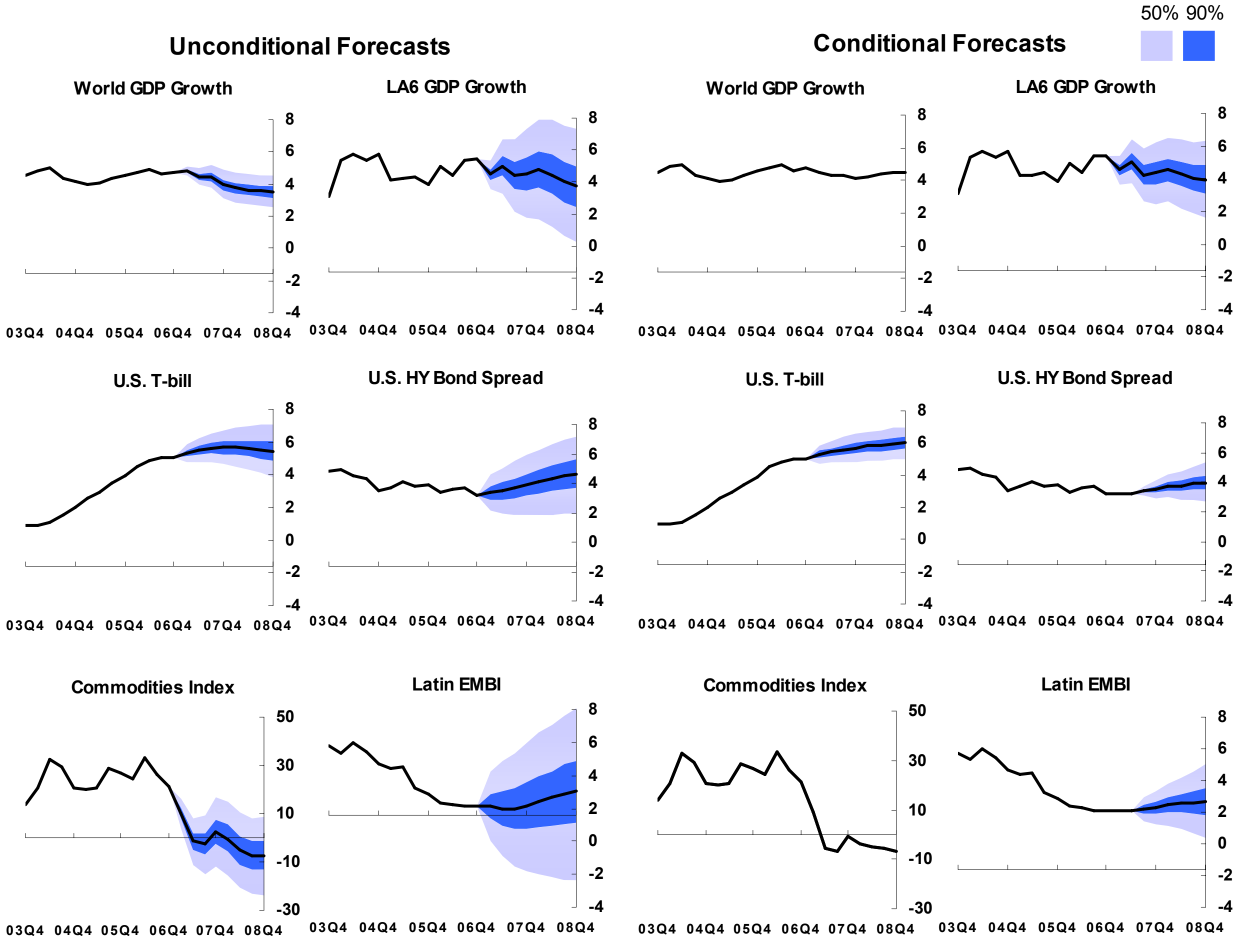
orthogonal shocks of the conditioning variables are implied by the assumed conditioning path. For a given set of randomly generated orthogonal shocks of the endogenous variables and a given path of the conditioning variables, the implicit orthogonal shocks of the conditioning variables and the forecasts for the endogenous variables are generated sequentially, one horizon at a time.

Figure 5 shows the unconditional forecast of the model, based on data through the end of 2006, as well as a "baseline" conditional forecast based on three assumptions: the world growth path projected by the April 2007 *World Economic Outlook*; a path for commodity prices, also based on the April 2007 WEO; and, finally, an assumption that favorable world liquidity conditions will persist in the very short run, made by imposing flat paths for the U.S. high yield bond spread and the Latin EMBI for two quarter after the end of the sample. 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 very close to the endogenous forecasts for the respective variables. This implies, not surprisingly, that the annual average projections for LA6 growth are virtually the same in both forecasts (4.6 for 2007, and 4.2 for 2008). Hence, in this case the conditioning assumptions do not change much, except that they lead to much tighter probability fans around the forecasts.

Both conditional and unconditional projections based on the model with world growth are also very close to the Spring 2007 WEO projection for the LA6, namely, 4.8 and 4.3 percent, respectively. In contrast, the model based on U.S. growth only delivers significantly lower forecasts, in the order of 3.8 percent for 2007 and 3.5 for 2008. This is not surprising, since in this model the only source of external demand is the U.S., which is growing at a comparatively slow pace, while world growth is projected to remain vigorous (according to both the endogenous forecast of the model with world growth, and the WEO).

We next examine how the baseline forecast is affected by a number of scenarios, which represent particular risks to the external environment that are suspected to have an impact on Latin American growth. These broadly follow the risks to the outlook described in the Spring 2007 issue of the WEO.

Figure 5. Unconditional vs. Conditional Forecasts, Mean-Adjusted BVAR Model

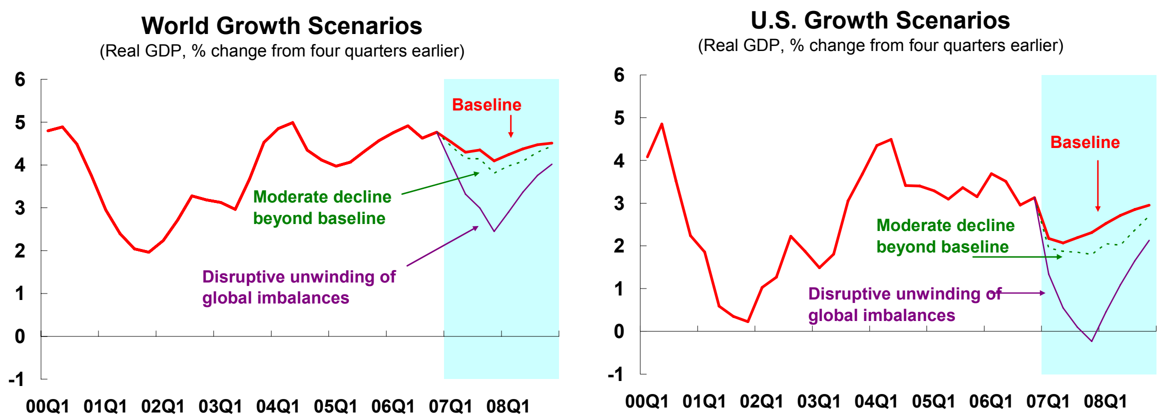


Source: Authors' calculations.

A moderate downturn in external growth

A moderate downturn in world growth is conceivable for a variety of reasons, of which spillovers from a larger than expected slowing of the U.S. economy—driven by the cooling housing market—have received most attention. The April 2007 issue of the WEO (Chapter 4) examined this scenario, and found the effects on world growth to be minor (Figure 6, left chart). Hence, not surprisingly, the impact of such a shock on Latin American growth would be very minor as well—in fact, it is hardly noticeable in the left chart of Figure 7, which shows the reaction of LA6 growth to the moderately lower paths of external growth depicted by the dotted lines in Figure 6.

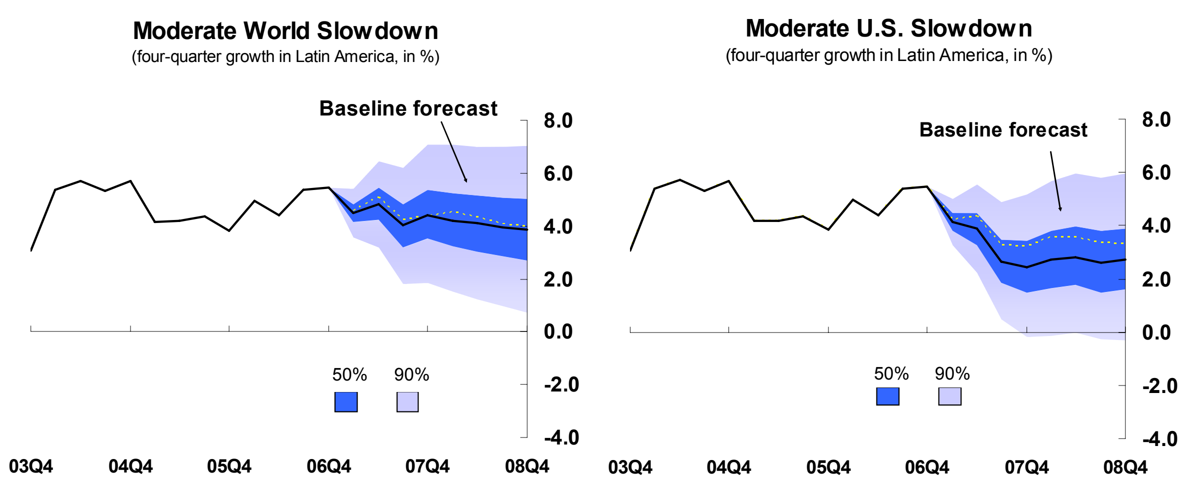
Figure 6. World and U.S. Growth Paths



Sources: WEO, and authors' calculations.

This result could be misleading, however, if the cause of the moderate slowdown in world growth is a slowdown in the U.S.. The latter could have direct effects on Latin America—given close trade and financing ties—that are larger than its impact via world growth. Furthermore, the size of the U.S. shock is of course larger than the reaction of world growth to this shock. To investigate the impact of a moderate U.S. slowdown on Latin America more directly, we hence looked at the conditional forecast for LA6 growth in the variant of the model that includes U.S. growth and inflation, conditioning on the U.S. slowdown that we think of as triggering the minor decline in world growth shown in Figure 6. As expected, the impact on Latin America is substantially larger—see Figure 7, right chart—but remains contained, with around 0.5 lower average growth relative to baseline in 2007 and about 0.7 lower growth in 2008.

Figure 7. Effect of a Moderate External Slowdown

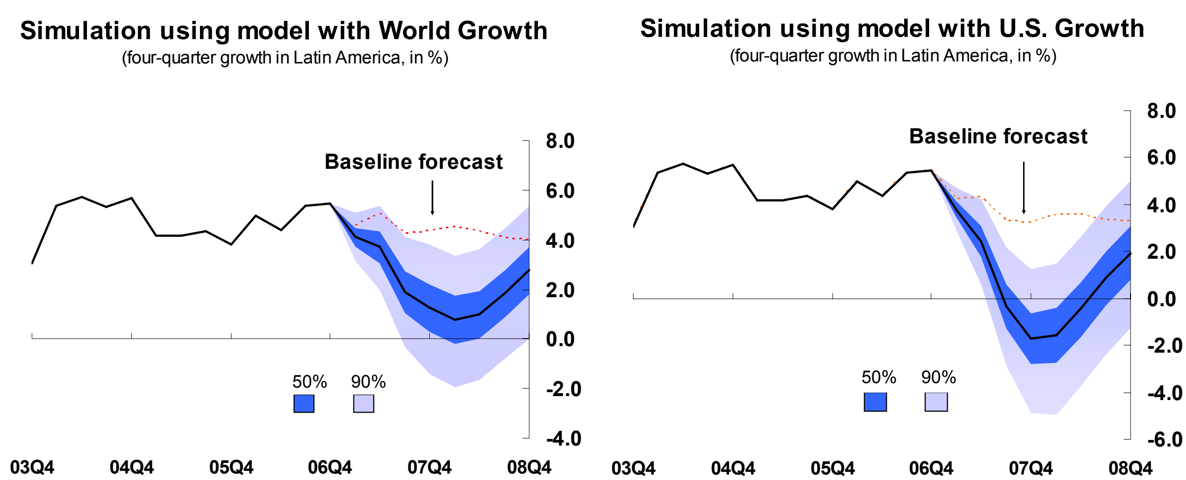


A disruptive unwinding of global imbalances

"Global imbalances"—in essence, the large U.S. current account deficit offset by large current account surpluses in Asia—have been a source of concern for some time now. If these imbalances were to unwind suddenly, in the form of a sudden reduction in the demand for U.S. financial assets and sharply lower U.S. asset prices—this could severely disrupt both the U.S. and the global economy. In our model, we capture this shock through a 400 basis point jump in the U.S. high yield bond spread—and much lower external growth. Following IMF simulations (Box 1.3 in IMF, 2006b) we assumed that U.S. growth would decline to 1 percent for two years, triggering a milder, albeit still sharp, decline in world growth (see Figure 6).

Figure 8 shows that the impact of this shock would indeed be very severe for Latin America. In the model featuring world growth, Latin American four-quarter growth would be predicted to fall to less than 1 percent by early 2008, with average annual growth falling to about 2¾ percent in 2007 and 1½ percent in 2008 (left chart). In the model featuring U.S. growth, the fall is even larger, with four-quarter growth turning sharply negative after about 4 quarters, and average annual growth falling to about one percent in 2007 and about zero in 2008.

Figure 8. Combined Effect of a Large External Growth and Financing Shock Caused by a "Disruptive Unwinding of Global Imbalances"

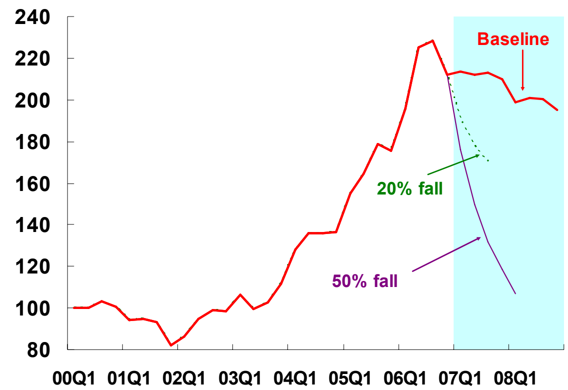


The impulse response functions (see Figure 2 for the world growth model and Appendix, Figure A1 for the U.S. growth model) give a good sense of why these effects are so large. In essence, a disorderly unwinding of global imbalances would expose Latin America to combined external demand and financing shocks. In addition to declining exports, the sharp rise in maturity and risk premia in U.S. bond markets would spill over to much higher borrowing costs for emerging markets, as exemplified by the impact of shocks to the high yield corporate bond spread on the Latin EMBI in Figure 2.

Declines in nonfuel commodity prices

Both the endogenous forecast and the WEO-based baseline projection for the Latin American commodity price index already envisage a moderate price decline during 2007 and 2008 (Figure 9). The question is how Latin American growth would react if nonfuel commodity prices experienced a larger fall, for example, say, to end-2005 levels (approximately 20 percent below end-2006 levels, in terms of the LA6 net commodity export index used to estimate the model) or end-2003 levels (an approximately 50 percent decline relative to end-2006, undoing the sharp rise in prices from which Latin America has benefited over the course of the most recent expansion). To focus on the effect of commodity price corrections, both scenarios retained the baseline world growth path, while the remaining variables were allowed to adjust endogenously.[17]

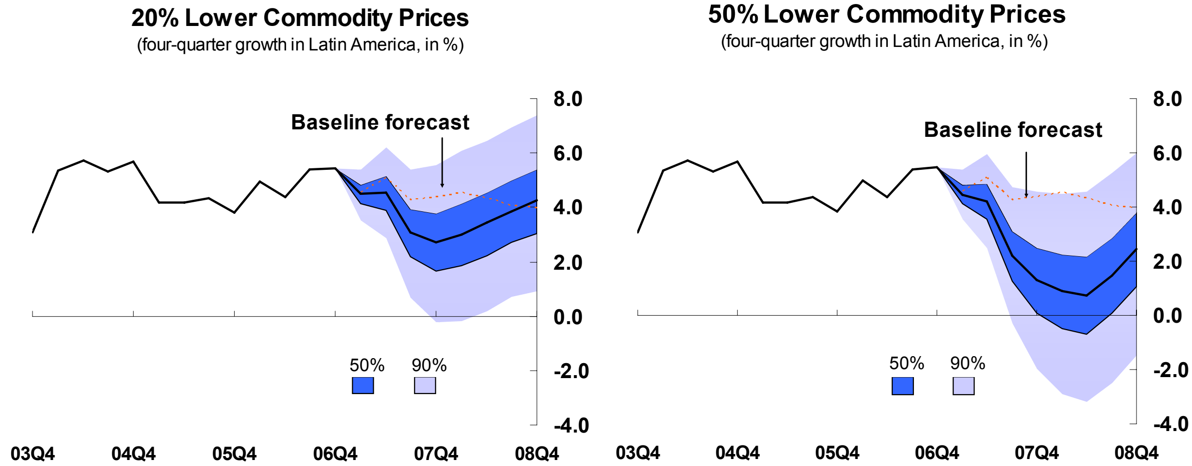
Figure 9. Commodity Index
(2000Q1 = 100)



The model predicts that a 20 percent fall in commodities prices in early 2007 would lead to noticeably lower, but still robust, growth in Latin America (about 3½–3¾ percent on average in 2007 and 2008, see Figure 10). In contrast, a 50 percent decline would lead to a severe slowdown, of almost the same magnitude as caused by a disruptive unwinding in global imbalances. Four-quarter growth would fall to around ¾ percent by mid-2008, while average growth would decline to 3 percent in 2007 and about 1¼ percent in 2008. This mainly reflects the direct effect of net commodity export income on the economy, but also indirect effects through less favorable financing conditions, via EMBI spreads. The latter could reflect the impact of sharply lower terms of trade both on the trade balance—a 50 percent commodity shock would imply that trade surpluses would be erased, removing one important element that currently provides comfort to external investors in Latin America—and on the fiscal accounts, by significantly reducing primary surpluses (IMF, 2006a).

[17] In this and the next subsection, we present results from "world growth model" only, as the results from the model that includes U.S. growth are very similar.

Figure 10. Effect of Declines in Commodity Prices

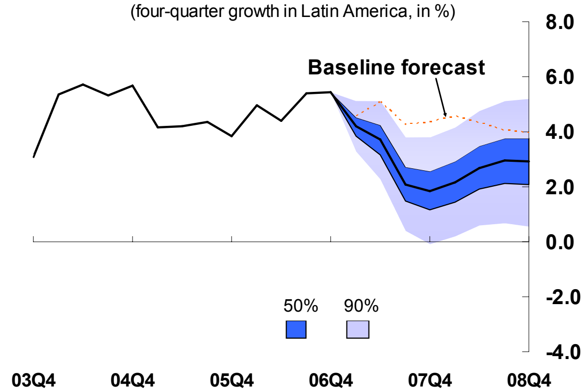


An emerging market financing shock

Finally, a scenario illustrating much tighter emerging market financing conditions was considered, in the form of a 400-basis-point shock to the Latin EMBI spread and a 200-basis-point increase in the U.S. high-yield bond spread—close to the changes in these variables during one of the major "sudden stop" events of the 1990s. Unlike a disruptive adjustment in global imbalances, this financing shock was not assumed to impact industrial country growth. Hence, the scenario isolates the effects of a "pure" emerging market financing shock from a global crisis involving a growth decline in all major regions.

The model suggests that a financing shock would significantly reduce growth in Latin America, but by less than either a global crisis or a 50 percent drop in commodity prices. On an annual basis, the model predicts growth to drop to just under 3 percent in 2007 and to about 2¾ in 2008 (Figure 11). In practice, this is likely to overestimate the average impact of a financing shock on LA6 growth, as it is based on the reaction of the LA6 to the EMBI during the 1994–2006 period, in which these countries for the most part suffered from higher macroeconomic vulnerability than they do today.

Figure 11. Effect of Emerging Market Financing Shock
(four-quarter growth in Latin America, in %)



IV. Conclusions

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 also outperforms WEO forecasts at the 2 year/next year horizon, though not at the 1 year/same year horizon. Using impulse responses and conditional forecasts, we evaluated the sensitivity of Latin American growth to a variety of shocks, including a moderate slowdown in the United States, commodity price shocks of various magnitudes, a combined slowdown in global growth and sharp tightening of financial conditions (interpreted as a "disruptive unwinding of global imbalances") and an emerging market financing shock.

The basic sense of these exercises is that Latin America would be fairly robust to the moderate—and hence more likely—external shocks considered, such as a moderately larger-than-expected slowdown in the U.S, and a 20 percent reduction in commodity prices. It is possible to construct more extreme scenarios that would have a very large impact, such as a sudden unwinding of global imbalances leading to much lower U.S. and/or world growth, combined with much higher term and risk premia. For the moment, however, these scenarios seem very unlikely.

The reactions of Latin American growth to various external shocks that are estimated in this paper reflect the average behavior of Latin American economies in the 1994-2006 period. To the extent that fundamentals in Latin America have improved in the meantime—beyond improvements that are themselves a reflection of favorable external conditions, of course—one would expect Latin America to be less sensitive to external shocks than suggested by our model. Two areas in which changes have occurred are more credible monetary policy frameworks and institutions, and improved public debt structures, with much less reliance on foreign currency and short term debt. Both are likely to have reduced Latin America's vulnerabilities to external economic shocks.

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

I. DATA SOURCES

World Quarterly GDP: *World Economic Outlook* Database (IMF).

Quarterly GDP for the U.S. and Latin American countries: Haver Analytics.

U.S. 3 month T-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.

II. UNIT ROOT TESTS

Table A1. Unit Root Tests

Variable	Level		First difference	
	ADF	KPSS	ADF	KPSS
y_t^{world}	-0.881	0.154*	-3.847**	0.277
i_t^{US}	-2	0.458	-3.274**	0.148
HY_t	-1.427	0.212	-6.770**	0.199
y_t	-1.815	0.122	-3.549	0.245
c_t	-0.317	0.219**	-4.646**	0.389
$EMBI_t$	-1.609	0.333	-6.722**	0.093

** Indicates rejection of the unit root null hypothesis at the 1% level;
* indicates rejection at the 5% level.

Note: The null hypothesis of the ADF test is the presence of a unit root in the time series, while the null hypothesis of the KPSS test is stationarity (absence of a unit root in the time series). Hence, the presence of a unit root in levels is unambiguously supported by both tests only for world GDP y_t^{world} and commodity prices c_t.

III. Results from Model Based on U.S. Growth

Figure A1. Impulse Response Functions from Mean-Adjusted Bayesian VAR with U.S. GDP Growth and Inflation

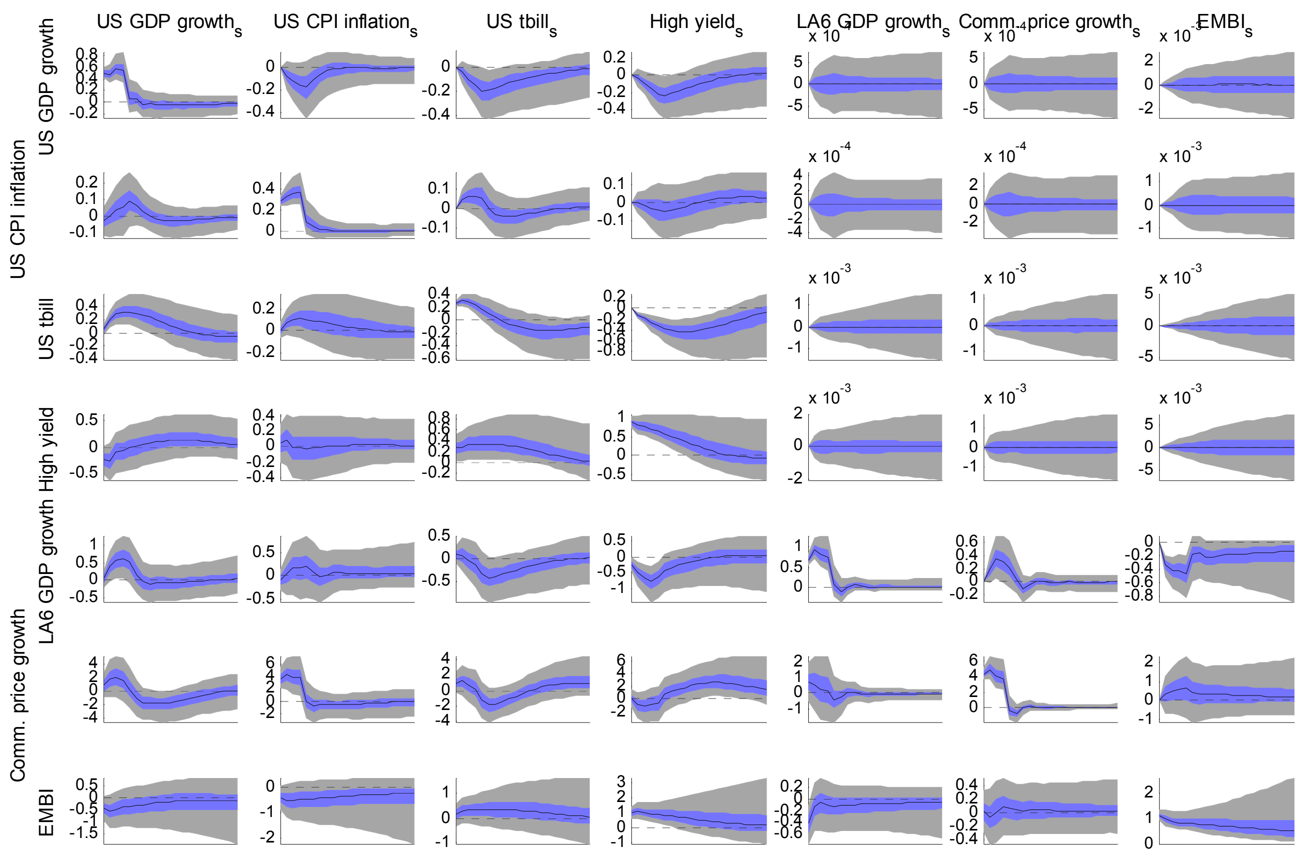
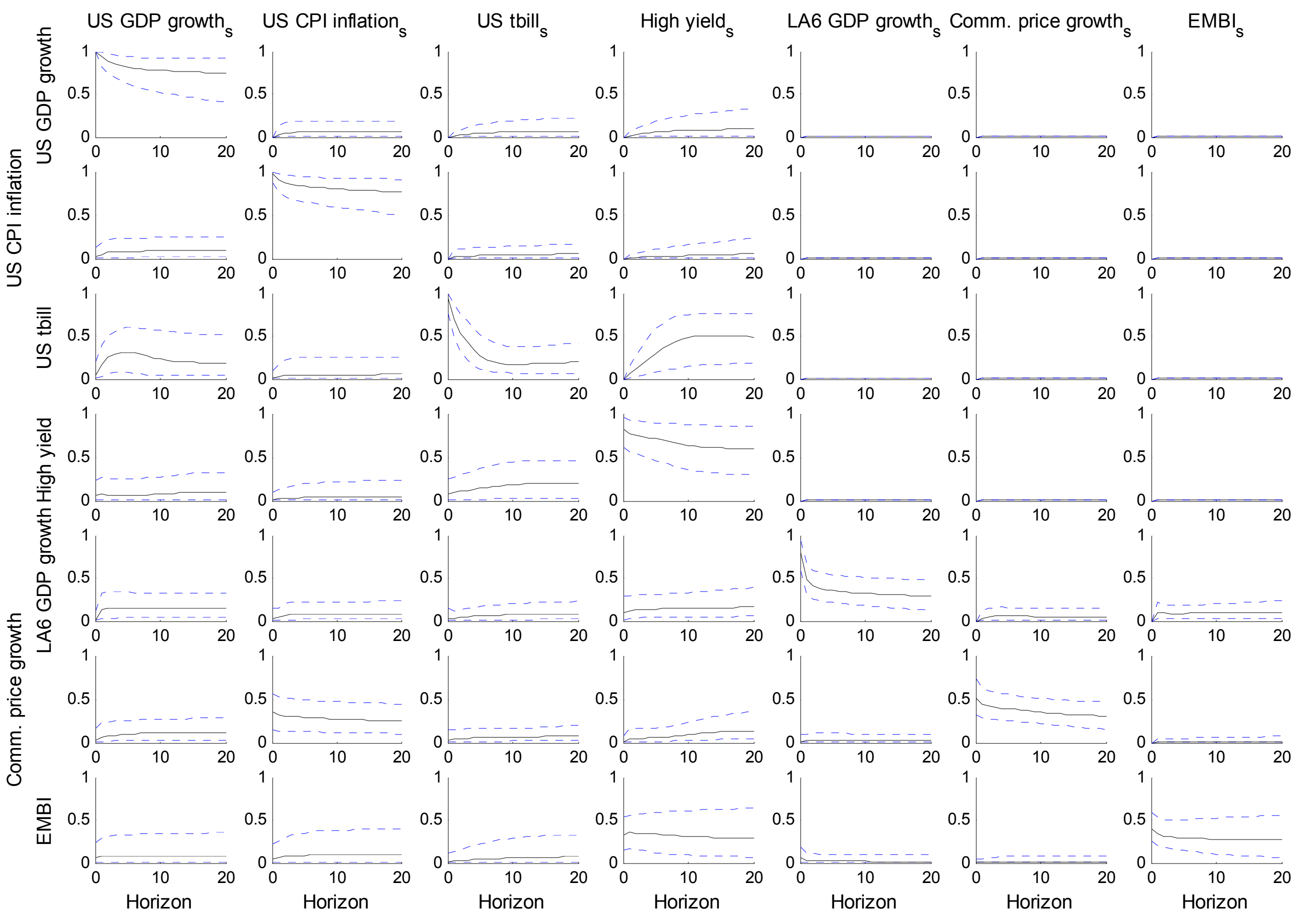


Figure A2. Variance Decomposition from Mean-Adjusted Bayesian VAR
with U.S. GDP Growth and Inflation



IV. Results for Individual Countries

This appendix presents results obtained by estimating the two mean-adjusted BVAR models explored in this paper (see equations (2) – (4)) at the country level. The main purpose of doing this is to get a sense of heterogeneity across the countries making up the LA6 group. It is important to note, however, that the model specification which we have proposed for the aggregate need not work well at the individual country level, as the specification should be customized to best fit country circumstances. We have not done this here, except in the sense that the commodities price index c_t is now a net export weighted index for each country rather than for the LA6 region.

The most important sense in which the aggregate specification may not work is by failing to correctly capture import demand, both by ignoring important trading partners inside the region (for example, Brazil for Argentina or Peru) and by ignoring the relative importance of outside partners. Also note that the EMBI variable continues to be defined as the Latin EMBI, rather than the country risk spread; hence it is now a (mostly) "external" variable. With these caveats, the main results of the applying the model at the country level can be summarized as follows:

Variance decompositions reveal significant variation in the role of external shocks in the region. In the model featuring world growth, the contribution of external factors (defined to include all variables except growth) at the 20 quarter horizon runs from only around 40 percent for Brazil, Mexico and Peru to around 50 percent for Chile and Colombia and over 60 percent for Argentina. In the alternative model, which includes U.S. growth and inflation, the influence of external factors rises to approximately 50 percent for Mexico and Brazil, while it falls to a touch over 40 percent for Peru. For Argentina, Chile and Colombia, the contribution of external factors is similar to that in the model with world growth.
The **impulse responses** look sensible in most cases, in the sense that the shocks lead to changes in growth in the expected directions. The most important exception is the response with respect to U.S. treasury bill rates, which is often insignificantly different from zero and sometimes "goes the wrong way." The following points are noteworthy:

- U.S. growth shocks seem to have larger and tighter effects than world growth shocks in the case of Mexico and (to a lesser extent) Argentina. Not surprisingly, the reaction of Mexican GDP in response to a U.S. growth shock is significantly higher than the aggregate LA6 reaction that was estimated earlier, with a 0.5 point U.S. growth shock leading to a 0.3 response on impact which rises to almost 1.0 (the LA6 impulse response begins with almost no effect on impact and rises to 0.6). In contrast, world growth shocks appear to have larger effects than U.S. growth shocks for Chile, Colombia, and Peru. The response of Brazilian growth is about the same in both cases, with a 0.3 percent World growth shock leading to a maximum response of four quarter growth of about 0.5 after 4 quarters, and a 0.5 U.S. growth leading to a maximum response of almost 0.6 after 3 quarters, roughly in line with the LA6 aggregate response.

- Argentina shows by far the greatest contractionary response to the U.S. high yield bond spread and the Latin EMBI, presumably reflecting the 1998 “sudden stop” episode and the 2001 crisis. Brazil, Colombia, Mexico and Peru also show contractionary responses to these variables, though they are more muted. For Chile, Latin EMBI shocks appear to be associated with an *expansionary* response.

- Standard deviation commodities shocks solicit the largest output response in Argentina, followed by Peru and Chile. It is interesting that the reaction to these shocks in Chile seems to occur with a lag, peaking after about 5 quarters (on a four quarter growth rate basis) while it is much more immediate in Argentina and Peru.

Figure A3. Impulse Response of GDP Growth, Individual Countries
(In percent)

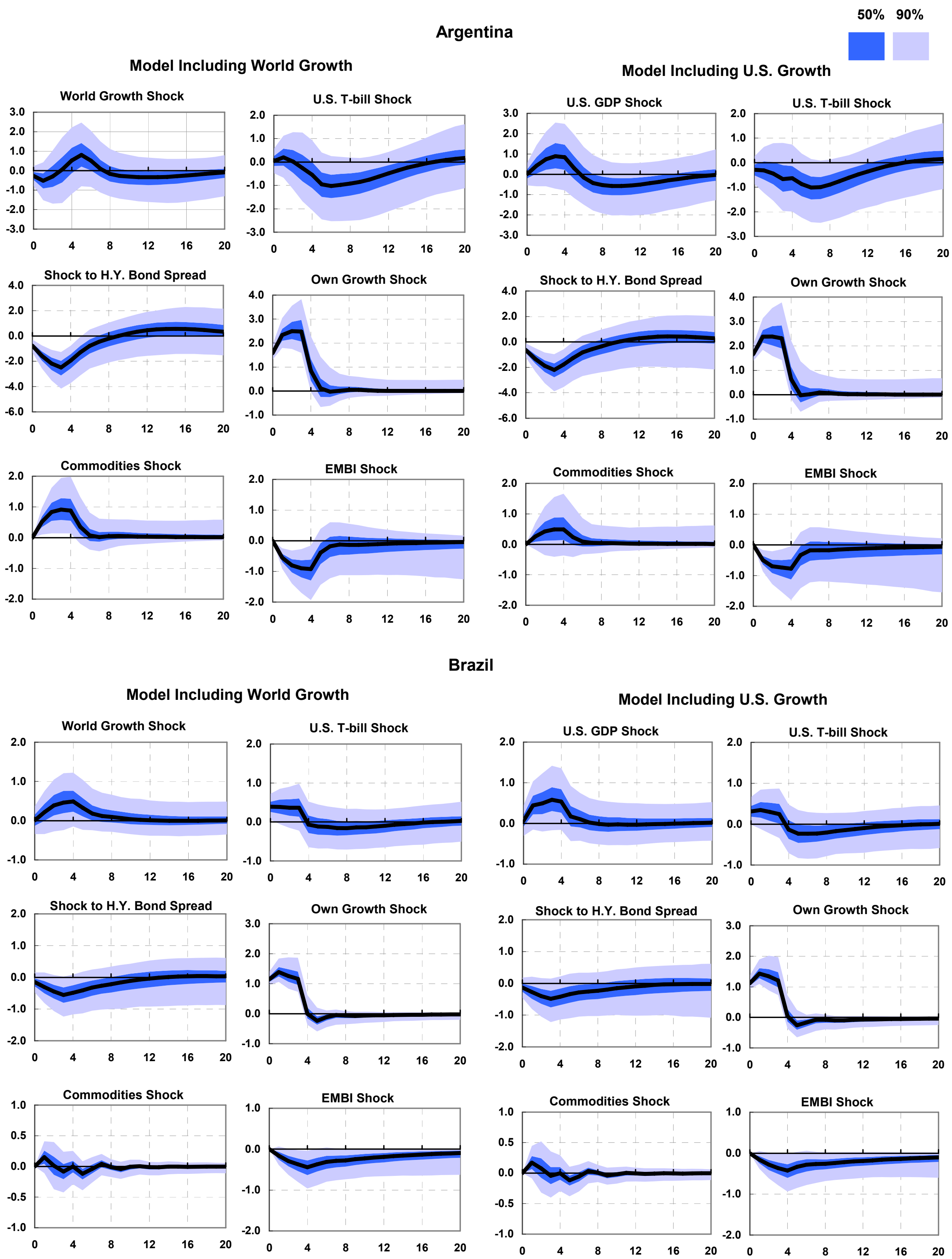


Figure A3. Impulse Response of GDP Growth, Individual Countries (continued)
(In percent)

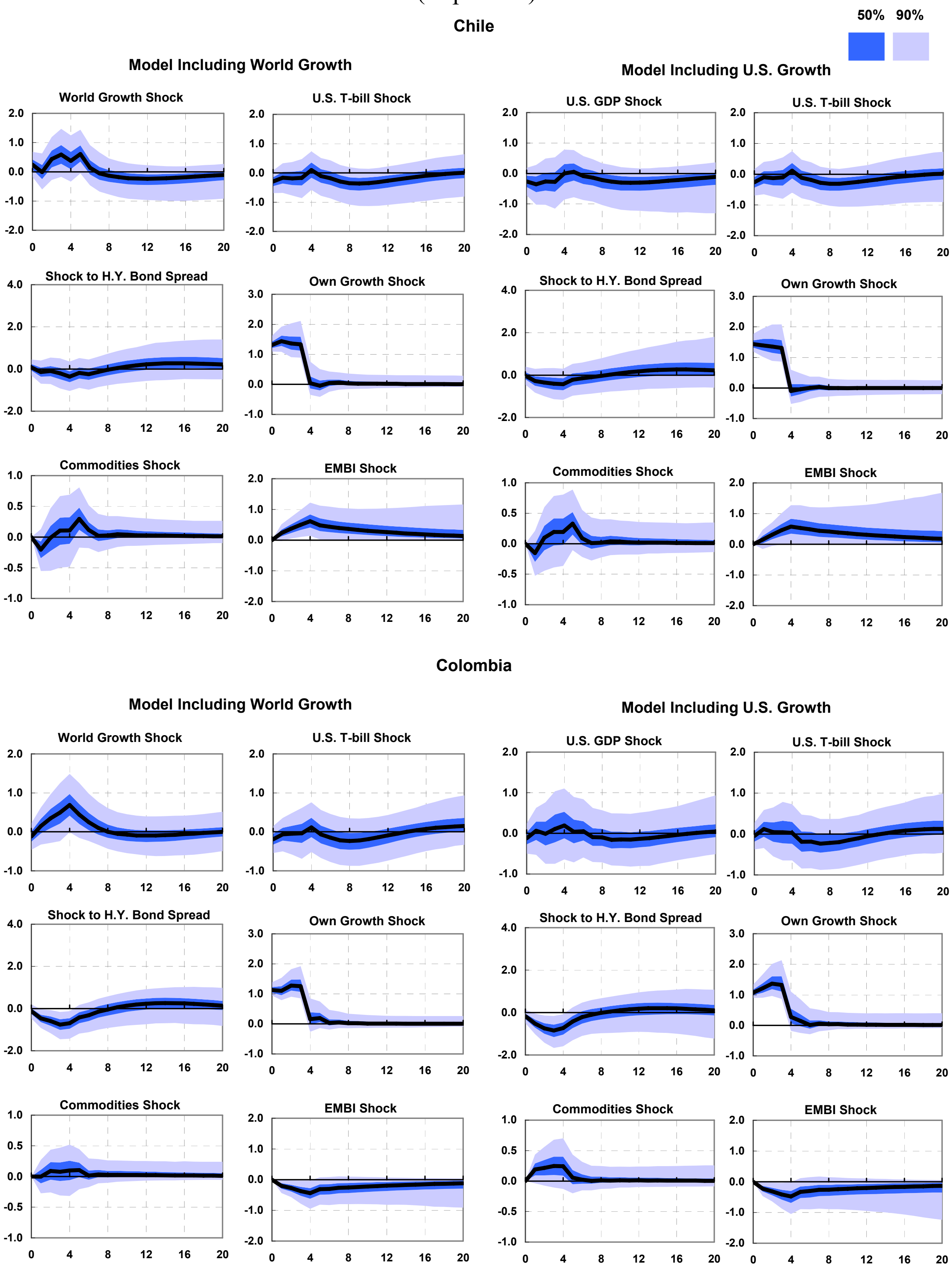
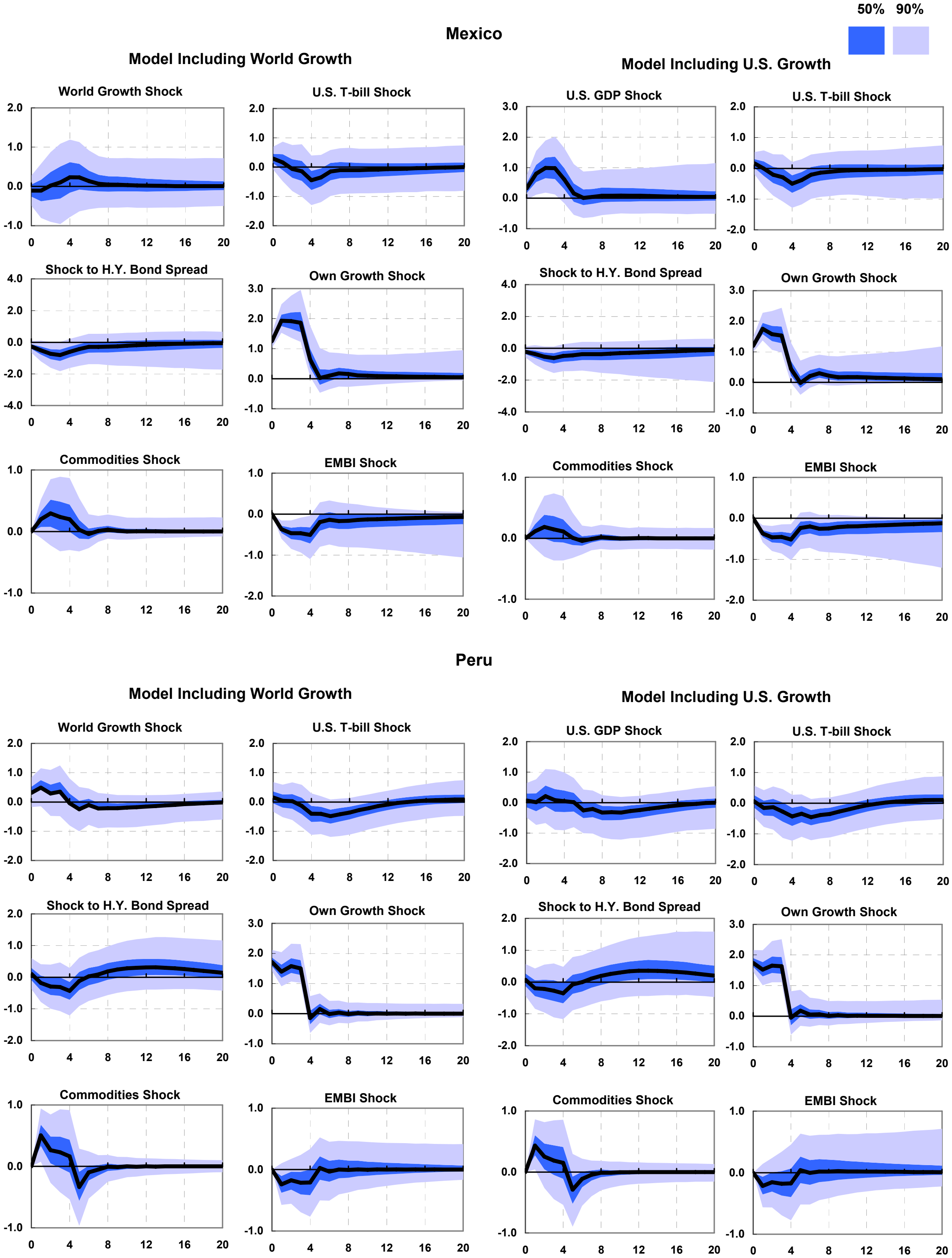


Figure A3. Impulse Response of GDP Growth, Individual Countries (concluded)
(In percent)



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