Openness, Specialization, and the External Vulnerability of Developing Countries

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Abstract

Deepening real and financial integration of developing countries into the world economy has prompted renewed interest in the contribution of external shocks to their macroeconomic fluctuations. This paper revisits the issue using four decades of annual data for a large sample of developing countries. The paper implements a conditionally-homogeneous panel vector autoregression with exogenous variables to model GDP fluctuations in these countries. It uses sign restrictions to identify four external structural shocks—demand, supply, monetary, and commodity shocks—and analyzes how their impact on growth is shaped by countries' policy and structural framework. External shocks are found to account for a small share of the forecast error

variance of GDP, especially at short horizons. However, their contribution has been on the rise in recent decades. Further, global monetary shocks have become the leading external source of GDP volatility in developing countries. The paper presents a quantitative assessment of the effects of real and financial opening up, as well as those of commodity specialization, on the impact of external shocks on GDP. The results suggest that increasing openness can account for the increasing trend in the volatility attributable to external shocks, as well as the changing roles of different shocks. Moreover, commodity-intensive developing countries are found to be more vulnerable than the rest to all types of external shocks, not just commodity shocks.

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1. Introduction

A large empirical literature has been concerned with the sources of macroeconomic fluctuations in developing countries, seeking to disentangle the respective contributions of domestic and external disturbances to business cycles. For the most part, the literature finds that idiosyncratic shocks play a much bigger role than external shocks. The latter are typically taken to include global output shocks, terms of trade (or global commodity price) disturbances, and international interest rate disturbances plus, in some cases, other exogenous shocks such as natural disasters or shifts in investor risk perceptions; see for example Hoffmeister, Roldós and Wickham (1998) and Raddatz (2008a) on Sub-Saharan Africa, Raddatz (2007) on low-income countries, and Ahmed (2003) and Raddatz (2008b) on Latin America. These papers employ VAR (or PVAR) methods, but similar conclusions emerge from other approaches – e.g., using a factor model, Kose, Otrok and Whiteman (2003) conclude that domestic factors typically account for the lion’s share of output fluctuations in developing countries.¹

The literature also tries to establish the leading sources of these externally-driven fluctuations. However, except in rare cases, the global variables affecting developing economies are not mutually orthogonal, and therefore this requires a suitable approach to identification. Most of the literature employs Cholesky factorizations imposing a causal ordering among the external variables considered in the analysis. Depending on the country and time samples employed, the studies variously attribute the leading role to financial disturbances – usually in the form of

¹ These papers use annual data. Empirical studies using higher-frequency (i.e., monthly or quarterly) data often find a bigger (but in most cases still secondary) role of external shocks; see e.g., Canova (2005), Uribe and Yue (2006) and Mackowiak (2007).

international interest rate shocks – or relative price disturbances, in the form of terms of trade or global commodity price shocks.²

An important question from the policy perspective concerns the propagation and amplification mechanisms at work, namely, how do economies' structural and policy features shape their response to external shocks? The question has become increasingly important in view of the generalized decline in developing countries' barriers to cross-border real and financial transactions. A number of papers have focused on the volatility consequences of increased trade openness, concluding in most (but not all) cases that higher openness leads to larger aggregate fluctuations.³ Likewise, the role of financial openness has also attracted considerable interest. While there are no clear theoretical predictions regarding its consequences for output fluctuations, on the whole the evidence suggests that increased financial openness has been accompanied by larger fluctuations.⁴

Another propagation mechanism that has attracted interest is countries' production structure, and in particular their reliance on primary commodities. In this regard, Kose (2001) and Koren and Tenreyro (2007) find that much of the volatility differential between developing

² For example, Raddatz (2007) finds commodity prices to be the most important source of external shocks to developing countries, while Ahmed (2003) assigns that role to international interest rates.

³ Using sector-level data, Di Giovanni and Levchenko (2013) find that higher trade openness leads to higher aggregate volatility, especially among developing countries. However, Van der Ploeg and Poelhekke (2009), using aggregate data, conclude that increased trade openness reduces aggregate volatility. Loayza and Raddatz (2007), using also aggregate data, find that increased trade openness tends to magnify the growth impact of terms of trade disturbances. Related to this, Broda (2004) also finds that trade openness, in addition to the exchange rate regime, affects the size of the impact of given terms of trade shocks. In turn, Cavallo and Frankel (2007) find that greater trade openness is associated with a reduced incidence of financial shocks ('sudden stops') and thereby diminished aggregate volatility.

⁴ See, e.g., Prasad et al (2003) and Van der Ploeg and Poelhekke (2009).

and advanced countries can be traced to the higher degree of specialization of the former in primary commodities, which are more prone to shocks than other productive sectors.⁵

This paper revisits macroeconomic fluctuations in a large sample of developing countries. The paper undertakes two tasks. First, it identifies the leading external sources of fluctuations. Second, it provides a quantitative assessment of key propagation mechanisms. The paper adds to the literature in both dimensions.

Regarding the sources of fluctuations, the paper departs from the majority of the literature that equates specific external shocks with individual external variables. As a number of authors have argued, fluctuations in global output, world inflation, and other global variables can be understood as the result of a handful of primitive shocks with clear economic interpretation – e.g., shocks to global demand, global supply, world monetary policy, and so on; see e.g., Canova and Nicolo (2003). To establish the sources of global fluctuations, this paper uses sign restrictions – i.e., restrictions on the signs of the conditional correlations among the global variables of interest in response to orthogonal shocks, an approach pioneered by Uhlig (2005). The analysis distinguishes three real shocks – to global aggregate demand and supply, and to world commodity prices – and a monetary shock. The paper’s methodological approach permits assessing, first, the role of the various shocks in global fluctuations and, second, their contribution to domestic fluctuations – through the links between domestic and global variables.⁶

Regarding the propagation mechanisms, the paper uses a flexible empirical framework that allows the response to real and financial external shocks to vary systematically with a set of

⁵ Van der Ploeg and Poelhekke (2009) likewise conclude that commodity dependence has an unambiguously positive impact on growth volatility.

⁶ Canova (2005) employs a similar approach, but his paper is more narrowly focused on the effect of U.S. fluctuations on Latin America.

conditioning factors. The analysis focuses on three such factors – trade openness, financial openness, and specialization in commodities. The objective is to assess how these features augment or reduce the effects of *given* shocks. In other words, the paper focuses on the consequences of varying the economy’s *exposure* to shocks, while holding constant the *magnitude* of the shocks. For this purpose, the paper estimates a panel VAR with exogenous variables whose coefficients are (linear) functions of the chosen conditioning variables– what has been termed the conditionally homogenous PVAR (Georgiadis 2013). These estimates allow tracing out the economy’s response to a given shock along the entire range of the conditioning variables – e.g., the degree of trade or financial openness. This represents a generalization of the methodological approach pioneered by Loayza and Raddatz (2007), and employed more recently by Towbin and Weber (2013).⁷

The rest of the paper is organized as follows. The next section lays out the methodological framework. Section 3 describes the empirical implementation, and section 4 presents the empirical results. Finally, section 5 concludes.

2. Methodological framework

Our objective is to assess how economically-interpretable external shocks affect real GDP growth in developing and emerging economies. For this purpose, we adopt the framework of a structural panel VAR with exogenous variables – PVARX for short. Standard reduced-form VARs offer a useful summary of the correlations and temporal dependence of a set of time series. However, their associated residuals do not have any economic interpretation—they are simply projection errors. In contrast, *structural* VARs impose restrictions on the reduced form to identify,

⁷ See also Georgiadis (2014), Saborowski and Weber (2013) and Saborowski, Sanya, Weisfeld, and Yezpe (2014).

or recover, structural shocks or policy changes with a clear economic interpretation. While there are several ways to impose these identification restrictions, the most compelling ones are those that use economic reasoning to disentangle structural shocks from the set of reduced form shocks.

Before describing our approach to identification, we outline the main features of the PVARX that we use to model the dynamics of GDP growth. The starting point is the autoregressive-distributed lag equation

$$y_{it} = \alpha_i + \sum_{j=1}^p a_j y_{it-j} + \sum_{h=0}^q \mathbf{b}_h' \mathbf{x}_{t-h} + \epsilon_{it} \quad i = 1, \dots, N; t = 1, \dots, T \quad (1)$$

Here y_{it} denotes the growth rate of country i 's real GDP in period t , and a_j are coefficients capturing the effects of lagged growth. In turn, $\mathbf{x}_{t-h}$ is an $M \times 1$ vector of external (or global) real and financial variables, and $\mathbf{b}_h$ is a vector containing their corresponding coefficients. Finally, ϵ_{it} is an i.i.d. residual with mean zero and variance σ^2 .

Equation (1) allows for rich dynamics of the endogenous variable, reflecting its own history as well as feedback effects from current and lagged external variables. External real and financial shocks impact on growth through their effect on the global variables $\mathbf{x}$. Among these, we include a measure of global GDP growth, to capture world economic activity; a measure of world interest rates, to capture international financial conditions; and a measure of global commodity prices, recognizing the fact that many emerging and developing countries exhibit a commodity-intensive pattern of specialization. We also include a measure of global inflation for two reasons, first to summarize the stance of global markets beyond that captured by the measure of global economic activity and commodity prices, and second, and most important, because it allows us to differentiate among global structural shocks, as we discuss below,

To capture the sources and propagation of the shocks, we model the evolution of the global variables as a vector autoregression, given by

$$\mathbf{x}_t = \boldsymbol{\beta} + \sum_{j=1}^r \mathbf{C}_j \mathbf{x}_{t-j} + \mathbf{v}_t, \quad (2)$$

where $\boldsymbol{\beta}$ is a $k \times 1$ vector of constants, $\mathbf{C}_j$ is a $k \times k$ matrix of coefficients, and $\mathbf{v}_t$ is a $k \times 1$ vector of i.i.d. reduced form shocks orthogonal to ϵ_{it} for all i and t , with covariance matrix $\boldsymbol{\Sigma}$. The key assumption in (2) is that domestic growth y does not enter the VAR for the global variables. In economic terms, the countries in the sample are ‘small’ relative to the world, and thus their actions do not affect global quantities and prices. Thus, the model consisting of (1) and (2) is block-recursive, and the two equations can be estimated separately.

Equation (1) follows convention in assuming that the slope coefficients (i.e., the a_j and $\mathbf{b}_h$) are constant across countries and over time. However, below we relax this restriction and allow slope coefficients to depend systematically on a set of time-varying country characteristics. Assume these can be summarized in the $n_z \times 1$ vector $\mathbf{z}_{it}$, whose first element is a 1. Thus, we can write $a_{ijt} = \boldsymbol{\gamma}'_j \mathbf{z}_{it}$ and $\mathbf{b}_{iht} = (\mathbf{I}_M \otimes \mathbf{z}_{it})' \boldsymbol{\lambda}_h$, where $\boldsymbol{\gamma}_j$ and $\boldsymbol{\lambda}_h$ are respectively $n_z \times 1$ and $n_z M \times 1$ vectors of parameters to be estimated. Note that this constrains the original parameters of (1) to be linear functions of $\mathbf{z}_{it}$; however, $\mathbf{z}_{it}$ itself can always be defined to include both linear and nonlinear functions of a set of primitive variables. Equation (1) can be now rewritten

$$y_{it} = \alpha_i + \sum_{j=1}^p \boldsymbol{\gamma}'_j (\mathbf{z}_{it} y_{it-j}) + \sum_{h=0}^q \boldsymbol{\lambda}'_h (\mathbf{I}_M \otimes \mathbf{z}_{it}) \mathbf{x}_{t-h} + \epsilon_{it} \quad (1')$$

Comparing (1') with the homogeneous case (1) above, it can be seen that allowing for parameter heterogeneity amounts to replacing in (1) the regressors y_{it-j} with $(\mathbf{z}_{it}y_{it-j})$ and $\mathbf{x}_{t-h}$ with $(\mathbf{I}_M \otimes \mathbf{z}_{it})\mathbf{x}_{t-h}$.⁸ The fully homogeneous case obtains when $\mathbf{z}_{it} = 1$ for all i, t .⁹

The expanded model (1') is a simplified version of the Panel Conditionally Homogeneous VARX (PCHVARX for short) developed by Georgiadis (2013), building on earlier work by Loayza and Raddatz (2007). Its main virtue is that it allows assessing how the economy's response to shocks depends on its structural features and initial conditions. Below we apply this framework to study how real and financial openness and the pattern of specialization shape the response to external shocks.

We next turn to identification. As noted, our objective is to trace the impact on real GDP of different types of external shocks with clear economic interpretation – shocks to the global demand or supply of goods, global financial shocks, and shocks to world commodity prices. All those shocks are associated with the reduced-form residual vector $\mathbf{v}_t$ from equation (2). However, simply tracing the impact of the various elements of $\mathbf{v}_t$ on real GDP is of limited interest because they are not uncorrelated and lack a structural interpretation.¹⁰ Formally, each element of $\mathbf{v}_t$ can be thought of as a linear combination of a set of structural shocks $\boldsymbol{\xi}_t$, that is,

$$\mathbf{v}_t = \mathbf{R}\boldsymbol{\xi}_t \quad (3)$$

⁸ In equation (1'), all the coefficients are assumed to depend on the same set of conditioning $\mathbf{z}$ variables. However, it is easy to accommodate the case in which different coefficients depend on different sets of conditioning variables (or on different functions of them), at the cost of additional notation.

⁹ Also, it can be shown that the often-encountered scenario in which parameters vary freely over cross-sectional units but are fixed over time arises when for all t $\mathbf{z}_{it}$ equals the i -th column of $\mathbf{I}_N$.

¹⁰ This is in contrast with the single domestic shock ϵ_{it} , which is trivially "identified" as the combination of all disturbances orthogonal to the global variables.

where $\mathbf{R}$ is an invertible matrix, referred to as the identification matrix, and $E[\xi_t \xi_t'] = \mathbf{I}$. Each element of ξ_t represents a structural global shock – e.g., a shift in global demand or supply for goods or assets. We are interested in the response of GDP growth to these shocks. To recover them from the reduced-form disturbances, we need to pin down the matrix $\mathbf{R}$ through suitable identifying assumptions. The literature has employed a variety of approaches to identify structural shocks. The three most commonly used are (i) *short-run restrictions*, (ii) *long-run restrictions*, and (iii) *sign restrictions*. Combinations of these approaches have also been used.

Identification by short-run restrictions is based on timing assumptions about the response of certain endogenous variables to certain structural shocks. For example, the literature on fiscal multipliers typically assumes that output responds to fiscal expenditure shocks with a lag. Given a sufficiently large number of these restrictions, one is able to identify all the structural shocks of interest. A common approach to imposing short run restrictions is through a Cholesky factorization of the covariance matrix of the reduced form residuals, given by $\mathbf{R}\mathbf{R}'$. However, this typically amounts to assuming a particular causal ordering of the variables, which can be rarely justified on analytical grounds.

In turn, identification by long-run restrictions is typically based on the assumption that certain shocks do not have a long-run impact on certain variables. Consider, for example, a bivariate VAR with output and employment and two structural shocks: a supply and a demand shock. A common identification restriction is that demand shocks do not have an effect on the level of output in the long run, based on the idea that the long-run supply curve is vertical and only depends on technological factors. While consistent with theory, this approach faces a serious small-sample problem. Identification by long-run restrictions requires an accurate estimation of

the impulse responses of the VAR at the infinite horizon. However, sample sizes need to be quite large to estimate these long-run values accurately (Chari, Kehoe, and McGrattan, 2005).

The approach to identification we use in this paper is based on sign restrictions, that is, restrictions on the sign of the impulse responses of the endogenous variables at different horizons. For example, in a VAR with output and inflation, one could identify a supply and a demand shock using the theoretical predictions regarding the sign of the effect of such shocks on output and inflation. In particular, standard structural models predict that a supply shock leads to an increase in output and a *decline* in inflation, while a demand shock leads to an increase in output and an *increase* in inflation. The different response of inflation to the shocks on impact—and perhaps for a number of periods after the shock—is what allows disentangling structural supply and demand shocks.

As in Canova (2005), we are interested in tracing the response of domestic output growth to global structural shocks. We consider four such shocks: supply, demand, monetary, and commodity shocks. We identify the structural shocks by the sign of their impact on the impulse responses of the different variables of the global VAR (2). Table 1 displays the restrictions that we impose on the sign of the impulse responses of the different variables. The restrictions are imposed only on the contemporaneous responses; the responses over longer horizons are left unrestricted.

A (non-commodity) supply shock – i.e., an outward shift of non-commodity global supply – is assumed to increase global output growth and reduce inflation on impact, and to raise the relative price of commodities. Given the opposing responses of output and inflation, the overall effect on global interest rates is uncertain on analytical grounds, so we leave it unrestricted. Next, a global demand shock is assumed to raise global output on impact, as well as inflation, relative

commodity prices, and short-term interest rates. The fact that inflation rises following a demand shock but falls with a supply shock allows us to disentangle one type of shock from the other.

A global monetary shock – i.e., an expansionary shift in global monetary policy – increases output, inflation, and commodity prices, but reduces the short term interest rate on impact. This latter sign allows us to distinguish demand from monetary shocks. Finally, a global commodity shock, understood as a decline in global excess demand for commodities, is assumed to increase global output and to reduce inflation and commodity prices on impact. Note how the opposing impacts on commodity prices allow us to disentangle a commodity price shock from a (non-commodity) supply shock. In both cases, we leave the response of the interest rate unrestricted.

It is important to stress that sign restrictions, unlike conventional parametric (zero) restrictions, only achieve what has been termed set identification. That is, they help identify a set of models, rather than a single model, consistent with the assumed restrictions (see, e.g., Fry and Pagan 2011). Below we describe how we deal with this issue when reporting the empirical results.

3. Empirical implementation

The empirical sample is dictated by data availability. We take all countries with complete GDP data in PWT 8.1 over the period 1970-2011. After dropping countries with anomalous observations, high-income, and very small economies, we are left with 82 developing and emerging countries. In terms of the World Bank 2014 classification, 79 belong to the ‘middle income’ category, and 3 are low-income countries. They are listed in table A1 in the Appendix.¹¹

¹¹ From the overall sample of 167 countries, we retain only those with complete GDP data over the period 1970-2011. Next, we drop 11 countries exhibiting anomalous and/or possibly erroneous observations, as well as 24 countries with population fewer than 500,000 in 2005. Lastly, we exclude 24 OECD or high-income economies.

Table A2 in the appendix describes the definitions and sources for the remaining data series. We use G7 GDP growth to measure global growth; using U.S. GDP instead made little difference for the results. Global inflation is measured by the log-difference of the U.S. GDP deflator, while the global short-term interest rate is given by the 3-month U.S. Treasury Bill rate. Finally, real commodity prices are constructed deflating the UNCTAD index for all commodities with the U.S. GDP deflator.

In accordance with the discussion in the preceding section, we use as conditioning variables $\mathbf{z}$ in (1') a measure of trade openness (log imports plus exports as a fraction of GDP), the Chinn-Ito index of capital account openness, and an index of commodity intensity, to capture countries' degree of productive specialization in commodities. Following Leamer (1984, 1995), we measure commodity intensity by net exports of commodities per worker.¹²

The model consisting of (1) (or (1')) and (2) is block-recursive. Hence we estimate the GDP growth equation (1) and the global block (2) separately. In each case, we use Akaike, Hannan-Quinn, and Schwarz information criteria to determine the optimal number of lags. Although the three criteria are asymptotically equivalent, in small samples the Akaike criterion tends to select the highest number of lags, and the Schwartz criterion the lowest. Noting that the number of lags selected by the three criteria is not too different, we chose to use the Hannan-Quinn criterion as a compromise between the least and most conservative criteria. Specifically, for the domestic growth equation the Schwartz criterion selects 1 lag of the endogenous variable and only the contemporaneous global variables, while the other two criteria select 1 lag for the endogenous

¹² We compute aggregate net exports as the sum of net exports of Leamer's six commodity clusters: (i) petroleum, (ii) raw materials, (iii) forestry, (iv) live animals, (v) tropical agriculture, and (vi) cereals. Table A3 lists the SITC codes for each cluster.

and 2 for the global variables. As a compromise, we opt for 1 lag of both the endogenous and the global variables.¹³ In the case of the global block (2), the Akaike criterion selects two lags, while the other two criteria select only one; we opt for the latter specification.

Once we have estimated in this way the parameters of the reduced form, we identify the global structural shocks by imposing the sign restrictions described earlier. To do this efficiently, we follow the procedure proposed by Rubio-Ramirez, Waggoner, and Zha (2010). This approach consists in using an arbitrary identified VAR, in our case using a Cholesky decomposition of the covariance matrix of the reduced form residuals, and next randomly rotating this identification matrix until the required sign restrictions are satisfied. The random rotation is performed by post-multiplying the Cholesky identification matrix by an orthonormal matrix obtained by applying the QR decomposition to a random 4×4 matrix whose elements are drawn from a standard normal distribution. It can be shown that this procedure identifies all possible structural VARs (Rubio-Ramirez, Waggoner, and Zha, 2010). We apply this algorithm repeatedly to obtain 1,000 “identified” models satisfying the proposed sign restrictions—that is, until we recover 1,000 identification matrices $\mathbf{R}$ satisfying the restrictions in Table 1. Each identified model is associated with a particular set of impulse responses. We report median and 68-percent bands over all the impulse responses (or other statistics) from all the identified models satisfying the sign restrictions.

The impulse responses trace the dynamic impact of a given structural shock on the endogenous variables of the model. For example, suppose that we want to analyze the impact of a

¹³ Using instead 1 lag for the endogenous and 2 for the global variables is of no great consequence for the empirical results, although it does raise somewhat the contribution of the global variables to the variance of real GDP.

global demand shock on the global variables, and assume that the structural shocks are ordered so that the first element, say, of ξ_t corresponds to demand shocks. Given the particular identification matrix R , in equation (2) we replace the reduced form shock v_t with $R\xi_t$ and trace the dynamic response of the system to a sequence of shocks $\xi_0 = (1,0,0,0)'$ and $\xi_t = (0,0,0,0)'$ for all $t \geq 1$.

In addition to impulse responses, we will be interested also in the contribution of the different identified shocks to the variability of the observable global variables, as well as that of domestic GDP growth. Because the structural shocks are mutually orthogonal, we can unambiguously decompose the variance of the forecast errors of each variable of interest due to each of the identified structural shocks. We report the decomposition of the variances of the forecast errors at different horizons.¹⁴ As in the case of impulse responses, we obtain as many variance decompositions as identified models. We report the average variance decomposition across all identified models.

4. Empirical results

Before getting to the estimation results, we briefly review the facts regarding growth volatility. Figure 1 plots the standard deviation of real GDP growth over 1971-2010. It shows considerable variation across developing countries, from a low of 2 percent in Pakistan and Colombia, to a high of 10 percent in Iran and Gabon. On the whole, poorer countries tend to exhibit higher volatility, although both Iran and Gabon run counter this rule. Natural-resource exporters are abundantly represented among the most volatile countries; indeed, the top three are oil exporters.

¹⁴ The actual expressions for the variance decompositions can be found in Lutkepohl (2007).

In turn, Figure 2 offers an illustration of the patterns of growth volatility over time. It plots the standard deviation of growth over 1971-90 against its counterpart over 1991-2010. The graph shows a generalized decline in volatility between the two periods, as most countries lie below the 45-degree line. There are some clear exceptions, however, most notably Sierra Leone, Angola and Albania, which exhibit much higher volatility in the recent period than in the earlier one.

4.1 Global shocks and their impact on the global variables

We turn to estimation of the global VAR defined by equation (2). Figure 3 depicts the median impulse responses to the four global shocks identified by the sign restrictions in Table 1, along with the corresponding 68% bands. Panel (a) reports the effects of a unit-variance global demand shock. The sign restrictions mandate that global GDP growth, inflation, short-term interest rates and real commodity prices must all rise on impact. The figure shows that the four variables remain above their initial level for a few years – from two in the case of growth and commodity prices, to 5-6 in the case of inflation and interest rates. Thereafter, they return to their initial levels following a cyclical pattern. Further, there is a fair degree of agreement among all the identified models, as shown by the relatively narrow 68-percent bands in the graphs.

Figure 3(b) shows the effects of a global supply shock. As required by the sign restrictions, global output and real commodity prices rise on impact, while inflation falls. Except for commodity prices, the impact responses are of smaller magnitude than in the case of the demand shocks, and there seems to be less close agreement among the different estimates. In turn, the response of the interest rate is not mandated by sign restrictions. The median initial response reflects an interest rate increase, but the 68-percent bands allow also for negative responses as well.

The responses to a global monetary shock – a loosening of global monetary policy – are shown in Figure 3(c). Output growth, inflation and relative commodity prices all rise on impact, while the interest rate declines in accordance with the sign restrictions. The rise in output growth and commodity prices is short-lived, and the interest rate fall gets quickly reversed. In contrast, inflation remains above its initial value for an extended period.

Finally, Figure 3(d) reports the responses to a commodity shock – a fall in global excess demand for commodities. On impact, real commodity prices fall and output growth rises, while inflation declines. The responses of commodity prices and inflation are short-lived, while that of output growth is more persistent. In turn, the initial response of the global interest rate, which is not subject to sign restrictions, varies considerably across models. The median impact response is virtually zero, but it is followed by a gradual rise.

These dynamics are based on estimation of the global VAR (2) using a sample starting in 1970, and one may wonder if they may have changed significantly in recent decades with the trend towards increased international integration. To investigate this question, the global VAR was re-estimated over 1991-2010, a period which roughly corresponds to the globalization era. Given the short span of the sample, the results from this exercise have to be taken with a grain of salt. Nevertheless, the estimated impulse responses are generally similar to those just described, although they tend to be smaller on impact and somewhat less persistent. This is the case, for example, with global demand and monetary shocks. The main exception concerns the impact response of the interest rate to a commodity shock, which is found to be positive across the majority of identified models, in contrast with the ambiguous response obtained in the longer time sample.

Table 2 reports the decomposition of the variance of the forecast errors of the global variables, at the 1, 5 and 10-year horizons. Because the global model consists of four variables, the four structural shocks account for all of their variance. The left panel reports the results obtained with the full sample. At all horizons, commodity and demand shocks are the biggest contributors to the variance of global growth, although their relative roles change with the forecast horizon. Demand shocks dominate at the 1-year horizon, while commodity shocks do at longer horizons. Demand shocks are also the leading source of fluctuations for interest rates and inflation, except for the latter variable at long horizons, at which monetary shocks play the biggest role. Lastly, commodity and supply shocks drive most of the variance of commodity prices, although demand and monetary shocks also play significant roles.

The right panel of the table reports the variance decomposition obtained using the post-1990 sample. One remarkable feature is the generalized drop in the standard deviation of the forecast errors of the variables, relative to the full sample counterpart. This is particularly remarkable for inflation, largely reflecting the presence of a number of high-inflation episodes in the 1970s and 1980s. Such events are much less abundant in the post-1990 sample. But the decline in volatility also affects the other variables, including the most volatile of all – commodity prices. Such pattern is a reflection of the ‘great moderation’ of the 1990s and early 2000s.

There are also some differences between the post-1990 period and the full sample regarding the contributions of the various structural disturbances. Demand shocks remain the leading source of GDP growth and interest rate volatility, but monetary shocks acquire a bigger role than commodity shocks in the variance of GDP growth and commodity prices. Also, beyond

the very short term, in the recent sample supply shocks play a bigger role for the volatility of all four global variables considered.

4.2 The impact of global shocks on developing countries

The second stage of the empirical analysis involves estimating the growth equation, in its unconditional version (1), or the conditional version (1'), and using the estimated parameters to assess the response of GDP growth to the global structural shocks identified in the previous stage.

We first report the results from the unconditional model (1), which imposes constant parameters across countries and over time. The results are summarized in Figure 4. Panel (a) depicts the response to a global demand shock. Growth rises the first two periods, and its median response peaks at 0.2 percent above its pre-shock value. Thereafter it declines sharply below the initial level, and returns to zero following a cyclical pattern. In turn, the response to a global supply shock (shown in panel (b) of the figure) is broadly similar, although the cyclical pattern is less pronounced and the dynamic adjustment somewhat faster. The median response involves an impact rise of roughly the same magnitude as with the demand shock, which gives way to a fairly rapid return to the pre-shock value. Moreover, beyond the initial expansionary impact, the responses predicted by the different models are fairly disperse, unlike with the demand shock, for which the responses predicted by the different models show much more agreement.

In response to a global monetary shock, growth jumps on impact, as shown in panel (c) of the figure. The median response shows a growth increase of about 0.3 percent, after which growth remains above its pre-shock level for four periods. The subsequent adjustment involves a temporary growth decline below its initial value. As in the case of the demand shock, the various

models show a high degree of agreement. Finally, a global commodity shock, shown in panel (d), causes an impact growth increase but, unlike with the other shocks, the 68 percent bands are fairly broad and do not rule out a zero or negative growth response on impact, nor do they pin down the subsequent adjustment with any degree of precision.

The results just described are obtained with the full data sample. Has the response of growth to global shocks changed in the globalization era? To answer this question, we recalculate the impulse responses using the estimates of the model (that is, both the global VAR (2) and the growth equation) over the post-1990 period. As in the case of the global VAR, these estimates are computed over a fairly short time sample, and therefore they have to be taken with caution.

For ease of comparison, the resulting responses are shown in Figure 4 as well. Except for the commodity shock, they are not very different from those obtained with the full sample. However, the impact effects on growth of a global demand shock and a global monetary shock are much larger than in the full sample, and the subsequent cycle is also somewhat wider. In the case of the supply shock, the initial expansionary effect is roughly similar to that found in the full sample, but it is now amplified in the second period, beyond which the different models show a good deal of disagreement, as before. As for the commodity shock, the range of responses arising from the different models is again very wide. Indeed, while the median response appears markedly different than in the full sample, the 68 percent bands actually allow for the responses to have either sign on impact as well as along most of the adjustment path.

Table 3 reports the variance decomposition of the GDP forecast error at the 1, 5 and 10-year horizons into the portions attributable to domestic and external shocks. For ease of

comparability with earlier literature, the table reports the results in terms of the log of GDP, rather than its growth rate. Consider first panel (a), which shows the decomposition obtained using the full sample. At all horizons, the variance is overwhelmingly driven by domestic shocks. However, the contribution of global shocks rises with the forecast horizon, from a low of 1 percent at the 1-year mark, to over 8 percent at the 10-year horizon, a figure of a similar order of magnitude as in Raddatz (2007).¹⁵

Panel (b) of Table 3 reports the variance decomposition obtained when estimating the model over using the post-1990 sample. From the first column it can be seen that the standard deviation of the GDP forecast error is about 20 percent lower than in the full sample, in accordance with the evidence shown earlier in Figure 2. In turn, the percentage contribution of global shocks to the forecast error variance is about 5 percent larger at all horizons. At the 10-year horizon, it exceeds 13 percent.

The increased role of global shocks in the recent sample stands in contrast with the decline in the volatility of the global variables shown in Table 2. The implication is that it must reflect the growing exposure of developing economies to global economic forces. To verify this, panel (c) of Table 3 reports the forecast variance decomposition that would result from a thought experiment combining the post-1990 estimates of the global VAR, with the full-sample estimates of the growth equation. Comparing these results with those in the panel (a) of the table, we can get a rough idea of how the determinants of output volatility would have differed between the full sample and the post-1990 years if the only difference between the two periods were the changed global economic environment, holding constant the exposure of developing countries to

¹⁵ Raddatz (2007, table 4) finds that, depending on samples and specifications, external shocks account for between 7 and 12 percent of the variance of the GDP forecast error at the 10-year horizon.

it. In turn, comparing the results with those in panel (b) we get a rough idea of how the determinants of output volatility would have changed if the only difference were the changed exposure of developing countries to global disturbances.

Both comparisons confirm that the change in the global environment was not the main factor behind the increased contribution of global shocks to GDP volatility in recent decades. The variance contribution of global shocks under the counterfactual experiment in panel (c) is much lower than that actually found in the post-1990 sample, and virtually identical to the contribution that results from the full-sample estimates.

As a further check, panel (d) of Table 3 reports the opposite counterfactual experiment from that in panel (c), namely, combining the full-sample global VAR estimates with the post-1990 estimates of the growth equation. The resulting variance decomposition between domestic and global shocks is almost identical to that shown in panel (b), which employs the post-1990 estimates of the global VAR, rather than their full-sample counterpart. This confirms that the increased exposure of developing countries to global disturbances is the cause of the observed increase in the contribution of global shocks to the volatility of GDP.

These results refer to the variance contribution of all global shocks combined. Table 4 shows the relative contribution of each individual shock, as percentage of the total contribution of all four shocks. The top panel shows the results based on the full sample estimates. At the 1 and 5-year horizons, global monetary shocks are the leading external source of GDP volatility. In the long run, however, as given by the 10-year horizon, global demand shocks show the biggest contribution, doubling that of all other shocks combined.

In turn, the post-1990 results, shown in the bottom panel of Table 4, reveal two major differences relative to the full-sample results. First, global monetary shocks now represent the biggest external source of volatility not only at the 1 and 5-year horizons, but also at the 10-year horizon. Second, in the short term demand shocks still contribute a considerable (and increased) fraction of the variance, but at longer horizons they now play the smallest role among the four global shocks.

4.3 The role of policy and structural factors

The changing role of global shocks that the above results reveal suggests that the empirical specification of the growth equation (1) with constant parameters across countries (except for the intercept) and over time may not be appropriate. As earlier literature has argued, countries' policy framework and economic structure likely contribute to shape their response to global shocks. Thus, we next assess to what extent the changing role of global shocks found above can be traced to the changes in key features of developing economies occurred over the sample period. Specifically, we focus on the three ingredients discussed earlier: trade openness, financial openness, and degree of specialization in commodities.

Figure 5 offers a perspective on the trends in the three conditioning variables across countries and over time. In each case, the graphs depict the time path of the cross-sectional median as well as the 25th and 75th percentiles. Trade openness (shown in the top panel) has been on the rise in a majority of countries. The entire distribution of openness across countries has trended up steadily, except perhaps during the early 1980s. Its dispersion, as captured by the interquartile range, has not changed much – if anything, it has declined slightly. In turn, financial openness (shown in the middle panel) has been on an upward trend since the early 1990s, although it shows a slight decline following the global crisis. In contrast with trade openness, the

cross-country variation in the degree of financial openness has widened quite significantly. Lastly, commodity intensity (shown in the bottom panel of Figure 5) also shows increasing cross-country variation over time. Its median value remained roughly constant since the 1960s until the early 2000s, and fell afterwards to almost zero in 2010. In contrast, the 75th percentile more than doubled over the sample period, while the interquartile range rose threefold.

It is worth noting also that the three conditioning variables show fairly modest pairwise correlation. While trade and financial openness are moderately correlated (.28), commodity intensity appears virtually uncorrelated with both of them (the pairwise correlations are .16 and -.07, respectively). This suggests that the three variables capture different features of the economies under consideration.

To assess the role of these variables in shaping the response to global shocks, we use the framework of equation (1'). Specifically, we estimate the parameters of the equation letting the set of conditioning variables $\mathbf{z}$ consist of our indices of trade openness, financial openness, and commodity-intensity (plus a constant).¹⁶ Armed with the resulting estimates of $\boldsymbol{\gamma}$ and $\boldsymbol{\lambda}$, we can calculate the impulse responses generated by the model for alternative values of the three conditioning variables, and we can also construct the associated decompositions of the variance of the GDP forecast error.

We implement this approach one variable at a time: we let each one of them vary while holding the other two constant – a *ceteris paribus* exercise. For each value of the conditioning variable of interest, we follow the procedure described earlier to obtain 1,000 identified models

¹⁶ To minimize potential simultaneity problems, in the estimation we use the lagged values of the conditioning variables $\mathbf{z}$. Unavailability of the Chinn-Ito capital account openness index results in the loss of a few countries for this exercise. They are Cambodia, Angola, Botswana, Ethiopia, Lesotho, Namibia, Albania, Bulgaria and Mongolia.

satisfying the sign restrictions in Table 1. This allows us to generate a surface describing the economy's median response to a given shock at different values of the conditioning variable under consideration, holding fixed (specifically, at their sample median) the other conditioning variables.¹⁷ We can also generate 1,000 variance decompositions for each value of the conditioning variable, of which we report the average below.

Consider first the role of trade openness. Figure 6 reports the median response surfaces¹⁸ for each of the four global shocks considered, for values of the trade openness indicator ranging from the 10th to the 90th sample percentile, while holding the financial openness and commodity-intensity indices at their respective sample medians. For added detail, under each response surface the figure also plots the impulse responses at the 1, 3 and 5-year horizon, along with the corresponding 68-percent bands.

Panel (a) of Figure 6 shows the response of GDP growth to a global demand shock. The median impact response is monotonically increasing in the degree of trade openness. It is positive for high openness, but negative for low openness. This suggests that, for economies relatively closed to trade, the expansionary effects of increased global demand are more than offset by the adverse effects of the global increase in interest rates (and perhaps also increased commodity prices) derived from a global demand shock, shown in Table 1 and Figure 3. However, the fairly wide 68-percent bands shown in the period-wise figures at the bottom indicate that the impact responses obtained from the different models are relatively disperse, so that the sign of the impact response is not precisely determined except for very low and very

¹⁷ To generate the entire path of the impulse-responses, we hold the conditioning variable(s) constant over the horizon of the calculations.

¹⁸ Note that we obtain one response surface for each one of the estimated models satisfying the sign restrictions. The figures depict the median responses across all such models.

high openness. Beyond the impact effect, the response quickly turns negative, although over the first few years it remains monotonically increasing with the degree of trade openness. However, such feature gets reversed in later stages of the cyclical adjustment process.

Figure 6(b) shows the response surface for a global supply shock. Like with the demand shock, the median impact response is upward sloping with the degree of trade openness, although the slope is less pronounced in this case. The median impact response is uniformly positive, but the estimates from the different models are sufficiently disperse that the 68-percent bands do not exclude a zero response, nor do they allow firm conclusions regarding how the impact response changes with financial openness. Beyond the initial impact, the positive slope gets quickly inverted; by the third year it has become negative.

Panel (c) of Figure 6 reports the responses of GDP growth to a global monetary shock. Like with the supply shock, the median impact effect is positive for all levels of trade openness, and its magnitude increases with the latter. Moreover, the relatively narrow 68-percent bands suggest that this is unambiguously the case – i.e., the 68-percent areas at high and low levels of openness do not intersect. This differential pattern of responses according to the degree of openness persists for several periods.

Finally, Figure 6(d) shows the effects of a global commodity shock – an autonomous decline of global excess demand for commodities – under different degrees of trade openness. When the economy is nearly closed to trade, the median response is positive but small. As openness increases, it becomes increasingly large.¹⁹ Recall that the global commodity shock has,

¹⁹ This agrees with the results of Loayza and Raddatz (2007). However, the terms of trade is the only foreign variable considered in their analysis, and hence the interpretation of a terms of trade shock is not identical to that of a commodity shock in our setting.

by construction, an expansionary effect on global GDP, which raises export demand. The larger the degree of openness, the bigger the demand pull. Beyond the impact effect, however, growth responses quickly decline; by the 5th year they have virtually disappeared, and do not show any definite relation with the degree of trade openness anymore.

Consider next the consequences of financial openness for the response to global shocks. They are depicted in Figure 7. Panel (a) shows that the median impact of a global demand shock is close to zero at low levels of capital account openness, and becomes positive and increasingly large as the degree of financial openness grows. Intuitively, a global demand shock raises world growth, leading to an incipient rise in export demand and a current account surplus. With a closed capital account, however, the domestic interest rate must rise and the real exchange rate must appreciate offsetting much or all of the expansion. As the capital account becomes more open, the crowding out of domestic demand is reduced, allowing domestic output to expand further on impact. However, beyond the short run the expansion gets quickly reversed. In turn, the short-run response to a global supply shock, shown in Figure 7(b), follows a broadly similar pattern.

Next, Figure 7(c) reports the growth response to an expansionary global monetary shock. The median impact effect is positive across the full distribution of financial openness, and increases noticeably as financial openness grows. Further, the 68-percent bands consistently exclude zero. Higher financial openness implies that domestic interest rates follow more closely the decline of global interest rates, and this adds to the expansionary impact of growing world output on the domestic economy. The upward-sloping pattern of responses is noticeable for several periods, although the 68-percent bands gradually widen.

Lastly, Figure 7(d) depicts the pattern of responses to a global commodity shock. As with the monetary shock, the median impact effect is uniformly positive across the full range of financial openness, although for high degrees of openness the estimates from the different models are fairly disperse. Beyond the initial impact, the growth response is somewhat larger for higher degrees of financial openness. This likely reflects the fact that greater openness mitigates the upward pressure on domestic interest rates arising from the shift in aggregate demand induced by rising global growth – one of the main consequences of the shock – thus limiting the extent of financial crowding-out and thereby allowing a larger rise in domestic growth.

The last dimension to consider is the commodity orientation of production, as captured by the commodity-intensity indicator. Figure 8(a) shows how commodity intensity affects the response of growth to a global demand shock. Recall that a global demand shock raises global GDP but also global interest rates and real commodity prices. The latter effects impacts adversely on net commodity importers but favorably on net exporters. Accordingly, the figure reveals that the global demand shock has a more expansionary impact effect on growth when commodity intensity is high than when it is low. In fact, for low commodity intensity – that is, large net imports of commodities – the impact effect is close to zero. Beyond the short run, however, the median growth response changes sign, reflecting the rising global interest rates, and shows little variation across levels of commodity intensity. In turn, the effects of a global supply shock are shown in Figure 8(b). The impact response is qualitatively very similar to that just described, but quantitatively it is somewhat larger as the upward pressure on global interest rates found under the demand shock is absent under a supply shock.

A global monetary shock raises global growth, lowers interest rates, and raises relative commodity prices. The first two forces are generally expansionary, while the third is

expansionary (contractionary) for net commodity exporters (importers). Accordingly, Figure 8(c) shows that the median impact response of GDP growth, which is positive across the entire range of commodity intensity in the sample, grows in magnitude with the degree of commodity intensity, especially at the higher end of the distribution of the latter variable. Further, the positive response and its larger magnitude for higher degrees of commodity intensity persist for several periods.

Lastly, a global commodity shock raises global growth and lowers real commodity prices. The two effects are mutually reinforcing for net commodity importers, and opposing for commodity exporters. As a consequence, the median impact response of GDP growth, shown in Figure 8(d), is larger at low levels of commodity intensity than at high ones. Indeed, for high levels of commodity intensity, the initially positive growth response has turned negative by the third year.

Finally, we can examine how the structural and policy variables affect the variance decomposition of the GDP forecast error. Figures 9-11 report the average variance contribution of the different global shocks at different percentiles of the sample distribution of the three conditioning variables. In the graphs, the total height of the vertical bars reflects, at each percentile, the overall contribution of four global shocks, whose respective contributions are also shown.

Figure 9 illustrates the case of trade openness. In the short run, depicted in the top panel, a higher degree of trade openness augments the combined role of global shocks, although the range of variation (a combined contribution going from 0.4 percent to 1.3 percent) is quantitatively very modest. The contribution of the different individual shocks follows a rising

pattern, except for demand shocks, which exhibit a U-shaped pattern. Consistent with the results of the impulse responses, this reflects the fact that highly closed economies are (negatively) affected mainly by the rise in world interest rates triggered by the global demand shock, and little by the (positive) impact of the export demand expansion that follows from the shock. At intermediate degrees of openness, the latter effect becomes larger, partly offsetting the former; as a result of these countervailing effects, the variance contribution of demand shocks declines. At high levels of openness, the positive demand effect becomes large enough that the variance contribution rises again.

At longer horizons (middle and bottom panels of Figure 9), while the overall variance contribution of global shocks rises significantly at all levels of trade openness, it also adopts a U-shaped pattern. The reason is that, at longer horizons, the dampening effect of the global interest rate increase outweighs the export demand pull, and thus the global demand shock has a net contractionary effect on GDP, whose magnitude is smaller at higher degrees of openness, reflecting the bigger impact of the export demand increase. Hence the variance contribution of global demand shocks declines as the degree of trade openness increases. In contrast, the variance contribution of monetary shocks shows the opposite pattern, similar to the one found at the 1-year horizon, while the respective contributions of supply and commodity shocks are roughly invariant to trade openness. Combining these four ingredients yields the U-shaped pattern in the middle and bottom panels. It also results in an increasing role for monetary shocks as trade openness rises, not only in absolute terms, but also relative that that of the other three shocks.

Figure 10 turns to capital account openness. The overall variance contribution of global shocks rises monotonically with financial openness at the three horizons considered, in contrast

with the U-shaped pattern found in the previous figure for the medium and long term. The clear implication is that more financially-open economies are more vulnerable to global disturbances. Still, beyond the 1-year horizon (shown in the top panel), as financial openness rises the variance contribution of demand shocks follows a declining pattern, qualitatively similar to that in Figure 9, but much less pronounced. At long horizons, depicted in the middle and bottom panels of Figure 10, the rising profile of the total contribution of global shocks is primarily due to that of monetary shocks, although supply and commodity shocks also show a slightly increasing contribution.

Lastly, Figure 11 reports GDP forecast error variance decompositions at different percentiles of commodity intensity. Like in the previous figure, the total contribution of global shocks rises monotonically with commodity intensity at all time horizons, which agrees with the conventional view that commodity-intensive economies are more vulnerable to global shocks. Inspection of the graphs shows that this is mainly due to the rising profile of the variance contribution of global monetary shocks. However, at the 10-year horizon the contributions of the other three shocks also show a rising profile, suggesting that the added vulnerability of commodity-intensive economies applies to all types of shocks.

5. Conclusion

This paper takes a fresh look at the impact of external shocks on output fluctuations in developing countries. Using a large annual dataset comprising 82 countries over four decades, the analysis focuses on the effects of a set of real and financial global structural shocks that admit a clear economic interpretation. We consider four types of global shocks – demand, supply, monetary, and commodity shocks. In contrast with standard practice, each of these

shocks is not associated with a change in a particular global variable, but rather with a pattern of change in multiple variables at a time that accords with first principles.

The paper's results indicate that external shocks account for a relatively small fraction of the volatility of GDP in developing countries. In the full sample, their combined contribution to the long-run variance of the growth forecast error is under 10 percent. However, comparing these results with those obtained using only the post-1990 years, we also find that the contribution has increased over time, even though the volatility of global variables declined. Thus, the reason is the increased sensitivity of developing countries to external disturbances over the recent sample. Furthermore, the variance contributions of the various structural shocks also show marked differences between the two samples. In particular, in the recent sample global monetary shocks account for a much bigger fraction of the forecast error variance of GDP at medium and long horizons than in the full sample.

Importantly, the paper's empirical framework allows us to trace these changes in developing countries' response to shocks to changes in their structural features and policy frameworks. We use the framework to relate shock responses, and their contribution to the variance of GDP, to countries' real and financial openness and to their degree of specialization in commodities. We find that increased openness along either dimension generally amplifies the short-run effects of global shocks – both real and financial. In particular, increased financial openness is unambiguously associated with an increased contribution of external disturbances to the variance of GDP, while increased trade openness has a similar effect except at low levels of openness. Moreover, higher openness along either dimension also raises the variance contribution of global monetary shocks relative to that of the other shocks. Hence, the increase in the degree of real and financial openness across the developing world can explain the observed

increase in the role of global shocks, and in particular monetary shocks, for the volatility of GDP in developing countries.

Finally, our results also cast light on the reasons behind the volatility of GDP in commodity-intensive economies underscored in earlier literature. Unlike most previous studies, our framework allows us to draw a transparent distinction between the effects of commodity specialization on economies' external vulnerability, and the magnitude of the shocks to which they are subject, which we can hold constant in our setting. We find that commodity-intensive countries exhibit greater sensitivity to non-commodity external disturbances, both real and nominal. Thus, the greater role of external shocks for the volatility of commodity-intensive economies, relative to that of other countries, reflects a greater contribution to the variance of GDP of all shocks, rather than just commodity shocks.

References

- Ahmed, S. (2003): "Sources of economic fluctuations in Latin America and implications for choice of exchange rate regimes", *Journal of Development Economics* 72, 181-202.
- Broda, C. (2004): "Terms of trade and exchange rate regimes in developing countries", *Journal of International Economics* 63, 31-58.
- Canova, F. (2005): "The transmission of US shocks to Latin America", *Journal of Applied Econometrics* 20, 229-251.
- Canova, F. and G. Nicolo (2003): "On the sources of business cycles in the G-7", *Journal of International Economics* 59, 77-100.
- Cavallo, E. (2008): "Output Volatility and Openness to Trade: A Reassessment," *Economía* 9, 105-138.
- Cavallo, E. and J. Frankel (2007): "Does openness to trade make countries more vulnerable to sudden stops, or less? Using gravity to establish causality", *Journal of International Money and Finance*.
- Di Giovanni, J. and A. Levchenko (2009): "Trade openness and volatility", *Review of Economics and Statistics* 91, 558-585.
- Fry, R. and A. Pagan (2011): "Sign Restrictions in Structural Vector Autoregressions: A Critical Review", *Journal of Economic Literature* 49, 938-60.
- Georgiadis, G. (2013): "The panel conditionally homogeneous vector autoregressive model", unpublished manuscript.
- Georgiadis, G. (2014): "Towards an explanation of cross-country asymmetries in monetary transmission", *Journal of Macroeconomics* 39, 66-84.
- Hoffmaister, A., J. Roldós and P. Wickham (1998): "Macroeconomic Fluctuations in Sub-Saharan Africa", *IMF Staff Papers* 45.
- Hory, M-P. (2015). "Fiscal multipliers in Emerging Market Economies: can we learn something from Advanced Economies?", unpublished manuscript.
- Koren, M. and S. Tenreyro (2007): "Volatility and development", *Quarterly Journal of Economics* 122, 243-287.
- Kose, A. (2001): "Explaining business cycles in small open economies: 'How much do world prices matter?'", *Journal of International Economics* 56, 299-327.
- Kose, A., C. Otrok and C. Whiteman (2003): "International Business Cycles: World, Region, and Country-Specific Factors", *American Economic Review* 93, 1216-1239.
- Leamer, Edward E. (1984): *Sources of International Comparative Advantage: Theory and Evidence*. Cambridge, MA: MIT Press.
- Leamer, Edward E. (1995): "The Heckscher-Ohlin Model in Theory and Practice." *Princeton Studies in International Finance* 77.
- Loayza, N. and C. Raddatz (2007): "The structural determinants of external vulnerability", *World Bank Economic Review* 21, 359-387.
- Lutkepohl, H. (2007): *New Introduction to Multiple Time Series Analysis*. Springer.
- Mackowiak, B. (2007): "External shocks, U.S. monetary policy, and macroeconomic fluctuations in emerging markets", *Journal of Monetary Economics* 54, 2512-2520.
- Prasad, E., K. Rogoff, S. Wei and A. Kose (2003): "Effects of financial liberalization on developing countries: some empirical evidence", IMF Occasional Paper 220.
- Raddatz, C. (2007): "Are external shocks responsible for the instability of output in low-income countries?", *Journal of Development Economics* 84, 155-187.

- Raddatz, C. (2008a) “Have External Shocks Become More Important for Output Fluctuations in African Countries?” In: Go, Delfin S., and John Page (eds.) *Africa at a Turning Point? Growth, Aid, and External Shocks.* Washington, DC: The World Bank, pp. 343-374.
- Raddatz, C. (2008b): “External Shocks and Macroeconomic Volatility in Latin America”, unpublished manuscript.
- Rubio-Ramirez, J., D. Waggoner, and T. Zha (2010): “Structural vector autoregressions: Theory of identification and algorithms for inference”, *Review of Economic Studies* 77, 665-696
- Saborowski, C. and S. Weber (2013): “Assessing the determinants of interest rate transmission through conditional impulse-response functions”, IMF Working Paper 13/23.
- Saborowski, C., S. Sanya, H. Weisfeld, and J. Yezpez (2014). “Effectiveness of Capital Outflow Restrictions”, IMF Working Paper 14/8.
- Towbin, P. and S. Weber (2013): “Limits of floating exchange rates: The role of foreign currency debt and import structure”, *Journal of Development Economics* 101, 179-194.
- Uhlig, H. (2005): “What are the effects of monetary policy on output? Results from an agnostic identification procedure”, *Journal of Monetary Economics* 52, 381–419.
- Uribe, M. and V. Yue (2006): “Country spreads and emerging countries: Who drives whom?”, *Journal of International Economics* 69, 6–36.
- Van der Ploeg, F. and S. Poelhekke (2009): “Volatility and the natural resource curse”, *Oxford Economic Papers* 61, 727-760.

Table 1
Sign restrictions on the responses of global variables to global shocks

	World output	World inflation	Short-term interest rate	Commodity prices
Global shock				
Supply	+	-	?	+
Demand	+	+	+	+
Monetary	+	+	-	+
Commodity	+	-	?	-

Table 2
Global variables: variance decomposition of the forecast error

	Full sample						Post-1990 sample					
	Standard deviation	Percent of variance explained by					Standard deviation	Percent of variance explained by				
		Total	Demand shock	Supply shock	Monet. Shock	Commod shock		Total	Demand shock	Supply shock	Monet. Shock	Commod shock
(a) 1 year ahead												
Real GDP growth	1.40	100.0	46.2	14.0	14.3	25.4	1.29	100.0	57.1	14.2	18.6	10.0
Inflation	0.75	100.0	44.3	25.4	17.1	13.2	0.36	100.0	49.8	12.6	25.0	12.6
Interest Rate	1.29	100.0	68.5	11.7	8.5	11.2	1.09	100.0	60.7	15.8	11.0	12.4
Commodity Prices	12.59	100.0	12.6	33.0	18.9	35.5	9.94	100.0	21.7	30.9	29.8	17.5
(b) 5 years ahead												
Real GDP growth	1.92	100.0	28.5	15.4	11.9	44.2	1.58	100.0	40.9	17.6	21.1	20.4
Inflation	1.84	100.0	36.9	11.8	41.6	9.7	0.63	100.0	28.4	27.0	29.5	15.0
Interest Rate	2.55	100.0	72.0	9.6	8.5	10.0	1.65	100.0	51.9	14.3	11.4	22.3
Commodity Prices	14.12	100.0	21.0	29.2	18.3	31.5	11.96	100.0	22.9	32.3	27.9	16.9
(c) 10 years ahead												
Real GDP growth	1.92	100.0	28.5	15.4	11.9	44.1	1.62	100.0	40.2	18.7	21.0	20.1
Inflation	2.14	100.0	30.3	14.7	45.4	9.6	0.63	100.0	28.3	27.1	29.6	15.0
Interest Rate	2.82	100.0	64.3	10.5	15.2	10.0	1.75	100.0	48.3	17.0	13.1	21.5
Commodity Prices	14.58	100.0	23.1	27.9	18.8	30.2	12.17	100.0	22.9	32.4	27.7	16.9

Table 3
Real GDP: variance decomposition of the forecast error

	Standard deviation of forecast error	Percent of variance explained by	
		Global shocks	Domestic shock
(a) Full sample estimates			
1 year ahead	4.8	1.0	99.0
5 years ahead	6.6	4.0	96.0
10 years ahead	6.8	8.3	91.7
(b) Post-1990 estimates			
1 year ahead	4.1	5.0	95.0
5 years ahead	5.6	8.1	91.9
10 years ahead	5.8	13.4	86.6
(c) Post-1990 Global VAR and full-sample PVAR estimates			
1 year ahead	4.8	1.1	98.9
5 years ahead	6.6	3.5	96.5
10 years ahead	6.7	7.3	92.7
(d) Full-sample Global VAR and post-1990 PVAR estimates			
1 year ahead	4.1	5.0	95.0
5 years ahead	5.6	8.7	91.3
10 years ahead	5.8	13.7	86.3

Table 4**Real GDP: contribution of global shocks to the variance of the forecast error**

	Percentage contribution of each global shock (percent of total)				Total (% of GDP forecast error variance)
	Demand shock	Supply shock	Monet. Shock	Commod shock	
Full sample estimates					
1 year ahead	17.3	27.8	44.4	10.5	1.0
5 years ahead	38.4	11.9	39.1	10.5	4.0
10 years ahead	67.7	11.0	10.6	10.7	8.3
Post-1990 estimates					
1 year ahead	35.9	14.1	44.4	5.5	5.0
5 years ahead	4.6	11.6	62.4	21.4	8.1
10 years ahead	6.5	13.8	56.3	23.3	13.4

Figure 1
Growth volatility
 (Standard deviation of real GDP growth, 1970-2010)

Figure 2
Growth volatility over time
 (Standard deviation of real GDP growth)

Figure 3
Global variables: responses to global shocks

Figure 3
Global variables: responses to global shocks (continued)

Figure 4
Real GDP growth: responses to global shocks

Figure 5
Conditioning variables

Figure 6

Real GDP growth: response to global shocks conditional on trade openness

Figure 6

Real GDP growth: response to global shocks conditional on trade openness (continued)

Figure 7

Real GDP growth: response to global shocks conditional on capital account openness

Figure 7

Real GDP growth: response to global shocks conditional on capital account openness (continued)

Figure 8

Real GDP growth: response to global shocks conditional on commodity intensity

Figure 8

Real GDP growth: response to global shocks conditional on commodity intensity (continued)

Figure 9
Real GDP: variance decomposition conditional on trade openness
 (a) 1 year ahead

(b) 5 years ahead

(c) 10 years ahead

Figure 10
Real GDP: variance decomposition conditional on capital account openness
 (a) 1 year ahead

(b) 5 years ahead

(c) 10 years ahead

Figure 11
Real GDP: variance decomposition conditional on commodity intensity
 (a) 1 year ahead

(b) 5 years ahead

(c) 10 years ahead

Table A1

List of countries

#	country	pwt_code	wb_code	ifs_code	#	country	pwt_code	wb_code	ifs_code
1	Albania	ALB	ALB	914	43	Lesotho	LSO	LSO	666
2	Angola	AGO	AGO	614	44	Madagascar	MDG	MDG	674
3	Argentina	ARG	ARG	213	45	Malawi	MWI	MWI	676
4	Bangladesh	BGD	BGD	513	46	Malaysia	MYS	MYS	548
5	Benin	BEN	BEN	638	47	Mali	MLI	MLI	678
6	Bolivia	BOL	BOL	218	48	Mauritania	MRT	MRT	682
7	Botswana	BWA	BWA	616	49	Mauritius	MUS	MUS	684
8	Brazil	BRA	BRA	223	50	Mexico	MEX	MEX	273
9	Bulgaria	BGR	BGR	918	51	Mongolia	MNG	MNG	948
10	Burkina Faso	BFA	BFA	748	52	Morocco	MAR	MAR	686
11	Burundi	BDI	BDI	618	53	Mozambique	MOZ	MOZ	688
12	Cambodia	KHM	KHM	522	54	Namibia	NAM	NAM	728
13	Cameroon	CMR	CMR	622	55	Nepal	NPL	NPL	558
14	Central African Republic	CAF	CAF	626	56	Niger	NER	NER	692
15	Chad	TCD	TCD	628	57	Nigeria	NGA	NGA	694
16	Chile	CHL	CHL	228	58	Pakistan	PAK	PAK	564
17	China	CHN	CHN	924	59	Panama	PAN	PAN	283
18	Colombia	COL	COL	233	60	Paraguay	PRY	PRY	288
19	Congo, Dem. Rep.	COD	ZAR	636	61	Peru	PER	PER	293
20	Congo, Rep.	COG	COG	634	62	Philippines	PHL	PHL	566
21	Costa Rica	CRI	CRI	238	63	Poland	POL	POL	964
22	Côte d'Ivoire	CIV	CIV	662	64	Romania	ROU	ROM	968
23	Dominican Republic	DOM	DOM	243	65	Senegal	SEN	SEN	722
24	Ecuador	ECU	ECU	248	66	Sierra Leone	SLE	SLE	724
25	Egypt, Arab Rep.	EGY	EGY	469	67	South Africa	ZAF	ZAF	199
26	El Salvador	SLV	SLV	253	68	Sri Lanka	LKA	LKA	524
27	Ethiopia	ETH	ETH	644	69	Sudan	SDN	SDN	732
28	Gabon	GAB	GAB	646	70	Syrian Arab Republic	SYR	SYR	463
29	Gambia, The	GMB	GMB	648	71	Tanzania	TZA	TZA	738
30	Ghana	GHA	GHA	652	72	Thailand	THA	THA	578
31	Guatemala	GTM	GTM	258	73	Togo	TGO	TGO	742
32	Guinea	GIN	GIN	656	74	Trinidad and Tobago	TTO	TTO	369
33	Guinea-Bissau	GNB	GNB	654	75	Tunisia	TUN	TUN	744
34	Honduras	HND	HND	268	76	Turkey	TUR	TUR	186
35	Hungary	HUN	HUN	944	77	Uganda	UGA	UGA	746
36	India	IND	IND	534	78	Uruguay	URY	URY	298
37	Indonesia	IDN	IDN	536	79	Venezuela, RB	VEN	VEN	299
38	Iran, Islamic Rep.	IRN	IRN	429	80	Vietnam	VNM	VNM	582
39	Jamaica	JAM	JAM	343	81	Zambia	ZMB	ZMB	754
40	Jordan	JOR	JOR	439	82	Zimbabwe	ZWE	ZWE	698
41	Kenya	KEN	KEN	664					
42	Lao PDR	LAO	LAO	544					

Table A2**Data Sources**

Series	Description and source
Real GDP	GDP at 2005 national prices, from PWT 8.1
Trade openness	Imports + Exports from UNCTAD relative to GDP (logs)
Capital account openness	Chinn-Ito KAOPEN, from http://web.pdx.edu/~ito/Chinn-Ito_website.htm
Commodity Intensity	Net exports of commodities per worker, based on own calculation using data from UNCTAD (see Table A3)
Global GDP	G7 real GDP, from PWT 8.1
Global inflation	Log-difference of the U.S. GDP deflator, from FRED
Global interest rate	3-month U.S. T-Bill rate, from FRED
Global commodity Price	Commodity price index for all items, from UNCTAD, relative to the U.S. GDP deflator, from FRED

Table A3

Measuring commodity intensity

(Defined as total net exports per worker of 6 commodity aggregates, from UNCTAD)

Commodity cluster	SITC codes
Petroleum and derivatives	33
Raw materials	27, 28, 32, 34, 35, and 68
Forest products	24, 25, 63, and 64
Tropical agriculture	5, 6, 7, 11, and 23
Animal products	0 to 3, 21, 29, 43, and 9
Cereals, oil, textile fibers, tobacco, and others	4, 8, 9, 12, 22, 26, 41, and 42