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Abstract

Do sources of volatility differ by country characteristics such as the level of development, country size, quality of institutions, and presence of restrictions on fiscal policy? This paper sets out to answer this question in a quarterly panel of 48 developed and developing countries for 1960–2015. Using individual country and panel vector autoregressions, the paper shows that factors affecting gross domestic product volatility differ systematically by country size, development level, and whether a country has adopted fiscal rule(s). The role of country size is particularly pronounced in developing countries. The paper shows that small developing countries are more prone to domestic output shocks, while shocks to the world interest rate and real exchange rate are more important in large developing countries. Small countries are also more susceptible to terms of trade shocks. These results suggest that stabilization policies must be designed with these country characteristics in mind.

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Sources of Volatility in Small Economies[*]

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1. Introduction

The main objective of this paper is to provide an exploration into the sources of macroeconomic volatility in the small open developing economies. An important aspect of our study is to contrast the sources of volatility based on a series of country characteristics, such as size, development level, institutional quality, and the incidence of fiscal rules adoption. Such analysis allows us to highlight the key shocks and frictions affecting the small developing countries and provide some insights into the stabilization role of the fiscal policy in these economies.

For this purpose, we construct a data set covering 48 countries, of which 20 are developing and 28 are developed economies, at quarterly frequency during 1960:Q1-2015:Q4 period, and use it to investigate the sources of volatility by means of several methods. We begin by estimating a Structural Vector Autoregression (SVAR) for each country in our sample. This allows us to analyze and quantify the effects of various shocks on GDP in each country. We report the results of these variance decompositions conditional on various country characteristics: size, development level, institutional quality and the presence of fiscal rules.

We find that across all countries, on average, about 22% of the overall GDP volatility is driven by external shocks which include shocks to the world real interest rate (proxied by the US T-bill rate) and to the foreign demand conditions (proxied by the US GDP). The contribution of shocks to each external variable is roughly equal at 11% each. The remaining 78% are accounted for by domestic shocks including shocks to government expenditures, trade balance, real interest rate, real exchange rate and GDP itself. Among domestic factors, shocks to GDP contribute the most to GDP fluctuations (just over 50%), followed by the shocks to government expenditures (10%), trade balance (7%), real exchange rate (6%) and domestic real interest rate (3%).

These decompositions change as we condition on country size, where the latter is measured by average population. Specifically, we find that larger countries are more susceptible to external shocks, as the overall contribution of these shocks to their GDP volatility equals 29%, compared to just 17% in smaller economies. This difference is driven by both shocks to the world interest rate and foreign demand, with the latter being somewhat more important. In terms of the domestic factors, shocks to GDP are more important drivers of GDP volatility in small economies relative to larger countries. For instance, mean contribution of GDP shocks is 58% in small countries, while it is a significantly smaller 46% in large economies. At the same time shocks to the real exchange rate carry a greater importance in larger countries relative to smaller ones. The contributions of all other shocks to GDP volatility are indistinguishable between large and small countries.

Turning to the level of development, we find that the role played by external shocks for GDP volatility is slightly larger in developed economies and that most of the difference is driven by the predominance of shocks to external demand in these economies. Among domestic factors, shocks to GDP are more important drivers of GDP volatility in developed countries relative to developing economies, while the reverse is true for the shocks to government expenditures and the real exchange rate.

It is possible, however, that the country size and level of development are correlated. Indeed, in our sample, developing countries are more likely to be larger, while developed economies are likely to be smaller. Thus, a question arises to what extent the sources of volatility are driven by country size versus the level of development. To investigate this issue, we condition the variance decomposition results on both characteristics.

We find that the effects of country size remain practically unchanged in the group of developing countries. Specifically, GDP volatility in small developing countries is predominantly attributable to shocks to domestic output, while large developing countries are more prone to world interest rate shocks and shocks to the real exchange rate. The exposure to external demand shocks does not differ systematically across small and large developing countries. This is in stark contrast with developed economies where the contribution of external demand conditions to GDP volatility varies significantly between small and large countries. In particular, large developed countries are more susceptible to these shocks relative to small developed economies. All other shocks contribute to GDP volatility in the same way in small and large developed countries.

We also consider a model specification with terms of trade. Due to a lack of quarterly data on terms of trade, this specification can only be estimated on 21 countries. We find that adding terms of trade to the set of external factors in the estimation, raises the contribution of external shocks to the overall GDP volatility, especially in small economies. The contribution of terms of trade shocks in small economies is estimated at 15% of overall GDP volatility, while in large countries it is equal to just 7.7%.

To better understand the inter-relationships between different variables in our analysis and check the robustness of our findings, we also perform panel VAR estimations separately for each income group, each size group, as well as for each size group, conditional on income group. We find that most variables have an expected effect on GDP in small and large economies. For instance, a positive shock to government expenditures, productivity, or foreign demand has an expansionary effect on GDP in both groups of countries. The effects, however, differ in strength and duration. For instance, productivity shocks tend to be more persistent in larger economies. Shocks that raise domestic real interest rate tend to have contractionary effects on GDP in both groups, while shocks that appreciate real exchange rate lead to output expansions in both groups.

The main differences between large and small economies arise in the responses of GDP to trade balance and world interest rate shocks. Specifically, a positive shock to the world interest rate leads to a fall in GDP in large economies, but to an expansion, although statistically insignificant, in small economies. A shock that raises trade balance is followed by an expansion in GDP in small economies but a contraction in GDP, albeit very short-lived, in large economies.

Consistent with variance decomposition results from individual country VARs, we find that impulse responses from panel VARs for large and small economies go through practically unchanged when we focus only on the subset of developing countries. In contrast, for developed economies, the impulse responses look much more symmetric in terms of direction, size, and duration. We interpret this finding as suggesting that country size matters for business cycle

dynamics and sources of volatility in developing countries, but does not seem to play an important role in developed economies.

Lastly, we investigate how volatility sources differ by institutional quality and the presence of fiscal rules. When conditioning the sources of GDP volatility on whether or not a country has adopted fiscal rule(s), we find that shocks to GDP and government expenditures are responsible for a larger share of GDP volatility in fiscal rule(s) non-adopters. On the other hand, shocks to the world demand conditions and trade balance play a greater role for GDP volatility in fiscal adopters.

As for the measure of institutional development, we find that it is highly correlated with the measure of economic development in our sample of countries as both variance decompositions and impulse responses in countries with high quality of institutions are almost identical to those in developed economies, while the results in countries with low quality of institutions are symmetric to our findings obtained for developing economies. These results therefore are rendered to the appendix.

Overall, our results indicate that sources of volatility differ systematically by country size (especially for the developing countries group), by the level of development, and by whether or not a country has adopted fiscal rule(s). Our results also suggest a few directions for fiscal policy in small countries. In particular, given greater susceptibility of small countries to terms of trade shocks and shocks to domestic GDP, a countercyclical fiscal policy and fiscal policy rules that encourage accumulation of precautionary fiscal savings would help cushion the effects of these shocks on the economy and thus lower GDP volatility in these countries.

The rest of the paper is structured as follows. Section 2 provides the description of our data set, while Section 3 contains the literature overview and methodology. The results from country-by-country and panel VARs are summarized in Section 4. Section 5 discusses policy implications of our findings. Section 6 concludes.

2. Data Description

Our data come from several sources. To capture country size, we use population. These data are taken from the *World Development Indicators* (WDI) database of the World Bank and cover the period of 1960-2015 at annual frequency.

Most macroeconomic variables such as GDP, government expenditures, trade balance, current account, CPI, terms of trade, real exchange rate, and various interest rates are from the International Financial Statistics (IFS) database by the International Monetary Fund. The data cover the period of 1960-2015. For many developing countries, the IFS data are either incomplete, or not available altogether. In addition, as was highlighted in the literature (see, for instance, Ilzetzki et al. 2013), quarterly data for many developing countries could be problematic because it is often interpolated from annual data, rather than originally collected at the quarterly frequency. We try to address this issue by supplementing and/or replacing IFS data using the series collected from national data sources, such as National Central Banks or National Statistical Agencies.

The macroeconomic quantities in our data set are measured in current local currency units. To transform the data into real terms, all nominal quantities are deflated by the CPI deflator. Nominal

interest rate is measured as the lending rate, whenever available. In the subset of countries where lending rate was not available, we used the deposit rate or the money market rate. If those were not available, we used the discount rate or the T-bill rate. In our analysis we focus on the real interest rate computed as the difference between the nominal interest rate and the annualized consumer price index (CPI) inflation rate. Terms of trade is computed as the ratio of export unit value to import unit value, so that $tot_t = \frac{P_t^x}{P_t^m}$, where P_t^x is the unit value of exports and P_t^m is the unit value of imports. Unfortunately, terms of trade is not available for the majority of the countries in our data set, so in our benchmark analysis we omit it. Real exchange rate is the real effective exchange rate which is a measure of the value of a country's currency against an inflation-adjusted and trade-weighted index of foreign currencies. Thus, an increase in the real exchange rate implies an appreciation.

Next, to control for the potential effects of governance, political, economic and financial risk, and political conditions on the business cycles characteristics and sources of volatility, we use the *International Country Risk Guide* (ICRG) database. This data covers the period going back to 1984.

Lastly, to assess the effects of fiscal rules on the sources of volatility we rely on the International Monetary Fund's *Fiscal Rules database* which contains information on the type of fiscal rule in place, year of implementation, monitoring and enforcement procedures used. This data set is at annual frequency and covers 1985-2014 period.

3. Literature and Methodology

Our methodological approach relies on multivariate time-series analysis. We start by providing a comprehensive account of volatility of the key macroeconomic aggregates in each country in our sample using a vector autoregression (VAR) model estimated country by country. To assess the role played by various internal and external shocks in each individual country we employ the Forecast Error Variance Decomposition (FEVDC) and Impulse Response Function (IRF) techniques. To contrast the sources of volatility in small and large, developed and developing, high risk and low risk, with and without fiscal rules countries, we report the results separately for these groups.

Among domestic variables influencing business cycles we consider technology (productivity) shocks, shocks to trade balance and the real exchange rate, as well as variables that capture the stance of policy. In terms of the latter, we focus on two key variables: domestic real interest rate and government expenditures. The inclusion of policy variables reflects the possibility that government policies in smaller and developing countries often exacerbate business cycle fluctuations.

For instance, a large literature has documented that interest rates tend to be countercyclical in developing countries, while they tend to be procyclical in developed economies (see Neumeyer and Perri (2005), Uribe and Yue (2006) and others). The typical explanations for this cyclical behavior of real interest rates is the presence of financial frictions, such as the requirement that firms have to pay for part or all of the factors of production before production takes place. This

creates a need for borrowing by firms for working capital and leads to countercyclicality of factors demand and output. If these effects are more pronounced in smaller economies, the effects of interest rate shocks will be more important for them, relative to larger economies.

The procyclicality of fiscal policy in developing countries, as opposed to countercyclical or acyclical fiscal policy in developed countries, has also been highlighted in the literature. Gavin and Perotti (1997) showed that this is the case in Latin America, while Talvi and Végh (2005) and Ilzetzki and Vegh (2008) extended this finding to the entire developing world. Recently, the fiscal stance in developing countries has been changing. For instance, Frankel, Vegh, and Vuletin (2013) showed that many developing countries are moving away from pro-cyclicality, although it still remains predominantly pro-cyclical. Carneiro and Garrido (2015) evaluate this claim in a larger sample of countries, for various sub-periods and stages of the business cycle, as well as using a variety of de-trending methods and generally confirm it. Hnatkovska and Koehler-Geib (2016) using simple unconditional correlations, evaluate the cyclicality of fiscal consumption, investment, revenues and expenditures in small and large countries, and find that smaller countries have significantly more procyclical public revenues and fiscal balance compared to large economies. One shortcoming of their analysis is that an unconditional correlation compounds the endogenous feedback effects between fiscal policy and economic conditions of the country. In this paper, we revisit the evidence on fiscal policy cyclicality in small and large economies by means of a VAR analysis, which allows us to estimate the effects of government expenditure shocks on GDP and other key macroeconomic aggregates. Such an analysis is particularly relevant in small economies, given their lack of economies of scale and larger size of the government sector.

Among external drivers of business cycle fluctuations, we consider the world real interest rate shocks and shocks to foreign demand. To capture the foreign demand conditions, we would have liked to use the trade-weighted real GDP of the key trade partners for each country. However, these data are not available for most of the countries. Instead we chose to proxy for the world demand conditions using real GDP in the United States obtained from the Bureau of Economic Analysis (BEA).

The existing literature also emphasized that world interest rate is an important factor driving business cycle fluctuations in developed and developing countries. Lubik and Teo (2005) using an estimated model of small open economy show that world interest rate can account for over 40% of business cycle fluctuations in developing countries. Neumeyer and Perri (2005) in a representative emerging economy find a number that is around 30%. Uribe and Yue (2006) using a panel of emerging market economies reports that about 20% of aggregated fluctuations can be attributed to the world interest rate shocks. This contribution is estimated to be significant in developed economies as well. For instance, Blankenau, Kose and Yi (2001) find that world interest rate shocks account for about 30% of business cycle volatility in Canada. Therefore, to account for the effects of world interest rates shocks on the economies in our sample, we include the real 3-month US T-bill rate in our estimation. The latter is obtained as the difference between nominal 3-month US T-bill rate and annualized CPI inflation rate, both from the BEA.

For a few countries, for which the data are available, we also consider shocks to the terms of trade. Fluctuations in the terms of trade have historically been viewed as an important source of

business cycle volatility in developing countries. This may be even more so in smaller economies for several reasons: one, these economies tend to be less diversified in terms of their production and exports and thus more exposed to fluctuations in the world prices of a few goods or commodities; two, they are typically more dependent on imports of intermediate inputs and capital goods; and three, smaller economies tend to be more open to trade.

The existing literature has investigated the role played by terms of trade shocks in developed and developing countries extensively. For instance, Mendoza (1995) shows in a three-sector intertemporal model that terms of trade shocks contribute about 50% to GDP volatility in developed and developing countries. Kose and Riezman (2001) also show that fluctuations in international relative prices explain 44% of the output volatility in Africa. Kose (2002) breaks the import prices into the price of imported capital and the price of imported inputs and shows an even larger contribution of the terms of trade shocks, finding that the world price shocks are responsible for more than 80% of output fluctuations in a representative developing economy.

The estimates obtained in these papers are generally based on the analysis of calibrated business-cycle models. On the other hand, Lubik and Teo (2005) report a significantly smaller contribution of terms of trade shocks to business cycles fluctuation in a sample of 3 developed and 2 developing countries. In fact, they find that interest rate shocks are a more important source of business cycles than terms of trade shocks. Their analysis relies on estimating a small open economy model with full information Bayesian method. In the same spirit, Schmitt-Grohe and Uribe (2017), using a structural vector autoregression (SVAR) approach, find that terms of trade shocks explain just 10% of movement in the aggregate activity in a sample of 38 poor and emerging market countries at annual frequency. We contribute to this debate by studying a sample of developed and developing countries, at quarterly frequency. We also condition the analysis on country size and the presence of fiscal rules.

To provide an empirical assessment of the importance of various shocks discussed above for aggregate fluctuations, we begin by estimating a structural vector autoregression (SVAR) model country by country. Our empirical model has the following form:

$$Aw_t = Bw_{t-1} + \varepsilon_t$$

where w_t is a vector of domestic and external variables; and *A* and *B* are parameters matrices. The vector w_t consists of two blocks of variables. A foreign block is $[r_t^f, y_t^f]'$ or $[\, tot_t,\ r_t^f, y_t^f]'$. Here *tot* is the terms of trade, r^f is the world interest rate measured as the real (3-month) T-bill rate in the US, and y^f if the foreign demand measured as the US real GDP. The domestic block is composed of $[g_t, tby_t, r_t, y_t, rer_t]'$, where g is real government consumption expenditures, *tby* – real trade balance to GDP ratio, *r* is the real domestic interest rate, *y* is real GDP, and *rer* is the real exchange rate.[1] The variables to be included in the SVAR are chosen to capture the factors

[1] If trade balance data were not available, we used current account.

identified in the literature as important determinants of business cycles in developed and developing countries, as discussed above.

The data exhibit seasonal patterns. We de-seasonalize all series, except domestic and US interest rates, and US GDP (which is already seasonally adjusted) using a moving average smoother. All variables are non-stationary, with the exception of interest rates. We transform the variables into stationary form by computing their (log) first-difference. This de-trending rendered all series stationary as unit root was rejected by the augmented Dickey-Fuller test and Phillips-Perron test in all variables in 95% percent of countries at 10 percent significance level. Thus, the domestic and US real interest rates are included in the regressions in levels, while all other variables are in (log) first-differences.

In our analysis we restrict the attention only to those countries that have non-missing values for at least 30 quarters for all variables of interest. With this restriction, our final sample of countries consists of 48 economies, of which 20 are developing countries and 28 are developed economies. The sample of developing countries (low and middle income countries by the World Bank income classification) includes Armenia, Bolivia, Botswana, Brazil, Bulgaria, Colombia, Costa Rica, Ecuador, Georgia, Macedonia, FYR, Malaysia, Mexico, Paraguay, Peru, Philippines, Romania, South Africa, Thailand, Turkey, and Ukraine. The sample of developed (high-income OECD and non-OECD countries) includes Australia, Belgium, Canada, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Iceland, Israel, Italy, Latvia, Lithuania, Malta, Netherlands, Norway, Poland, Portugal, Russian Federation, Slovak Republic, Slovenia, Sweden, United Kingdom, and the United States.[2] The average time span of the data for developing countries in our sample is 73 quarters, while for developed countries it is 80 quarters.

In order to identify the structural parameters of the model, we must impose restrictions on the parameter matrices A and B above. First, we require that matrix A is lower triangular with unit elements on the diagonal. Since external variables in the SVAR system appear before domestic variables, our identification strategy assumes that external variables affect domestic conditions contemporaneously. Similarly, among domestic variables, those that appear higher up in the vector have a contemporaneous effect on the variables that are at the bottom of the vector, while the latter variables feed back into the system with a one-period lag.

In the international block of variables, we order interest rate before output to capture the potential effects of the US real interest rates on the US GDP. The ordering within the domestic block follows conventions in the literature. Specifically, our identification assumes that the causal order runs from government consumption to trade balance to interest rates to output to real exchange rate. This allows fiscal shocks to have a contemporaneous effect on trade balance, domestic interest rate, GDP, and real exchange rate. A similar ordering of variables was used in Blanchard and Perotti (2002) and Ilzetzki, Mendoza and Vegh (2013). In ordering current account balance before the real effective exchange rate, we follow Kim and Roubini (2008). We also assume that shocks to trade balance and real interest rates can affect domestic output within the

[2] Note that our sample contains the US, while the external block of variables in the model uses US real T-bill rate and US real GDP to proxy for world interest rate and external demand. We find that omitting the US from the estimation changes the results only marginally.

same quarter. This assumption is in line with Schmitt-Grohe and Uribe (2017). Changing the order of the first three variables in the domestic block, while retaining the position of domestic GDP had practically no effect on the results.

The second set of restrictions is motivated by the fact that the majority of the economies in our sample are small relative to the rest of the world. As a result, external variables are unlikely to be affected by the domestic conditions in these economies, either contemporaneously or with a lag. By imposing these restrictions, we are effectively using a block recursive structure in our SVAR (see Zha (1996) for theory and application for Canada, and Canova (2005), Uribe and Yue (2006) for applications to emerging economies). Hence, in our model external variables are determined independently of domestic variables, both contemporaneously and in lags.

There is a growing literature that studies the role of domestic and external factors in macroeconomic fluctuations of developed and developing countries. For instance, in a sample of low income countries, Raddatz (2007) shows that external shocks, including commodity price shocks, natural disasters, etc. account for only a small fraction of overall output fluctuations. Instead, he argues that domestic shocks play a key important role in these countries. Raddatz (2008) revisits the evidence for a sample of Latin American and Caribbean (LAC) countries and confirms the result that the majority of domestic variability seems to be accounted for by domestic shocks. Canova (2005) focuses on the effects of external (US) shocks on the economics of LAC region and uses structural panel VARs to identify the external demand, supply and monetary shocks. He finds that only external monetary shocks seem to be important for the region. Hevia and Serven (2014) use a similar methodology to Canova (2005) but are also interested in identifying various domestic shocks in the LAC economies. They use sign restrictions (Canova 2005, Fry and Pagan 2011) to identify various domestic and external shocks. Interestingly, despite a different methodology they find that domestic shocks account for the majority of GDP fluctuations. This result echoes the findings in Raddatz (2008). The contribution of our work is to extend the coverage of countries to the broadest possible, to employ several methodologies such as individual and panel SVARs, as well as to focus the attention on the role of country size for macroeconomic fluctuations.

We estimate the SVAR on a country-by-country basis. The optimal lag length is chosen for each country individually using Schwarz's Bayesian information criterion (BIC). The results are robust to using Akaike criterion as the two criteria choose the same lag length in a majority of all cases. We then use the estimated SVARs to calculate the impulse response of GDP to orthogonalized one standard deviation innovations in all the variables included in the regression. To assess the contribution of these shocks to aggregate fluctuations we also use the model to compute the Forecast Error Variance Decomposition (FEVDC). Since our analysis includes a large number of countries, we summarize our findings by reporting the mean, median, 25^{th} and 75^{th} percentiles for the variance decompositions across countries. Since we are interested in inferring business cycle patterns for developed and developing, large and small, with and without fiscal rules, and high and low ICRG countries, we report these statistics separately for these groups.

To assess the robustness of our findings we also perform a panel VAR estimation by grouping countries by their key characteristics of interest, i.e. developed vs developing, small vs large, high

risk vs low risk, with and without fiscal rules in place. The optimal lag length is again chosen based on the Schwarz's Bayesian information criterion (BIC). In the panel VAR analysis, we have to worry about country heterogeneity arising due to the presence of unobservable individual country fixed effects. We eliminate country-specific fixed effects by first-differencing all variables, except real interest rates for each country and the US. The real interest rates are transformed by the forward mean differencing (the Helmert procedure) as in Holtz-Eakin, Newey, and Rosen (1988) and Love and Zicchino (2006). Another issue, however, remains -- the fact that the lagged dependent variable and the error term are correlated. This could lead the within-estimators to be inconsistent. We address this correlation by estimating the model coefficients using an instrumental variable (IV) method. Specifically, we rely on the system generalized method of moments (GMM) of Arellano and Bond (1991) that uses lagged regressors as instruments.

4. Results

4.1 Overall Variance Decomposition

We begin by reporting the results from the country-by-country SVAR regressions. In particular, we compute the forecast error variance decomposition of GDP for each country and summarize the contribution of shocks to all variables included in the SVAR to the variance of forecasting error for output in Table **1**. Our sample contains 48 countries, so we have 48 variance decompositions. We report the mean, median, 25th and 75th percentiles, and the standard deviation of the mean from these decompositions. Throughout we focus on the variance decomposition at 12 quarters which is where the percentages tend to stabilize.

Table 1. Variance Decomposition of GDP Volatility: All countries

	N	mean	median	25th percentile	75th percentile	stdev mean
rrate_us	48	0.114	0.083	0.042	0.134	0.016
(log) gdp_us	48	0.111	0.073	0.019	0.162	0.019
(log) govexp	48	0.101	0.077	0.025	0.143	0.015
tby	48	0.066	0.044	0.013	0.097	0.010
rrate	48	0.033	0.024	0.011	0.040	0.005
(log) gdp	48	0.518	0.554	0.425	0.633	0.026
(log) reer	48	0.057	0.027	0.009	0.063	0.012

Note: Authors' calculations.

Table **1** shows that the majority of GDP variance in our sample of countries can be attributed to the domestic shocks. Specifically, domestic shocks containing shocks to government expenditures, trade balance, real interest rate, real exchange rate and GDP itself account for 78% of overall GDP volatility. The remaining 22% are driven by external shocks, such as shocks to the world real interest rate and to the foreign demand conditions. These results are very much in line with the findings in Raddatz (2007, 2008) and Hevia and Serven (2014).

Among the two external factors, the contribution of the world interest rate and foreign demand conditions is roughly equal at 11% each. Among the domestic factors, shocks to GDP itself are the major driver of overall GDP volatility, contributing just over 50%. It is followed by the shocks to

government expenditures (10%), trade balance (7%), real exchange rate (6%) and domestic real interest rate (3%).

Next, we examine how the responses to shocks and sources of shocks to GDP differ between large and small countries, low income and high income countries, countries with and without fiscal rules.

4.2 Individual and Panel VAR Results by Country Size

Do sources of shocks differ between large and small economies? To answer this question, we group all countries in our sample into large (above median population) and small (below median population) and contrast their variance decompositions. Median country population in our sample of countries equals just over 10 million people. Table **2** reports the number of countries in each group, and the mean, median, 25th and 75th percentiles of the estimated contribution of each variable in the SVAR to the GDP variance. We also consider a threshold of 4 million people which corresponds to the median of world-wide cross-country population averages over 1960-2015 period and find that our results remain robust. The main difference is that some of the statistical significance in the comparisons of small and large countries is lost due to smaller number of countries falling into small size group.[3]

To check whether the differences in the mean contributions of different shocks are statistically significant, we employ the Wilcoxon-Mann-Whitney rank-sum test which tests the hypothesis that two independent samples are from populations with the same distribution. The important advantage of this test relative to a conventional independent samples t-test is that it does not rely on the assumption of normal distribution for the dependent variable. Effectively, this test is a non-parametric analog to the independent samples t-test. Column labelled "mean diff" reports the difference in the mean contribution of each variable between the large and small country groups and their significance levels.

To evaluate whether the median contributions differ significantly between large and small countries, we perform a nonparametric K-sample test on the equality of medians. The null hypothesis is that the samples were drawn from populations with the same median. The differences in the median contributions of various variables in the SVARs together with their significance levels are reported in the column "median diff".

Table 2. Variance decomposition of GDP volatility: By population size

	Small countries: by population					**Large countries: by population**					**mean diff**	**median diff**
	N	mean	median	p25	p75	N	mean	median	p25	p75		
rrate_us	24	0.093	0.058	0.020	0.149	24	0.135	0.095	0.068	0.134	0.042*	0.037*
(log) gdp_us	24	0.072	0.039	0.007	0.103	24	0.150	0.087	0.027	0.249	0.078*	0.048
(log) govexp	24	0.103	0.080	0.042	0.141	24	0.100	0.063	0.011	0.145	-0.003	-0.017
tby	24	0.077	0.052	0.021	0.111	24	0.055	0.037	0.011	0.074	-0.022	-0.015
rrate	24	0.032	0.021	0.007	0.054	24	0.033	0.024	0.016	0.038	0.001	0.003
(log) gdp	24	0.581	0.601	0.489	0.672	24	0.455	0.510	0.303	0.572	-0.126**	-0.091*

[3] Specifically, with the threshold of 4 million people, we have only 11 countries in the small size group.

(log) reer	24	0.042	0.021	0.004	0.051	24	0.072	0.039	0.012	0.091	0.030	0.017

Note: Authors' calculations. * p<0.10, ** p<0.05, *** p<0.01

It is easy to see from Table **2** that larger countries are more susceptible to the external shocks, as the overall contribution of these shocks to their GDP volatility equals to 29%, compared to just 17% in smaller economies. This difference is driven by both shocks to the world interest rate and foreign demand, with the latter being somewhat more important. Thus, shocks to the US GDP account for 15% in large economies, while they account for 7% in smaller countries, on average. Similarly, shocks to the world interest rate are responsible, on average, for 15% of GDP volatility in large countries, but just for 9% in small economies. Both differences are statistically significant.

One potential explanation for the smaller role played by external interest rate shocks in small economies is their less favorable access to world financial markets. Indeed, small economies may be at a disadvantage in accessing global capital due to a small scale of transactions and a fixed cost of researching and monitoring repayment ability of small countries faced by international lenders. In addition, creditors may have limited knowledge about small states and thus face higher costs of differentiating them. All these factors point to a lower integration of small countries into the international capital markets.

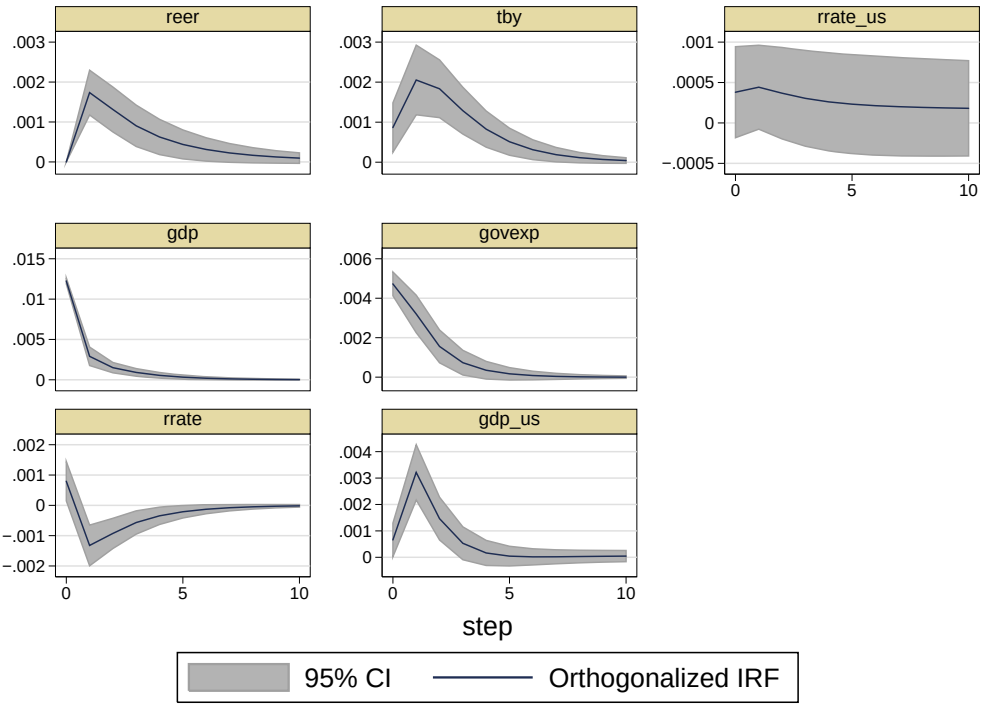
In terms of the domestic factors, shocks to GDP are more important drivers of GDP volatility in small economies relative to larger countries. For instance, mean contribution of GDP shocks is 58% in small countries, while it is a much smaller 46% in large economies. This 12 percentage points gap in mean contribution is statistically significant. The greater exposure of small economies to output shocks could be the outcome of their more concentrated production structure which limits their ability to diversify shocks across sectors and thus amplifies the responses of the economy to these shocks. In addition, small economies have higher propensity to have significant disruptions in output due to natural disasters and weather shocks.

We also find that shocks to the real exchange rate carry a greater importance in larger countries relative to smaller economies (7% on average in large countries versus 4% on average in small economies) but this difference is not statistically significant. The contributions of all other shocks to GDP volatility are indistinguishable between large and small countries.

It is also informative to compare the responses of GDP to various shocks. For this purpose, we estimate a panel VAR separately for small and large economies and compute the impulse responses of GDP to various shocks. These responses are presented in Figures **1** and **2**.

Figure **1** presents the impulse responses of real GDP implied by our panel VAR to various shocks, together with 95% confidence interval for the panel of small countries, while Figure **2** does the same for the panel of large economies. Consider shocks to external variables first. In response to a unit unanticipated innovation in the US real interest rate (rrate_us), output in small countries rises on impact and remains higher over the next several quarters. This response, however, is not statistically significant. In contrast, a rise in the US real interest rate leads to a fall in output in large economies. This result suggests that external financial conditions indeed spill over onto the domestic performance, but do so differently for small and large countries. There are several possible explanations for this differential effect.

Figure **1**. Impulse Responses of GDP to Various Shocks: Small countries, by population

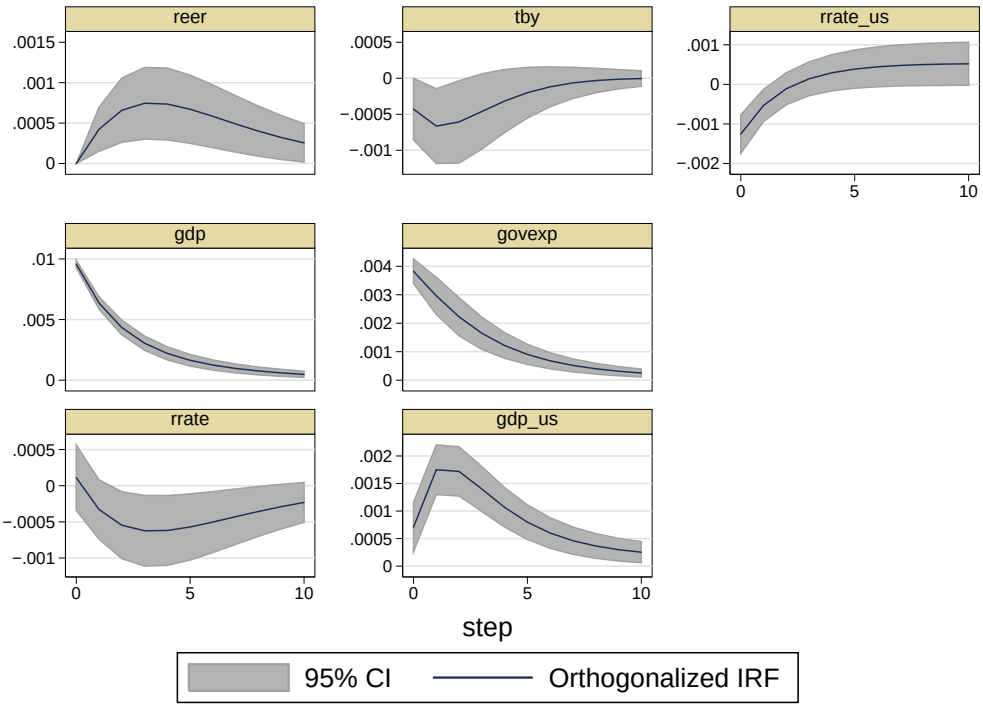


First, the direct effect of higher US interest rates is to trigger portfolio reallocation into higher yielding US assets. Such outflows can be strongly contractionary as shown in Calvo, Leiderman and Reinhart (1993) and Gavin, Hausmann and Leiderman (1995), at least in the short run. The second effect relates to the cost of international borrowing. When the US interest rates rise, they likely increase the cost of borrowing in the international financial markets, which again can have contractionary effects on the economies integrated in the world financial markets. The third effect arises through the relationship between world interest rates and commodity prices. For instance, Frankel (2008) argues that higher world real interest rate would lead to lower commodity prices by reducing speculative demand for commodities. In addition, higher interest rates make it costlier to hold commodity inventories, pushing their prices further down. Similarly, Calvo (2008) shows that low interest rates lead to a portfolio reallocation away from liquid assets and can drive commodity prices up. The effects of commodity prices on GDP then depend on whether a country is a net importer or a net exporter of commodities. Of course, commodity prices will also likely feed back into interest rates as well. By passing-through into domestic prices and/or affecting inflationary expectations, higher commodity prices could lead to higher inflation and interest rates.

Overall, this discussion makes clear that the relationship between the world interest rates and GDP in large and small countries is likely to be complex and determined by the relative strength of the effects described above. Our empirical findings indicate that smaller countries on net benefit from the US interest hikes, while larger countries tend to experience contractions after the same shocks. This could be a consequence of the fact that smaller countries are less integrated into the world financial system and thus are less subject to portfolio rebalancing and borrowing cost effect,

or because they are net importers of commodities. Larger countries, in contrast, are more affected by the capital outflows and higher borrowing costs as they tend to be more exposed to the international financial markets, or lacking appropriate insurance mechanisms, and/or tend to be net exporters of commodities.

Figure 2. Impulse Responses of GDP to Various Shocks: Large countries, by population



Next, consider the effects of the shocks to world demand conditions, proxied by the US GDP. A positive 1 unit shock to the US GDP is followed by a rise in domestic output in both small and large economies. The response, however, is larger in small economies, which is not surprising given their smaller scale.

Turning to domestic variables, the effects of these variables on domestic GDP are quite intuitive and generally symmetric for small and large economies. The only exception is the trade balance to which we return below. For instance, a positive unanticipated shock to government expenditures is followed by an increase in domestic GDP in both small and large countries. Similarly, a rise in the domestic interest rate has contractionary consequence in both small and large economies, although the effect is more short-lived in smaller countries. In response to an unanticipated domestic output shock, GDP itself increases and then gradually returns toward its steady-state level, in both groups of countries, although the convergence back to the steady state is slower in larger economies, indicating higher persistence of output shocks in this group of countries.

An increase in the real exchange rate (real appreciation) leads to an expansion in GDP in both small and large countries. The effect is quite long-lived in larger economies, but dissipates after

about 6 quarters in smaller countries. The expansion is statistically significant in both groups of economies. The improvement in GDP following real appreciation may seem puzzling if one expects real appreciation to be accompanied by trade and current account deterioration. Note, however, that we are already controlling for trade balance response in our estimation. Thus, the influence of real exchange rate on GDP is already purged of the trade balance channel. Instead, we interpret the improvement in GDP following real exchange rate appreciation as indicative of the importance of demand-side shocks.[4] Such shocks lead the real exchange rate and GDP to move in the same direction, as greater demand is accompanied by higher prices of tradable and non-tradable goods, and higher output. Our results indicate that these shocks are more persistent in larger economies.

Lastly, turning to trade balance, we find that an unanticipated improvement in trade balance leads to contrasting responses of GDP in small and large economies. Specifically, following these shocks GDP rises in small countries, but falls in large economies. Notice, however, that the fall in GDP experienced by larger economies is small and very short-lived.

4.3 Individual and Panel VAR Results by Level of Development

Next, we subdivide countries by their income level and contrast their sources of volatility. We combine countries classified by the World Bank as low income and middle income countries into a "developing" countries group, while high income OECD and non-OECD countries are combined into a "developed" countries group. As before we report the number of countries, and cross-country mean, median, 25th, and 75th percentiles of the contribution that each variable included in the SVAR makes to GDP volatility for each income group. We also compute the difference in mean and median contributions between developed and developing countries, together with their statistical significance level. These results are summarized in Table **3**.

Table 3. Variance decomposition of GDP volatility: By level of development

	Developing countries					Developed countries					mean diff	median diff
	N	mean	median	p25	p75	N	mean	median	p25	p75		
rrate_us	20	0.119	0.086	0.043	0.134	28	0.110	0.078	0.038	0.153	-0.009	-0.008
(log) gdp_us	20	0.078	0.043	0.023	0.096	28	0.135	0.077	0.014	0.219	0.057	0.034
(log) govexp	20	0.128	0.093	0.027	0.170	28	0.082	0.059	0.014	0.124	-0.046	-0.034*
tby	20	0.075	0.062	0.026	0.109	28	0.059	0.039	0.011	0.085	-0.016	-0.023
rrate	20	0.031	0.021	0.013	0.035	28	0.034	0.027	0.008	0.048	0.004	0.006
(log) gdp	20	0.480	0.525	0.345	0.629	28	0.545	0.560	0.486	0.650	0.065	0.034
(log) reer	20	0.089	0.031	0.017	0.143	28	0.034	0.019	0.005	0.050	-0.055**	-0.012*

Note: Authors' calculations. * p<0.10, ** p<0.05, *** p<0.01

Several results can be highlighted from Table **3**. First, the contribution of external shocks to GDP volatility is slightly larger in developed economies (at 25%) as compared to developing countries (at 20%). Most of the difference is driven by the predominance of shocks to external

[4] The responses could also be due to Balassa-Samuelson effects.

demand (proxied by the US GDP) in developed economies. The contribution of shocks to the world interest rate is practically the same in developed and developing countries.

Second, shocks to government expenditures contribute more to the overall GDP volatility in developing countries as opposed to developed economies. Specifically, these shocks account for 13% of GDP volatility in developing countries and for 8% in developed countries, on average. Importantly, the difference in contribution of government expenditure shocks between developed and developing countries is statistically significant (for the median).

Third, shocks to GDP are more important for GDP volatility in developed countries relative to developing economies. The difference in contribution is quite large (55% in developed countries, and 48% in developing countries), but it is not statistically significant. Lastly, shocks to real exchange rate are responsible for a larger share of GDP volatility in developing countries (9% on average) than in developed economies (3% on average), and this difference is statistically significant. This result can be potentially explained by the prevalence of the terms of trade shocks in developing countries.

Overall, our results suggest a few important dichotomies in the sources of GDP volatility between developed and developing countries.

Next, we turn to the comparison of impulse responses of GDP to various shocks by means of the panel VAR analysis. Thus, we estimate a separate VAR for a panel of developed countries and a panel of developing countries and present impulse responses from these panel VARs.

Figure **3** reports the results for developing countries, while Figure **4** is for developed economies. We find several interesting dichotomies in the impulse responses of developed and developing countries. First, higher US real interest rate depresses output in developing economies, but has an expansionary effect on the GDP of developed countries, although the latter effect is not statistically significant. Second, world demand conditions (as proxied by the US GDP) lead to an increase in GDP of both developed and developing countries, but the effect tends to be larger for developing economies. Third, unanticipated positive innovations to government expenditures lead to output expansion on impact in both developed and developing countries, but in developing countries, the effect on output is much larger. Fourth, an appreciation of the real exchange rate causes a rise in GDP in both developed and developing countries, but the response is more persistent, although not statistically significant, in developed economies. Fifth, unanticipated increase in domestic real interest rate leads to output contraction in both developed and developing countries. However, the effects dissipate rather quickly -- after 5 quarters -- in developing countries, but are much more long-lived in developed economies. Sixth, shocks to GDP are much more persistent in developed countries than in developing economies. Specifically, the effects of these shocks on GDP disappear after just a year in developing countries, but last for over 2.5 years in developed economies. Lastly, positive shocks to trade balance lead to higher output in both groups, but are statistically insignificant in developing economies.

Figure 3. Impulse Responses of GDP to Various Shocks: Developing countries

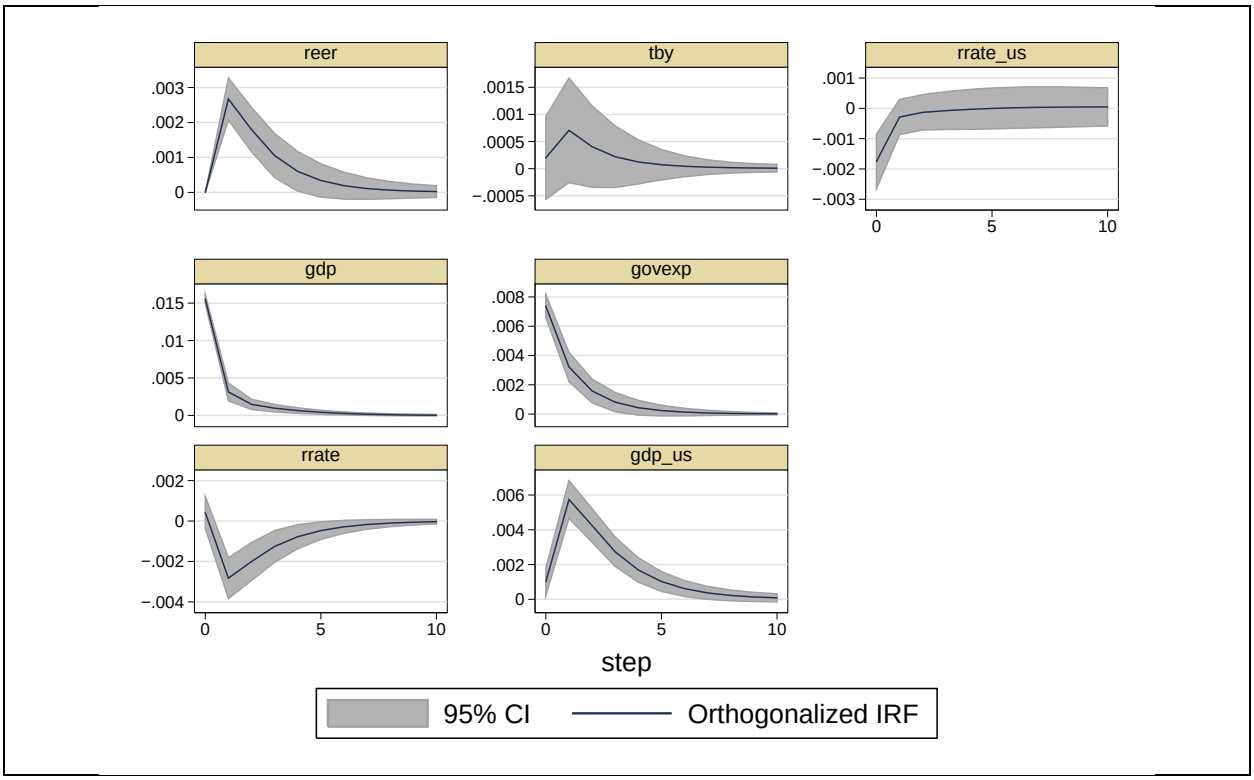
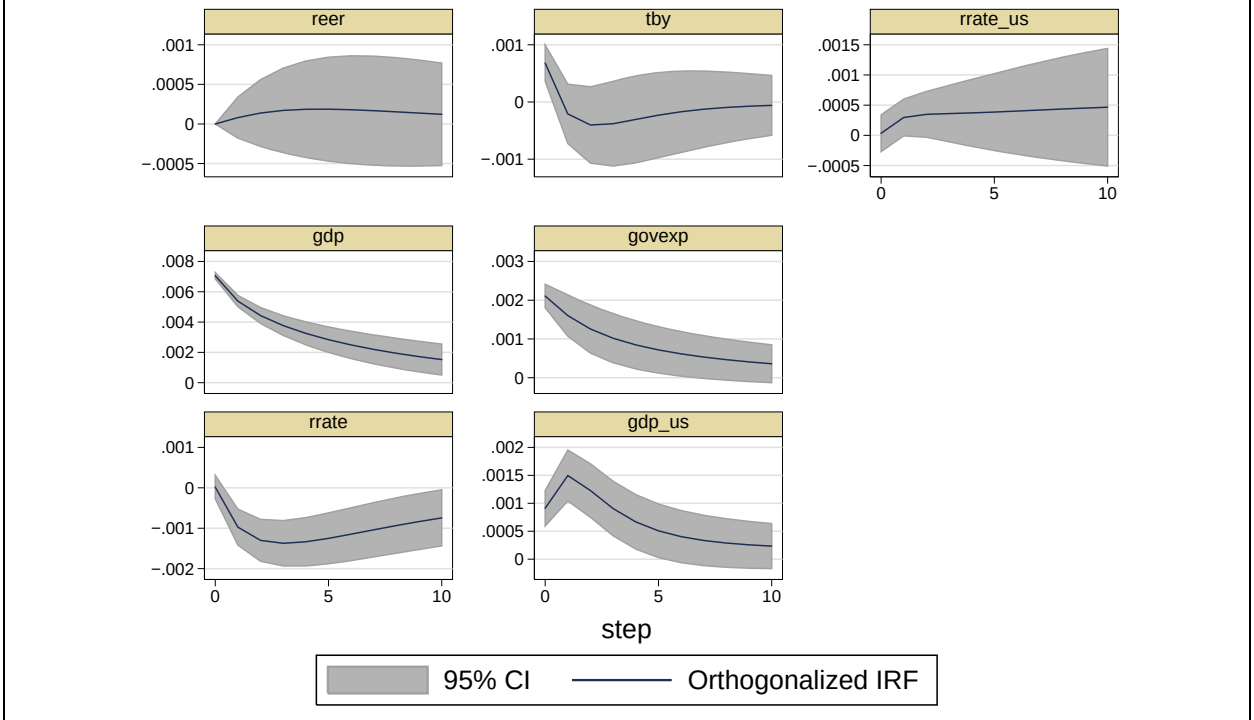


Figure 4. Impulse Responses of GDP to Various Shocks: Developed economies



4.4 Country size or level of development?

Our results for the variance decompositions and impulse response functions in the previous section comparing developed and developing countries have some similarities with our findings for small and large economies reported in Section 4.2. This is probably not surprising given that a few of the small economies also belong to the developed country group. To understand whether the results are being driven by the country size or the level of development we also summarize the variance decompositions from country-by-country VARs and estimate panel VARs while simultaneously conditioning on country size and developmental status.

Consider first, the variance decompositions obtained from the individual country SVARs. To assess the role played by country size versus developmental status we contrast the mean and median contributions of various shocks in small versus large economies, conditional on the level of development. Table 4 presents the results. Panel A reports the decompositions for developing countries, while panel B is for developed economies.

For developing countries, we find that the contribution of world interest rate shocks to GDP volatility is significantly lower in small countries, and so is the contribution of real exchange rate shocks. This is compensated by the greater role of domestic GDP shocks in small economies. All other shocks play comparable roles in small and large economies.

In developed countries, country size only influences the contribution of world demand shocks to GDP volatility, with larger countries affected more by these shocks. Domestic GDP shocks also make a bigger contribution to GDP volatility in small countries, but the difference in quantitatively small.

These results suggest that the majority of unconditional differences between large and small economies in the sources of business cycle volatility we uncovered in Section 4.2 are driven by the developing country group. Small developing countries are less susceptible to world interest rate shocks relative to large countries, which confirms our conjecture that size matters for access and degree of integration into international financial markets. Instead, small developing countries are more prone to domestic GDP shocks. The gap in the contribution of these shocks to GDP volatility is quite large, equal to 20% for the mean and 24% for the median. We conjecture that this gap is likely driven by omitted terms of trade shocks, shocks to weather conditions, and domestic technology and demand shocks. Several characteristics of small countries underlie this conjecture. First, small economies are more prone to weather shocks and natural disasters. Second, small economies are more concentrated in their production and exports, making them more susceptible to terms of trade and weather shocks. This amplifies the effects of shocks. Third, Hnatkovska and Koehler-Geib (2016) in their study of business cycle characteristics of small and large economies show that small countries exhibit stronger positive comovement between inflation and GDP suggesting that demand shocks play an important role in these countries. Below we check some of these conjectures by introducing terms of trade variable into country VARs. Unfortunately, due to lack of quarterly terms of trade data, we are only able to do so for a subsample of countries.

Another key difference between small and large developing countries is that the latter are more susceptible to the shocks to the real exchange rate, which likely reflect the prevalence of domestic demand shocks and Balassa-Samuelson effect. At the same time, shocks to world demand conditions play a comparable role in small and large developing countries. This suggests that there are no perceptible differences between small and large developing countries in the degree of their integration into the world trade markets.

Turning to developed economies, our finding that large developed countries are more susceptible to world demand shocks relative to small developed countries, is likely a reflection of the historical importance of the trade relationships between the US and other developed countries (North-North trade) (UNCTAD, 2015). We find no difference in the effects of all other shocks.

	Table 4. Variance decomposition of GDP volatility: By level of development and country size											
	A. Developing countries											
	small					**large**						
	N	mean	median	p25	p75	N	mean	median	p25	p75	mean diff	median diff
rrate_us	9	0.072	0.042	0.027	0.083	11	0.157	0.124	0.083	0.134	0.084**	0.082**
(log) gdp_us	9	0.059	0.072	0.030	0.096	11	0.094	0.030	0.019	0.202	0.035	-0.042
(log) govexp	9	0.124	0.120	0.079	0.175	11	0.131	0.080	0.024	0.164	0.007	-0.040
tby	9	0.081	0.064	0.027	0.121	11	0.070	0.059	0.013	0.096	-0.011	-0.005
rrate	9	0.029	0.027	0.012	0.039	11	0.032	0.021	0.013	0.029	0.003	-0.006
(log) gdp	9	0.589	0.614	0.514	0.630	11	0.391	0.377	0.289	0.583	-0.198**	-0.237
(log) reer	9	0.046	0.023	0.013	0.029	11	0.125	0.115	0.031	0.182	0.079*	0.092**
	B. Developed countries											
	small					**large**						
	N	mean	median	p25	p75	N	mean	median	p25	p75	mean diff	median diff
rrate_us	15	0.105	0.080	0.018	0.177	13	0.116	0.076	0.059	0.116	0.011	-0.004
(log) gdp_us	15	0.080	0.033	0.006	0.169	13	0.198	0.137	0.074	0.321	0.118**	0.104*
(log) govexp	15	0.090	0.067	0.039	0.118	13	0.074	0.036	0.010	0.130	-0.016	-0.032
tby	15	0.074	0.046	0.014	0.101	13	0.042	0.018	0.009	0.046	-0.032	-0.028
rrate	15	0.035	0.014	0.007	0.056	13	0.034	0.032	0.024	0.039	-0.001	0.019
(log) gdp	15	0.577	0.587	0.433	0.695	13	0.509	0.552	0.488	0.561	-0.068	-0.035*
(log) reer	15	0.040	0.012	0.003	0.069	13	0.028	0.022	0.010	0.049	-0.012	0.010

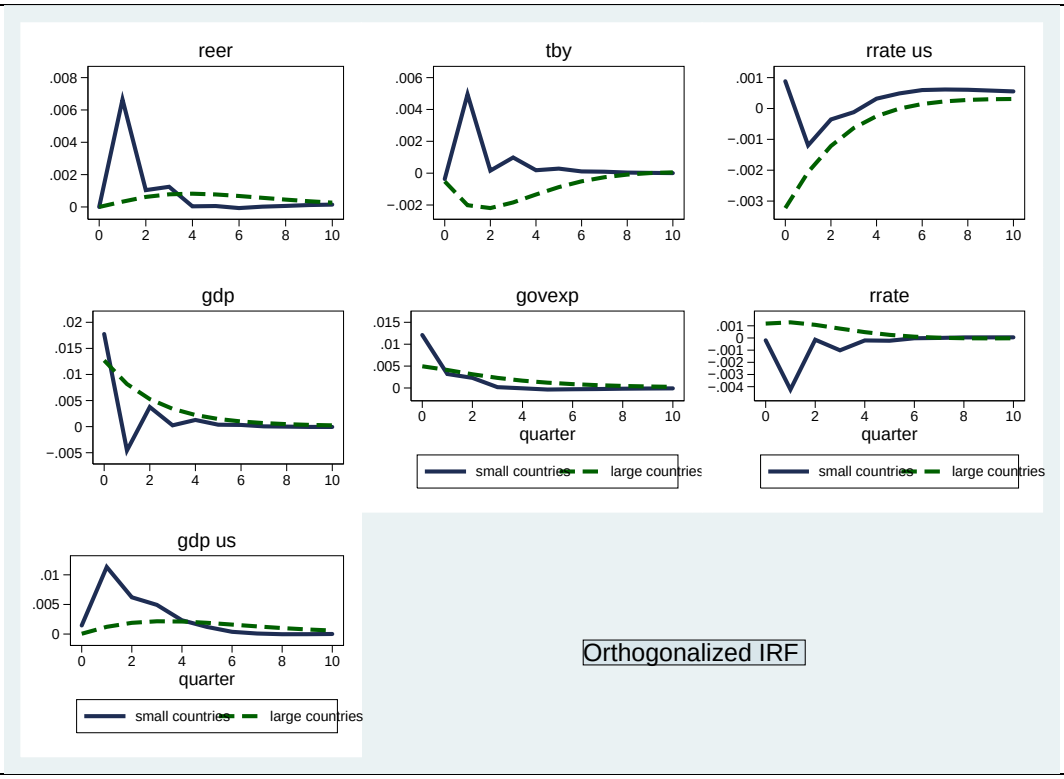
Note: Authors' calculations. * p<0.10, ** p<0.05, *** p<0.01

To better understand the differences between small and large economies within each development group we estimate panel VARs separately for large and small countries, while conditioning on the developmental status. The hypothesis is that impulse responses in the VARs differ between small and large countries, especially for the developing countries group, mirroring our variance decomposition results. Figure **5** contrasts the resulting impulse responses of GDP to various shocks in small and large *developing* countries. By comparing these responses with the unconditional ones for large and small countries reported in Figures **1** and **2** in Section 4.2, it is easy to see that they are very similar. That is, in terms of external variables, a rise in the US real interest rate leads to a contraction in large developing economies, but a mild expansion in small

developing economies. A positive shock to the world demand raises GDP in both small and large developing countries, but the effect is more pronounced in smaller economies.

Turning to domestic variables, shocks that lead to real exchange rate appreciation also increase output in small and large developing economies, with the effects being larger and more short-lived in small economies. Shocks to GDP are more persistent in larger developing economies; while shocks to government expenditures have similar degree of persistence in both groups of countries and lead to an expansion of their GDP. A positive shock to domestic real interest rate is followed by a fall in GDP in small developing economies, but has a negligible effect on GDP in larger developing countries. Lastly, unanticipated positive shocks to trade balance are followed by an expansion in GDP in small developing countries, but a small contraction in GDP in larger developing countries.

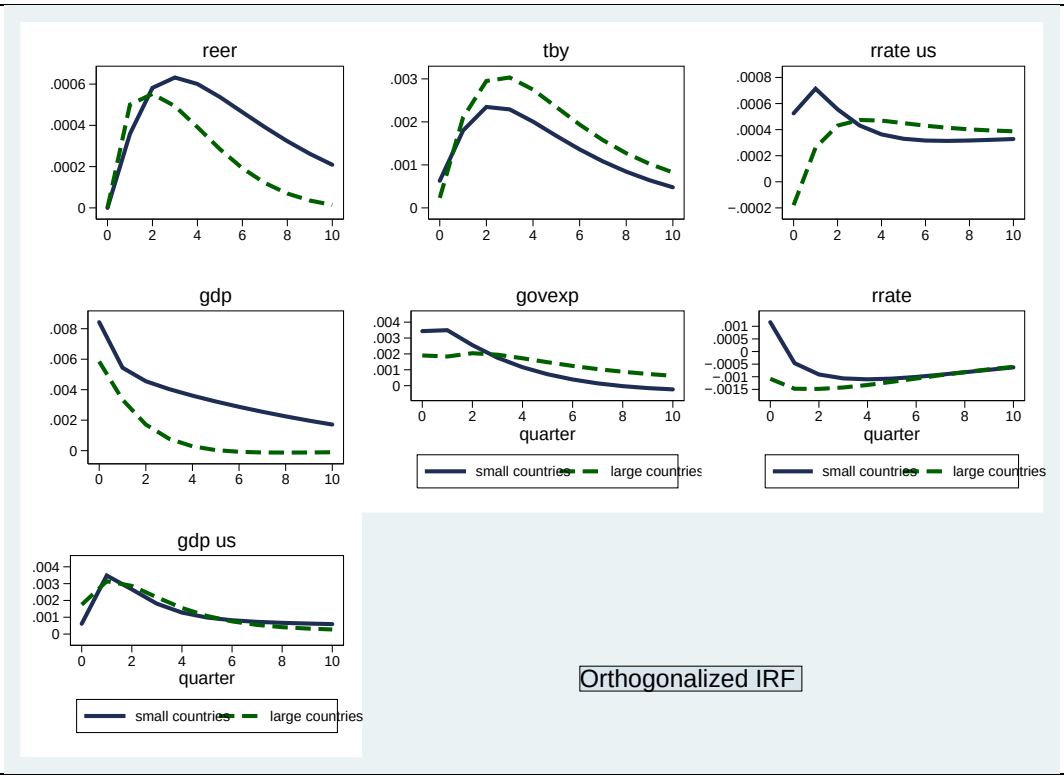
Figure **5**. Impulse Responses of GDP to Various Shocks in Developing Economies: Small vs Large Countries



Now, contrast the impulse responses of large and small economies belonging to the developed (or high income) group. These are presented in Figure **6**. It is easy to see that the impulse responses of GDP are symmetric for the two groups of developed economies, with the exception of just the effects of US and domestic interest rate. For instance, an increase in US GDP triggers a rise in domestic GDP of both small and large developed economies and the effects are practically identical. For shocks originating in the domestic variables, positive shocks to real exchange rate, trade balance, domestic GDP and government expenditures all have expansionary effects on GDP in the small and large developed economies and the effects are quite symmetric. Shocks to the

interest rates, both domestic and world have expected contractionary effects in large developed countries, but tend to lead to GDP expansion in small developed economies. We should note that in this group of counties, the effect of US interest rate shock is not statistically significant, while the effect of the domestic interest rate shock is very short-lived and dissipates within just 2 quarters. Overall, we interpret these results as suggestive that country size matters for business cycle dynamics and sources of volatility in developing countries, but does not seem to play an important role in developed economies.

Figure **6**. Impulse Responses of GDP to Various Shocks in Developed Economies: Small vs Large Countries



4.5 Individual and Panel VAR Results by Fiscal Rules

An important aspect of our analysis is to understand whether the adoption of fiscal rule(s) by a country has an effect on the sources of its GDP volatility. To study this question, we split all countries in our data set into a group that have adopted one or more fiscal rules since 1985, and a group that did not adopt any such rules. Note that the fiscal rules data set only identifies the presence of fiscal rules in various countries starting from 1985. Our data often start before that year. To maximize the time coverage, we consider a country to be a fiscal rule(s) adopter if it had a fiscal rule(s) at any point in time since 1985. Based to this classification, our sample of fiscal rule(s) adopters consists of 40 countries, while the sample of non-adopters contains 8 countries. The non-adopters are Bolivia, Macedonia, FYR, Paraguay, Philippines, South Africa, Thailand, Turkey, and Ukraine. The rest of the countries are classified as adopters.

Fiscal rules can be of four types – expenditure rule, revenue rule, budget balance rule, and debt rule. It is also very common for countries to have several of these rules in place simultaneously. If a country has adopted any of these rules we classify it as fiscal rule adopter. We compare the sources of GDP volatility for the two groups of countries in Table **5**.

Table 5. Variance decomposition of GDP volatility: By the presence of fiscal rule(s)

	Countries with fiscal rule(s)					Countries with no fiscal rule(s)					mean diff	median diff
	N	mean	median	p25	p75	N	mean	median	p25	p75		
rrate_us	40	0.116	0.081	0.042	0.149	8	0.102	0.123	0.043	0.134	-0.014	0.042
(log) gdp_us	40	0.119	0.077	0.016	0.182	8	0.074	0.032	0.029	0.066	-0.045	-0.045
(log) govexp	40	0.093	0.075	0.026	0.143	8	0.145	0.088	0.020	0.221	0.052	0.013
tby	40	0.065	0.044	0.014	0.097	8	0.070	0.046	0.012	0.114	0.006	0.002
rrate	40	0.035	0.025	0.010	0.046	8	0.022	0.017	0.011	0.028	-0.013	-0.008
(log) gdp	40	0.514	0.553	0.447	0.626	8	0.538	0.607	0.336	0.662	0.024	0.054
(log) reer	40	0.059	0.025	0.009	0.063	8	0.049	0.030	0.009	0.084	-0.009	0.005

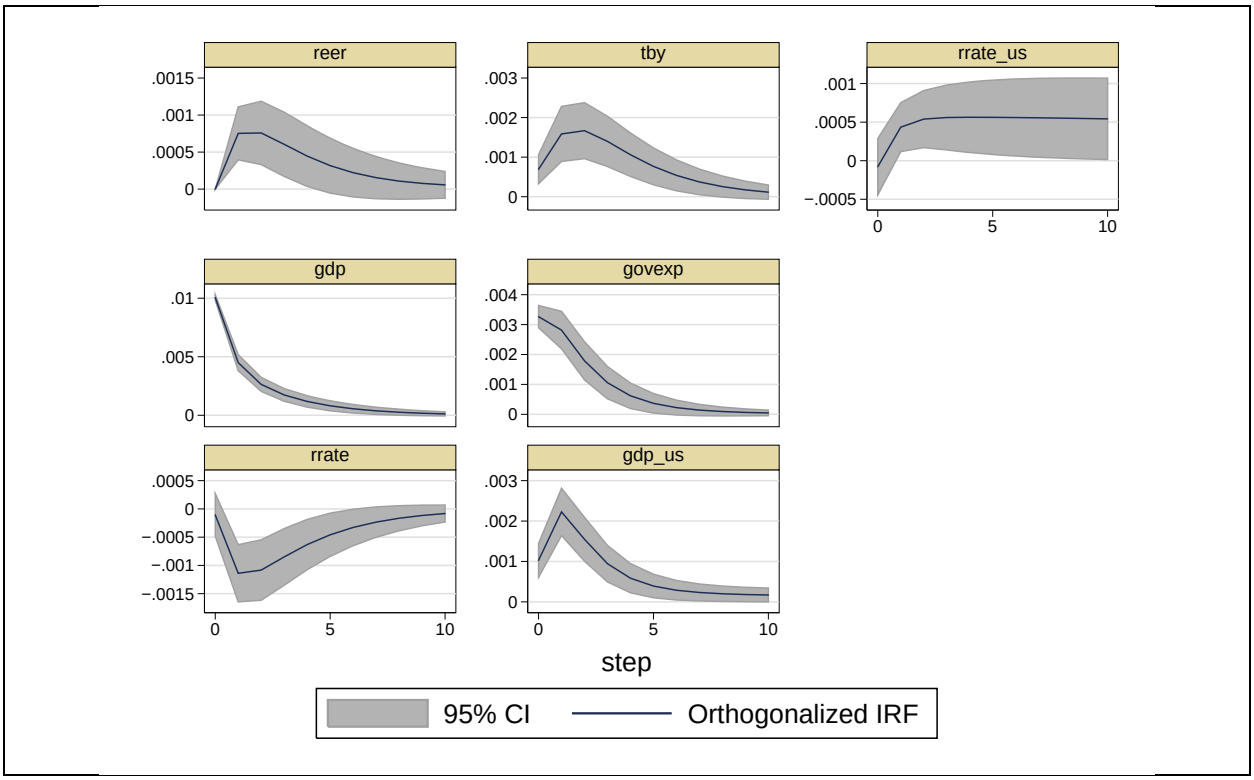
Note: Authors' calculations. * p<0.10, ** p<0.05, *** p<0.01

Two interesting results stand out from the table. First, shocks to world demand play a more important role in countries with fiscal rules relative to non-adopters. This could be a consequence of the fact that fiscal rule adopters tend to be larger countries (see Hnatkovska and Koehler-Geib, 2016) and, as we showed above, larger countries tend to be more susceptible to world demand shocks. Second, countries with no fiscal rules have a larger fraction of their GDP volatility driven by shocks to government expenditures. Compare the contribution of these shocks equal to 15% in non-adopters with 10% in adopters, on average. The contribution of all other shocks to GDP volatility tends to be symmetric in fiscal rules adopters and non-adopters.

Overall, our results suggest that there exist some interesting differences in the sources of volatility between fiscal rules adopters and non-adopters. However, the small number of countries with no fiscal rules in our sample precludes us from finding statistically significant differences between the two groups.

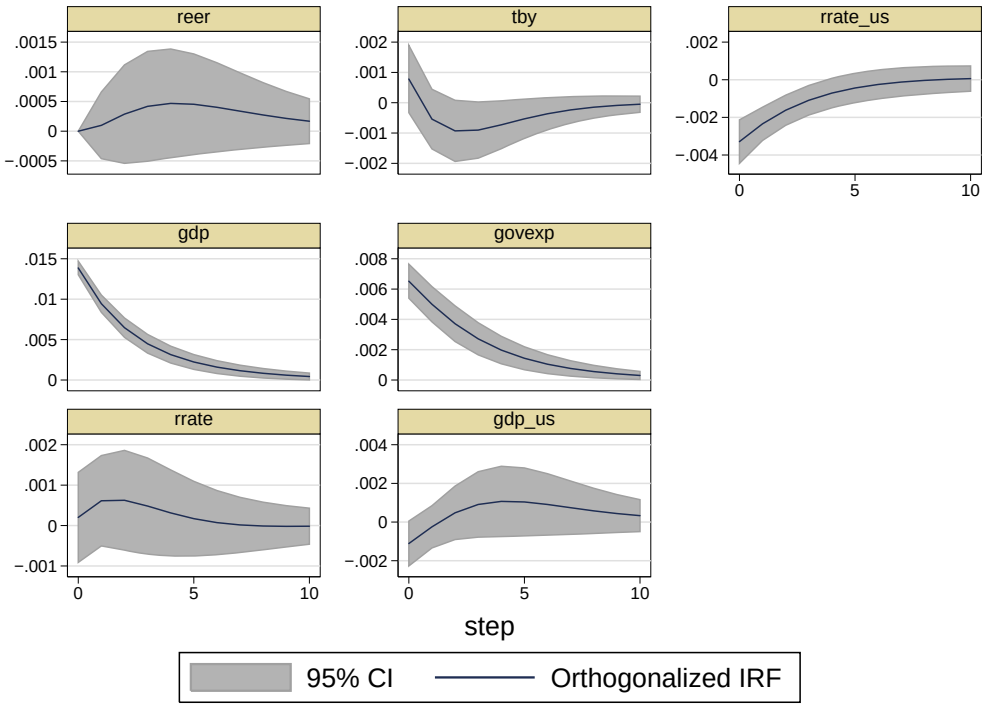
Next, we investigate whether there are significant differences in the responses of GDP to various shocks in fiscal rule adopters and non-adopters. For this purpose, we estimate a panel VAR separately for the two groups of countries and plot the estimated impulse responses of GDP. Figure **7** summarizes the results for countries with fiscal rules, while Figure **8** does the same for countries with no fiscal rules.

Figure 7. Impulse Responses of GDP to Various Shocks: Countries with fiscal rules



We find a few contrasting results for fiscal rule(s) adopters and non-adopters. First, a positive shock to the US real interest rate leads to an increase in GDP for the countries with fiscal rule(s) in place, but to a fall in GDP in non-adopters. Second, shocks to GDP tend to be larger in non-adopters than in adopters, although the degree of persistence of these shocks is similar for the two groups. Third, positive shocks to government expenditures raise GDP in both groups of countries, but have larger effects on GDP in countries with no fiscal rules than in those with fiscal rules in place. Fourth, shocks resulting in higher domestic real interest rate have contractionary effects on GDP in the countries with fiscal rules, but have no significant effects in non-adopters. Lastly, a positive foreign demand shock and a shock that appreciates the real exchange rate, both raise GDP in fiscal rule(s) adopters, but has no significant effect in countries without fiscal rule(s). Given a small number of non-adopters in our data set, it is not surprising that most of the responses for this group are not statistically significant.

Figure 8. Impulse Responses of GDP to Various Shocks: Countries with no fiscal rules



We confirm our findings from the impulse responses using the forecast error variance decomposition computed from the panel VARs for the two groups. Table **6** reports the results. It shows the share of GDP variance in the two groups of countries accounted for by various shocks. We see that shocks to GDP and government expenditures are responsible for a larger share of GDP volatility in fiscal rule(s) non-adopters. On the other hand, shocks to the world demand conditions (proxied by the US GDP) and trade balance play a greater role for GDP volatility in fiscal adopters. These results are consistent with the findings from individual country VARs reported in Table **5**.

Table 6. Forecast error variance decomposition from panel VARs by fiscal rule(s) presence

	rrate_us	(log) gdp_us	(log) govexp	tby	rrate	(log) gdp	(log) reer
fiscal adopters	0.017	0.054	0.126	0.054	0.022	0.718	0.010
fiscal non-adopters	0.042	0.013	0.196	0.007	0.002	0.736	0.002

4.6. Robustness: Adding terms of trade

Terms of trade shocks have been highlighted as an important source of business cycle fluctuations, especially in developing countries. The existing literature, however, lacks consensus on exactly how important these shocks are for GDP volatility. In this section we revisit the evidence by extending our benchmark SVAR specification to include terms of trade. As discussed in Section 3, our modified specification for the SVAR now includes a modified external block as $[\, tot_t,\ r_t^f, y_t^f\,]'$, where tot_t is the terms of trade, r_t^f and y_t^f are world real interest rate and external

demand, respectively, as in the benchmark specification. Our identification strategy remains the same as in the benchmark estimation.

Unfortunately, quarterly data for the terms of trade are not available for a large subset of countries in our sample, which somewhat limits our analysis. Nevertheless, we are able to estimate the SVARs for a set of 21 countries, of which 6 are developing economies and 15 developed countries. The set of developing countries includes Brazil, Colombia, Philippines, Thailand, Turkey, and South Africa, while the subsample of developed countries contains Australia, Canada, Germany, Denmark, Finland, France, UK, Hungary, Israel, Italy, Netherlands, Norway, Poland, Sweden, and the US. Of these 21 countries, based on the median cross-country population in our full sample, 5 are classified as small economies and 16 are classified as large economies. There are also just 4 countries without fiscal rule(s) in this subsample, and 17 with the fiscal rule(s). So, clearly, the set of countries with terms of trade data under-represents developing and small economies, as well as economies without the fiscal rule(s).

We re-estimate the individual country SVARs for this subset of countries and summarize the results from the variance decompositions for the overall set of 21 countries, and separately for small vs large countries. Table 7 presents the results for the overall sub-sample.

Table 7. Variance Decomposition of GDP Volatility (with terms of trade): All countries

	N	mean	median	p25	p75	stdev mean
(log) tot	21	0.094	0.036	0.018	0.124	0.032
rrate_us	21	0.113	0.086	0.021	0.168	0.023
(log) gdp_us	21	0.132	0.083	0.041	0.100	0.037
(log) govexp	21	0.091	0.084	0.046	0.103	0.018
tby	21	0.048	0.033	0.010	0.073	0.010
rrate	21	0.039	0.030	0.009	0.044	0.009
(log) gdp	21	0.431	0.437	0.330	0.537	0.041
(log) reer	21	0.051	0.021	0.004	0.075	0.016

Adding terms of trade to the SVAR regressions raises the contribution of external factors to the overall GDP volatility in our set of countries to 34%. Of these, terms of trade account for about 9% of GDP volatility. Interestingly, the contribution of the two external factors we had in the benchmark specification – the world interest rate and foreign demand – does not change much relative to the benchmark, as each is still responsible for close to 11% of the overall GDP volatility. The remaining 66% is attributable to domestic shocks. The contribution of domestic factors to GDP volatility also did not change much relative to the results for the benchmark sample, with the exception of trade balance, the shocks to which are now contributing 4.8% to the overall GDP volatility (relative to 6.6% in the benchmark specification). The main culprit for the decline in the effects of domestic factors are the shocks to GDP itself, whose effects are now lower at 43%.

Next, we report the variance decomposition results separately for small and large economies and test whether the differences in the role played by different shocks in the two groups are statistically significant. Table 8 reports the results.

Table 8. Variance decomposition of GDP volatility (with terms of trade): By population size												
	Small countries: by population					Large countries: by population					mean diff	median diff
	N	mean	median	p25	p75	N	mean	median	p25	p75		
(log) tot	5	0.150	0.027	0.024	0.039	16	0.077	0.036	0.014	0.142	-0.074	0.008
rrate_us	5	0.044	0.013	0.008	0.060	16	0.135	0.108	0.065	0.177	0.091**	0.095
(log) gdp_us	5	0.055	0.052	0.009	0.087	16	0.156	0.088	0.050	0.217	0.101	0.036
(log) govexp	5	0.108	0.064	0.061	0.103	16	0.086	0.084	0.025	0.104	-0.022	0.020
tby	5	0.023	0.008	0.006	0.010	16	0.056	0.048	0.018	0.091	0.033*	0.040
rrate	5	0.051	0.033	0.002	0.060	16	0.035	0.030	0.011	0.043	-0.017	-0.003
(log) gdp	5	0.540	0.562	0.516	0.704	16	0.397	0.427	0.328	0.527	-0.143	-0.135*
(log) reer	5	0.028	0.004	0.004	0.021	16	0.058	0.025	0.008	0.097	0.030	0.021

We find the results to be quite similar to those obtained for the benchmark specification without terms of trade. For instance, the role played by external factors is more pronounced in large economies, where they contribute 37% to GDP volatility relative to small economies where they contribute just 25%, on average. While world interest rates and foreign demand are less important in small economies, terms of trade tend to play a larger role in these economies. For instance, the contribution of the terms of trade shocks to GDP volatility is equal to 15% in small economies – twice the corresponding contribution in large countries. Greater contribution of terms of trade shocks in small economies is not surprising given higher concentration of their exports coupled with greater trade openness.

Among the domestic factors, we find that shocks to GDP are more important in smaller economies (54% in small economies vs 40% in large, on average), very much in line with our benchmark findings, and this difference is statistically significant.

We also re-estimate panel VARs for this new specification with terms of trade and find the impulse responses to be similar to those reported above. Overall, our results are robust to the inclusion of terms of trade into the estimation.[5]

5. Discussion and policy recommendations

Our main results can be summarized as follows. First, we find that GDP volatility in all countries in our sample is driven predominantly by domestic shocks. Second, we find significant differences in the sources of shocks in small and large economies. Specifically, we show that external factors, such as world interest rate and world demand conditions play a more important role in larger economies. GDP volatility in small economies, in contrast, is attributed predominantly to shocks to domestic output and terms of trade. Third, we find that these dichotomies in the behavior of small and large countries are driven primarily by developing countries. In addition, we find that within developing countries group, large economies are more exposed to real exchange rate shocks relative to small economies.

[5] At the same time, the results should be taken with some caution given the small number of countries with terms of trade data among the groups of small countries and developing countries.

How can fiscal policy take account of these country characteristics? The exposure of larger developing countries to world interest rate shocks implies that fiscal policy that stabilizes the country's cost of international borrowing would also have a stabilizing effect on the country's GDP. For instance, by adopting countercyclical fiscal policy rules, fiscal authorities in larger developing countries may be able to reduce and stabilize the country risk premium demanded by international lenders. This would help to reduce GDP volatility in these economies.

Large developing countries are also more susceptible to real exchange rate shocks, which, as we conjectured above, may in part be driven by demand shocks. A countercyclical fiscal policy would cushion the effects of these shocks on the economy and thus lower GDP volatility in these countries.

In small countries, given their greater susceptibility to terms of trade shocks, fiscal policy that relies on pro-saving fiscal rules that force these economies to accumulate precautionary fiscal savings during good times would help to smooth out the effects of these shocks. Shocks to domestic GDP, such as weather shocks, could be self-insured in a similar manner. Indeed, our comparisons of countries that have adopted fiscal rules with non-adopters suggest that the former are less affected by shocks to GDP and government consumption.

6. Conclusion

Understanding the sources of volatility is one of the more pressing policy objectives in developing countries. This is even more so in smaller developing countries which lack economies of scale and often have undiversified trade and production structures, thus often suffering from greater economic volatility. In this paper we attempt to shed some light on how sources of volatility experienced by various countries differ with their characteristics. Specifically, we consider countries' size, level of economic development, institutional quality, and the presence of restrictions on fiscal policy in the form of fiscal rules.

We estimate the causes of volatility in a sample of 48 countries during 1960:Q1-2015:Q4 period using individual country and panel vector autoregressions. We find that GDP volatility in all countries in our sample is driven predominantly by domestic shocks. On average, these shocks, which include shocks to government expenditures, trade balance, real interest rate, real exchange rate and GDP itself, account for 78% of the overall GDP volatility, with shocks to domestic output playing the most important role. The remaining 22% of GDP volatility is driven by external shocks, which include shocks to the world real interest rate and to the foreign demand conditions. When terms of trade are added to the block of external variables, the contribution of external shocks rises to 34%.

Conditioning the analysis on country characteristics, we find that the sources of GDP volatility differ across countries of different size, different level of development, and by whether or not a country has adopted fiscal rules.[6] Specifically, in the developing countries group, small developing countries are more prone to shocks to GDP likely reflecting shocks to omitted variables such as weather, terms of trade, technology, demand, etc. and amplified by more concentrated production

[6] Institutional quality in our sample is highly correlated with the level of economic development.

structure. Large developing countries are more susceptible to shocks to the world interest rate -- likely due to greater integration of larger economies into world capital markets; and shocks to the real exchange rate -- likely reflecting the prevalence of domestic demand shocks and Balassa-Samuelson effect. We find no difference in the effects of external demand shocks.

In the developed countries group, we find no difference in the effects of shocks, with the exception of shocks to world demand, which tend to be more pronounced in large developed countries. We conjecture that this likely reflects historical importance of the trade relationships between the US and other developed countries. Adding terms of trade to the set of regressors, raises the contribution of external shocks to GDP volatility, especially in small countries.

Lastly, to better understand the inter-relations between different variables in the estimation and to check the robustness of our findings from the individual SVARs we estimate panel VARs for different country groups and contrast the resulting impulse responses of GDP to various shocks. We show that our results from the individual SVARs are generally robust. Moreover, by conditioning the analysis on both country size and level of development we also show that country size seems to matter most for business cycle dynamics and sources of volatility in developing countries, but does not seem to play an important role for developed economies.

These results suggest that policy makers, when designing stabilization policies, should take into a careful consideration the characteristics of countries, such as size and the level of economic development.

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Appendix

A. Individual and Panel VAR Results by Institutional Quality

In this appendix we investigate whether the sources of volatility vary with the level of institutional development. We proxy the latter by a subjective index of investor perceptions, the Composite Risk Rating index from the International Country Risk Guide (ICRG). This index is a composite of political, financial, and economic risk ratings and can take values from 0 to 100, with a rating of 100 indicating the lowest risk, and a rating of 0 indicating the highest risk. We classify all countries in our sample into "low risk" countries whose ICRG index is above the sample median, and "high risk" countries as those whose ICRG index is below the sample median.[7]

Table A1. Variance decomposition of GDP volatility: By level of institutional development

	High risk countries					Low risk countries					mean diff	median diff
	N	mean	median	p25	p75	N	mean	median	p25	p75		
rrate_us	23	0.123	0.083	0.042	0.134	23	0.112	0.083	0.043	0.163	-0.011	0.000
(log) gdp_us	23	0.078	0.033	0.019	0.096	23	0.148	0.096	0.008	0.244	0.070	0.063
(log) govexp	23	0.124	0.096	0.026	0.164	23	0.075	0.051	0.012	0.118	-0.049	-0.045
tby	23	0.079	0.073	0.014	0.121	23	0.057	0.040	0.008	0.058	-0.022*	-0.034
rrate	23	0.042	0.028	0.014	0.053	23	0.026	0.024	0.007	0.037	-0.016	-0.004
(log) gdp	23	0.479	0.537	0.402	0.604	23	0.541	0.553	0.485	0.695	0.062	0.016
(log) reer	23	0.076	0.029	0.009	0.124	23	0.042	0.023	0.007	0.055	-0.034	-0.006

Note: Authors' calculations. * p<0.10, ** p<0.05, *** p<0.01

Table **A1** reports the results. Not surprisingly, we find that the results for the level of institutional quality are quite symmetric to those we reported for the level of economic development. Thus, GDP volatility in low risk countries, very much like in developed economies, tends to be driven more by world demand shocks and shocks to GDP relative to high risk countries. In the high risk countries, very much like in developing economies, the shocks to government expenditures, trade balance, real interest rates and real exchange rate tend to be more prevalent. However, the differences in contribution are statistically significant only for shocks to trade balance.

We further explore the effects of institutional development on the sources of GDP volatility by estimating impulse responses of GDP to various shocks separately for a panel of low risk countries and a panel of high risk countries. Figures **A1** and **A2** report the corresponding results. It is easy to see that the estimated impulse responses conditional on institutional quality look quite symmetric to the impulse responses we obtained conditional on the level of economic development. Specifically, the impulse responses for low risk countries look similar to the impulse responses for developed economies, while the impulse responses for high risk countries are quite symmetric to those we obtained for developing countries. Clearly, in our sample the two characteristics are closely correlated.

Figure **A1**. Impulse Responses of GDP to Various Shocks: High Risk Countries

[7] Note that we have 23 countries in each risk group, not 24. This is because ICRG data for 2 countries (Georgia and Macedonia) in our sample are missing.

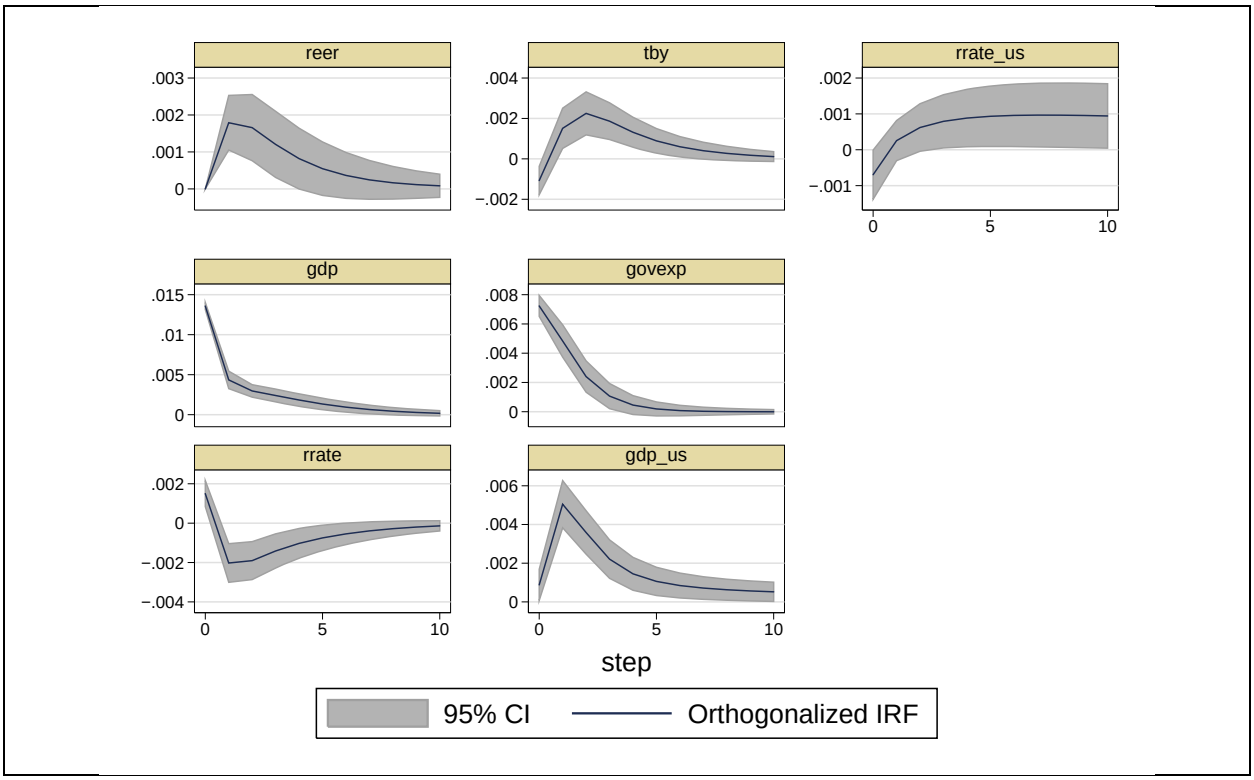

Figure **A2**. Impulse Responses of GDP to Various Shocks: Low Risk Countries