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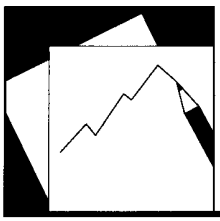

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Low-Income Countries' BRIC Linkage: Are There Growth Spillovers?

Issouf Samake and Yongzheng Yang

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Western Hemisphere Department and Asia and Pacific Department

Low-Income Countries' BRIC Linkage: Are There Growth Spillovers?

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Abstract

Trade and financial ties between low-income countries (LICs) and Brazil, Russia, India, and China (BRICs) have expanded rapidly in recent years. This gives rise to the potential for growth to spill over from the latter to the former. We employ a global vector autoregression (GVAR) model to investigate the extent of business cycle transmission from BRICs to LICs through both direct (FDI, trade, productivity, exchange rates) and indirect (global commodity prices, demand, and interest rates) channels. The estimation results show that there are significant direct spillovers while indirect spillovers also matters in many cases. Based on these results, we show that growing LIC-BRIC ties have significantly helped alleviate the adverse impact of the recent global financial crisis on LIC economies.

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I. INTRODUCTION

Research on business cycle transmission has regained attention in the wake of the recent global financial crisis. The International Monetary Fund has, for instance, carried out several studies that examine spillovers from systemically important countries (the United States, European Union, Japan, and China) to the rest of the world.[2] These studies almost exclusively focus on business cycle transmission among advanced and major emerging market economies, with limited attention to transmission to low-income countries (LICs), particularly that from major emerging market economies such as BRICs (Brazil, Russia, India, and China). This is not surprising given that LIC-BRIC ties have become significant only recently. However, trade and financial relations between LICs and BRICs have grown so rapidly over the past decade that any analysis of LICs' growth prospects would not be complete without taking into account the impact of the BRIC economies.

The emergence of BRICs has brought about a significant redirection of LIC trade and financial ties toward these emerging markets. Bilateral trade between LICs and BRICs has grown exponentially in recent years, making BRICs collectively a trade partner that is comparable to the United States (IMF 2011).[3] BRIC FDI and development assistance, though remaining small relative to ODA from traditional donors, have also grown rapidly and are making a significant impact in certain key sectors (e.g., infrastructure and resource extraction) of LIC economies. In addition, the rise of BRICs in the global economy could exert significant indirect effects on LIC economies via global goods and financial markets. In particular, rising global demand for commodities as a result of strong economic growth in BRICs and their rapid reserve accumulation could alter the terms of trade and the cost of financing for LICs in the global market.

The relatively mild deceleration of LIC economic growth during the global financial crisis points to the potential benefits of their growing ties with BRICs. Most LICs were hit hard by the crisis, but growth often slowed less and recovered faster than anticipated. This milder impact was anticipated by some analysts at the onset of the global financial crisis. They argued that Sub-Saharan Africa, for instance, would be more resilient to the global financial crisis than conventional wisdom would suggest because of the region's strong trade ties with BRICs, particularly China.[4] To the extent that BRIC growth suffered much less from the crisis than that of advanced economies, LICs' ties with BRICs must have helped them lessen

[2] Recently, Arora and Vamvakidis (2010) show significant spillovers from China to the rest of the world both in short and long run.

[3] IMF, 2011, "New Growth Drivers for Low-Income Countries: The Role of BRICs." International Monetary Fund, Washington.

[4] Dr. Harry G. Broadman, Managing Director, The Albright Group LLC Chief Economist, Albright Capital Management LLC, International Monetary Fund, Washington, DC, January 19, 2010; "Economic Drivers of China's Foreign Policy Toward Sub-Saharan Africa" (PowerPoint).

the impact of the global financial crisis, though the extent of this alleviation is unknown. More generally, as long as BRIC business cycles are not completely synchronized with those of advanced economies, their spillovers to LICs should help dampen the volatility of LIC growth. Moreover, the emergence of BRICs provides another potential source of sustained external demand and source of financing for low-income countries, raising the prospects for faster growth and poverty reduction in the long term.

Against this background, this study employs a global vector autoregression (GVAR) model to examine growth spillovers from BRICs to LICs. We attempt to shed light on the following three questions:

- To what extent and through what channels does growth from BRICs spill over to LICs?
- Given LICs' high dependence on global demand and world commodity prices, does growth in BRICs have any indirect impact on LIC growth?
- To what extent, if any, did BRICs' resilience during the global financial crisis help LICs weather the storm of the crisis?

To preview the results, the following points stand out:

- Overall spillovers from BRICs to LICs are considerable and persistent in the long run.
- Trade shocks from BRICs exert the strongest effect on growth in LICs, followed by exchange rate shocks, with real appreciation of BRIC currencies improving LIC growth through higher exports to BRICs. BRIC FDI to LICs appears to have limited impact on LIC growth thus far.
- BRIC spillovers are strongest in commodity-exporting LICs, reflecting the importance of commodities in LIC-BRIC trade relations.
- Demand shocks from BRICs exert significant influence over global commodity prices and global demand, with global oil price and demand being the most affected by shocks originating in BRICs. This influence translates into significant spillovers to growth in many LICs.
- The resilience of the BRIC economies during the global crisis may have added 0.3-1.1 percentage points to LIC growth compared with a scenario in which BRIC GDP had declined at the same pace as advanced economies.

These results have significant policy implications. They point to the potential of the BRIC economies to alter the volatility of LIC economies in the short run and contribute to their sustainable growth rates in the long run. It also suggests that LICs' linkages with other dynamic emerging market economies (EMEs) could have similar impacts. Thus, in assessing the macroeconomic policy stance and growth potential in LICs, greater attention should be paid to their linkages with BRICs and other EMEs, both via direct and indirect channels.

The rest of the paper is organized as follows. Section II provides, as background, some stylized facts on the role of BRICs in the global economy and their growing trade and financial ties with LICs. Section III presents the basic setup of the GVAR model estimated in this paper, and Section IV reports the estimation and simulation results. Section V concludes.

II. BRICs IN THE WORLD ECONOMY AND LIC-BRIC LINKAGES

The growing LIC-BRIC relations can be best understood in the context of BRICs' increasing prominence in the global economy. With a combined labor force of more than 1 billion people, BRICs have always had the potential to be key players in the global economy. Rapid economic growth in recent decades has enabled BRICs to begin to tap this potential. While the rapidly growing LIC-BRIC ties have benefited from great economic complementarity—two of the BRICs, China and India, are in great need of natural resources that many LICs are abundantly endowed with and can supply in exchange for competitively priced manufactures—BRICs' growing weight in the world economy has been the fundamental force driving LIC-BRIC economic relations. With a large population base and relatively low per capita income, BRICs' role in the world economy is only likely to increase over time as they narrow their gap with advanced countries in income levels.

Table 1. BRICs in the Global Economy, 1991–2015[1]

	1991–94	2000–04	2005–09	2015
	(In percent of world total; period average)			
Population				
BRICs	44.7	43.6	42.8	41.7
Other EMEs[2/]	23.1	23.3	23.6	23.9
United States	4.8	4.7	4.6	4.5
Euro Area	5.6	5.1	4.9	4.6
Labor Force				
BRICs	47.0	45.8	45.4	44.0
Other EMEs[2/]	20.0	21.0	21.6	21.9
United States	5.4	5.3	5.1	5.0
Euro Area	5.6	5.1	4.8	4.5
GDP[3/]				
BRICs	5.8	8.5	13.1	20.7
Other EMEs	10.3	10.9	13.4	15.8
United States	26.3	30.6	25.6	21.1
Euro Area	24.9	21.2	22.0	16.9
Exports				
BRICs	4.2	7.9	12.4	18.8
Other EMEs	13.0	15.8	18.6	18.8
United States	13.3	12.0	9.7	9.3
Euro Area	34.6	30.8	29.0	23.2
Imports				
BRICs	4.0	7.0	10.5	17.5
Other EMEs	14.4	14.8	17.2	18.1
United States	14.6	17.2	14.1	11.8
Euro Area	34.0	29.4	28.5	22.8

Sources: IMF and World Economic Outlook, October 2010.
[1] WEO Projections for 2015.
[2] Emerging market economies excluding BRICs.
[3] At market exchange rates.

1. *Population.* The world population in 2009 was estimated at 6.7 billion people. Almost three out of every seven people in the world today live in BRICs. Although the share of BRICs in world population is projected to decline over time, similar to that of the Unites States and the Euro Area, it will remain a multiple of that of the United States and Euro area combined and could eventually supports economies that are commensurate to BRICs' human resource base.

2. *Growth.* Since the early 1990s, BRICs have more than doubled their share in global output. BRICs' GDP (based on market exchange rates) is now the third largest in the

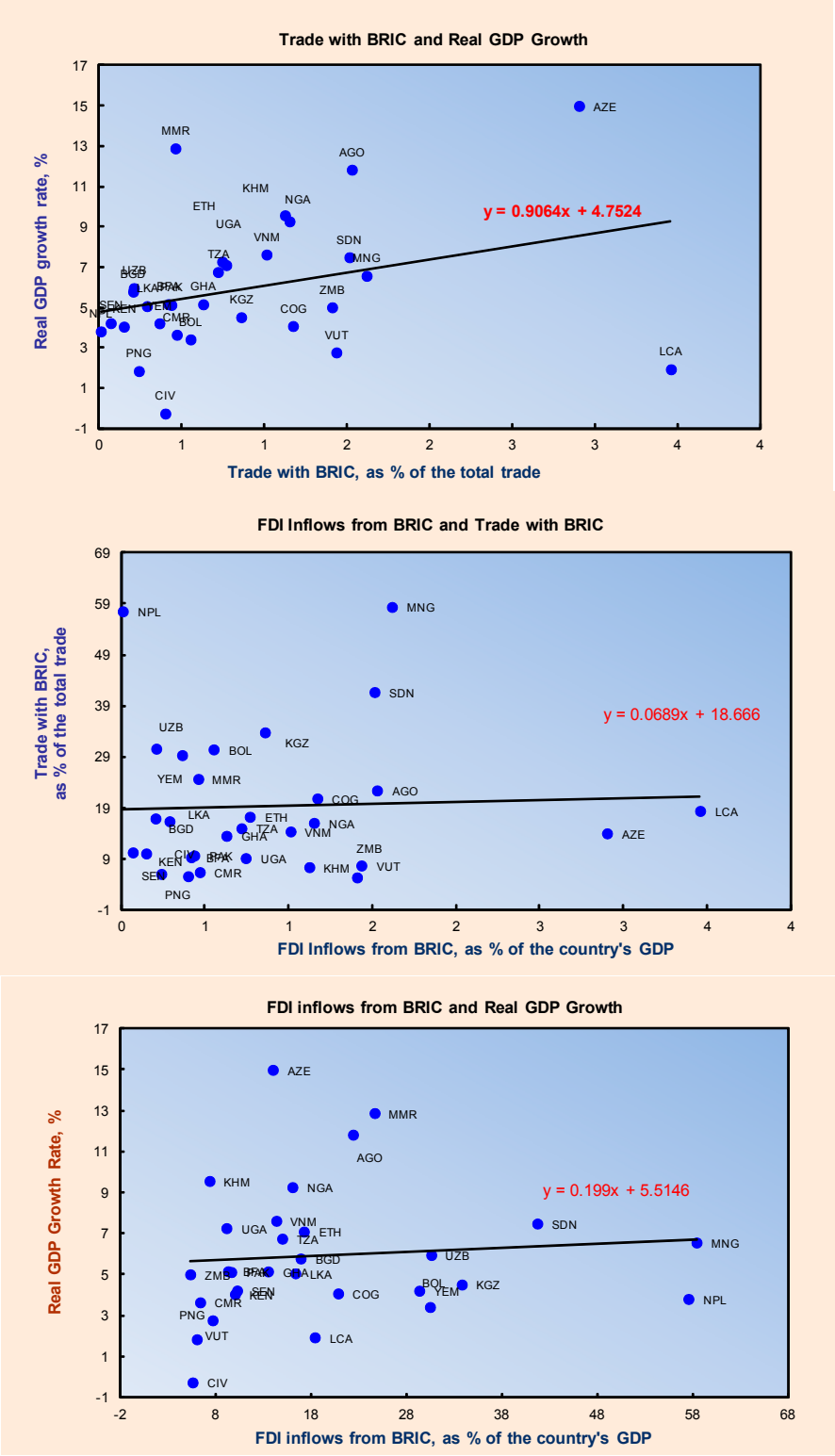
world after the United States and the Euro Area. According to IMF projections, BRICs' GDP will surpass that of the Euro area before 2015.

3. *Trade.* BRIC exports have been the most dynamic in their integration into the world economy. Over the past two decades, BRICs' share in world exports have nearly tripled, overtaking that of the United States and catching up rapidly with that of the Euro area. The growth of BRIC imports has been less spectacular but still very impressive—nearly doubling their share in world imports over the past two decades, and should catch up with the United States soon.

Given BRICs' strong growth and rapid integration into the global economy, it is not surprising that their trade and financial ties with LICs have bloomed. It must be noted, however, that these ties have also been re-enforced by improvements in macroeconomic management and the business climate in many LICs, while global commodity booms—which have partly resulted from BRICs' economic growth—have provided a critical linkage between LICs and BRICs. Below are a few stylized facts about LIC-BRIC linkages (Figures 1 to 3):

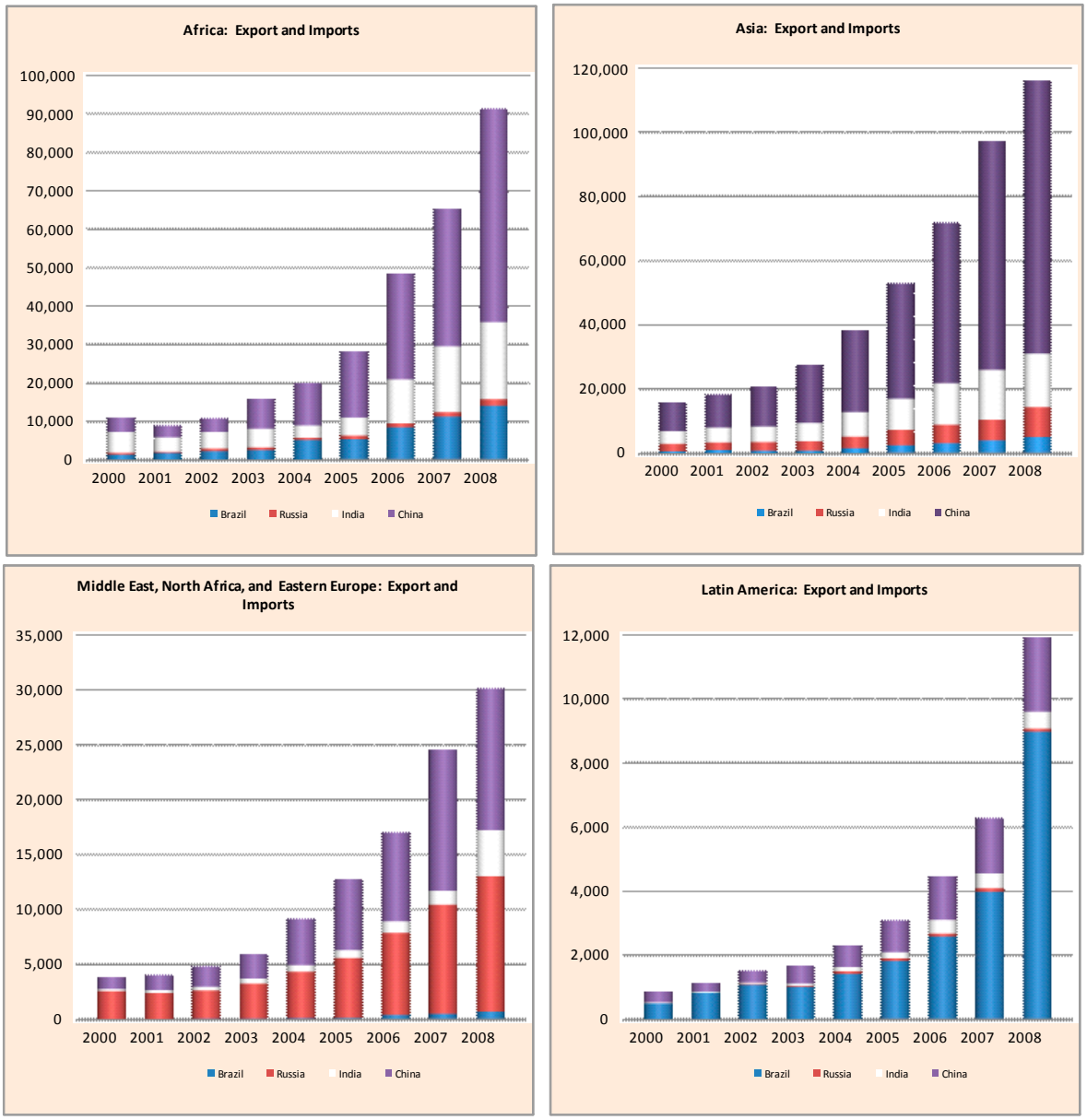
1. FDI inflows from BRICs to LICs appear to be positively correlated with LIC growth. This correlation is stronger for most Asian countries and Sub-Saharan African countries, particularly among resource-rich countries such as Angola, Nigeria, Zambia, and the Republic of Congo. A large part of FDI from BRICs (mostly China) to LICs is concentrated in natural resources and infrastructure. Given that these countries have often come out of conflict only recently, there are great needs for reconstruction, and their economic growth is more likely to be associated with BRIC investment.
2. Similarly, LIC trade with BRICs appears to be positively correlated with LIC growth. The correlation between BRIC-LIC trade and LIC growth is strongest for many Asian LICs, followed by some Sub-Saharan African countries, including Angola, Nigeria, Ethiopia, Uganda, and Tanzania.
3. The correlation between FDI from BRICs and LIC trade with BRICs is insignificant. This is somewhat surprising, as one would expect FDI to provide positive spillover effects on host countries, most prominently through exports, which can often be facilitated by plugging host countries into global value chains. Spillovers can also happen when the entry of foreign firms stimulates competition and promotes efficiency in host industries. The insignificant correlation is most likely to reflect the early stage of BRIC FDI in LICs and the dominance of BRIC economic growth (rather than FDI) in driving trade.
4. BRIC-LIC ties have significant regional dimensions as well as reflect the relative size of individual BRICs. BRIC trade ties with Africa and Asian LICs are far stronger than that with Latin American and Eastern Europe LICs. Among BRICs, China is by far the largest trade partner for LICs in Africa, Asia, Middle East and North Africa, while Brazil is a dominant partner in Latin America. Russia's prominence is seen in Eastern Europe.

Figure 1. LICs and BRIC Linkages: 2000-07 Average



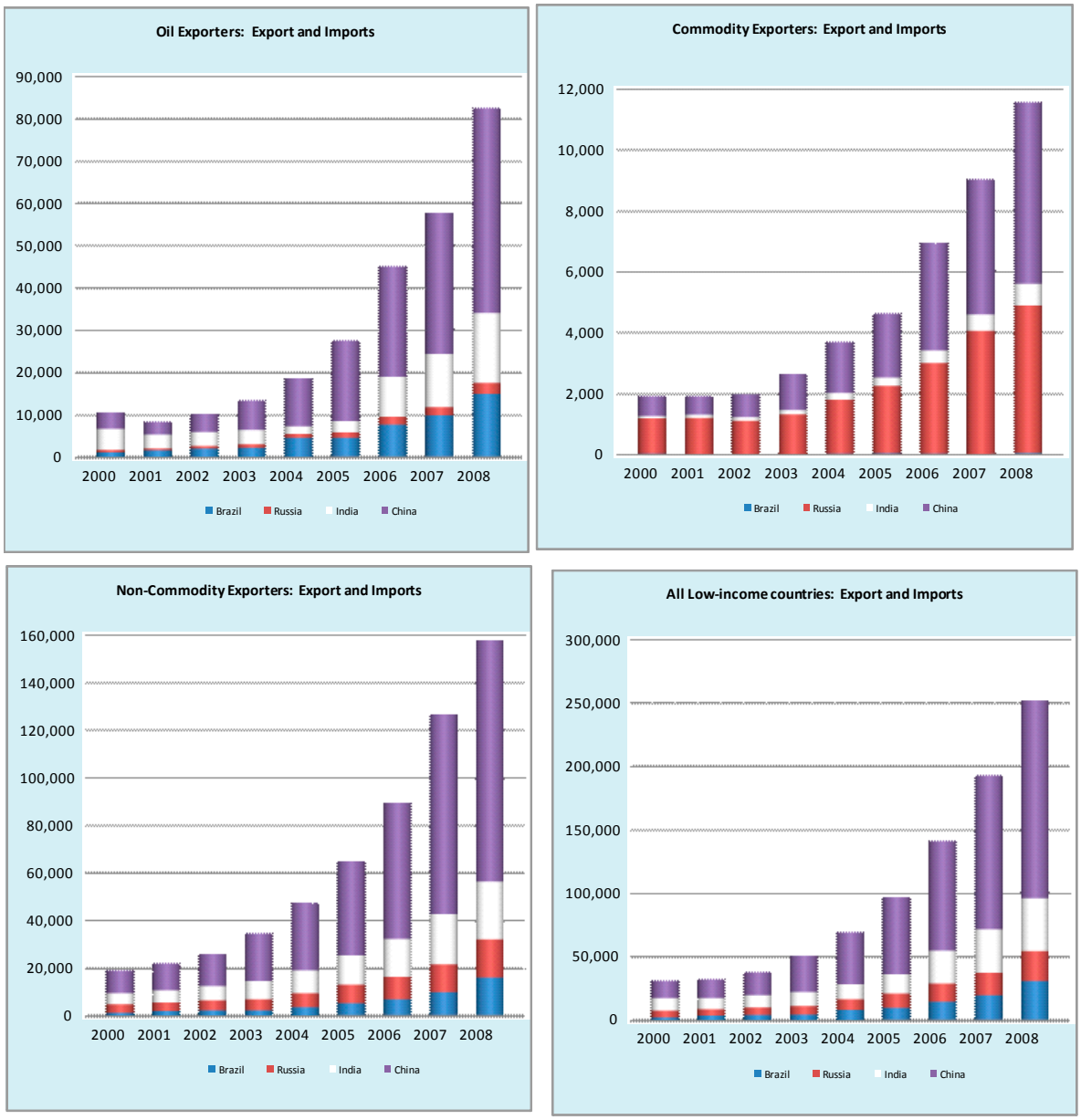
Sources: International Monetary Fund; WEO database, IFS database; and authors' calculations.

Figure 2. LICs' Trade with BRICs by Region, 2000-08
(In millions of US dollars)



Sources: International Monetary Fund; WEO database, IFS database; and authors' calculations.

Figure 3. LICs' Trade with BRICs by Type of Exporters, 2000-08
(In millions of US dollars)



Sources: International Monetary Fund; WEO database, IFS database; and authors' calculations.

III. THE GVAR MODEL AND ESTIMATION STRATEGY

Model Choice

A key challenge in the business cycle literature is to come up with a consistent and accurate identification technique for modeling international spillovers of shocks. Common techniques include panel data analysis, single-country VAR models, large-scale macroeconomic models, dynamic factor models, global models, and factor models. It is well known that panel data analysis suffers from one-size-fits-all (single equation) and endogeneity problems. Single-country VAR models for global transmission generally require the estimation of a large number of parameters and hence face a degree of freedom constraint, especially for models involving LICs, which often have limited data with frequent structural breaks. Moreover, panel VAR models have limited ability to control for cross-country differences. Finally, large-scale macroeconomic models require a large number of behavioral equations and parameters.

Dynamic factor models have remained until recently the most powerful and widely used econometric tool to analyze business cycle across countries or regions. However, factor models are criticized for being atheoretical and lacking a structural identification scheme. Additionally, even after controlling for "common" factors there are always important residual cross-country interdependencies due to policy and trade spillover effects that remain to be explained.

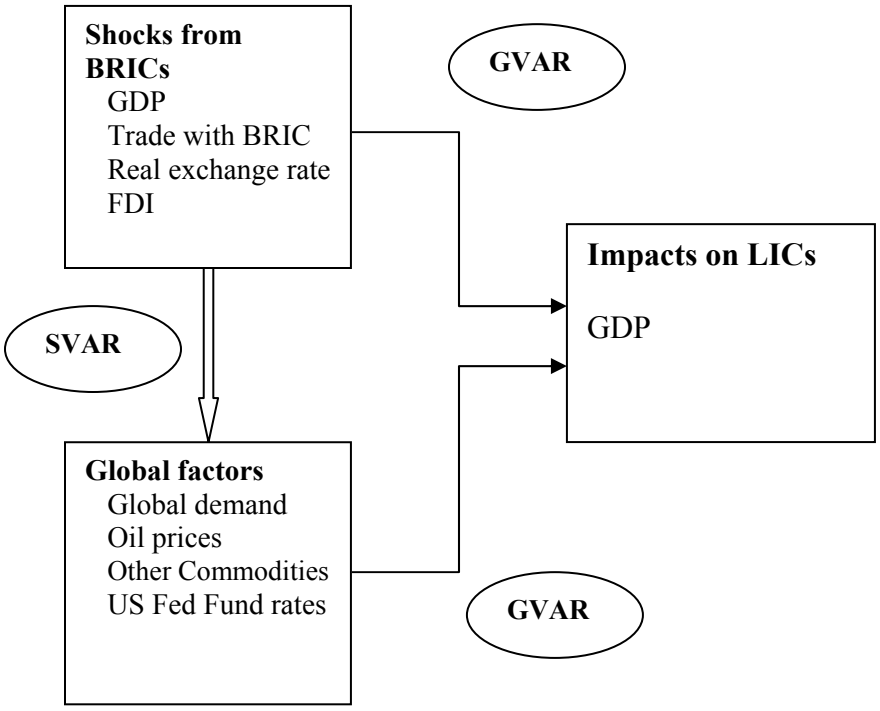
Against this backdrop, we use a global vector autoregression (GVAR) model to analyze BRIC spillovers to LICs. The GVAR approach is a recent development by Pesaran, Schuermann, and Weiner (PSW) (2001), Pesaran and Smith (2004), and Dées, di Mauro, Pesaran, and Smith (2004 and 2007). The GVAR model is a multivariate and multicountry framework that can be used to investigate cross-country and regional interdependency. While it allows to minimize parameter requirements and can cover a large number of geographical areas, the GVAR model typically links individual countries or regions by including foreign-specific fundamentals. Unlike the factor models, the GVAR model introduces observed country-specific foreign variables in individual country models to deal with pervasive dependencies in the global economy in a flexible manner.

The contribution of this paper to the literature in terms of methodologies is twofold. First, to the best of our knowledge this is the first attempt to model the LIC-BRIC linkages through multivariate time series analysis using a GVAR model. This approach alleviates two key shortcomings of previous methodologies: (i) a narrow focus of macroeconomic variables, usually solely on output, and (ii) limited capability to address international business cycle spillover issues. Like standard VAR models, the GVAR model allows for both backward (i.e., elasticities) and forward analysis (i.e., impulse response functions and variance decomposition). Typically, the GVAR model explicitly specifies international business cycle spillovers with following characteristics: (i) domestic variables are related to corresponding

trade-weighted foreign variables to match the international trade pattern of the country under consideration; (ii) non-zero pair-wise correlation in residuals between countries and equations are allowed, to capture a certain amount of dependence from idiosyncratic shocks; (iii) common observed shocks can be introduced; and (iv) country idiosyncratic factors are controlled for.

The GVAR outputs capture the direct impacts of shocks from BRICs to LICs. In addition to the analysis of direct channels of spillovers through GVAR estimations and simulations, we also examine spillovers from BRICs to LICs through indirect channels: global demand, commodity prices, and financial linkage (see Figure 4). We construct a structural VAR to estimate the impact of BRICs on global variables, which are then fed into the GVAR to compute the indirect spillovers. Few studies have explicitly estimated the extent to which growing BRIC economies influence global commodity prices, demand, and finance that could ultimately influence business cycles in LICs.

Figure 4. Assessing the Direct and Indirect Impact of Shocks from BRIC to LICs



The Framework

We consider *N* LICs in the global economy and *M* BRIC countries (*M* = 4). Let X_{it} denote a $k_i x1$ vector of (LICs') domestic (endogenous) variables (for instance, LIC GDP and inflation), X_{it}^* denote a $k_i^* x1$ vector of BRIC variables–or country-specific foreign variables– (such as BRIC GDP per capita and exchange rates); and D_t denote a *mx1* vector of (common) global factor variables (such as global demand, international oil prices, and U.S. Fed Fund rates). X_{it}^* and D_t are assumed to be weakly exogenous.

The general individual LIC country/region VAR$X^*(1,1)$ model is as follows:[5]

$$X_{it} = a_{io} + a_{i1}t + \Phi_i X_{it-1} + \Lambda_{i0} X_{it}^* + \Lambda_{i1} X_{it-1}^* + \Gamma_{i0} D_t + \Gamma_{i1} D_{t-1} + u_{it} \quad (1)$$

Where:

- a_{io} is a $k_i x1$ vector of fixed intercepts;
- Φ_i is a $k_i x k_i$ matrix of coefficients associated with lagged domestic variables, X_{it-1};
- Λ_{i0} and Λ_{i1} are $k_i x k_i^*$ matrices of coefficients associated with, respectively, contemporaneous and lagged foreign variables, X^*_{it} and X^*_{it-1};
- Γ_{i0} and Γ_{i1} are $k_i xm$ matrices of coefficients associated with, respectively, contemporaneous and lagged global (weakly) exogenous factor variables, D_t and D_{t-1}.
- u_{it} is a $k_i x1$ vector of country-specific shocks, assumed serially uncorrelated with zero mean and a non-singular covariance matrix, $\Sigma_{ii} = (\sigma_{ii,ls})$, where $\sigma_{ii,ls} = cov(u_{ilt}, u_{ist})$, or more compactly, $u_{it} \sim$ i. i. d. $(0, \Sigma_{ii})$.[6]
- We, however, as in PSW (2004), allow the idiosyncratic shocks u_{it} to be correlated across countries/regions, to a limited degree. In a sense, for $i \neq j$

$$E(u_{it} u'_{jt'}) = Cov(u_{it}, u'_{jt}) = \begin{cases} \Sigma_{ij} & \text{for } t = t' \\ 0 & \text{for } t \neq t' \end{cases}$$

We impose that k_i, the number of country-specific variables, is the same across countries. However, we recognize that (i) not all LICs are equally important in the global economy; (ii) country-specific shocks might be cross-sectionally correlated due to geographic or contagion effects that are not totally caused by common factors; and (iii) markets might not be equally important or present in LICs countries. In light of these considerations, we adopted an approach developed by PSW, which uses country-specific weights w_{ij}, as opposed to

[5] Given data limitation and the number of parameters to be estimated, we limit the lag length to 1.

[6] Note, however as in PSW (2004), that we allow the idiosyncratic shocks u_{it} to be correlated across country/region to a limited degree.

common weights w_j, in constructing cross-country averages (Table 2). More specifically, PSW uses the following formula to weigh country-specific foreign variables:

$$X_{it}^{*} = \sum_{j=0}^{N} w_{ijt} X_{jt} + \sum_{j=0}^{M} w_{ijt} X_{jt}$$

The weight w_{ijt} (for *j=1,..., N+M*) captures the relative importance of country *j* for the *i*th country in the world economy. For instance, if *i=1,* w_{1jt} captures the relative importance of countries *j= 2, 3, ..., N+M* for country *i*=1. This formulation allows us to better control for shocks from BRICs and other observed factors that impact on LICs' endogenous variables. More importantly, it also helps assign appropriate weights to various foreign shocks. At the same time, these time-varying weights control for any breaks induced by the fast growing BRIC-LIC trade and financial ties.

Given the size of the GVAR, the model cannot be estimated using standard VAR techniques because it would require more estimated parameters than available observations. The assumption of weak exogeneity of country-specific foreign variables allows for constructing country-specific variables using time-varying trade weights. This greatly reduces the number of unrestricted parameters to be estimated. The corresponding vector error correction model of equation (1) that serves as the basis for the generalized impulse response (GIRF) is:

$$\Delta X_{it} = c_{io} - \alpha_i \beta_i^{'}[Z_{it-1} - \gamma_i(t-1)] + \Lambda_{i0}\Delta X_{it}^{*} + \Psi_{io}\Delta Z_{it-1} + \Gamma_{i0} D_t + \Gamma_{i1} D_{t-1} + u_{it} \quad (2)$$

where $Z_{it} = \left(X_{it}^{'}, X_{it}^{*\prime}\right)^{'}$, *is a* kxr_i matrix of rank r_i , and β_i is a $(k + k_i^{*})xr_i$ matrix of rank r_i.

Estimating Spillovers

***Econometric modeling steps*:**

- *Step 1*: Country-specific small-dimensional models are consistently estimated for each LIC. We typically estimate the VAR$X^{*}(1,1)$ for each LIC (see equation (1)). These models provide estimates of direct spillovers from BRICs and identified global factors to LICs.
- *Step 2*: Long-run (co-integrating) and error correction relations among variables for selected countries are identified.
- *Step 3*: Stack and solve in one large system (Global VAR) all estimated coefficients from the country-specific models. The resulting model is used for generalized impulse response function analysis.
- *Step 4*: Estimate an additional structural VAR including the country-specific foreign variables for BRICs (GDP, trade, real exchange rates, and FDI) and the identified global factors (global demand, international oil prices, global commodity prices, U.S.

Fed Fund rates). The estimation pins down the direct impact of BRICs on global factors, and ultimately indirect spillovers from BRICs to LICs through identified global factors in GVAR.

Other estimation steps and pre-requisites: The traditional Augmented Dickey-Fuller (ADF) test on each individual variable (in levels, first and second differences) suggests that most variables follow an *I(1)* process. Stability tests suggest that the model remains dynamically stable.

Estimating the impacts:

Estimating the Direct Impact of Shocks from BRICs. We first construct a GVAR framework with (i) LIC individual domestic variables, (ii) BRIC sources of spillover variables (e.g., productivity, trade, FDI, exchange rates), and (iii) global factor variables (world oil prices, world commodity prices, world demand, and U.S. Fed Fund rates). The GVAR provides estimates of the direct impact of shocks from BRICs through the generalized impulse response function (GIRF) of identified shocks to LICs' fundamentals (GDP, trade, inflation, and real exchange rates). It also provides endogenous responses of LIC variables to shocks to global factors (world demand, oil prices, other commodity prices, and U.S. Fed rates), which enable us to subsequently estimate the indirect impact.

Estimating the Indirect and Total Impact of Shocks from BRICs. We attempt to fully capture the spillovers from BRICs to LICs that could potentially transmit through global factors. A two-step approach is thus adopted. We complement the above GIRF results (the response of LIC growth to shocks to global factors) by estimating a simple structural VAR to identify unexpected shocks from BRICs to global factors. For simplicity and convenience, we limit the endogenous set of variables of the column vector (in the order) to growth (both for BRICs and LICs), trade, real exchange rates, global demand, oil prices, and U.S. Fed Fund rates. Impulse response from the SVAR model provides estimates of response of global factor variables (e.g., world oil price) to shocks (e.g., to productivity) in BRICs. This result, combines with the LICs growth response to shocks to global factors (e.g., oil price, from the GVAR) produces the indirect impact of shocks from BRICs (e.g., productivity) to LICs through any identified global factor. The total effect is finally obtained by summing up the direct and indirect effects.

Estimating BRICs' alleviating effects on LIC output during the global financial crisis. We estimate a Generalized Variance Decomposition output of the GVAR both in-sample (1972–2009, i.e., including a global financial crisis period dummy) and out-of-sample (1972–2007, i.e., excluding the crisis period). This allows us to calculate the relative contributions of (i) domestic variables, (ii) BRIC spillover variables, and (iii) global factor variables to the change in LICs' output. A comparison of the two sets of results enables us to gauge the increasing role of BRICs in determining the change in LIC growth. These calculations are complemented by a simulation exercised using a model estimated by Berg et al. (2010),

which links LIC growth with trading partner growth. This allows us to estimate the extent to which BRICs may have alleviated the impact of the global financial crisis.

Data

The GVAR model was estimated for 29 countries (Sub-Saharan Africa [12], Asia [10], Middle East and Europe [4], Latin America [3]) using annual data covering 1970 through 2009. Data for key variables were constructed as follows:

Individual LIC variables

1. Growth: log of real GDP, PPP-based, 2000=100
2. Trade: log of LIC-BRIC trade volume
   FDI: FDI from BRICs proxied by time-varying shares of FDI from BRICs to LICs multiplied by total FDI received by each country.[7]
3. Inflation: log of the CPI, $2000 = 100$

Country − specific foreign variables for BRICs

1. BRIC aggregate GDP (log), weighted by PPP − based average, 2000=100
2. BRIC aggregate demand (log), weighted average import volume (2000=100)
3. BRIC real effective exchange rate index (log), 2000=100

Global factors

1. International crude oil price (US$ per barrel)
2. World commodity price index (2000=100)
3. U.S. Fed Fund rate (percent), and
4. World import volume (log), excluding BRIC imports, 2000=100[8]

Variable Selection

Technology: We proxy technology shocks by shocks to BRICs' GDP per capita. The Ricardian model predicts that comparative advantage arises from technology differences between countries. Technology disturbances affect the marginal product of factors of production, influence investment opportunities within each country/region and alter trade

[7] $FDI\ inflows\ to\ LIC\ X_{it} = \left(\frac{Total\ BRIC\ FDI\ to\ LIC\ at\ t}{Total\ World\ FDI\ to\ LIC\ at\ t}\right) * (Total\ FDI\ recieved\ by\ LIC\ X_{it})$

[8] The last variable (the world global demand proxies by world import) is used to run another VAR$X^*(1,1)$ in which the US Fed Fund rate is replaced by the global demand variable. Doing so safeguards the minimum degree of freedom and the realization of various empirical model parameter estimates.

patterns of final goods. Changes in international specialization in production could also result in higher real aggregate income and welfare (OECD, 2005).

Trade: Heckscher-Ohlin-Samuelson and Stolper-Samuelson theories predict that comparative advantage results from differences in factor endowments across countries. As such, countries/regions export goods that intensively utilize factors of production with which they are relatively abundantly endowed, and import goods that use intensively factors that are relatively scarce at home. Trade linkages generated under such frameworks can lead to both demand- and supply-side spillovers across countries, resulting in a higher degree of synchronization of output across countries. On the other hand, if stronger trade linkages facilitate increased specialization of production across countries, and if sector-specific shocks are dominant, then the degree of co-movement of output could fall (see Baxter and Kouparitsas, 2005).

FDI: FDI shifts capital resources across countries. In the context of standard business cycle literature, this implies that LIC-BRIC ties could reduce their investment correlations and raise investment growth in LICs because of their potentially higher returns on capital. However, the empirical research has not yet produced conclusive findings on the impact of FDI on growth. While some authors have attributed this situation to methodological problems (Blonigen and Wang, 2005), others have identified threshold effects. For instance, Kose et al. (2009b) show that there are certain "threshold" levels of financial and institutional development that an economy needs to attain, over which financial flows, including FDI, could have significant growth effects. Recently, Dabla-Norris et al. (2010) find that FDI can significantly contribute to growth if host countries have sound economic fundamentals and macroeconomic stability.

Real exchange rates: Movements in BRICs' real exchange rates would affect relative prices of tradables versus nontradables in their economies. Thus, real exchange rate changes in BRICs should affect LIC exports, trade patterns, and business synchronization.

Financial linkages (through the U.S. Fed Fund Rate): Rising financial linkages could result in a higher degree of business cycle co-movement via the cost of capital and the wealth effects of external shocks. However, they could reduce cross-country output correlations by stimulating specialization of production through the reallocation of capital in a manner consistent with countries' comparative advantage (see Kose, 2008, and Bayoumi, 2007).

IV. Empirical Results

Based on the procedure (joint GVAR and SVAR outputs) shown in Figure 4 and detailed in the previous section, this section presents the estimates of direct and indirect spillovers. The

GVAR analysis uses time-varying trade weights of the last five years for country-specific foreign variables to capture changes in the global economic structure over time.[9, 10]

Direct Spillovers

Direct spillovers from BRICs are generally manifest in significant improvements in LIC output over time, but there are considerable variations in the impact across different channels of transmission as well as across different LIC regions (Figure 4 and 5).

- *Trade shocks:*[11] Of the four identified channels of spillovers, trade shocks dominate. The trade channel accounts for around 60 percent of the impact of BRICs on LIC growth—it is the most significant and persistent channel of transmission for all regions. In general, trade shocks lead to positive short- and long-run growth effects except in the European and Middle East LICs, where the short-run response is negative, possibly due to competition in third markets for imports (e.g., agricultural products). Ojeyide, Bankole, and Adewuyi (2009) also show that trade with China could potentially result in a short-term output contraction in Africa. In terms of magnitude of the impact, the greatest responses are seen in LICs in Asia and Middle East, North Africa, and Central Asia (MNCA), consistent with the strong trade links between BRICs and these countries. The response in African LICs is also quite strong, reflecting growing trade ties that these countries have forged with BRICs in recent years. Furthermore, the overall impact on oil exporters is considerably larger, almost twice as large as on non-oil exporters. This is hardly surprising given the strong complementarity between major BRICs (China and India) and oil exporters, discussed earlier on.
- *Real exchange rate shocks:* A positive shock to the real exchange rate (appreciation) in BRICs is associated with positive growth effects on LICs. Given that LIC-BRIC

[9] Given the forward-looking nature of the generalized impulse response analysis, we assume BRICs will keep the current trade momentum and hence the weights of the most recent five years are used. Analysis using fixed trade weights of the last ten years (2000-09) shows some sensitivity of FDI results, but overall results remain generally unchanged. Similar results generally hold when the average weights of 1970-2009 are used. The results differ quite significantly when the average weights of 1970-1979 are used. Analysis using time-varying weights has been criticized on the grounds that changes in trade weights tend to be counteracted by the comovement of macroeconomic variables so that country-specific variables computed using fixed and variable trade weights are often very close (Dées, di Mauro, Pesaran, and Smith, 2004 and 2007).

[10] The GVAR could also directly control for the effects of business cycles in advanced countries on LICs, but at the cost of a reduced degree of freedom and hence less efficient estimates. In the current setup, the "other" foreign variables (excluding shock emanating from BRICs) account for the effects of the rest of the World (including advanced countries).

[11] A one-standard error increase in the volume of total BRIC imports (in logs) from LICs. Same magnitude for other shocks discussed below.

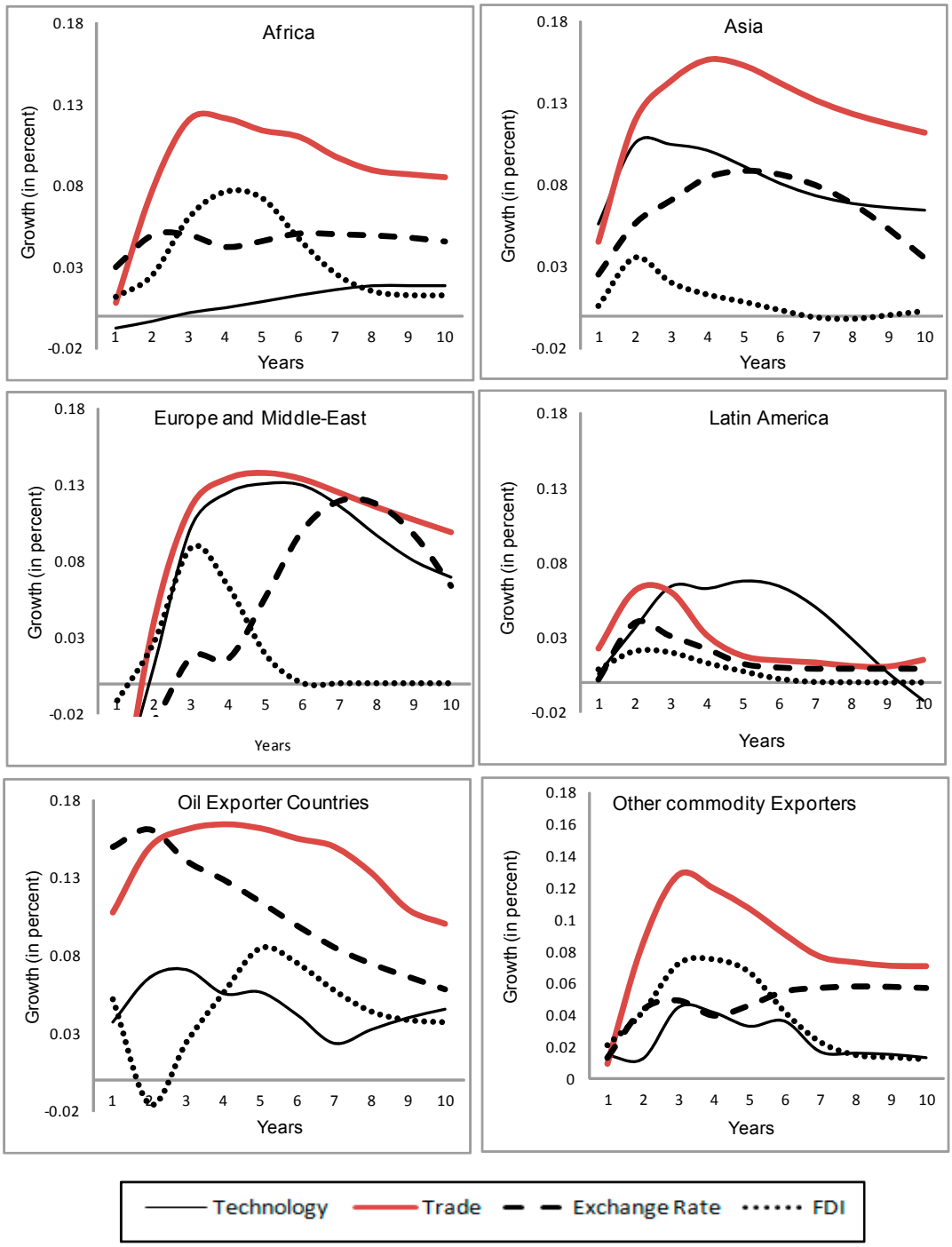
ties are dominated by trade in magnitude, exchange rate movements are likely to exert their impact through trade. As such, like trade shocks, these effects appear to be positive and particularly strong in oil exporters among LICs.[12] Surprisingly, however, real exchange rate appreciation is somewhat associated with reduced growth in LICs in Latin America and the Caribbean (LTNC) LICs in the short run. This could reflect the fact that the selected LTNC countries have limited exports destined for BRICs (except Brazil) and a real appreciation in BRICs leads to higher import costs, worsening the terms of trade.

- *Technology shocks.* The results show that this impact is generally significant and leads to higher long-run growth in LICs. Consistent with some recent studies of the relationship between BRICs (China in particular) and LICs, short-term responses in LICs are sometimes negative, but they tend to shift to a significant positive impact in the longer horizon. As observed by Ojeyide, Bankole, and Adewuyi (2009), such initial negative impact could be related to BRICs' (China in their case) competition in third markets for exports *and* imports.[13] Asian LICs stand out in terms of benefiting from technology shocks from BRICs. This probably reflects the closer integration of Asian LICs into global manufacturing supply chains, in which BRICs (particularly China and India) play a critical role. LICs in MNCA also benefit significantly from technology shocks, as do non-oil commodity exporters.
- *FDI shocks.* This channel also matters, but compared with the other three channels of spillovers, its impact on LIC growth is more modest even in the long run. While the empirical evidence on the growth benefits of FDI in general is inconclusive, this finding may reflect the relatively small volumes of BRIC FDI in LICs—the "threshold" effects are yet to manifest (Kose et al., 2009). Despite the recent surge in BRIC FDI to LICs, it remains relatively small compared to total FDI inflows to LICs. Nevertheless, the impact of BRIC FDI could be much larger in individual LICs that have received larger volumes of BRIC FDI.

[12] Statistically significant but the magnitude is small compared with trade shocks.

[13] Recently, Arora and Vamvakidis (2010) discussed that China's exports of goods to other countries could have a negative direct effect on those countries' net exporters.

Figure 5. Responses of LICs' Real GDP Growth to Shocks Originating from BRICs[1]
(In percent)



[1] Generalized impulse responses of Real GDP Growth to indentified (+1 s.e.) shocks to BRICs' trade, FDI, technology, and real effective exchange rate.
Source: Authors' calculations.

Table 2. BRIC Shocks to LICs: Direct Impacts
(Generalized impulse response of LICs' output to a one-percentage shocks)

	Overall impact[1]	Short run[2]	Long run[3]	Year ahead 1	4	7	10
Africa							
to BRIC technology shocks	0.09	-0.05	0.12	-0.07	-0.25	-0.02	0.30
to BRIC overall trade shocks	0.93	0.43	1.05	0.08	1.21	0.98	0.98
to BRIC real exchange rate shocks	0.47	0.40	0.48	0.30	0.43	0.51	0.46
to FDI shocks from BRIC	0.37	0.28	0.40	0.31	0.58	0.26	0.25
Asia							
to BRIC technology shocks	0.81	0.81	0.81	0.56	1.01	0.73	0.65
to BRIC overall trade shocks	1.25	0.82	1.35	0.46	1.57	1.32	1.12
to BRIC real exchange rate shocks	0.65	0.41	0.71	0.26	0.85	0.80	0.36
to FDI shocks from BRIC	0.09	0.21	0.06	0.06	0.13	-0.01	0.03
Europe and Middle-East							
to BRIC technology shocks	0.79	-0.31	1.07	-0.75	1.25	1.16	0.70
to BRIC overall trade shocks	1.31	-0.38	1.74	-1.36	1.93	1.79	1.42
to BRIC real exchange rate shocks	0.53	-0.30	0.74	-0.36	0.17	1.20	0.64
to FDI shocks from BRIC	0.38	0.15	0.44	-0.17	1.06	-0.06	0.45
Latin america							
to BRIC technology shocks	0.38	0.21	0.42	0.06	0.63	0.51	-0.11
to BRIC overall trade shocks	0.27	0.43	0.23	0.23	0.32	0.14	0.16
to BRIC real exchange rate shocks	-0.65	-0.21	-0.76	-0.02	-0.49	-0.76	-1.24
to FDI shocks from BRIC	0.44	0.76	0.37	0.45	0.67	-0.02	0.50
Oil exporter countries							
to BRIC technology shocks	0.36	0.52	0.32	0.37	-0.56	0.24	0.46
to BRIC overall trade shocks	1.51	1.29	1.57	1.08	1.64	1.50	1.58
to BRIC real exchange rate shocks	1.08	1.56	0.96	1.50	1.29	0.86	0.59
to FDI shocks from BRIC	0.44	0.18	0.50	0.52	0.36	0.58	0.37
Other commododity exporters							
to BRIC technology shocks	0.24	0.14	0.26	0.15	-0.21	0.17	0.43
to BRIC overall trade shocks	0.86	0.48	0.96	0.10	1.20	0.87	0.76
to BRIC real exchange rate shocks	0.48	0.29	0.53	0.14	0.40	0.57	0.57
to FDI shocks from BRIC	0.40	0.32	0.41	0.22	0.66	0.24	0.29

Source: Author's calculations.

[1]Sample average over 10 years.

[2]Average over the first 2 years.

[3]Average over the last 8 years.

Indirect Spillovers

As outlined earlier, the estimation of indirect spillovers involves two steps: (i) using an SVAR to estimate the impacts of shocks originating in BRICs on global variables, and (ii) feeding these impacts into the GVAR to assess their spillovers to LICs. BRIC shocks that are considered to influence global variables are technology and demand (proxied by GDP per capita and imports, respectively). Four global variables are considered important in the context of LIC-BRIC linkages. These are world oil prices, other commodity prices, global interest rates (proxied by the U.S. Federal Fund Rate), and global demand.[14]

- Overall, the estimation results show that BRICs exert significant impact on some of the global variables through their demand and technology innovations (Table 3 and 4, which depicts the response of global variables to BRIC shocks in different timeframes). Shocks to BRIC demand have larger impact on global variables than those to technology. While the effects of technology stocks tend to die down in the long run, those of demand shocks generally remain strong in the long run, even though the short-run impact tends to be larger as well. This is consistent with the earlier finding that shows the importance of trade to the transmission of business cycles from BRICs to LICs, and it is this channel of spillovers that LIC policymakers should pay the greatest attention in assessing the macroeconomic policy stance.

- Among the four identified channels of impacts on global variables, those on world oil and other commodity prices are the largest in the short run, and those through global demand and interest rates are generally small or negligible. Roughly one-third of changes in world oil prices can be attributed to shocks originating in BRICs. This seems to reflect the fact that commodity supply is generally inelastic in the short run and the hence price impact is large. In contrast, only less than 10 percent of the change in the U.S. Fed Fund rates is explained by shocks from BRICs.

[14] On the BRIC impact on global interest rates, the presumption here is that BRIC technology and demand changes could alter the pace of their foreign exchange reserves accumulation and hence their purchase of U.S. securities, thus affecting U.S. interest rates. BRIC demand shocks on U.S. interest rates could also affect commodity prices. For instance, higher U.S. interest rates could lower global output prospects and raise storage costs, leading to lower raw material prices. Reisen et al. (2004) have argued that the integration of BRICs into the world economy has dramatically changed the nature of global macroeconomic and financial interdependence that shapes primary commodity markets.

Table 3. Changes in Global Variables–Contributions of BRICs (Average, in percent, 10 years ahead)

	Contribution of BRICs:			
	Total	of which:		Other Factors
		Technology	Demand[1]	
To 10 percent change in:				
Global Demand[2]	20.4	2.3	18.1	79.6
World Oil Prices	33.5	14.2	19.3	66.5
Other Global Commodity Prices	17.6	6.2	11.4	82.4
US Fed Fund Rates	8.1	2.7	5.4	91.9

Source: Authors' calculations.

[1] Total BRIC imports of goods and services.

[2] Total World imports of goods and services, excluding BRIC imports.

These effects of BRIC shocks on global variables translate into some significant and positive spillovers to LICs, though they are mostly smaller than direct spillovers (Table 4).[15] Consistent with BRIC impact on global variables and the importance of commodities in LIC-BRIC ties, the overall indirect spillovers from BRICs to LICs through world oil and other commodity prices are the largest in the short run, and those through global demand and interest rates are generally small or negligible. Thus, African LICs seem to receive stronger indirect spillovers, as do oil-exporting countries through commodity prices. In some cases, however, the overall indirect impact is comparable to the direct impact or provides an important addition to the direct impact. In Africa, for example, technology shocks originating in BRICs produce a similar magnitude of spillover effects both through direct and indirect channels, and in oil exporters the indirect impact of technology shocks is about one-third of direct impact. In the case of LTNC, the indirect impact through global demand is even more significant than the relatively weak direct impact.

[15] Results in this table are obtained by combining results in Tables 2, 3, and 4, namely, feeding the impact of BRIC productivity and demand shocks (from the SVAR model) to the linkage between the global variables and LIC GDP growth as estimated in the GVAR model.

Table 4. Estimated Indirect Response of LIC Outputs to Shocks from BRIC[1]

	to productivity shocks			to demand shocks		
	Overall impact[1]	Short run[2]	Long run[3]	Overall impact[1]	Short run[2]	Long run[3]
Africa						
Total, indirect (through)	0.09	0.18	0.06	0.09	0.07	0.10
World Oil Prices	0.05	0.08	0.04	0.06	0.00	0.07
Other Commodity Prices	0.04	0.09	0.03	0.04	0.11	0.03
US Fed Interest Rate	0.00	0.00	0.00	0.00	-0.02	0.00
Global Demand	0.00	0.01	0.00	-0.01	-0.02	0.00
Asia						
Total, indirect (through)	0.04	0.10	0.02	0.15	-0.21	0.24
World Oil Prices	0.02	0.04	0.02	0.03	0.00	0.03
Other Commodity Prices	0.02	0.04	0.01	0.02	0.04	0.01
US Fed Interest Rate	0.00	0.02	-0.01	0.10	-0.25	0.19
Global Demand	0.00	0.00	0.00	0.00	0.00	0.00
Europe and Middle-East						
Total, indirect (through)	-0.01	-0.03	-0.01	0.17	-0.26	0.28
World Oil Prices	0.00	-0.04	0.01	0.03	0.00	0.03
Other Commodity Prices	-0.01	0.00	-0.01	-0.01	0.00	-0.01
US Fed Interest Rate	0.00	0.01	-0.01	0.17	-0.24	0.27
Global Demand	0.00	0.01	-0.01	-0.01	-0.03	-0.01
Latin America						
Total, indirect (through)	0.07	0.10	0.07	0.13	0.01	0.16
World Oil Prices	0.07	0.10	0.07	0.12	0.00	0.15
Other Commodity Prices	0.00	0.00	0.00	0.00	0.00	0.00
US Fed Interest Rate	0.00	0.00	0.00	0.00	0.00	0.00
Global Demand	0.00	0.00	0.00	0.00	0.01	0.00
Oil Exporting Countries						
Total, indirect (through)	0.12	0.18	0.11	0.25	0.07	0.30
World Oil Prices	0.05	0.06	0.05	0.10	0.00	0.12
Other Commodity Prices	0.07	0.10	0.07	0.09	0.13	0.08
US Fed Interest Rate	0.00	0.00	0.00	0.08	-0.03	0.11
Global Demand	0.00	0.01	0.00	-0.01	-0.03	-0.01
Other Commodity Exporters						
Total, indirect (through)	0.04	0.09	0.02	-0.02	0.07	-0.05
World Oil Prices	0.02	0.03	0.02	0.02	0.00	0.03
Other Commodity Prices	0.01	0.05	0.01	0.01	0.07	0.00
US Fed Interest Rate	0.00	0.00	0.00	-0.05	0.02	-0.07
Global Demand	0.00	0.00	0.00	-0.01	-0.02	0.00

Source: Authors' calculations.

[1] The indirect impact calculation combines the estimated impact of (demand or supply) shocks emanated from BRIC to global variables (estimated by the SVAR) and the respond of LIC outputs to global variables (using the outcomes from the GVAR).

Total Spillovers[16]

The overall impact of BRICs on LIC growth appears to be both substantial and becoming larger over time (Table 5). The total impact of a 1 percentage point increase in BRICs' demand and productivity leads (through both direct and indirect channels) to a cumulative 0.7 percentage point increase in LICs' output over 3 years and 1.2 percentage point over 5 years.[17] The impact has increased from the pre-2007 period, when a 1 percentage point increase in BRICs' demand and productivity would change LICs' output by about 0.5 percentage point over 3 years and 0.6 percentage point over 5 years.

Table 5. Total Estimated Response of LIC Outputs to Shocks Originating from BRIC[1]

	to productivity shocks			to demand shocks		
	Overall impact[1]	Short run[2]	Long run[3]	Overall impact[1]	Short run[2]	Long run[3]
Africa	**0.17**	**0.13**	**0.18**	**1.02**	**0.50**	**1.15**
Direct	0.09	-0.05	0.12	0.93	0.43	1.05
Indirect (through)	0.09	0.18	0.06	0.09	0.07	0.10
Asia	**0.85**	**0.91**	**0.84**	**1.39**	**0.62**	**1.59**
Direct	0.81	0.81	0.81	1.25	0.82	1.35
Indirect (through)	0.04	0.10	0.02	0.15	-0.21	0.24
Europe and Middle-East	**0.78**	**-0.34**	**1.05**	**1.49**	**-0.64**	**2.02**
Direct	0.79	-0.31	1.07	1.31	-0.38	1.74
Indirect (through)	-0.01	-0.03	-0.01	0.17	-0.26	0.28
Latin America	**0.45**	**0.31**	**0.49**	**0.39**	**0.43**	**0.38**
Direct	0.38	0.21	0.42	0.27	0.43	0.23
Indirect (through)	0.07	0.10	0.07	0.13	0.01	0.16
Oil Exporting Countries	**0.48**	**0.70**	**0.43**	**1.77**	**1.36**	**1.87**
Direct	0.36	0.52	0.32	1.51	1.29	1.57
Indirect (through)	0.12	0.18	0.11	0.25	0.07	0.30
Other Commodity Exporters	**0.27**	**0.23**	**0.29**	**0.84**	**0.55**	**0.91**
Direct	0.24	0.14	0.26	0.86	0.48	0.96
Indirect (through)	0.04	0.09	0.02	-0.02	0.07	-0.05

Source: Authors' calculations.

[1] The indirect impact calculation combines the estimated impact of (demand or supply) shocks emanated from BRIC to global variables (estimated by the SVAR) and the respond of LIC outputs to global variables (using the outcomes from the GVAR).

[16] Note that total impact here is confined to those results from demand and technology shocks in BRICs. To the extent that these two categories of shocks differ from those transmitted from direct channels, the direct spillovers captured here are different in magnitude and time profile from the estimates of direct spillovers presented earlier. For this reason, one cannot sum results from Table 2, 4 and Appendix Table 4 as total spillovers.

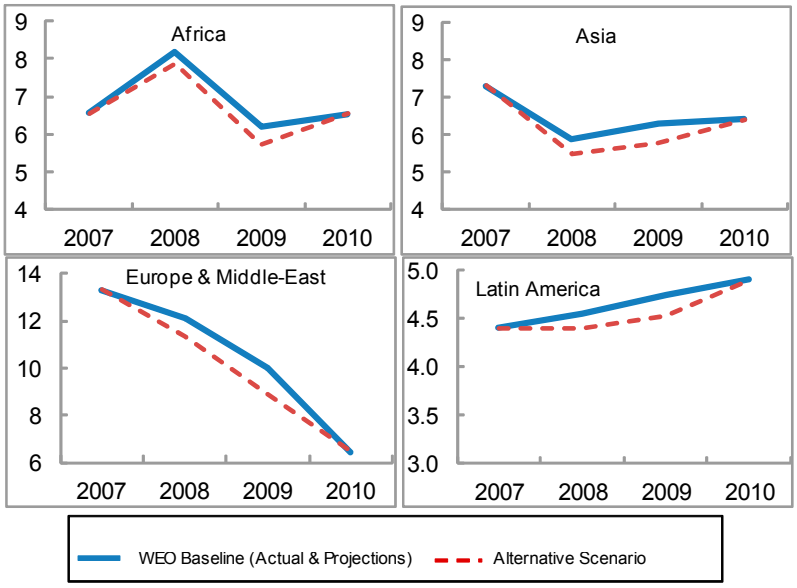
[17] Calculated from the impulse response functions. Note that there are significant variations across regions and type of exporters. We also attempted to estimate the response of LICs growth to shocks to advanced economies poductivity and demand, using a different methodology from the GVAR described above. These estimates are not associated with standard error as they combine two sets of estimates obtained using separate models. Nevertheless, the magnitudes are broadly similar to the estimated direct impact of demand and productivity shocks in advanced economies. A 1 percentage point increase in advanced economy's demand and productivity is associated with 0.9 and 1 percentage point increase in LIC output over 3 and 5 years respectively. Note that while this additional exercise is helpful to gauge the broad magnitudes of the spillovers from advanced economies, these estimates of direct impacts are based on a different methodology and so are not strictly comparable to the BRIC spillover estimates.

BRICs' Role during the Crisis

Given the increasing BRIC spillovers to LICs, a natural question to ask is how BRICs' resilience during the global financial crisis may have helped cushion LICs from the crisis impact. In answering this question, we first analyze the contributions of various sources using the generalized variance decomposition technique, and then simulate the effects of BRICs' resilience on LICs based on an existing study (see below).

The BRIC contributions to LICs growth during the crisis were generally significant, albeit varying considerably across regions. Even before the crisis, BRICs' contributions were already significant, ranging roughly from 20 percent to 30 percent in explaining changes in LICs output growth (Table 6). During the crisis period, however, BRICs' contributions increased significantly across all regions, with the largest increases seen in African and Asian LICs, and oil and other commodity exporters, consistent with the earlier analysis. It is worth noting that domestic factors also contributed GDP growth in these two regions during the crisis, reflecting improved macroeconomic management over time, including the significant policy buffer built prior to the crisis (IMF, 2009; 2010).[18]

Figure 6. Real GDP Growth in LICs, Actual and Counterfactual Scenario[1]



Sources: WEO projections, and authors' calculations.
[1] Assumes that BRICs' growth declines at the same rate as that of Advanced Economies (2.5 percent in 2008, and 3.5 percent in 2009).

[18] See: (i) International Monetary Fund, 2011, "Emerging from the Global Crisis–Macroeconomic Challenges Facing Low-Income Countries" SM/10/266 and (ii) International Monetary Fund, 2011, "The Implications of the Global Financial Crisis for Low-Income Countries" SM/09/57.

Table 6. Contribution to Changes in LICs' Growth Rates[1]
(Unweighted averages for each region, in percent)

	Factors		
	Country & Idiosyncratic	BRICs	Rest of the World
	Before, During, and Post-Crisis[2]		
Africa	43.1	29.7	27.2
Asia	53.8	27.6	18.6
Europe & Middle-East	37.1	31.1	31.8
Latin America	41.0	19.1	39.9
Oil Exporters	52.5	37.0	10.5
Other Commodity Exporters	35.1	37.4	27.4
	Before Crisis[3]		
Africa	39.9	18.8	41.3
Asia	44.4	25.1	30.4
Europe & Middle-East	44.9	30.5	24.5
Latin America	48.7	18.7	32.6
Oil Exporters	49.0	28.9	22.1
Other Commodity Exporters	32.1	28.8	39.1
	Change in Contribution[4]		
Africa	3.2	10.9	-14.1
Asia	9.4	2.5	-11.9
Europe & Middle-East	-7.8	0.6	7.2
Latin America	-7.7	0.5	7.2
Oil Exporters	3.5	8.1	-11.6
Other Commodity Exporters	3.1	8.6	-11.7

Source: Authors' calculations.

[1] The table shows the fraction of the variance of output growth attributable to each factor.

[2] Generated from variance decomposition of VAR regression, for period covering 1972-2009.

[3] Generated from variance decomposition of VAR regression for period covering 1972-2007.

[4] Difference between "During and post-crisis" and "Before the crisis". Positive sign implies an increase in contribution, and a negative sign means the opposite.

A simulation exercise confirms that LICs' growing ties with BRICs, particularly through robust trade links, helped cushion LICs' growth from the impact of the crisis. BRICs' growth declined by less than advanced economies during the crisis, providing stronger demand for LIC exports. LIC growth would have been 0.3 percentage point to 1.1 percentage points lower during the crisis if BRICs' GDP growth had declined at the same pace as advanced economies (See counterfactual scenario in Figure 5).[19] Given that average LICs growth was

[19] The scenario made use of a panel growth regression of growth in LICs on a number of its short run determinants, including external demand, measured as the trade-weighted growth of trading partners (Berg et

(continued…)

only about 7 percent in 2008-09, these impacts represent significant mitigation of the downward pressure on LIC growth in those two years.

V. CONCLUDING REMARKS

BRICs' rapid growth and integration into the world economy have substantially strengthened their trade and financial ties with LICs. This has been complemented by improved economic performance in many LICs. While LICs' traditional development partners remain dominant in many LICs' external economic relations, BRICs are rapidly catching up. This suggests that there might be significant growth spillovers from BRICs to LICs, not only through direct channels such as bilateral trade, FDI, exchange rate movements and technological change, but also through indirect channels such as global demand, international commodity prices, and world interest rates, all of which are influenced by BRICs. The considerable resilience demonstrated by many LICs during the recent global crisis, despite the worst recession experienced by advanced countries since World War II, also suggests a significant role of BRICs in influencing LICs' growth and its volatility.

To investigate these issues, we estimated a GVAR model, together with a structural VAR model, in possibly the first such attempt to assess the spillovers from BRICs to LICs. We also employed generalized variance decomposition technique to analyze the changing role of BRICs in influencing LICs' growth and output fluctuations. The analysis culminated in a simulation exercise that enabled us to quantify BRICs' contribution to LICs' resilience during the recent global financial crisis.

GVAR results show that direct spillovers from BRICs to LICs are significant and persistent, exerting considerable impact on LIC growth. Bilateral trade is the most powerful channel of transmission, but exchange rate movements, productivity innovations in BRICs, and FDI flows from BRICs also matter, albeit more modestly. The spillovers spread to all LIC regions, with commodity-exporting countries and those in Asia experiencing the strongest impact. The response in African countries is also quite strong, reflecting the rapid expansion of their trade with BRICs in recent years, particularly in commodities.

Indirect spillovers from BRICs to LICs through global demand and price channels are also significant, though generally much smaller in magnitude than the direct spillovers. Because BRICs are key players in the global commodity markets, their demand and productivity growth have large impact on world commodity prices, especially world oil prices, which in turn exert significant influence on LIC growth. The impact through global demand and

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al., 2010). Given the BRIC-LIC links, the Figure shows what would have been LIC output growth if the BRIC growth had declined as much as advanced economies. As pointed out in Berg et al., 2010, some limitations of this approach are that it considers only the impact of slower growth in BRICs and does not take into account possible associated changes, such as changes in commodity prices, interest rates, capital flows.

interest rates are generally small or negligible. African LICs seem to receive stronger indirect spillovers, as do oil-exporting countries.

BRICs' mild slowdown and quick recovery from the global financial crisis helped cushion LICs' growth from the impact of the crisis. Growing bilateral trade over the recent years seems to have played a key role. This is a major benefit from LICs' diversification of external demand in recent years and should continue to pay off in the future.

Looking forward, increasing LIC-BRIC trade and financial ties will only strengthen their business cycle synchronization over time. As long as BRIC business cycles are not fully synchronized with those of advanced countries, these growing ties should help dampen growth volatility in LICs. This also means that LICs will have to pay increased attention to macroeconomic developments in BRICs in assessing their macroeconomic policy stance. Moreover, continued expansion of BRIC economies could alter LICs' growth potential in the long run, serving as new drivers of growth for LICs.

Some caveats are worth highlighting. The estimated spillovers represent broad orders of magnitude rather than definitive estimates and should be treated with caution. Limited lengths of time series and frequent structural breaks in LIC and BRIC economies reduce the robustness of the estimates. Furthermore, neither BRICs nor LICs are homogenous entities. Bilateral relations thus often vary greatly from country to country, and any assessment of bilateral spillovers and policy implications should therefore be based on a close examination of these relations.

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Appendix Table 1. List of LICs and Selected Economic Indicators[1]

Country	Oil Exporters	Commodity Exporters	FDI Inflows from BRIC[2/]	Trade with BRIC[3/]	Real GDP Growth
Angola	1		1.5	22.4	11.8
Burkina Faso		1	0.4	9.3	5.2
Cameroon			0.5	6.4	3.6
Congo, Republic of	1		1.2	20.8	4.1
Cote D'Ivoire			0.4	5.6	-0.3
Ethiopia			0.8	17.2	7.1
Ghana			0.6	13.5	5.2
Kenya			0.1	10.0	4.0
Nigeria	1		1.2	16.0	9.3
Senegal			0.1	10.2	4.2
Tanzania			0.7	15.0	6.8
Uganda			0.7	9.1	7.3
Zambia		1	1.4	5.3	5.0
Bangladesh			0.2	16.9	5.8
Cambodia			1.1	7.4	9.6
Mongolia		1	1.6	58.4	6.6
Myanmar			0.5	24.7	12.9
Nepal			0.0	57.6	3.8
Pakistan			0.4	9.6	5.1
Sri Lanka			0.3	16.3	5.1
Vanuatu			1.4	7.7	2.8
Vietnam			1.0	14.4	7.6
Yemen, Republic of	1		0.4	29.3	4.2
Azerbaijan	1		2.9	14.0	15.0
Kyrgyz Republic			0.9	33.8	4.5
Sudan	1		1.5	41.7	7.5
Uzbekistan		1	0.2	30.6	6.0
Bolivia			0.6	30.5	3.4
Papua New Guinea		1	0.2	6.0	1.8
St. Lucia			3.5	18.4	1.9

Sources: International Monetary Fund, WEO database; OECD database; and authors' calculations.

[1] Unweighted average in 2000–07.

[2] Inward FDI flows to GDP ratio (in percent).

[3] LIC's trade (export plus import values) with BRICs to its total trade in percent.

Appendix Table 2. LIC, BRIC, and Rest of the World (RoW) Average Trade Weights, 2003–07[1 2 3]

Total LICs (in the sample)	Total LICs (a)	BRIC				Total BRIC (b)	RoW (c)	Sum d=a+b+c
		Brazil	Russia	India	China			
Africa								
Angola	0.024	0.032	0.001	0.011	0.244	0.289	0.687	1.000
Burkina	0.010	0.006	0.004	0.021	0.095	0.126	0.865	1.000
Cameroon	0.005	0.013	0.001	0.010	0.045	0.069	0.926	1.000
Congo, Rep	0.027	0.023	0.000	0.020	0.273	0.316	0.657	1.000
CIV	0.002	0.008	0.011	0.018	0.024	0.060	0.937	1.000
Ethiopia	0.014	0.010	0.008	0.060	0.135	0.213	0.773	1.000
Ghana	0.010	0.026	0.005	0.049	0.095	0.175	0.816	1.000
Kenya	0.005	0.005	0.007	0.081	0.049	0.141	0.854	1.000
Nigeria	0.004	0.062	0.002	0.051	0.041	0.157	0.839	1.000
Senegal	0.004	0.024	0.001	0.050	0.036	0.112	0.885	1.000
Tanzania	0.009	0.002	0.009	0.078	0.093	0.181	0.809	1.000
Uganda	0.005	0.002	0.006	0.059	0.047	0.114	0.881	1.000
Zambia	0.004	0.001	0.000	0.022	0.044	0.067	0.928	1.000
Asia and Europe								
Bangladesh	0.008	0.005	0.007	0.090	0.084	0.187	0.805	1.000
Cambodia	0.008	0.000	0.002	0.003	0.085	0.090	0.902	1.000
Mongolia	0.043	0.001	0.201	0.001	0.428	0.631	0.326	1.000
Myanmar	0.019	0.000	0.002	0.084	0.192	0.278	0.703	1.000
Nepal	0.005	0.002	0.002	0.589	0.054	0.648	0.347	1.000
Pakistan	0.009	0.004	0.008	0.027	0.090	0.129	0.862	1.000
Srilanka	0.004	0.002	0.011	0.147	0.042	0.203	0.793	1.000
Vanuatu	0.003	0.000	0.000	0.032	0.032	0.063	0.934	1.000
Vietnam	0.013	0.002	0.012	0.012	0.132	0.158	0.829	1.000
Yemen	0.019	0.015	0.008	0.122	0.191	0.337	0.644	1.000
Azerbaijan	0.002	0.007	0.121	0.010	0.024	0.162	0.836	1.000
Kyrgyz	0.010	0.002	0.301	0.004	0.098	0.405	0.585	1.000
Sudan	0.045	0.006	0.001	0.035	0.446	0.488	0.468	1.000
Uzbekistan	0.009	0.001	0.247	0.006	0.093	0.347	0.643	1.000
Latine America								
Bolivia	0.003	0.341	0.001	0.002	0.027	0.371	0.626	1.000
Papua N.G.	0.005	0.001	0.001	0.016	0.054	0.071	0.923	1.000
St Lucia	0.001	0.251	0.000	0.001	0.011	0.263	0.736	1.000

Source: IMF, *Direction of Trade Statistics*, 1960–2009.

[1] Trade weights are computed as shares of exports and imports displayed in rows by region and by country in the sample.

[2] 2008 and 2009 are excluded from the trade weights because of relative large volatility in trade dynamics in these periods due to the 2008 fuel and food price shocks and the 2009 global financial crisis.

[3] The displayed weight matrix is just indicative, the estimation and simulation used time-varying weights given the fast growing trade patterns of BRIC-LICs.

Appendix Table 3. SVAR–Impulse Resonse of Global Factors
(10 years ahead)

	Productivity Shocks from BRIC			Demand Shocks from BRIC		
	Overall impact[1]	Short run[2]	Long run[3]	Overall impact[1]	Short run[2]	Long run[3]
Response of:						
World oil prices	0.06	0.12	0.05	0.10	0.00	0.12
Standard deviation	*0.07*	*0.10*	*0.07*	0.13	0.15	0.13
World commodity prices	0.06	0.09	0.06	0.08	0.12	0.07
Standard deviation	*0.05*	*0.07*	*0.05*	0.09	0.10	0.08
US Fed rate	0.00	0.02	-0.01	0.19	-0.21	0.30
Standard deviation	*0.35*	*0.58*	*0.32*	0.63	0.84	0.60
Global demand	0.00	0.01	-0.01	-0.01	-0.05	0.00
Standard deviation	*0.03*	*0.03*	*0.03*	0.05	0.04	0.05

Source: Authors' calculations.

Appendix Table 4. BRIC Shocks to LICs: Indirect Impacts:
(Generalized impulse response of LICs' output to a one-percentage shocks)

	Overall impact[1]	Short run[2]	Long run[3]	Year ahead 1	4	7	10
Africa							
to World oil price shocks	0.69	0.67	0.70	0.55	1.09	0.51	0.38
to World commodity price shocks	0.47	0.97	0.35	0.72	0.95	-0.02	-0.03
to US Fed interest rate shocks	-0.05	0.00	-0.06	-0.09	0.32	-0.28	-0.21
to world demand shocks	0.70	0.62	0.73	0.43	0.91	0.69	0.63
Asia							
to World oil price shocks	0.32	0.36	0.31	0.33	0.43	0.23	0.27
to World commodity price shocks	0.21	0.38	0.17	0.24	0.41	0.03	0.04
to US Fed interest rate shocks	0.68	0.96	0.61	0.72	1.00	0.39	0.38
to world demand shocks	0.15	0.21	0.14	0.34	0.22	0.19	0.03
Europe and Middle-East							
to World oil price shocks	0.19	-0.31	0.31	-0.92	0.54	0.05	0.58
to World commodity price shocks	-0.23	-0.02	-0.28	-0.27	-0.14	-0.71	0.19
to US Fed interest rate shocks	0.86	0.26	1.02	-0.61	1.53	0.54	1.08
to world demand shocks	1.21	0.84	1.31	0.66	1.59	1.53	0.43
Latin america							
to World oil price shocks	-0.19	-0.25	-0.18	-0.25	-0.32	-0.35	0.39
to World commodity price shocks	0.43	0.37	0.44	0.09	0.44	0.15	0.94
to US Fed interest rate shocks	-0.38	0.24	-0.53	0.14	-0.11	-0.79	-0.83
to world demand shocks	1.00	0.76	1.05	0.71	0.07	1.44	1.53
Oil exporter countries							
to World oil price shocks	0.91	0.54	1.01	0.45	1.10	1.01	0.90
to World commodity price shocks	1.13	1.13	1.13	0.83	1.37	1.00	0.92
to US Fed interest rate shocks	0.26	0.20	0.28	0.24	0.52	0.20	0.13
to world demand shocks	1.06	1.35	0.98	1.54	1.12	1.00	0.67
Other commododity exporters							
to World oil price shocks	0.30	0.29	0.30	0.20	0.66	0.11	0.05
to World commodity price shocks	0.04	0.57	-0.10	0.37	0.52	-0.48	-0.45
to US Fed interest rate shocks	-0.29	-0.15	-0.32	-0.19	0.12	-0.57	-0.49
to world demand shocks	0.65	0.36	0.72	0.09	0.90	0.68	0.70

Source: Authors' calculations.

[1]Sample average over 10 years.

[2]Average over the first 2 years.

[3]Average over the last 8 years.

Appendix Table 5. Variance Decompostion: Forecast Error Variance of LICs' Real GDP Growth Explained by Identified Total Domestic Factors, BRIC Demand and Technology, and Global Factors[1]

	S.E.		Domestic factors		Contribution of BRIC		Global factors	
	In-sample (after)	Out-of-sample (before)	In-sample (after)	Out-of-sample (before)	In-sample (after)	Out-of-sample (before)	In-sample (after)	Out-of-sample (before)
Africa								
Fist year	0.0089	0.0099	59.43	55.59	21.86	15.61	18.72	28.79
Second year	0.0115	0.0128	51.19	50.67	27.96	19.97	20.85	29.35
Third year	0.0136	0.0151	44.86	44.85	32.14	22.96	23.00	32.19
Asia								
Fist year	0.0167	0.0179	53.67	44.45	14.66	13.33	31.66	42.22
Second year	0.0222	0.0238	46.75	42.53	20.17	18.33	33.08	39.13
Third year	0.0270	0.0290	38.53	34.27	25.30	23.00	36.17	42.73
Europe and Middle-East								
Fist year	0.0562	0.0556	55.12	51.69	11.93	11.70	32.95	36.61
Second year	0.0724	0.0717	46.44	51.26	24.53	24.05	29.02	24.68
Third year	0.0841	0.0832	36.74	41.90	27.06	26.53	36.20	31.57
Latin America								
Fist year	0.0582	0.0647	52.97	56.23	10.81	10.55	36.22	33.23
Second year	0.0658	0.0731	45.76	51.80	14.51	14.15	39.73	34.04
Third year	0.0683	0.0759	42.17	51.26	16.96	16.55	40.87	32.19
Oil exporters								
Fist year	0.0132	0.0166	61.75	54.66	17.84	13.94	20.41	31.39
Second year	0.0186	0.0232	51.54	53.55	31.43	24.56	17.03	21.90
Third year	0.0225	0.0281	46.33	48.18	34.47	26.93	19.20	24.89
Other commodity exporters								
Fist year	0.0208	0.0219	56.58	51.69	25.20	19.39	18.22	28.92
Second year	0.0280	0.0295	52.64	48.37	24.91	19.16	22.45	32.47
Third year	0.0356	0.0375	45.43	40.06	27.60	21.23	26.97	38.71

Source: Authors' calculations.

[1] In-sample, including the global financial crisis: (1972–2009) and out-of-sample (1972–2007).