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After the Boom–Commodity Prices and Economic Growth in Latin America and the Caribbean

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Abstract

After skyrocketing over the past decade, commodity prices have remained stable or eased somewhat since mid-2011—and most projections suggest they are not likely to resume the upward trend observed in the last decade. This paper analyzes what this turn in the commodity price cycle may imply for output growth in Latin America and the Caribbean. The analysis suggests that growth in the years ahead for the average commodity exporter in the region could be significantly lower than during the commodity boom, even if commodity prices were to remain stable at their current still-high levels. Slower-than-expected growth in China represents a key downside risk. The results caution against trying to offset the current economic slowdown with demand-side stimulus and underscore the need for ambitious structural reforms to secure strong growth over the medium term.

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I. Introduction

Following nearly a decade of rapid, broad-based gains, international commodity prices peaked in mid-2011 and have fallen somewhat since then (Figure 1). Many analysts now argue that the upward phase of the commodity "super-cycle" that started in the early 2000s has run its course.[2] Indeed, most market futures and analyst forecasts show commodity prices softening further in the near term, reflecting an anticipated increase in commodity supply along with weaker demand from some of the major commodity-importing economies, notably China.[3] While these projections are subject to large uncertainty, there is nonetheless a wide consensus that the period of ever-increasing commodity prices has come to an end.

What would this imply for the commodity exporters of Latin America and the Caribbean ("LAC" hereafter)? The region is highly dependent on commodities and has greatly benefited from the recent commodity boom.[4] Average annual output growth in the region increased from less than 2.5 percent between 1980 and 2002 to more than 4 percent in 2003–11 (see Figure 2). More recently, however, growth has decelerated considerably. Average output growth fell from 4.6 percent in 2011, to 3.1 percent in 2012 and 2.7 percent in 2013. Some observers claim that the recent economic slowdown across the region is primarily linked to the end of the upswing in commodity prices, raising obvious concerns for the future.[5] Others have downplayed these concerns, pointing out that commodity prices are still higher than in the mid-2000s, let alone in the 1990s (Figure 1).

This paper explores the possible consequences of weaker commodity price dynamics on economic growth in LAC over the medium term (defined as the period 2014–19 in this paper). We start by constructing a country-specific commodity price index aimed at capturing the impact of variations in commodity prices at the country level. Our analysis of the recent commodity price boom reveals that, for most commodity exporters of LAC, it does indeed stand out from a historical perspective. Next, we use prices of commodity futures to characterize the country-specific commodity price outlook for the medium term. For most countries in the region, the outlook is characterized by a sharp decline in the growth rates of their country-specific commodity price indices. The level of these indices is nonetheless projected to remain well above the averages attained during the boom years.

We then investigate whether it is the lower *growth* of commodity prices or their still-high *levels* that will matter the most for output growth in the region over the coming years. To this end, we use a variant of the dynamic multi-country GVAR model originally proposed by Pesaran, Schuermann, and Weiner (2004, PSW), an approach especially designed to model

[2] See, for instance, Erten and Ocampo (2013a), Goldman Sachs (2014), and Jacks (2013).

[3] See the "Commodity Market Review" in the October 2013 *World Economic Outlook* (IMF, 2013).

[4] Adler and Sosa (2011) show that the degree of commodity dependence in LAC is not only high compared with other regions, such as emerging Asia, but also has increased over the last four decades.

[5] See, for instance, Roubini (2013).

the interactions between many countries. In a first stage, individual vector error correction models are estimated for a large set of countries. These country-specific models are linked to each other by including foreign variables and, in the second stage, stacked into a global model in which national and global variables are determined jointly. Our model specification considers 13 LAC economies, including the12 largest commodity exporters in the region, and includes a broad set of global variables related to commodity prices. The model is estimated on annual data from 1970 to 2013, and used to generate conditional out-of-sample GDP growth forecasts under different commodity price scenarios over the period 2014–19. We also use the model to assess the potential impact of slower-than-expected growth in China on commodity prices and output growth in LAC.

Our quantitative exercise suggests that the end of the commodity price boom implies a significant drag on growth for the commodity exporters of LAC. Even if prices were to remain stable at the relatively high levels observed in 2013, the annual average output growth rate over the medium term (2014–19) would be almost 1 percentage point lower than in 2012-13, and more than 1½ percentage points lower than during the boom years. Projected growth is even a bit weaker when we condition on the path for spot commodity prices suggested by futures prevailing at end-February 2014. Our simulations also confirm that a slowdown in China's growth represents a key downside risk for commodity-exporting countries across LAC.

This paper is mainly related to two strands of the literature. First, it is related to several studies that analyze the macroeconomic effects of terms-of-trade shocks. Some recent examples include Ahmed (2003), Broda (2004), Raddatz (2007), and Izquierdo, Romero and Talvi (2008). A particularly close link exists with studies focused on the macroeconomic effects of shocks to commodity prices (e.g., De Gregorio and Labbé, 2011; Céspedes and Velasco, 2012) and on the relationship between commodity-price fluctuations and economic growth (e.g., Deaton and Miller, 1996; Dehn, 2000; Collier and Goderis, 2012; Cavalcanti et al., 2014).

Second, this paper is also related to a growing literature using the GVAR framework to address diverse macroeconomic issues, including forecasting economic variables for a large number of countries in the global economy (Pesaran, Schuermann and Smith, 2009) and analyzing the transmission of the international business cycle to Latin America (Cesa-Bianchi et al., 2011).[6] To our knowledge, this paper presents the first application of the GVAR methodology to analyze the link between commodity prices and growth. While most applications in the GVAR literature include one global variable (e.g., oil prices), typically modeled as an endogenous element of the U.S. model, ours includes 14 global variables, including 13 country-specific commodity price indices, that are ultimately related to 33 underlying international commodity prices. These commodity price variables are not modeled in any country model but in auxiliary non-country models within the GVAR. The model is extended to cover a large number of commodity exporters (especially in LAC, but

[6] See Di Mauro, Pesaran and Hashem (2013) and Chudik and Pesaran (2014) for a review of recent applications using the GVAR framework.

also in other regions). Overall, the model covers 30 economies, accounting for more than 80 percent of world GDP.

The rest of the paper is organized as follows. Section II describes the country-specific commodity price indices, analyses how they behaved during the recent boom and how they might evolve in the coming years. Section III.A describes the GVAR model we use, and Section IV.B reports the simulation results. Finally, section IV concludes and outlines some policy implications from the analysis.

II. Characterizing the Commodity Boom—and its Aftermath—in LAC

While the increase in commodity prices during the recent boom was quite generalized, the magnitude of the increase differed considerably across categories (see Figure 1): oil prices in current U.S. dollars almost quadrupled between 2003 and 2013 and metal prices tripled, while food prices doubled and prices of agricultural products rose by about 50 percent "only". Before analyzing the linkages between commodity prices and economic growth in LAC countries, we need a metric that captures the effects of commodity price variations at the country level. These, in turn, depend on the specific mix of commodities they export and import. This section describes the country-specific net commodity price index ("NCPI" hereafter) used in this paper, documents how it evolved during the recent boom for individual LAC countries, and uses commodity futures to infer how they might evolve over the medium term.

A. A Country-specific Net Commodity Price Index (NCPI)

With a few exceptions (e.g., Deaton and Miller, 1996; Dehn, 2000; Céspedes and Velasco, 2012), most studies on the macroeconomic effects of commodity-price fluctuations have used either prices of individual commodities, aggregate (i.e., not country-specific) indices of commodity prices, or standard terms-of-trade measures. None of these alternatives, however, is particularly suited for our purposes. First, few commodity exporters are so specialized that focusing on just one commodity price is enough (except maybe for the case of some oil producers). Second, there tends to be substantial heterogeneity in price variations within aggregate commodity categories, so even if a country specializes in commodities that mostly belong to one given category (e.g., metals), an aggregate price index is likely to poorly track the price variations of the specific commodities it trades. Third, broad terms of trade measures capture non-commodity price influences and are affected by the composition of exports (Deaton and Miller, 1996). Moreover, international commodity prices have been shown to be better at capturing the exogenous component of terms-of-trade shocks for commodity exporters than standard measures (Chen and Rogoff, 2003).

The country-specific commodity export price index proposed by Deaton and Miller (1996), which combines international prices and country-level data on export volumes for individual commodities, provides a better alternative.[7] However, shocks to the price of imported

[7] The approach in Deaton and Miller (1996) has been used in many studies on the macroeconomic effects of commodity price fluctuations. Some examples are Dehn (2000) and Cashin, Céspedes, and Sahay (2004).

commodities are also likely to matter for growth. For instance, an increase in the price of imported commodities (e.g. oil or primary intermediate inputs) is likely to reduce profit margins for firms and disposable income for households, weighing on domestic demand and output growth. In order to capture the net income effects from changes in commodity prices, the weights in our net index are based on *net* exports of each commodity.[8] Accordingly, a commodity price increase that would imply a positive (negative) income shock if the economy is a net exporter (net importer) of that commodity would be captured by an increase (decrease) of its NCPI.

To illustrate that looking at net commodity exports can make a difference in some cases, Figure 3 compares the NCPI with an export-based commodity price index for Colombia and Uruguay during 2000–13. For Colombia, both indices track each other very closely. In the case of Uruguay, however, the export-based index shows a gain of more than 20 percent in 2003–11 while the NCPI decreased by about 15 percent over the same period, mainly reflecting its high reliance on imported crude oil.

Deaton and Miller (1996) argue in favor of using fixed weights to construct the price index, so as to ensure that endogenous supply responses to price changes do not affect the analysis. But the commodity mix traded by many countries has changed significantly over the last four decades (see Table A1 in the Appendix). For instance, coffee accounted for more than 40 percent of Brazil's commodity exports in the early 1970s, but its share was less than 6 percent towards the end of the 2000s, falling from the 1st to the 5th position among Brazil's commodity exports. Accordingly, the net income effect for Brazil from an increase in the international price of coffee is much lower now than what it was in the 1970s. Similarly, none of the top three commodities that represented 70 percent of Argentina's exports in 1970-72 is among the top three commodity exports in 2010–12. In order to take this into account, the weights used in our index are allowed to vary over time. They are based on three-year rolling averages of trade values (to smooth fluctuations) and lagged one year (so that changes in the price index reflect variations in commodity prices rather than endogenous changes in volumes).

Taking these considerations into account, the annual change in country *i*'s NCPI is given by:

$$\Delta \text{Log}(\text{NCPI})_{i,t} = \sum_{j=1}^{J} \Delta P_{j,t} . \tau_{i,j,t}, \tag{1}$$

where $P_{j,t}$ is the logarithm of the relative price of commodity *j* at time t (in U.S. dollars and divided by the IMF's unit value index for manufactured exports);[9] and Δ denotes first differences.[10] Country *i*'s weights for each commodity price ($\tau_{i,j,t}$) are given by:

[8] The price index in Collier and Goderis (2012) also takes into account net exports of each commodity, but excludes those goods for which the country is a net importer, while they are kept in our NCPI.

[9] Using an international manufacturing trade price index as deflator is standard in the literature (e.g., Deaton and Miller, 1996; Erten and Ocampo, 2013b). It is preferred to the alternative of using consumer price indices from major economies, as these also include non-tradables which may distort price trends.

$$\tau_{i,j,t} = \frac{x_{i,j,t-1} - m_{i,j,t-1}}{\sum_{j=1}^{J} x_{i,j,t-1} + \sum_{j=1}^{J} m_{i,j,t-1}}, \quad (2)$$

where $x_{i,j,t-1}$ ($m_{i,j,t-1}$) denote the average exports (imports) value of commodity j by country i between $t-1$ and $t-3$ (in U.S. dollars).[11] [12]

B. The Mid-2000s Commodity Boom

The average annual NCPI growth rate across the 12 largest commodity exporters in LAC turned positive in 2003, reached double digits in 2004, and remained positive and large until 2011, with the exception of 2009.[13] The sustained increases in NCPIs along these years also stand out in a historical perspective (Figure 4). Given this, we refer to 2003–11 as a "commodity boom" period for LAC.

During the recent commodity boom, NCPIs in the region grew on average by 5½ percent per year (Figure 5). This increase is similar to that recorded in commodity exporters of other regions, such as Australia and Indonesia. But there are important differences across countries. For instance, Uruguay did not experience NCPI gains along this period.[14] Other countries that also export mainly food commodities, such as Honduras and Paraguay, experienced a lower-than-average NCPI growth rate, of about 3½-4 percent. On the other end, Bolivia, Ecuador, Colombia and Chile experienced average annual increases in their NCPIs of more than 6 percent and, in the case of Venezuela, of close to 11 percent per year (similar to pure oil producers outside the region).

The commodity price boom of the last decade is considered to have been unprecedented in its magnitude and duration (see Erten and Ocampo, 2013b). But was it also unprecedented from the perspective of LAC commodity exporters? Comparing the average NCPI growth rate in

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[10] We use international prices from the IMF's International Financial Statistics database for 33 commodities with data availability since 1970. See data sources in the Appendix for more detail.

[11] We use country-level trade values from UN Comtrade. Typically, more than one SITC category is associated with each commodity price. For instance, the price of crude oil is linked with "crude petroleum" but also with "petroleum, partly refined (including topped crudes)" and other similar categories.

[12] There are two variations of the NCPI used along the paper, based on different specifications for the weights in equation (2). The export-based index shown in Figure 3 is constructed using $\tau_{i,j,t}^{X} = x_{i,j,t-1}/\sum_{j=1}^{J} x_{i,j,t-1}$. The weights for the adjusted NCPI series used in the scatter plots in Figure 8 are given by $\tau_{i,j,t} = (x_{i,j,t-1} - m_{i,j,t-1})/\mathrm{GDP\_USD}_{i,t-1}$, where $\mathrm{GDP\_USD}_{i,t-1}$ denotes lagged GDP in U.S. dollars. This adjusted index is similar to the "commodity terms of trade" index used in some studies (e.g., Spatafora and Tytell, 2009).

[13] For the purposes of this paper we refer to commodity exporters as those countries whose share of commodity exports in total exports is higher than the average for a sample of 169 countries during 2000–12.

[14] Using a different metric, Adler and Magud (2013) also consider that Uruguay did not experience a terms-of-trade boom in the 2000s.

2003–11 (5½ percent per year), with its long-run average (-1.4% in 1970–2002) suggests so (Figure 4).[15] Another way to see this is to compare the increase in NCPIs in 2003–11 with comparable periods since 1970.[16] Figure 6, left panel, shows the distribution of average NCPI growth rates over rolling nine-year windows for these commodity exporters. In all cases except Uruguay, the average annual NCPI growth rate during the recent boom was above the eighth decile of the distribution. Moreover, in many cases the average NCPI *growth* during 2003–11 was at, or very close to, the sample maximum. By contrast, the average NCPI *levels* observed during the last decade do not typically stand out in a historical perspective, except for Chile and Venezuela (Figure 6, right panel). In fact, in some countries (for example, Honduras and Uruguay) the average NCPI level in 2003–11 is close to the sample minimum.

C. Is the Commodity Boom Over for LAC Countries?

Commodity prices seem to have passed their peaks within the current "super-cycle" (Figure 1). Nominal fuel prices peaked in mid-2008, while the prices of metals, food and agricultural raw materials peaked sometime in the first half of 2011. In the last quarter of 2013, in fact, 46 out of 51 international commodity prices were more than 10 percent below the maximum values attained between 2000 and 2013—and eight of them were more than 50 percent below their peaks.

Going forward, most forecasts suggest that overall commodity prices will soften somewhat over the medium term. For instance, the prices of commodity futures prevailing at end-February 2014 suggested that the spot prices of fuel, food and metals in 2019 will be 15, 12 and 6 percent respectively lower than in 2013—although they would still be 30, 23 and 17 percent higher than their average prices in 2003–11.

What does this general price outlook imply for the commodity exporters of LAC? Figure 7 shows the average projected NCPI growth rates over the medium term based on the current prices of commodity futures.[17] The current market-based outlook for 2014–19 is characterized by a sharp decline in NCPI growth rates across LAC, with an annual growth rate (averaged over time and across economies) about 6½ percentage points lower than during the commodity boom—and actually negative for most countries.

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[15] Figure A1 in the Appendix shows the NCPI time series for LAC commodity exporters since 1970, and Table A2 reports the summary statistics for their annual growth rates. Figure A2 shows the NCPIs for commodity exporters from other regions, as well as the time series for (real) oil prices.

[16] Identifying the timing, duration and magnitude of succeeding super-cycles for LAC economies is beyond the scope of this paper. See Erten and Ocampo (2013b) and Jacks (2013) for recent analysis of commodity price cycles.

[17] We used prices of commodity futures prevailing at February 28th, 2014, to construct projected NCPIs. The only international price among the 33 commodities considered for which there was no data from futures was coconut oil, for which we assumed its price would remain constant at its average price in 2013. In any case, its share in commodity exports for the LAC countries in the sample is very low (and in all cases below 0.1 percent).

This notwithstanding, average NCPI levels during 2014–19 would remain about 13 percent higher than during the boom years according to commodity futures (Figure 7). Even by the end of the forecast horizon, in 2019, the projected NCPIs in LAC countries are, on average, about 10 percent higher than the 2003–11 average, and more than 30 percent higher than in the 1990s.

The uncertainty surrounding commodity price projections is large, and the ability of futures to forecast commodity spot prices has often been questioned.[18] Still, if we take this market-based price projections as a benchmark, the question in terms of the impulse to economic growth seems to boil down to what will predominate: the potential positive effect from the still relatively high *levels* of commodity prices, or the negative effect from the sharp deceleration in price *growth*. We turn to this question in the following sections.

III. Growth in LAC After the Commodity Boom

Before examining the evidence, it is useful to briefly review the potential links between commodity prices and growth. Consider a commodity exporter that is growing at its steady-state rate and suddenly faces a positive commodity price shock that is expected to persist. The higher income resulting from the improved terms of trade would boost demand for consumption, supporting domestic output (along with an increase in imports). This positive cyclical impulse would be reinforced by the rise of investment in the commodity sector in response to improved profitability, and probably also in sectors that face higher demand from the commodity sectors (e.g., transportation, logistics, etc.). Higher investment, in turn, would expand the productive capacity of the economy. Thus, both potential and actual output would grow faster than in the absence of the commodity price shock.

This effect, however, will be temporary. Once investment and consumption have adjusted to the new commodity price outlook after the price shock, output growth would revert to its pre-shock level—unless the new investment leads to permanently higher productivity growth. Of course, the distinction between the shock period and the subsequent one can be diffuse in practice (due, for instance, to investment gestation lags). And other effects could play an important role in shaping the dynamics (e.g., an intensification of capital inflows triggered by the commodity price shock, an appreciation of the real exchange rate, alternative policy responses to the commodity price shock, etc.). But the outlined mechanism would suggest that moving from a period of ever-increasing commodity prices to a period of still high but non-growing prices entails a deceleration of output growth.

What does the empirical evidence say about the link between commodity prices and growth in LAC? Before moving to a more formal framework, we report simple evidence from the unconditional bivariate correlations between NCPI levels and NCPI growth rates on one side, and output growth on the other, for a sample of commodity exporters in LAC. The data in the

[18] Many studies have nonetheless found that futures prices can be a reasonable guide for forecasting commodity prices. See, for instance, Chinn and Coibion (2010), Reichsfeld and Roache (2011), and Reeve and Vigfusson (2011).

left panel of Figure 8 do not point to any significant relationship between NCPI *levels* and output growth in LAC, at least since the 1970s. By contrast, the right panel suggests there may have been a positive relationship between the *growth* in NCPIs and output growth in these economies.

This simple pattern provides a prima facie indication that non-growing commodity prices could be a drag on growth in LAC in the next few years, even if they were to remain steady at their current high levels. But this simple analysis does not control for other factors that might have affected output growth (e.g., demand from trading partners, variations in external financing, etc.). Moreover, even if we take this evidence as suggesting that non-growing commodity prices could be a drag on growth, a more relevant question is: how much of a drag? In the next sections we turn to a multivariate framework to investigate the underlying relationships and obtain quantitative predictions for concrete commodity price scenarios.

A. A GVAR Model for Commodity Prices and Output Growth

Our multivariate analysis of the relationship between commodity prices and output growth is based on a variant of the global vector autoregression (GVAR) model proposed by PSW and further developed by Dees et al. (2007, DdPS). The GVAR modeling strategy involves two main steps. In the first step, each country/region is modeled as a small open economy by estimating a country-specific augmented vector autoregressive model (VARX*) in which domestic variables are related to country-specific foreign variables (constructed as the cross-section weighted averages of the domestic variables of the other economies) and global variables, both assumed to be weakly exogenous at this stage. In a second step the estimated country-specific models are combined into a global model and linked consistently using a matrix of predetermined (i.e., non-estimated) cross-country linkages.

Given that our main objective is to generate out-of-sample forecasts, conditioning on specific paths for commodity prices, this coherent framework for modeling international linkages has many advantages. First, the country-specific models allow for the possibility of cointegration and hence long-run relationships between domestic variables, and between domestic and foreign variables (including the commodity price variables). This is particularly suitable to capture the effects of both commodity price *levels* and commodity price *changes* on output growth—which is particularly relevant given the current commodity outlook. At the same time, by modeling these relationships at the country level, the model can cope with idiosyncratic differences across countries related, for instance, to the structure of the commodity sector (e.g. private versus public property, domestic versus foreign shareholders, etc.).

Second, combining the individual models into a global model ensures that key cross-country interdependencies (owing to observed and unobserved common factors, but also to trade and policy spillover effects) and general equilibrium dynamics are taken into account. It also implies that predictions for domestic and foreign variables are simultaneously determined. This ensures that the forecast exercise takes into account not only the direct effects from conditioning on a given commodity price scenario (through the implications it entails for its terms of trade), but also the indirect effects from the outcomes of such scenario on output growth in other economies, on exchange rates, on capital flows to the region, etc.

The general setup of the GVAR framework is presented in the Appendix. Here we elaborate on the specification adopted for the purpose of this paper, including the innovations regarding the modeling of commodity prices.

Model specification

The version of the GVAR in this paper covers 30 economies, 5 of which (France, Germany, Italy, Spain, the United Kingdom) are modeled as a group. The other 25 economies include 13 LAC countries, covering the 12 largest commodity exporters (Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Honduras, Paraguay, Peru, Trinidad and Tobago, Uruguay, Venezuela) and Mexico; other commodity exporters outside the region (Australia, Indonesia, Iran, Nigeria, Norway, Qatar, Saudi Arabia); and other large economies (Canada, China, India, Japan, the United States). Altogether these economies account for more than 80% of world GDP.

In order to capture as many commodity cycles as possible, the model is estimated using annual data over the period 1970 to 2013. This, however, conditions data availability and limits the number of observations, forcing to keep the country models as parsimonious as possible. All models include real GDP (y_{it}), which is the main focus in our simulation exercises. The extent to which an income shock from rising commodity prices affects domestic output would depend, among other things, on how much of the bonanza is used to accumulate foreign assets or reduce external debt. It would also depend on how the commodity price shock affects relative prices. With this in mind, the country models also include the current account to trend GDP ratio (ca_{it}) to proxy for changes in net foreign assets excluding valuation effects, and the real exchange rate, defined as the nominal exchange rate in terms of U.S. dollars deflated by domestic consumer prices ($e_{it} - p_{it}$, as in PSW and DdPS).[19] See Table 1 for a summary of the model specifications and the Appendix for data sources.

All country models include foreign real GDP as a country-specific foreign variable (y^*_{it}). As it is common in the GVAR literature, our set of real exchange rates constitutes a closed system and therefore this variable is included as a country-specific foreign variable in the U.S. model and as an endogenous variable in all the other country-models (see PSW).

The weights used to construct the country-specific foreign variables ($w_{ij,t}$ in equation (4) in the Appendix) are derived from bilateral trade data from the UN Comtrade database. More precisely, $w_{ij,t}$ is computed as the ratio of bilateral trade between country i and country j (exports plus imports) in period t to the sum of bilateral trade between country i and all countries in the model. Given that trade linkages have varied considerably over the sample period, we use rolling three-year moving averages of the annual trade shares to compute

[19] The current account ratio is defined as a ratio of trend GDP (expressed in U.S. dollars), instead of actual GDP, to avoid the measure to be contaminated by contemporaneous movements in GDP.

these weights.[20] The weights used to link the country-specific models (W_i in equation (10) in the Appendix) are based on the trade shares at the end of the sample (averages over 2010–12).

Table 1. Specification of the Country-Specific VARX* Models

Models for commodity exporters (excluding pure oil producers)		Models for pure oil producers and non-commodity exporters		The U.S. model	
Domestic	Foreign	Domestic	Foreign	Domestic	Foreign
y_{it}	y_{it}^*	y_{it}	y_{it}^*	y_{it}	y_{it}^*
$e_{it} - p_{it}$	-	$e_{it} - p_{it}$	-	-	$e_{USt}^* - p_{USt}^*$
ca_{it}	-	ca_{it}	-	ca_{it}	-
-	$NCPI_{it}$	-	-	-	-
-	-	-	$poil_t$	-	$poil_t$

Most papers in the GVAR literature include one global variable, typically the price of oil.[21] Given our interest in capturing the impulse to growth from commodity price cycles, we augmented the model significantly along this dimension, including 14 global variables related to commodity prices. More precisely, we include a country-specific commodity price index ($NCPI_{it}$, as defined in section II.A) as a global variable in the models for non pure-oil commodity exporters (Argentina, Australia, Bolivia, Brazil, Chile, Colombia, Ecuador, Honduras, Indonesia, Peru, Paraguay, Trinidad and Tobago and Uruguay).[22] The models for pure oil exporters (Iran, Nigeria, Norway, Qatar, Saudi Arabia and Venezuela) and for non-commodity exporters (all the remaining countries in the model), instead, include real oil prices ($poil_t$) as a global variable.

At the end of the day, all variables are endogenous to the global model. The common approach in the literature has been to model the global variable (e.g. oil prices) as endogenous in the model of the U.S.[23] With 14 global variables and given the number of

[20] For example, the share of China in total trade of goods among the 30 economies in our sample for the average LAC commodity exporter has increased from less than 1 percent in 1970 to 14.7 percent in 2012.

[21] For instance, PSW, Dees et al (2007) and Cesa-Bianchi et al (2011) include only one global variable, the price of oil, modeled as endogenous to the U.S. model. Cashin et al. (2014) add the quantity of oil produced in the world, which is modeled as endogenous to the Gulf Cooperation Council group of countries.

[22] An alternative strategy is to use directly the international prices of individual commodities. But this has at least two drawbacks: it is unfeasible (it would be impossible to include 33 global variables in each country-specific model); and it would implicitly assume that the basket of commodities traded by each country is constant over time.

[23] A notable exception is the GVAR model in Gauvin and Rebillard (2014), in which metal and oil prices are not endogenous to the U.S. model or to any other country-model, but are modeled in two auxiliary models for commodity prices.

observations, however, including them in the U.S. model is not an option. Moreover, while the U.S. is a large consumer of oil, it is not the main consumer of many of the other 32 commodities used in the construction of the NCPIs—in fact, it is the largest world exporter of some of them, such as corn and wheat. Instead, we model the global commodity price variables in three auxiliary VARX* models (labeled Model A, B, and C in Table 2 below).[24] The 'domestic' variables in these models include the 13 NCPI series and the (real) oil price series (in Model A). The foreign variables in these models are the real output of the economies in the model weighted by their share in global trade (which we denote as y^*_{Wt}), and the real price of oil ($poil_t$) in two of these three auxiliary models (Models B and C).[25]

Table 2. Specification of the Commodity-Price VARX* Models

Model A		Model B		Model C	
Domestic	Foreign	Domestic	Foreign	Domestic	Foreign
$NCPI_{BOL,t}$		$NCPI_{AUS,t}$		$NCPI_{ARG,t}$	
$NCPI_{COL,t}$		$NCPI_{BRA,t}$		$NCPI_{HND,t}$	
$NCPI_{ECU,t}$		$NCPI_{CHL,t}$		$NCPI_{PRY,t}$	
$NCPI_{IDN,t}$		$NCPI_{PER,t}$		$NCPI_{URY,t}$	
$NCPI_{TTO,t}$					
$poil_t$			$poil_t$		$poil_t$
	y^*_{Wt}		y^*_{Wt}		y^*_{Wt}

Specification tests

In general, and despite data limitations given the broad nature of the sample, both in terms of the countries included and the time span covered, the model specification tests broadly confirm the validity of the assumptions.

The main assumption underlying the estimation strategy is the weak exogeneity of country-specific foreign variables and global variables with respect to the long-run parameters of the conditional model (equation (5) in the Appendix). Table A4 in the Appendix reports the test results. The weak exogeneity assumption is rejected only for one out of the 58 foreign variables (foreign output in the model for Iran). This could be, however, by chance: using a 5 percent significance level, one would expect about 3 tests (i.e. 5 percent of 58) to fail, even if the hypothesis were valid in all cases. Importantly, the weak exogeneity assumption is not rejected for any of the NCPI variables, or for the foreign variables in the models of large economies such as the U.S. or China.

[24] The NCPIs were grouped in three models according to similarities in the commodity mix among countries (whether they are mainly specialized on energy, metals or food commodities).

[25] The weights $w_{ij,t}$ for *i=A,B,C* (see equation (4) in the Appendix) are such that the weight of each country *j* corresponds to its share in total trade among the economies in the model (and so $w_{Aj,t} = w_{Bj,t} = w_{Cj,t}, \forall j$).

Another key assumption of the GVAR framework is that the country-specific shocks are cross-sectionally weakly correlated. Comparing the average pair-wise cross-section correlations for the levels and first differences of all endogenous variables, with those of the residuals of the VECMX* models, suggests this is indeed the case (see Table A5 in the Appendix). The remaining correlation after conditioning the country-specific models on weakly exogenous foreign variables—considered proxies for global factors—is much smaller than among the variables themselves.

Regarding the number of cointegrating relations, we first used the Johansen's trace and maximum eigenvalue statistics to determine the dimension of the cointegration space of the individual models. However, to address the possible overestimation of the number of cointegrating relations based on asymptotic critical values and to ensure the stability of the GVAR model, we reduced the number of relations for a number of models (similarly to, e.g., DdPS and Cesa-Bianchi et al., 2011). Our final specification has one cointegrating relation in each individual model, which proved to be necessary to obtain convergent persistence profiles (see Figure A.3 in Appendix).[26]

The lag orders p_i and q_i of the VARX* models were selected on the base of the Schwartz Bayesian criterion. All models are either (2,1) or (1,1), as shown in Table A3 in the Appendix.

Assessing the goodness of fit of the model

In order to get a sense of the adequacy of the model for our purpose (that is, to obtain out-of-sample growth projections under alternative commodity price scenarios), we compared the projections in the IMF World Economic Outlook (WEO) with the model's unconditional out-of-sample forecasts for output growth.

To this end, we first computed the root mean squared error between the model's unconditional forecast, for each country and forecast horizon, from 1 to 6 years ahead, and the corresponding WEO projection, for all six vintages between 2003 and 2008. The set of differences between the model and WEO projections was computed as follows. The model was estimated with data up to 2002 and its unconditional output growth forecasts for each country for 2003 through 2008 were compared with the April 2003 WEO growth projections for those years. Next, the model was estimated with data up to 2003 and its output growth forecasts were compared with WEO projections from the April 2004 vintage for 2004 through 2009. The process was repeated for all remaining vintages up to the one of April 2008. The root mean squared error considering all countries, forecast horizons and vintages was 2.9 percent, which is reasonably small, especially given that we are considering forecast horizons of up to 6 years ahead.

[26]Another way of checking the stability of the system is through the eigenvalues of the solved GVAR model. In this case, there are exactly 62 eigenvalues equal to one in absolute value (and no eigenvalue larger than one), which coincides with the number of endogenous variables minus the number of cointegrating relations (91-29).

Second, we computed the root mean squared error with respect to actual data both for the model and for WEO projections. As expected, the root mean squared error of WEO projections was lower than the one of the model, but only by 0.8 percentage points. Again, this difference is quite small considering the simplicity of the underlying country models.

B. Results From the GVAR Model

This section reports the results from two exercises conducted with the GVAR model: producing conditional output growth forecasts for the commodity exporters of LAC over the medium term, and simulating the response of commodity prices and GDP growth in LAC to a potential shock to China's GDP.[27]

Conditional Growth Forecasts—Scenarios

The model is used to generate forecasts for output growth over 2014–19 conditioning on certain assumed paths for the country-specific NCPIs and oil prices.[28] These paths, in turn, correspond to three alternative scenarios for individual commodity prices. The first scenario, labeled *stable prices*, is a key benchmark aimed at answering what could happen to economic growth in LAC if commodity prices were to remain high but stop increasing. It simply assumes that commodity prices in current U.S. dollars remain constant over 2014–19 at their 2013 average levels.

However, even if a scenario of stable prices is deemed to be likely, assuming constant prices for each individual commodity may be an overstretch as it ignores existing information about commodity markets. In particular, it may ignore plausible relative price variations over the medium term associated with developments that are already known (e.g., the maturing of investment projects that would increase commodity supply). To take this into account, the second scenario (called *futures*) assumes that spot commodity prices evolve in line with the market price of commodity futures (prevailing at end-February 2014).[29] As shown in Figure 2, commodity futures suggest that spot prices for broad commodity aggregates will remain stable or decrease moderately over the coming years. The third and final scenario (called *adverse*) preserves the relative price variations implied by the *futures* scenario but assumes lower price growth, such that all commodity prices under the *adverse* scenario are 10 percent below those implied by the *futures* scenario by the end of the forecast horizon.

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[27] For the purpose of the applications in this paper, the model is estimated using the toolbox by Smith and Galesi (2011).

[28] To compute conditional output forecasts under alternative future paths for a set of endogenous variables in the model (all NCPIs and the oil price), we use the Kalman filter approach proposed by Camba-Mendez (2012).

[29] Although this market-based scenario could be thought of as a neutral scenario, it has been argued that using futures to forecast spot prices may imply a downward bias (see, for instance, "Special Feature: Commodity Price Forecasting" in the April 2014 World Economic Outlook (IMF, 2014)).

Figure 9 shows the average growth rate of the country-specific NCPIs and the (real) oil price assumed under the three alternative commodity price scenarios. It also reports their average growth rates over 2003–11 and, as a reference, the model's unconditional NCPI growth forecasts for 2014–19. It is worth noting that in most cases the unconditional forecasts for the NCPIs imply relatively stable prices over the medium term and, in all cases except Uruguay, a sharp deceleration compared to the boom years.

Conditional Growth Forecasts—Results

What would these commodity price scenarios imply for economic growth in LAC commodity exporters? The main result from the conditional forecast exercise is that even if commodity prices were to remain stable at the relatively high levels attained in 2013, as in the *stable prices* scenario, output growth in LAC commodity exporters would be substantially lower than in recent years. On average, output growth would be about 0.8 percentage points lower than in 2012–13 and 1.8 percentage points lower than during the commodity boom (Figure 10).

The slowdown vis-à-vis the boom period would be quite generalized (Figure 11). In all countries except Paraguay, average projected growth over 2014–19 is lower than in 2003–11.[30] The projected slowdown is particularly large in the case of Trinidad and Tobago and, to a somewhat lesser extent, in the cases of Argentina and Venezuela.[31] Excluding these four cases, the slowdown under the stable prices scenario in the other eight countries ranges from 0.8 percentage points in the case of Chile to about 2 percentage points in the case of Peru. In all of these eight cases, the conditional projections under stable prices scenario is within about ½ percentage point from the model's unconditional growth forecast (except for Uruguay, were the unconditional growth forecast is 1.2 percent lower). Although the region slowed down considerably in 2012–13 vis-à-vis the boom years, the model still predicts a further slowdown in 2014–19 for all counties except Brazil and Paraguay.

Output growth for the average commodity exporter in LAC under the *futures* scenario would be about ¾ of a percentage point lower than under the *stable prices* scenario (Figure 10). If, instead, commodity prices evolve as in the *adverse* scenario, growth would be even lower by an additional ½ percentage point (with country-specific differences ranging from -0.1 to -1.2 percent), highlighting further downside risk.

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[30] In Paraguay, where the agricultural sector still represents a large share of the economy, there have been strong output fluctuations due to weather-related supply shocks, which affects the ability of the model to capture the link between commodity prices and growth. Accordingly, the model's forecasts for this country need to be taken with caution.

[31] Trinidad and Tobago's economy has been recently subject to strong output swings related to supply shocks in the energy sector (maintenance-related outages), which could in part explain the pessimistic forecasts from the model. In the case of Argentina, the results could be contaminated by measurement issues in official GDP data (alternative data sources have indeed reported significantly lower real GDP growth than according to official data since 2008; see Coremberg, 2014).

The results in this section suggest that output growth in LAC commodity exporters over the next few years will be more affected by the lower projected *growth* of commodity prices, than by the still-high *levels* of those prices. This means that even if commodity prices do not revert to their long-run trends anytime soon, the end of the period of ever-increasing prices is likely to imply a significant drag on growth for the region.[32]

Assessing the effects of lower output growth in China

Demand from China has been a key driver of global commodity prices in recent years (see Erten and Ocampo, 2013b) and, consequently, of the favorable economic performance in many LAC economies along the 2000s. A key question, then, is what may be the impact on commodity prices and, more generally, on economic growth in the commodity exporting countries of LAC, if China's economy slows down more than currently expected.

In this section we report results from simulating the effects that shocks to China's GDP may have on the NCPI series and on output for the average commodity exporter in LAC. Given the difficulty in identifying the structural shocks in a GVAR framework, and as it is commonly done in this literature, we rely on the generalized impulse response function (GIRF) analysis developed in Pesaran and Shin (1998).[33]

Figure 12 shows a summary of the results from this exercise. A 1 percent decline in China's GDP (relative to baseline) would lower the average NCPI of LAC commodity exporters by about 3 percent on impact—and in some cases the decline in the NCPI would be close to 8 percent. Moreover, the average NCPI would still be more than 1½ percentage points below trend two years after the shock.[34]

The relevance of China for commodity prices is likely to reflect its large (and increasing) weight in the global economy, but also its relatively higher commodity intensity of demand.[35]

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[32] Although the quantitative exercise in this paper is grounded in very specific price scenarios, the results are reminiscent of Dehn (2000) and Collier and Goderis (2012), who find that commodity price booms have positive short-term effects on output growth but either no long-term effects, or even negative effects in some cases.

[33] Having 91 variables in the model, exact identification would require imposing an incredibly high number of restrictions, so we do not attempt to identify the ultimate source of the disturbance. The GIRF approach reports how shocks to one variable (say China GDP) affect the other variables of the system, on impact and over time, regardless of the source of the change, but taking into account the possibility that the error terms of the GVAR are contemporaneously correlated.

[34] While differences in the construction of variables, samples, etc. make it difficult to do direct comparisons with other studies in the literature, the results reported here appear quantitatively plausible and in line with previous findings. For instance, the IMF Spillover Report on China (IMF, 2011) finds that a shock to real activity in China of 1 percent of GDP would lead to an increase in metals prices (in current U.S. dollars) of about 6 percent after six months. In our model, a similar shock would lead to an increase in the *net* commodity price index of metal exporters, such as Chile and Peru, of around 3.9 percent in the first year after the shock.

[35] China's consumption accounted for about 20 percent of global non-renewable energy production, 23 percent in the case of major agricultural crops and 40 percent of base metals (see Roache, 2012).

To try to assess whether the effects of a shock to China are different from those of a shock to global demand, Figure 14 compares the effect on the NCPI from a 1 percent decline in China's GDP (relative to baseline) with that of an equivalent shock to the U.S.[36] While a U.S. output shock also has a large effect on the average NCPI in the region, the effect from the shock to China's output is roughly 50 percent larger, even if China's share in total trade is about 30 percent lower.

Turning to the response of output in LAC to a shock to China's GDP, the model suggests that, for the average commodity exporter in the region, GDP would be about ½ percentage point below trend three years after the shock (Figure 12). The output level would still be 0.3-0.4 percentage points below trend even six years after the shock. Figure 13 shows the cumulative drop in GDP with respect to the baseline, by country, three years after the shock. The model suggests a bigger than average drop in GDP for Honduras and Peru, of around 0.9 percent. Brazil, a much less open economy, shows a smaller response, of about 0.1 percent.

Overall, the results in this section confirm that slower growth in China represents a key downside risk for LAC commodity exporters and that commodity prices are a key channel through which such a shock would affect the region.

IV. Concluding Remarks

International commodity prices skyrocketed during 2003–11, boosting economic growth of commodity exporters around the world. But after peaking in mid-2011, commodity prices have languished—and most projections suggest they are not likely to resume the upward trend observed in the last decade. This paper analyzes what this turn in the commodity price cycle may imply for output growth in LAC using a GVAR model that includes the 12 largest commodity exporters in the region and a rich set of country-specific commodity price indices. The model is also used to explore the potential effects of slower-than-expected economic growth in China, a key determinant of global commodity prices.

The results suggest that the end of the commodity price boom will entail a significant drag on growth for the average commodity exporter of LAC. Even in a context of still high but non-increasing commodity prices, which a priori would appear as a rather benign scenario, these economies would grow significantly less than in the last decade. More precisely, if prices were to remain stable at their 2013 average levels, average annual GDP growth over the medium term (2014–19) would be almost 1 percentage point lower than in 2012–13 and more than 1½ percentage points lower than over 2003–11. If commodity prices were to evolve as implied by commodity futures as of early 2014, average output growth would be even lower, by roughly another ¾ of a percentage point.

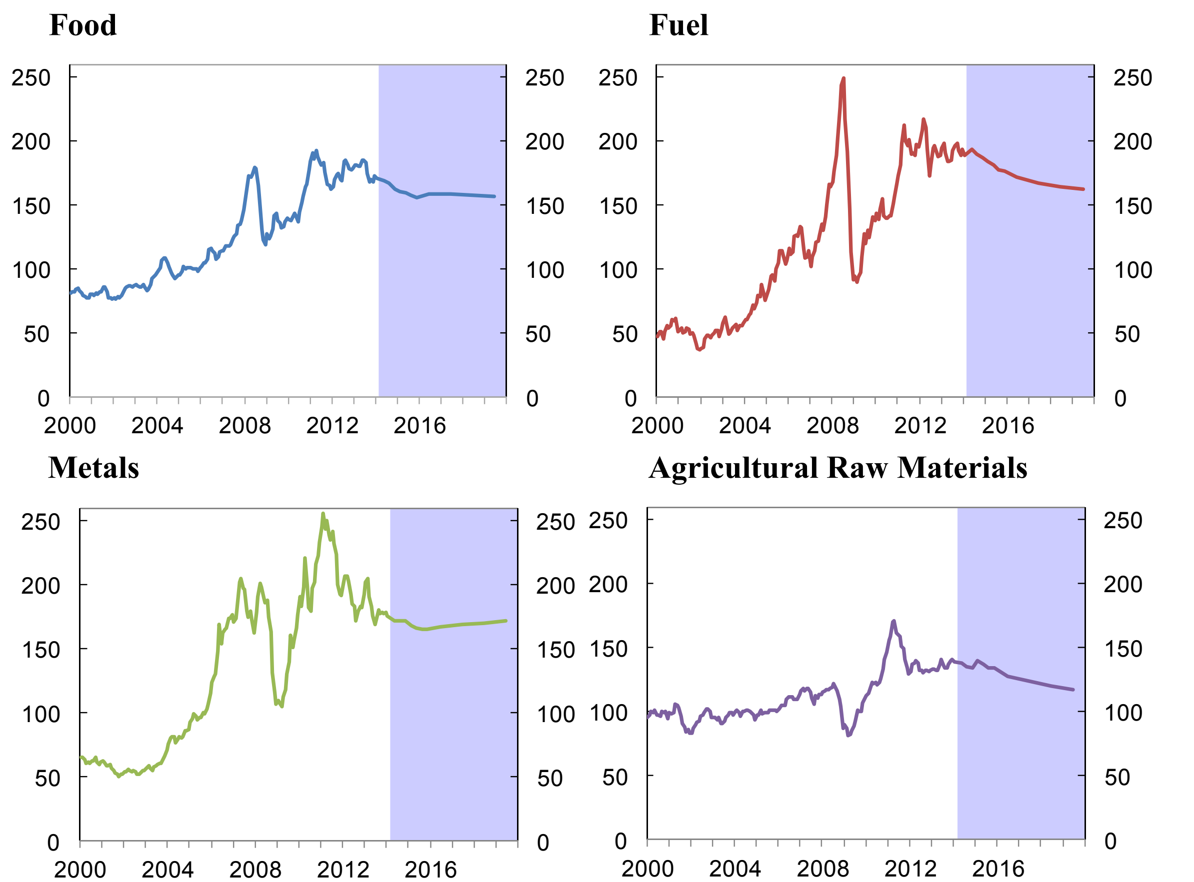
[36] The share of China in total trade has increased dramatically in the last few decades. Considering only trade of goods among the 30 economies included in the model, China's share in total trade increased from about 1½ percent in 1990 to 14½ percent in 2010-12. The share in the case of the U.S. decreased from 23 percent to 21 percent in the same period.

Our results also confirm that slower-than-expected economic growth in China represents an important downside risk for the region. A 1 percent decline in China's GDP relative to trend would be associated with a decrease in the average commodity price index in LAC by about 3 percent—and by as much as 8 percent in a few cases. In such a scenario, GDP in the average commodity exporter in LAC would fall by more than ½ percentage point below trend about 3-4 years after the shock.

The results from this exercise are nonetheless subject to important caveats. First, the estimated model assumes stable relations, including policy responses to external shocks, over the period 1970–2013. In reality, most LAC economies have undergone important structural transformations over these four decades. Moreover, many have significantly strengthened their policy frameworks more recently (for instance, by allowing greater exchange rate flexibility and reducing the procyclicality of fiscal policy). Second, the model does not take into account future developments that are already foreseen but not readily captured by key macroeconomic relationships (for example, planned structural reforms aimed at raising future potential output). To the extent that these changes have a direct positive effect on future growth, the projections from the model used here are likely to have a downward bias.

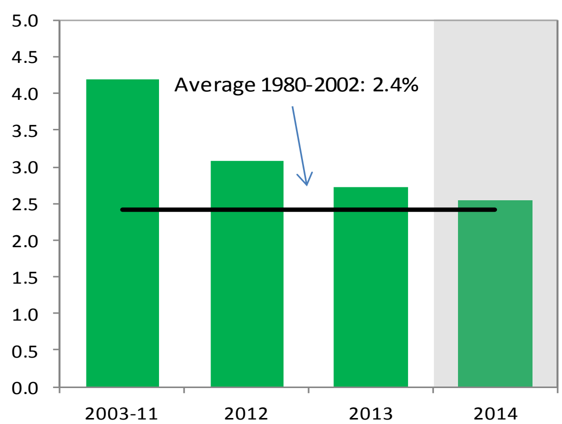
Despite these caveats, the model results carry important policy implications for LAC commodity exporters. First, the recent slowdown in many LAC economies could be the result, to a large extent, of having passed the peak of the commodity super-cycle. If that is indeed the case, using demand-side stimulus to keep growth at recent high rates would not be warranted and could give rise to problematic macroeconomic imbalances. Policies should focus instead on structural reforms to raise productivity and potential output growth. Second, policymakers in these economies should work to further weaken the link between commodity prices and economic activity to avoid the boom-bust dynamics often associated with past commodity cycles. Fiscal policy needs to play a critical role in this regard, by striking the right balance between building buffers and frontloading capital spending to raise potential growth. A formal fiscal framework that explicitly accounts for natural resource revenues, potentially including a stabilization fund, can support this effort. Exchange rate flexibility, underpinned by credible monetary and macroprudential frameworks, provides an additional buffer for shocks to the terms of trade.

Figure 1. Commodity Price Indices, 2000–19 (2005=100)[1]



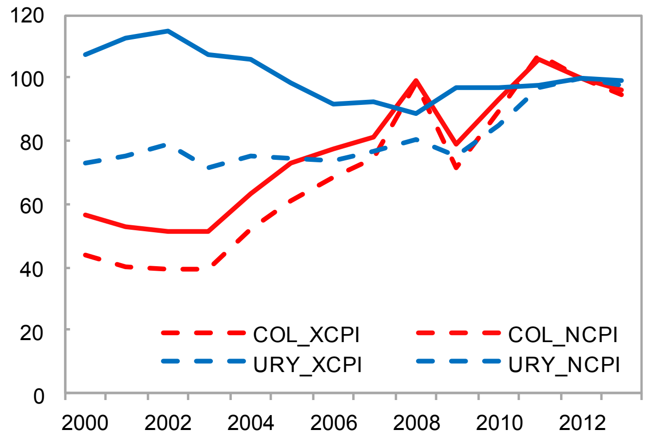
Sources: IMF, World Economic Outlook; and author's calculations.
[1] Based on international prices in current U.S. dollars. Values in shaded areas correspond to projections based on the prices of commodity futures prevailing at end-February 2014.

Figure 2. LAC: Real GDP Growth[1]
(Percent)



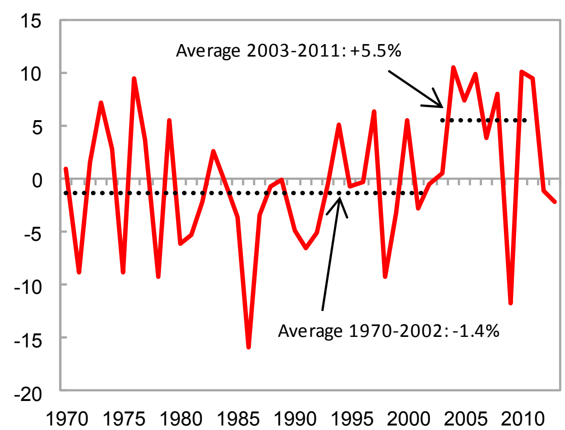
Sources: IMF, World Economic Outlook.
[1] Purchasing power parity GDP-weighted averages of all LAC countries.
GDP growth in 2014 corresponds to April 2014 WEO projections.

Figure 3. Comparison Between the NCPI and an Export-Based Index[1]
(2012=100)



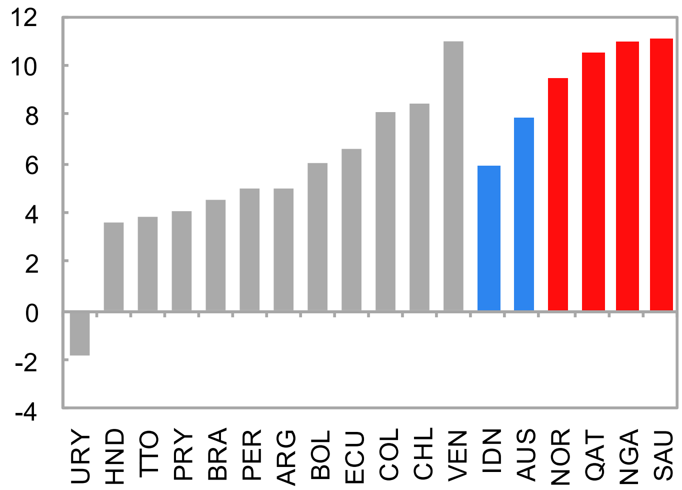
Sources: UN Comtrade; IMF, World Economic Outlook; World Bank, Global Economic Monitor; and author's calculations.
[1] See footnote 12 for details on the export-based commodity price index (XCPI).

Figure 4. NCPIs of Commodity Exporters in LAC, 1970–2013[1]
(Average annual growth of NCPI across LAC economies; percent)



Sources: UN Comtrade; IMF, World Economic Outlook; World Bank, Global Economic Monitor; and author's calculations.
[1] Simple average of NCPI annual growth rate of Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Honduras, Paraguay, Peru, Trinidad and Tobago, Uruguay, and Venezuela.

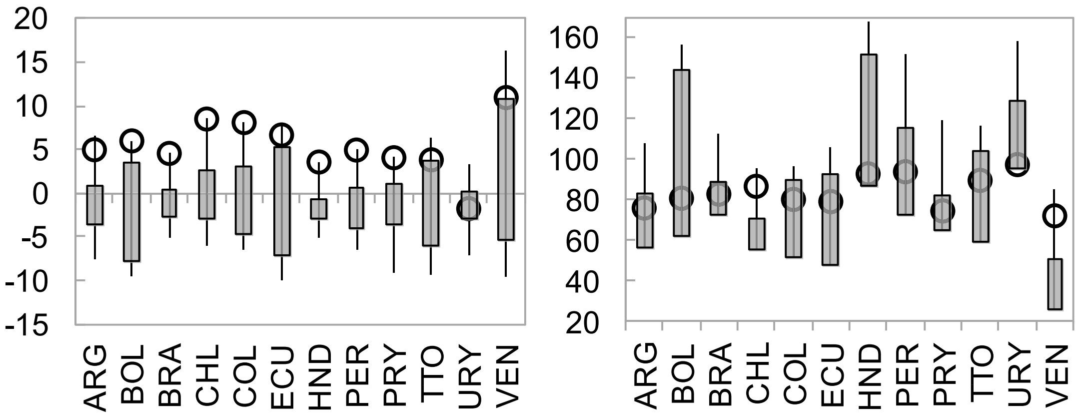
Figure 5. Commodity Price Growth, 2003–11
(Average annual growth of NCPI; percent)



Sources: UN Comtrade; IMF, World Economic Outlook; World Bank, Global Economic Monitor; and author's calculations.
Note: See Table A6 for a list of country ISO codes.

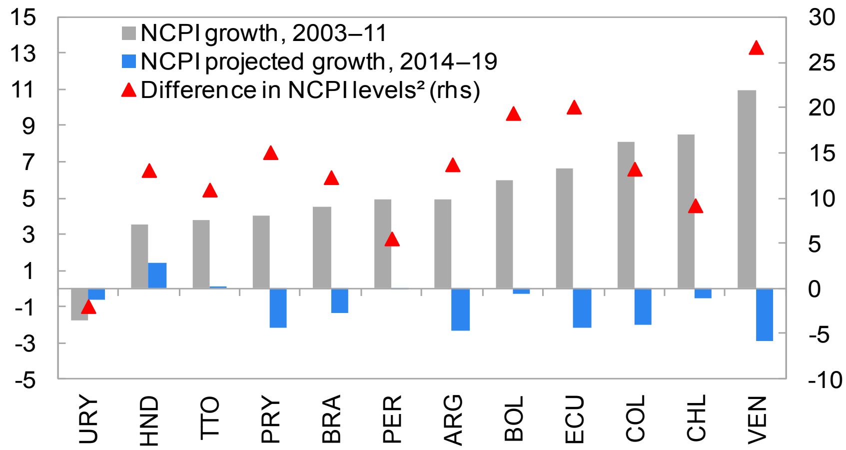
Figure 6. Commodity Price Growth and Level, 1970–2013[1]

(Average growth rate of NCPI over nine-year rolling windows; percent) *(Average NCPI level over nine-year rolling windows; NCPI in 2012=100)*



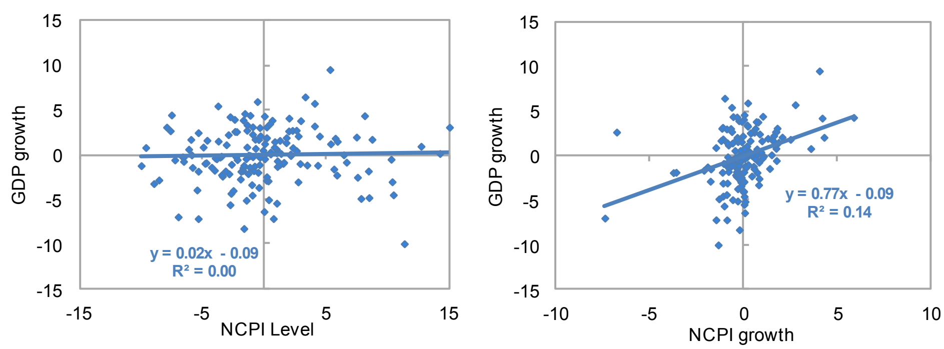
Sources: UN Comtrade; IMF, World Economic Outlook; World Bank, Global Economic Monitor; and author's calculations.
[1] The black lines denote the range for the nine-year window averages of NCPI annual growth rates and NCPI level; the rectangle denotes the second through eighth deciles of its distribution; the marker denotes the average values in 2003–11.

Figure 7. Commodity Price Outlook, 2014–19[1]
(Average annual growth of NCPI; percent)



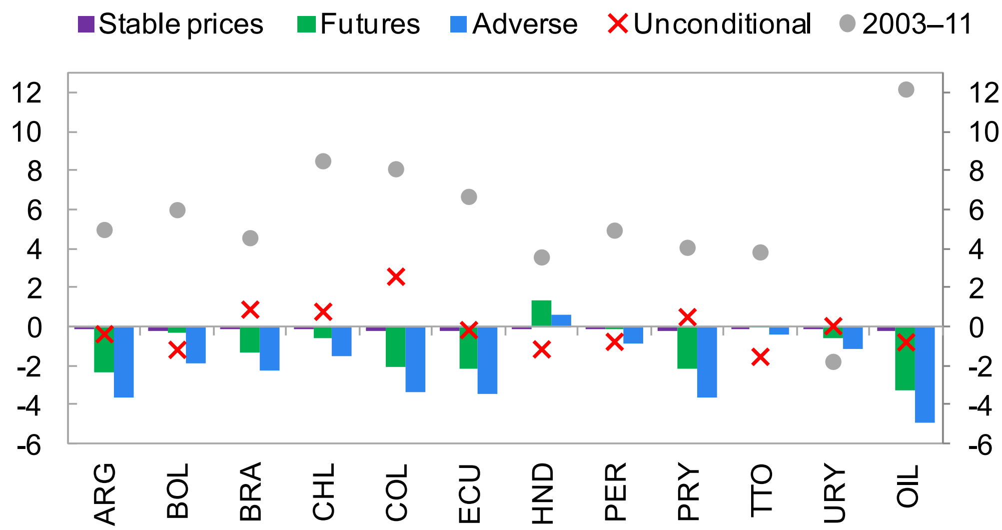
Sources: UN Comtrade; IMF, World Economic Outlook; World Bank, Global Economic Monitor; and author's calculations.
[1] NCPIs for 2014–19 are constructed from prices of commodity futures prevailing at end-February 2014.
[2] Percentage difference between average NCPI levels in 2014–19 vs. 2003–11

Figure 8. LAC: Commodity Prices and GDP Growth[1]
(Deviation from sample average; percent)



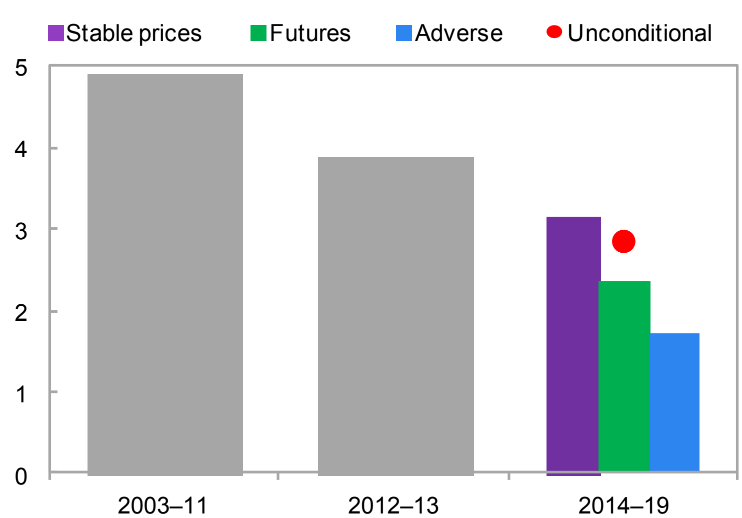
Sources: UN Comtrade; IMF, World Economic Outlook; World Bank, Global Economic Monitor; and author's calculations.
[1] NCPI growth rates, NCPI levels, and GDP growth rates correspond to the average over three-year windows and are reported as deviations from their country-specific sample averages. NCPIs are adjusted by the share of commodity trade in GDP in order to identify the actual economic impact of commodity prices on output in a cross-country comparison (see footnote 12).

Figure 9. Projected Growth of NCPIs and Oil Prices Under Alternative Price Scenarios, 2014–19
(Average annual growth rate; percent)



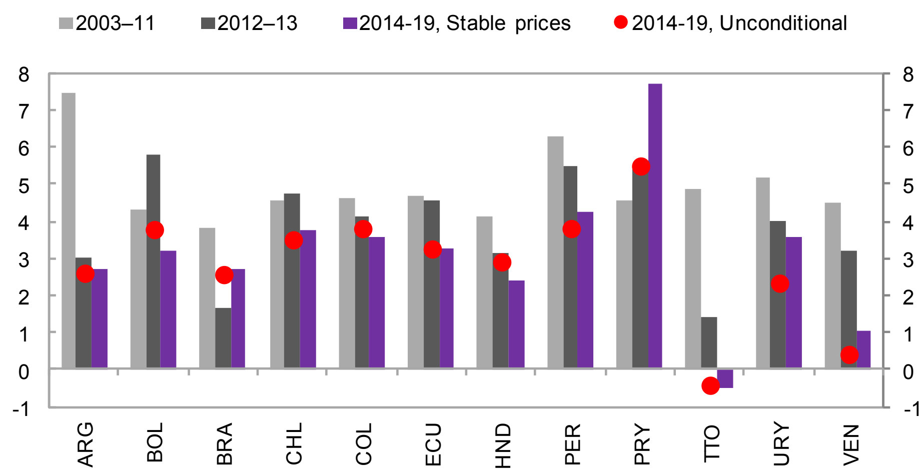
Source: UN Comtrade; IMF, World Economic Outlook; World Bank, Global Economic Monitor; and author's calculations.
Note: 'OIL' corresponds to the real oil prices variable (*poil*) as described in the text.

Figure 10. Projected Average GDP Growth under Alternative Price Scenarios[1]
(Average annual growth rate; percent)



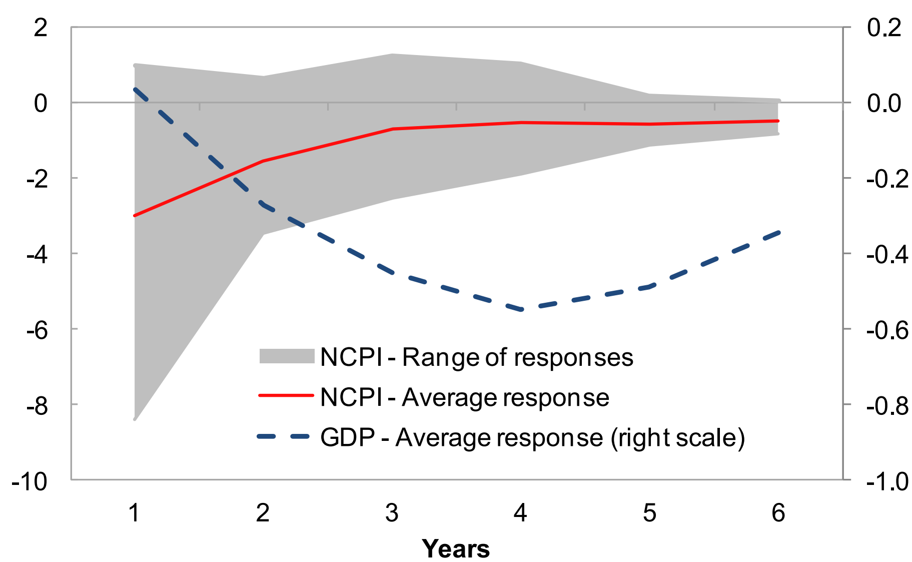
Source: Author's calculations.
[1] Simple average for selected commodity exporters of LAC (Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Honduras, Paraguay, Peru, Trinidad and Tobago, Uruguay, and Venezuela).

Figure 11. Projected GDP Growth, 2014–19
(Average annual growth rate; percent)



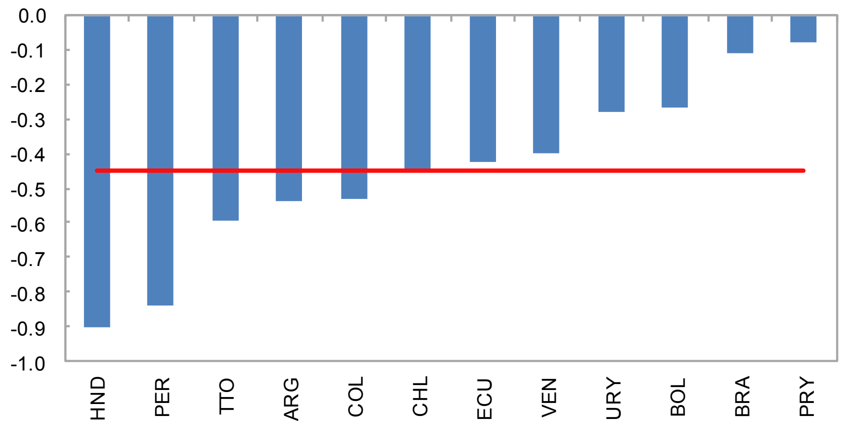
Sources: UN Comtrade; IMF, World Economic Outlook; World Bank, Global Economic Monitor; and author's calculations.

Figure 12. Response of NCPIs and GDP in LAC Countries to a 1 Percent Decrease in China's GDP (Relative to Trend)[1]
(Percentage deviation from trend)



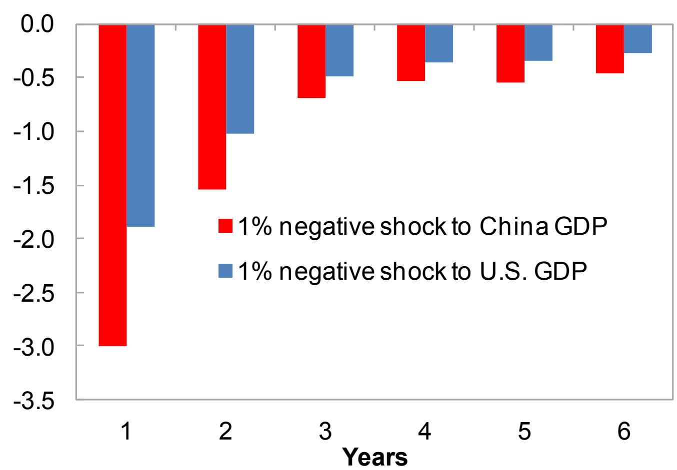
Source: Author's calculations.
[1] The shaded area reports the range of deviations from trend of the NCPIs for Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Honduras, Paraguay, Peru, Trinidad and Tobago, and Uruguay. The red solid line shows the simple average of the NCPI responses for these countries. The blue dashed line corresponds to the simple average of the deviations from trend of GDP for all LAC commodity exporters in the model (Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Honduras, Paraguay, Peru, Trinidad and Tobago, Uruguay, and Venezuela) and is reported in the right hand side scale.

Figure 13. Response of GDP in LAC Countries to a 1 Percent Decrease in China's GDP (Relative to Trend)
(Cumulative response after three years; percent)



Source: Author's calculations.

Figure 14. Response of the Average NCPI of LAC Commodity Exporters to a 1 Percent Decrease in GDP in China and in the U.S. (Relative to Trend)[1]
(Percentage deviation from trend)



Source: Author's calculations.
[1] Average of the deviations from trend of the NCPIs for Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Honduras, Paraguay, Peru, Trinidad and Tobago, and Uruguay.

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APPENDIX

GVAR model—General structure

The description of the GVAR model that follows draws on the exposition and notation in PSW and DdPS.

First step: Country-specific models
For each country/region i (i=0,1,…,N) consider the following augmented vector autoregressive model (denoted VARX*(p_i, q_i)):

$$\Phi_i(L,p_i)\mathrm{x}_{it} = \mathrm{a}_{i0} + \mathrm{a}_{i1}.t + \Lambda_i(L,q_i)\mathrm{x}^*_{i,t} + \Psi_i(L,q_i)\mathrm{d}_t + \mathrm{u}_{it} \qquad (3)$$

where $\Phi_i(L,p_i) = I - \sum_{s=1}^{p_i}\Phi_i L^i$, $\Lambda_i(L,q_i) = \sum_{s=0}^{q_i}\Lambda_i L^i$ and $\Psi_i(L,q_i) = \sum_{s=0}^{q_i}\Psi_i L^i$ are matrices of lag polynomials; a_{i0} and a_{i1} are k_i x 1 vectors of fixed intercepts and coefficients on the deterministic time trends, respectively; x_{it} is a k_i x 1 vector of country-specific variables; $\mathrm{x}^*_{i,t}$ is a k_i^* x 1 vector of foreign variables specific to country i, constructed as the cross-section weighted averages of the domestic variables of the other economies (as explained below); d_t is a m_{di} x 1 vector of global common variables (that enter un-weighted in country i's model but are endogenous to some individual model within the GVAR); u_{it} is a k_i x 1 vector of country-specific shocks, assumed to be serially uncorrelated with zero mean and a non-singular covariance matrix Σ_{ii}. A cross-country contemporaneous correlation among the shocks is allowed.[37] The variables included, as well as their lag orders (p_i and q_i), can differ across individual VARX* models.

The country-specific foreign variables ($\mathrm{x}^*_{i,t}$) and the global variables (d_t) are assumed to be weakly exogenous for the estimation of the VARX* model for country i—an assumption that was confirmed by the corresponding tests. The foreign-specific variables are constructed as weighted cross-sectional averages of the domestic variables for the other economies on the model:

$$\mathrm{x}^*_{i,t} = \sum_{j=0}^{N} w_{ij,t}\,\mathrm{x}_{j,t} \qquad (4)$$

where

$$w_{ii,t} = 0; \quad \sum_{j=1}^{N} w_{ij,t} = 1, \qquad \forall\, i,j = 1,\dots,N$$

[37] Note that, by construction, the GVAR model allows for interaction among the different economies through two channels, namely: i) the contemporaneous interrelation of domestic variables with foreign-specific variables; and ii) the contemporaneous correlation of shocks across countries.

The weights ($w_{ij,t}$) in (4) are not estimated but specified based on information that captures the strength of bilateral linkages, and can be time-varying. In this paper we use trade data to quantify these linkages.

The GVAR model can be applied to stationary and/or integrated variables. In this paper we assume that the variables included in the country-specific models are integrated of order one—and this assumption has been broadly confirmed by the corresponding statistical tests. For the empirical application in this paper we consider at most a VARX*(2,2), which in its error correction form can be written as:[38]

$$\Delta \mathrm{x}_{it} = \mathrm{c}_{i0} - \alpha_i \beta_i' \left[\zeta_{i,t-1} - \gamma_i (t-1)\right] + \Lambda_{i0} \Delta \mathrm{x}_{i,t}^* + \Psi_{i0} \Delta \mathrm{d}_t + \Psi_{i1} \Delta \mathrm{d}_{t-1} + \Gamma_i \Delta \mathrm{z}_{i,t-1} + \mathrm{u}_{it} \quad (5)$$

where $\mathrm{z}_{i,t} = (\mathrm{x}_{it}', \mathrm{x}_{it}^{*\prime})'$ and $\zeta_{i,t} = (\mathrm{z}_{it}', \mathrm{d}_t')'$, α_i is a k_ix r_i matrix of rank r_i and , β_i is $(k_i + k_i^* + m_d)$ x r_i matrix of rank r_i (where r_i is the number of cointegrating relations).

Second step: Stacking the country-specific models

Once the individual VARX*(p_i, q_i) models have been estimated, all the $k = \sum_{i=0}^{N} k_i$ endogenous variables of the global economy, collected in the k x 1 vector $\mathrm{x}_t = (\mathrm{x}_{0t}', \mathrm{x}_{1t}', \dots, \mathrm{x}_{Nt}')'$, need to be solved simultaneously. To this end, the estimated individual models are stacked to build a GVAR model, and linked with a matrix of predetermined weights. First, rewrite (3) more compactly as:

$$\mathrm{A}_i(L, p_i, q_i)\mathrm{z}_{it} = \varphi_{it,}, \qquad \text{for } i = 0, \dots, N \quad (6)$$

where

$$\mathrm{A}_i(L, p_i, q_i) = [\Phi_i(L, p_i), -\Lambda_i(L, q_i)], \quad (7)$$

$$\mathrm{z}_{it} = \begin{pmatrix} \mathrm{x}_{it} \\ \mathrm{x}_{i,t}^* \end{pmatrix}, \quad (8)$$

$$\varphi_{it} = \mathrm{a}_{i0} + \mathrm{a}_{i1}.t + \Psi_i(L, q_i)\mathrm{d}_t + \mathrm{u}_{it}. \quad (9)$$

Note also that (8) can be written as

$$\mathrm{z}_{it} = \mathrm{W}_i \mathrm{x}_t, \qquad \text{for } i = 0, \dots, N \quad (10)$$

where $\mathrm{W}_i = (\mathrm{W}_{i0}, \mathrm{W}_{i1}, \dots, \mathrm{W}_{iN})$ is a $(k_i + k_i^*)$ x k country-specific weight matrix. The set of weights used to combine the individual country-models can be based on the trade flows on a particular year or on average trade flows over a given period. Using W_i, equation (6) can be rewritten as

$$\mathrm{A}_i(L, p)\mathrm{W}_i \mathrm{x}_t = \varphi_{it}, \qquad \text{for } i = 0, \dots, N \quad (11)$$

[38] The trends have been restricted to lie in the cointegration space to avoid the problem of introducing quadratic trends in the level of the variables. See PSW for more details.

and stacked to yield a VAR(p) model in $\mathrm{x}_t = (\mathrm{x}'_{0t}, \mathrm{x}'_{1t}, \dots, \mathrm{x}'_{Nt})'$:[39]

$$\mathrm{G}(L, p)\mathrm{x}_t = \varphi_{t,} \tag{12}$$

where

$$\mathrm{G}(L,p) = \begin{pmatrix} \mathrm{A}_0(L,p) \\ \mathrm{A}_1(L,p) \\ \vdots \\ \mathrm{A}_N(L,p) \end{pmatrix}, \quad \varphi_t = \begin{pmatrix} \varphi_{0t} \\ \varphi_{1t} \\ \vdots \\ \varphi_{Nt} \end{pmatrix}.$$

The GVAR(p) model in (12) can now be solved recursively and used to forecast all the variables in the model simultaneously or to conduct generalized impulse response analysis (see PSW for an illustration of the solution of the model in the case of p=1).

Data sources

The source for real GDP (y_{it}) for all 30 economies is Penn World Table, version 8.0 (GDP at constant national 2005 prices, 'q_gdp'). Real GDP growth rates from the IMF April 2014 WEO database were used to extend the real GDP series to 2013. The real exchange rate ($e_{it} - p_{it}$) is constructed as the nominal exchange rate in terms of U.S. dollars deflated by domestic consumer prices, using data from the IMF April WEO database. The current account variable (ca_{it}) is the ratio of the current account balance in U.S. dollars from the IMF April 2014 WEO database to the Hodrick-Prescott trend component of GDP in current U.S. dollars. The latter is constructed using nominal GDP from Penn World Table, version 8.0 (GDP at current national prices, 'v_gdp') and nominal exchange rate from the IMF April 2014 WEO database.

The source for commodity prices is the IMF's International Financial Statistics database. Due to data availability, 33 commodities prices with data since 1970 were used: aluminum, bananas, barley, beef, coal, cocoa, coconut oil, coffee, copper, corn, cotton, crude oil, fishmeal, hides, iron ore, lamb, lead, natural gas, natural rubber, nickel, palm oil, rice, shrimp, soybean meal, soybean oil, soybeans, sugar, sunflower, tea, tin, wheat, wool, and zinc. The price of crude oil is the simple average of three spot prices: Dated Brent, West Texas Intermediate, and the Dubai Fateh and $poil$ is this average divided by the IMF's unit value index for manufactured exports. The World Bank's *Global Economic Monitor* database was used to extend the following IFS commodity price series back to 1970: barley, coal, iron ore and natural gas.

The source for the export and import value data for individual commodities used to weight the commodity price series for each country is the UN Comtrade database (SITC Revision 1).

[39] Let $p = \max(p_0, p_1, \dots, p_N, q_0, q_1, \dots, q_N)$. $\mathrm{A}_i(L,p)$ is constructed from $\mathrm{A}_i(L, p_i, q_i)$ by augmenting the $p - p_i$ or $q - q_i$ additional terms in the power of the lag operator by zeros.

Table A1. LAC Main Commodity Exports in the 1970s and the 2000s

1970–72	First	Share	Second	Share	Third	Share	Sum
ARG	Beef	35.1	Corn	25.1	Wheat	9.5	69.8
BOL	Tin	58.7	Crude oil	12.8	Zinc	9.2	80.8
BRA	Coffee	43.8	Iron ore	10.9	Sugar	9.8	64.5
CHL	Copper	88.4	Iron ore	7.8	Fishmeal	2.5	98.7
COL	Coffee	68.9	Crude oil	10.8	Cotton	6.1	85.7
ECU	Banana	47.5	Coffee	21.8	Cocoa	13.6	82.9
HND	Banana	62.5	Coffee	19.1	Beef	10.0	91.6
PER	Fishmeal	32.0	Copper	25.8	Sugar	8.5	66.3
PRY	Beef	39.4	Cotton	11.0	Soybean meal	10.2	60.5
TTO	Crude oil	92.1	Sugar	5.8	Cocoa	0.8	98.7
URY	Rice	65.8	Barley	21.0	Wheat	12.4	99.2
VEN	Crude oil	91.8	Iron ore	5.3	Gas	1.0	98.2

2010–12	First	Share	Second	Share	Third	Share	Sum
ARG	Soybean meal	26.5	Soybeans	12.6	Soybean oil	12.5	51.5
BOL	Gas	59.2	Zinc	13.4	Soybean meal	6.3	78.9
BRA	Iron ore	30.4	Crude oil	16.7	Soybeans	12.7	59.8
CHL	Copper	94.0	Iron ore	3.2	Fishmeal	1.1	98.3
COL	Crude oil	61.6	Coal	22.5	Coffee	7.5	91.6
ECU	Crude oil	71.3	Banana	13.8	Shrimp	7.0	92.2
HND	Coffee	44.6	Banana	15.6	Palm oil	11.3	71.5
PER	Copper	51.6	Zinc	8.7	Fishmeal	8.5	68.9
PRY	Soybeans	43.4	Beef	19.2	Corn	9.1	71.7
TTO	Gas	45.7	Crude oil	33.1	Iron ore	20.4	99.2
URY	Beef	36.9	Soybeans	24.5	Rice	12.2	73.6
VEN	Crude oil	96.5	Iron ore	2.1	Aluminum	0.9	99.6

Notes: The table reports the average share of each country's three main commodity exports in their total exports of the 33 commodities considered here.

Table A2. Summary Statistics of NCPI Annual Percentage Change, 1970–2013.

	Average	Standard deviation	Min	Max	Skewness	Kurtosis
ARG	-0.4	9.8	-21.2	22.0	0.0	-0.2
BOL	-0.3	11.7	-28.3	37.0	0.1	2.1
BRA	-0.3	8.3	-25.1	21.7	-0.5	1.4
CHL	-0.4	13.0	-33.9	38.5	0.5	1.6
COL	0.6	14.1	-33.5	40.8	0.1	1.2
ECU	0.6	14.2	-53.1	34.6	-0.9	4.2
HND	-1.6	10.2	-20.6	21.8	0.0	-0.4
PER	-1.1	10.6	-26.8	29.3	0.5	2.1
PRY	-0.8	11.3	-39.6	17.0	-1.0	1.9
TTO	0.2	14.1	-66.5	24.0	-2.5	11.3
URY	-1.6	9.8	-47.9	18.9	-2.4	11.4
VEN	4.3	24.8	-68.4	98.4	1.0	5.6

Table A3. Order of Individual VARX* Models
(p: lag order of domestic variables, q: lag order of foreign variables)

Country-specific Models	p_i	q_i	Commodity-price Models	p_i	q_i
Europe[1]	1	1	Model A	2	1
Argentina	1	1	Model B	1	1
Australia	1	1	Model C	1	1
Bolivia	2	1			
Brazil	1	1			
Canada	1	1			
Chile	2	1			
China	1	1			
Colombia	1	1			
Ecuador	1	1			
Honduras	2	1			
Indonesia	1	1			
India	1	1			
Iran	2	1			
Japan	1	1			
Mexico	1	1			
Nigeria	1	1			
Norway	1	1			
Peru	2	1			
Paraguay	1	1			
Qatar	1	1			
Saudi Arabia	2	1			
Trinidad and Tobago	1	1			
Uruguay	1	1			
United States	1	1			
Venezuela	1	1			

[1] The 'Europe' model includes France, Germany, Italy, Spain, and the United Kingdom.

Table A4. F-Statistics for Testing the Weak Exogeneity of the Country-specific Foreign Variables, the Oil Prices and the Country-specific NCPIs.

Model	5% Crit. Value	y^*	$e^* - p^*$	$poil$	$NCPI_i$
Europe[1]	4.13	1.17		0.02	
ARG	4.13	0.24			1.07
AUS	4.13	0.01			0.04
BOL	4.16	0.01			1.38
BRA	4.13	0.67			1.26
CAN	4.13	2.10		0.07	
CHL	4.16	0.02			0.11
CHN	4.13	0.00		1.50	
COL	4.13	0.00			0.48
ECU	4.13	0.69			0.02
HND	4.16	0.62			0.04
IDN	4.13	0.66			0.00
IND	4.13	0.19		0.00	
IRN	4.16	6.12*		0.40	
JPN	4.13	0.49		0.13	
MEX	4.13	0.67		0.56	
NGA	4.13	1.10		0.00	
NOR	4.13	0.03		0.10	
PER	4.16	1.69			1.13
PRY	4.13	2.82			0.06
QAT	4.13	0.40		1.17	
SAU	4.16	0.87		0.54	
TTO	4.13	1.63			0.04
URY	4.13	1.71			0.29
USA	4.14	0.16	0.15	1.85	
VEN	4.13	1.22		1.11	
Model A	4.23	0.41			
Model B	4.14	0.24		0.15	
Model C	4.14	0.03		0.76	

Note: * denotes significance at the 5 percent significance level.
[1]The 'Europe' model includes France, Germany, Italy, Spain, and the United Kingdom.

Table A5. Average Pairwise Cross-Section Correlations of Variables and Associated Model's Residuals.

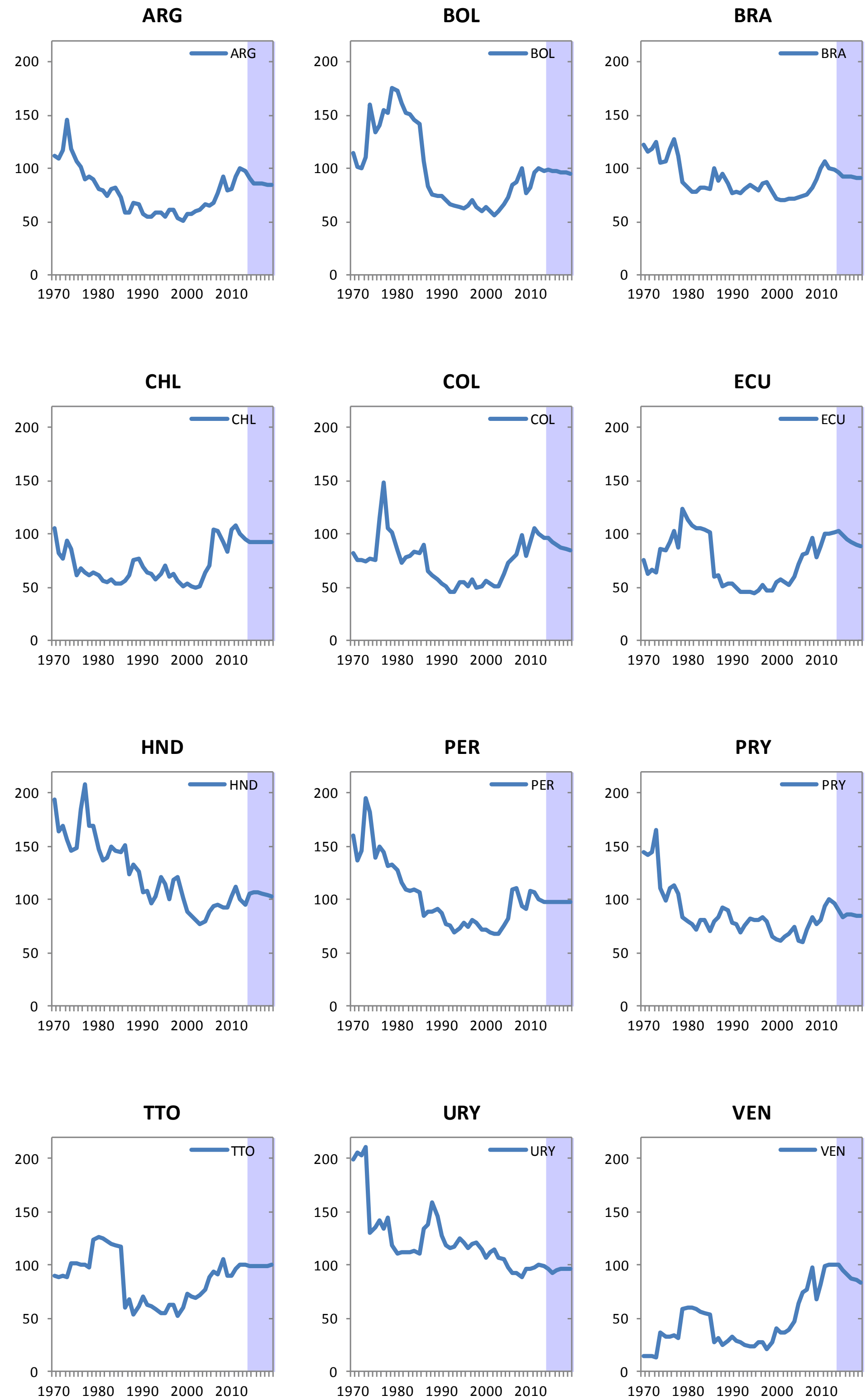
	Real GDP			Real Exchange Rate			Current Account Balance		
	Levels	First Differences	VECMX* Residuals	Levels	First Differences	VECMX* Residuals	Levels	First Differences	VECMX* Residuals
Europe[1]	0.94	0.20	-0.05	0.79	0.24	0.16	-0.04	-0.10	-0.02
ARG	0.91	0.16	0.00	0.53	0.12	0.05	0.22	0.10	0.03
AUS	0.96	0.10	0.00	0.82	0.31	0.20	-0.12	-0.03	0.05
BOL	0.94	0.18	0.04	0.81	0.22	0.10	0.22	0.04	0.02
BRA	0.95	0.24	0.03	0.76	0.14	0.03	0.12	0.03	0.07
CAN	0.95	0.21	-0.04	0.80	0.25	0.16	0.17	0.06	0.03
CHL	0.95	0.15	0.01	0.68	0.12	0.06	0.25	0.09	0.11
CHN	0.96	0.00	0.03	0.00	0.19	0.10	0.19	-0.03	-0.04
COL	0.96	0.26	0.07	0.82	0.30	0.19	0.04	0.05	0.08
ECU	0.96	0.24	0.05	0.77	0.10	0.04	0.24	0.12	0.10
HND	0.96	0.27	0.04	0.77	0.07	0.05	-0.04	-0.02	0.06
IDN	0.94	0.09	0.01	0.49	0.17	0.11	0.16	0.03	0.06
IND	0.96	-0.04	-0.01	0.76	0.21	0.13	0.00	-0.01	-0.02
IRN	0.91	-0.09	-0.10	0.48	0.24	0.22	0.10	0.02	-0.01
JPN	0.88	0.12	0.00	0.75	0.14	0.10	0.11	-0.08	-0.06
MEX	0.95	0.20	0.04	0.76	0.07	0.02	0.10	0.06	0.04
NGA	0.86	0.05	-0.04	0.64	0.25	0.13	0.21	0.10	0.06
NOR	0.94	0.18	0.05	0.80	0.28	0.16	0.19	0.04	0.03
PER	0.91	0.14	0.04	0.72	0.12	0.07	0.19	0.12	0.08
PRY	0.92	0.20	0.03	0.76	0.24	0.03	0.17	0.01	0.05
QAT	0.92	0.17	0.01	0.82	0.31	0.12	-0.12	-0.02	-0.03
SAU	0.93	0.22	0.03	0.68	0.25	0.06	0.10	-0.04	-0.09
TTO	0.87	0.11	0.02	0.81	0.12	0.07	0.20	0.00	-0.02
URY	0.94	0.20	0.03	0.79	0.28	0.13	0.09	0.02	0.02
USA	0.95	0.18	-0.05				-0.31	-0.12	-0.04
VEN	0.94	0.19	-0.04	0.77	0.09	0.06	0.15	0.07	0.01

[1] Includes France, Germany, Italy, Spain, and the United Kingdom.

Table A6. Country Names and ISO Codes

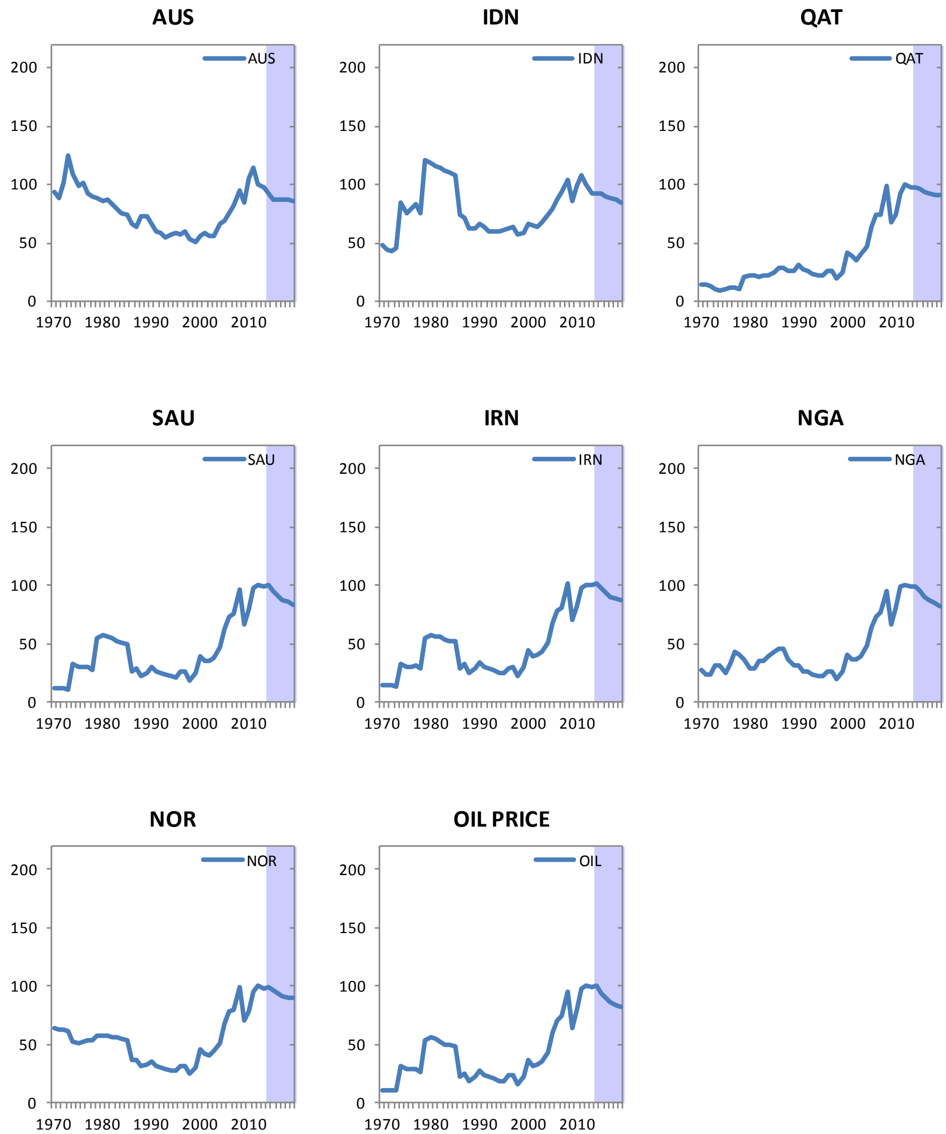
Country Names	ISO Codes
Argentina	ARG
Australia	AUS
Bolivia	BOL
Brazil	BRA
Canada	CAN
Chile	CHL
China	CHN
Colombia	COL
Ecuador	ECU
Honduras	HND
Indonesia	IDN
India	IND
Iran	IRN
Japan	JPN
Mexico	MEX
Nigeria	NGA
Norway	NOR
Peru	PER
Paraguay	PRY
Qatar	QAT
Saudi Arabia	SAU
Trinidad and Tobago	TTO
Uruguay	URY
United States	USA
Venezuela	VEN

Figure A1. NCPI Series for LAC Commodity Exporters, 1970–2019[1]



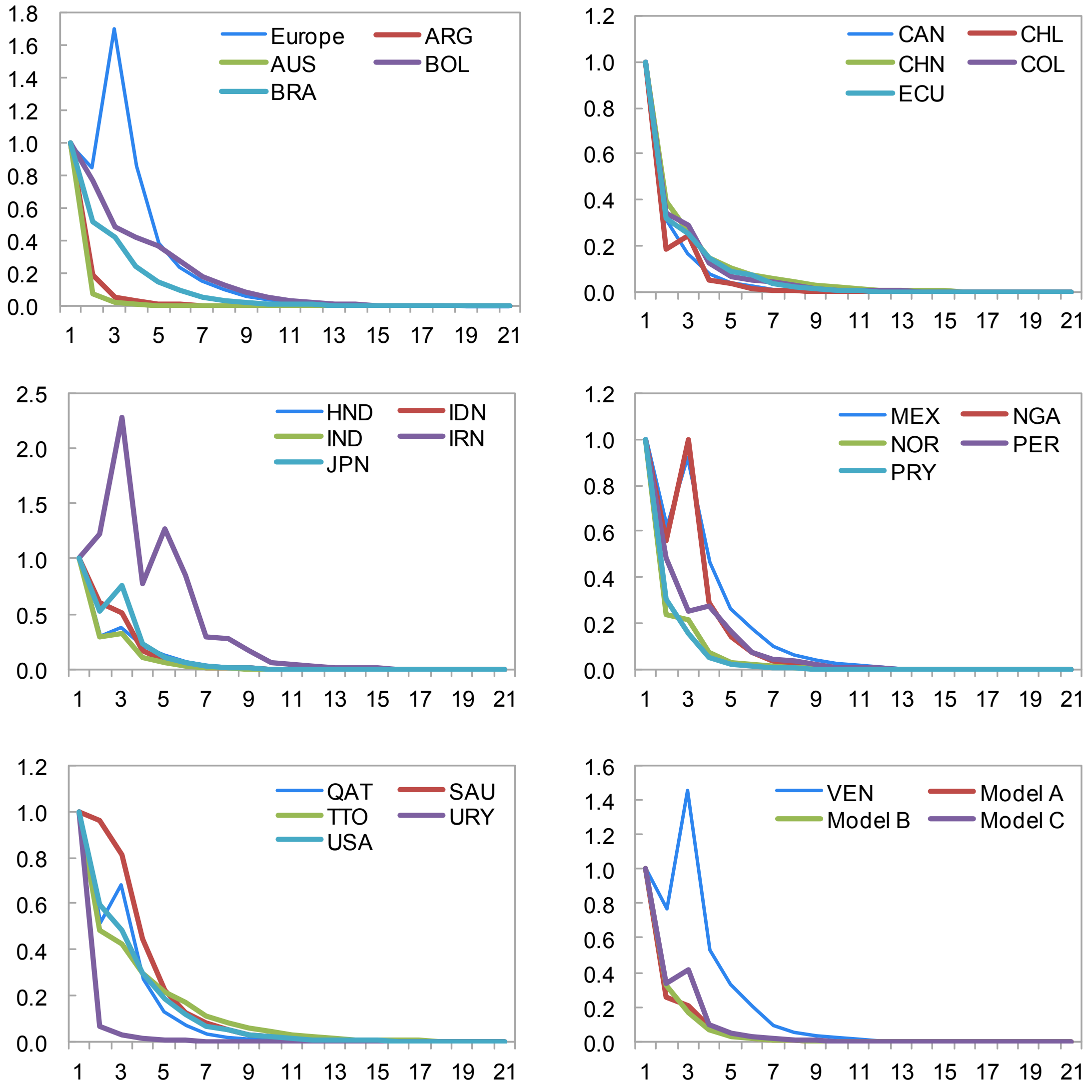
[1]NCPIs for 2014–19 are constructed from prices of commodity futures prevailing at end-February 2014

Figure A2. NCPI Series for Other Commodity Exporters, 1970–2019[1]



[1]NCPIs for 2014–19 are constructed from prices of commodity futures prevailing at end-February 2014

Figure A3. Persistence Profiles of the Effect of System-Wide Shocks to the Cointegrating Relations of the GVAR Model[1]



[1] The persistence profiles show the effect of system-wide shocks on the dynamics of the long-run relations (Pesaran and Shin, 1996). The value of these profiles is one on impact but should tend to zero as the horizon tends to infinity if the vector under investigation is indeed a cointegration vector. The figures report the bootstrap median effects of a system-wide shock to the cointegrating relations (1000 replications). The horizontal axis denotes years after the shock.