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Propagation of Commodity Market Shocks

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Abstract

We address the transmission of commodity price shocks and assess how source-specific shocks spillover to other exporting countries. Applying a multi-country panel VAR, we show that a model that allows for cross-country interdependencies is an appropriate specification of commodity markets. Source-specific shocks therefore have both direct and spillover effects and the results indicate that these spillover effects are both statistically and economically significant. Accounting for these spillover effects has important implications for understanding commodity price dynamics and the management of price shocks in both exporting and importing countries.

JEL F00, C3, C5, Q1

Keywords PVAR, Commodity Price Transmission, Spillovers

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While most research on the implications of commodity market shocks focus on 'world' prices, the role of value chains, the use of contracts between procurers and exporters, and the sourcing of commodity imports from a limited number of countries (reflecting, *inter alia*, geography and political ties) implies that the source of commodity shocks that impacts on importing countries are likely to be country or region specific. Commodity shocks can however propagate across other exporters such that the price transmission effect on the importing country will depend, not only on the direct effect of the shock in the original source country, but also the spillover effects as other exporting countries' prices change in response to the original (source-specific) shock. In this paper, we show that a model that allows for cross-country interdependencies is an appropriate specification of commodity markets; moreover, the spillover effects that arise following source-specific shocks are both statistically and economically significant. Highlighting the importance of direct and spillover dimensions of commodity price shocks gives a more nuanced perspective of commodity price dynamics that would arise when focusing on an aggregate world price and which has implications for addressing the impact of these shocks in both exporting and importing countries.

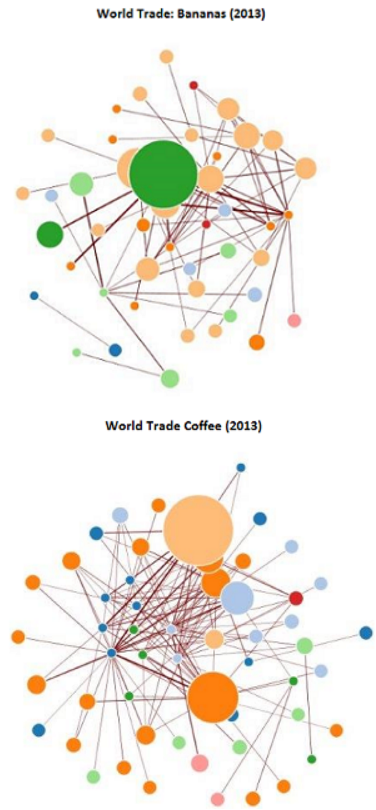
To provide some context to this perspective of commodity markets, we consider two examples of commodity markets (bananas and coffee which are among the most important commodities (by value) traded). Consider Figure 1: in the top figure, we characterize trade in the global banana market and in the bottom half, global trade in coffee. With regards to the banana market, the left side of the figure characterizes the network of world trade for bananas; the right hand side of the figure reports the geography of UK imports for bananas. As it can be seen, the UK sources its banana imports from a limited number of (mainly) Central and Latin American and African countries. Moreover, reflecting the importance of value chains in commodity markets, many of the leading food retailers in the UK have direct contracts with growers in these countries. A similar characterization arises with respect to coffee trade as presented in the bottom half of Figure 1. Extracting the export sources for US imports indicates the network of commodity trade for coffee that the US relies on. Focusing on other main importers in these two markets gives a similar picture to those portrayed in Figure 1.

This has two implications for addressing the impact of commodity price shocks in importing countries. First, commodity trade for many countries reflects a network structure. While these commodities need not reflect the complexity of value chains in manufacturing networks, even for commodities with little value added, trade will reflect a geographical network. This geography is also tied with the importance of vertical control in commodity value chains where vertical coordination is an increasingly important feature of many commodity markets.

Second, the network features have important implications for assessing the impact of commodity price shocks. Shocks to commodity markets are often source-specific reflecting variation in weather and climate, disease and pests, and country-specific economic and policy developments, but the impact on importing countries following country or region-specific events will propagate throughout the network.[1] For example, in relation to the right hand side of Figure 1, a commodity price shock originating in, say, Ecuador (the world's leading exporter of bananas) will not only have a direct impact on export prices to the UK but there may also be spillover effects: following the price change originating in Ecuador, prices may rise in the other exporting countries. Understanding how these country-specific shocks propagate through the trade network and assessing the relative importance of the direct and spillover effects across countries that export to the source

[1] In principle, importers can switch between sources of supply to other regions. In the short term, however, sources of supply are relatively fixed reflecting, for example, geography and the costs of trade of often perishable commodities, the duration of contracts and investment in coordination through value chains. Data on the structure of commodity trade suggests that the network structure of commodity trade is relatively stable.

Figure 1: Network Characterization of Commodity Trade: Bananas and Coffee (2013)



country is the focus of this paper. Exploring the source of shocks in this way will provide a different perspective on commodity price dynamics and the impact of these shocks on importing countries.

We do this by drawing on recent developments in cross-country panel VARs. The most recent developments of the panel VAR literature are targeted to investigate interdependences across economies (for example, Canova and Ciccarelli, 2004, 2009; Koop and Korobilis, 2016); however, while recent research applies cross-country panel VAR models to explore a number of issues associated with common shocks across countries (e.g., determinants of inflation and effects of financial contagion), to the best of our knowledge this is the first time that a multi-country VAR approach is used to assess the presence of spillovers in transmission of commodity price shocks.

We employ the framework outlined by Canova and Ciccarelli (2009) as we can isolate the impact of source-specific shocks and gauge the extent of the spillovers across other exporting countries. Specifically, this approach allows us to model cross-country interdependences while allowing for the presence of unit-specific dynamics and time-varying coefficients (TVC henceforth).

We apply this framework to UK imports of bananas and US imports of coffee. As detailed in Figure 1, the main characteristic of the UK banana market is that the UK imports from only a limited number of exporting countries primarily located in Central and Latin America and African countries. This is similar to the structure of US imports of coffee. For these commodities, supply shocks are typically country or region-specific reflecting weather and climate, pests and disease (e.g. Panama disease (TR4) in the case of bananas and coffee rust in the case of coffee) or government policies. Thus, unfolding the dynamics of price transmission and the linkages between commodity prices and specific shocks (e.g., weather and global warming (Guiot and Cramer, 2016; Skibba, 2016; The Guardian, 2017)) in these markets is of primary importance to face imminent threatens such as threats to supplies (Daily Express, 2017; CNN, 2017) or commodity price increases (BBC, 2017).

Our results show that, following country-specific shocks, the spillover effects are not only statistically significant but also economically important. For example, in gauging the pass-through effect to the UK market, a 1 per cent price shock for bananas in Ecuador (the leading exporter of bananas) will have a direct pass-through effect of 0.67 per cent. But the spillover effects to other exporters is also important: results show that prices increase by 0.4 per cent in Colombia and 0.3 per cent in Costa Rica even though the original price shock was not specific to these countries. While these price responses are lower compared with a scenario where all countries experienced a simultaneous price shock, they are nevertheless both statistically and economically significant. The extent of the spillover effects is similarly strong with regard to country-specific shocks to the US coffee market. A price shock to coffee exports from Brazil increases Brazilian export prices by 0.67 per cent; but export prices in Guatemala and Mexico also rise by 0.488 and 0.548 per cent respectively. As such, the spillover effects add to the price transmission impact associated with the direct impact from the (source-specific) price shock. The results are robust to additional checks.

There are several reasons why exploring the impact of price shocks in commodity markets in this way is important. First, in terms of understanding the nature of commodity price dynamics, tying the origin of price shocks with the geographical network of commodity trade gives a more nuanced insight of how source-specific shocks spillover to other exporting countries and hence propagate through the commodity network. Second, this perspective of commodity markets also has implications for understanding and managing price transmission in importing countries as source-specific commodity price shocks are contagious. Third, and related to this, managing commodity price volatility in specific exporting countries also relates to what happens in other exporting countries. While there may be many reasons why the spillover effects may vary across export sources (reflecting, for example, geography, the nature of contractual relations and so on), understanding exposure to spillover effects is an important dimension of addressing the volatility of export prices and the macroeconomic implications that arise. Finally, this framework allows predicting the implications of global and region-specific shocks, such as global warming and changes in weather and climate conditions.

The paper is organized as follows. In Section 1, we relate our approach to addressing the propagation of commodity shocks to relevant strands in the literature. The econometric methodology is outlined in Section 2 followed by a presentation of the data and specification issues in Section 3.

The main results and the robustness checks are reported in Section 4 and we summarize and conclude in Section 5. Our overall insight is that detailing the propagation of commodity market shocks gives a more nuanced perspective of how price volatility impacts on importing countries than reference to a broader notion of a 'world' price that does not reflect the role of value chains or the network nature of trade reflecting geography or history that is an important feature of many commodity markets. Implications for assessing price transmission and the management of commodity price volatility arise from this.

1 Related Literature

Our approach to identifying the nature and impact of price shocks in commodity markets ties with several themes in related research. First, as noted above, in commodity trade, there will be direct ties between exporters and procuring firms (including direct relations with retailers) in importing countries. These reflect the increasing use of vertical coordination in commodity supply chains, the need to ensure and enforce standards, the use of contracts to ensure price stability and security of supply and technological transfer. See, for example, Maertens and Swinnen (2012) and Swinnen (2007) and Swinnen et al. (2015) for an overview of these issues. For recent coverage of the implications of value chains for commodity exporting developing countries, see Devaux et al. (2017).

Second, the focus in this paper complements recent research on the impact of shocks in networks. Important in this regard is Acemoglu, Akcigit and Kerr (2015) who show that the network propagation of shocks are of first-order importance and that the indirect impact of a shock is larger than the direct effect. Although the primary focus of their network is on input:output relations between upstream and downstream industries, they also have a geographic dimension to the network effects through the location of industries. While their network structure reflects a more complex manufacturing network, the commodity network is characterized by a simpler input:output structure but reflects a more direct exporter:importer structure.[2] The trade effects of shocks through networks have also been explored by Carvalho (2014); Carvalho et al. (2017); Barrot and Sauvagnat (2016); Korniyenko, Pinat and Dew (2017).

Third, the empirical strategy employed here ties with econometric approaches addressing linkages across economies and the presence of direct and spillover effects (Anselin, 1988; Canova and Ciccarelli, 2004, 2009; Pesaran, Schuermann and Weiner, 2004; Chudik and Pesaran, 2014; Koop and Korobilis, 2016). A strand of research has developed panel VAR approaches that allow for multi-country interdependences, the main focus of the research being premised on the premise that country-specific VAR models miss the impact of spillovers between countries that condition the overall impact of events on individual countries. A popular method is the global VAR (GVAR) approach which accommodates the inter-connectedness between countries and has been applied to assess a variety of issues including contagion in financial markets (Pesaran, Schuermann and Weiner, 2004; Pesaran, Smith and Smith, 2007; Chudik and Fratzscher, 2011) and interdependencies relating to fiscal policy (Favero, Giavazzi and Perego, 2011) among others. In a recent application involving commodity markets, Cashin, Mohaddes and Raissi (2017) employ the GVAR approach to assess the impact of El Niño across countries. Chudik and Pesaran (2014) survey the global VAR literature and its broader applications.

Other approaches that accommodate multi-country VAR approaches include Koop and Korobilis (2016), who develop Bayesian methods for model selection in large panel VARs and then apply the methodology to study financial contagion across European countries. Canova and Ciccarelli (2004, 2009) provide a framework to estimate multi-country VAR presence of

[2] Of course, for some commodities, the network structure will be more complex than the banana and coffee markets explored here. For example, cocoa and dairy products are used as inputs in a wide variety of food processing activities.

medium length time series. Given the limitations in the available data, this method is the one that is most appropriate for characterising a trade network such as that outlined in Figure 1. By allowing for the cross-country interdependencies, we can estimate both the direct effects of a shock originating on one source on the importing country but also allow for the effect of this source-specific shock on other countries in the network. Accounting for these spillover effects allows a more nuanced and relevant assessment of how price transmission evolves across countries. We apply the Canova and Ciccarelli (2004, 2009) approach to modelling the trade network that characterizes UK imports of bananas and US imports of coffee.

Finally, since we are focussing on the effects of commodity shocks on the importing country, this focus here also ties with research on the price transmission impacts as a result of the recent commodity crises. As noted above, the 'world' price is usually the metric via which shocks (from any source) are transmitted into price changes in importing countries. Examples of world commodity-price transmission approach include Davidson et al. (2016); IMF (2011); Prakash (2011) among others.[3] Of course, in taking a bilateral approach to modelling the impact of 'world' commodity shocks, the potential spillover effects across countries are missed. Aside from the economic relevance accounting for cross-country effects, bilateral approaches to addressing the outcome of commodity or macroeconomic shocks are potentially less efficient; Georgiadis (2017) and Chudik and Pesaran (2011) advocate the use of bilateral approaches only when we can reasonably discard the impact of other countries.

[3]There is, of course, a long tradition in evaluating the macroeconomic consequences of commodity shocks with a considerable part of this research focussing on the relationship between oil prices and inflation. See, for example, Blanchard and Gali (2007) and Hamilton (2008) among many others.

2 Methodology

We estimate a panel VAR approach as it is potentially more accurate and insightful approach to addressing the impact of price shocks than approaches that do not allow for the possibility of spillover effects. There are several justifications for taking this approach. First, it fits with the characterization of the trade network with respect to the sourcing of country imports outlined in Figure 1. Second, a multi-country VAR model exploits the panel structure, which recovers better and more precisely estimated results, especially in presence of short or medium time series (as in our case). Finally, the presence of dynamic interdependences can be better analyzed using a multi-country framework; this is even more important in our case since, given the structure of the markets under consideration where a few countries are producing and exporting the commodity, it is reasonable to assume that shocks in one country, especially the leading exporting countries, may have an impact on the export prices of other countries.

Specifically, we follow Canova and Ciccarelli (2009) who propose a framework to estimate panel (multi-country) VAR models for time series of moderate length that allows for the presence of unit-specific and variable-specific dynamics as well as variation in the coefficients that are common across units. In other words, this methodology allows for the presence of a *common effect*, such as an international event that may affect all countries; it also allows for the presence of a *variable effect*, that is, coefficient variations that are specific to the variables of the system; finally, it allows also for the presence of *country effects*, which accounts for country-specific dynamics. The framework also allows for the presence of time-varying coefficients (TVC) as well as lagged interdependences, that is, the possibility that a variable in country i at time t-1 may affect a variable of another country at time t.

This framework is particularly suitable for assessing source-specific shocks which is the focus of our analysis. With a panel framework, we can explore the extent to which a possible shock in one of the countries may have an impact on (some of) the other exporting countries. As such, source-specific commodity market shocks will impact on importing countries via the direct impact from the shock-affected country plus the spillover effects across other exporting countries. Thus, this framework is suitable to investigate whether and the extent to which there exist cross-country spillovers in the transmission of shocks.

We choose to estimate a VAR model exploiting the panel structure rather than estimating single country or two-country models because, as pointed out by the literature (e.g., Canova and Ciccarelli, 2009; Georgiadis, 2017), this procedure is appealing for various reasons. Specifically, a multi-country VAR model exploits the panel structure, which may help to recover better and more precisely estimated results, especially in presence of short or medium VAR (as in our case). Furthermore, the presence of dynamic interdependences can be better analyzed using a multi-country framework; this is even more important in our case because, given the structure of the markets under consideration where a few countries are producing and exporting the commodity, it is reasonable to assume that shocks in one of the countries, especially the leading countries of the sector, may have an impact on the market of other countries. While these interdependences cannot be analyzed in a single country VAR, they can only be partially and not precisely analyzed in a bilateral model (Georgiadis, 2017).

Formally, we estimate the following model:

$$y_{it} = D_{it}\left(L\right)Y_{t-1} + C_{it}\left(L\right)W_{t-1} + e_{it} \tag{1}$$

where $i = 1, ..., N$ represents the units (countries) and $t = 1, ..., T$ represent time, y_{it} is a vector of dimension $G \times 1$ (G is the number of variables, in our case equal to 4) for each country i; $Y_t = (y'_{1t}, ..., y'_{Nt})'$, W_t is a q x 1 vector that may include common variables, time-invariant variables or unit-specific variables, e_{it} is a $G \times 1$ vector representing the error terms; $D_{it,j}$ are $G \times GN$ matrices and $C_{it,j}$ are G x q matrices for each j. Interdependences across countries exist if D_{it} is not a block diagonal matrix for at least one j.

However, allowing for the presence of interdependences and time varying coefficients increases the number of coefficients to estimate and causes an overparametrization problem. Thus, we adopt the factor structure used by Canova and Ciccarelli (2009) and impose restrictions to the coefficients. Define δ_{it}^{g} as a $k \times 1$ vector containing the stacked G rows of the matrices C_{it} and D_{it}; then, $\delta_{it} = (\delta_{it}^{1'}, ..., \delta_{it}^{G'})'$ and $\delta_t = (\delta_{it}', ..., \delta_{Nt}')'$ is a $NGk \times 1$ vector. This vector is factorized as

$$\delta_t = \sum_{f}^{F} \Xi_f \theta_{ft} + u_t \tag{2}$$

where the number of factors is lower than NGk and θ_{ft} is a low-dimensional vector, Ξ_f are matrices that can vary depending on the application and u_t is a vector of disturbances.

Now, assume $\mathbf{X}_t' = (Y_{t-1}', ..., Y_{t-p}', W_t', ..., W_{t-l}')'$ and $X_t = I_{NG} \otimes \mathbf{X}_t'$. If we set $\Xi = [\Xi_1, ..., \Xi_F]$ and $\chi_t \equiv X_t \Xi$ and $\zeta_t \equiv X_t u_t + E_t$, we can re-write equation 1 as follows:

$$\begin{aligned} Y_t &= X_t \delta_t + E_t \\ &= X_t \left(\Xi \theta_t + u_t \right) + E_t \equiv \chi_t \theta_t + \zeta_t \end{aligned} \tag{3}$$

This reduces the coefficients to estimate.

The choice of the factors depends on the application. In the benchmark model we want to test, we include three factors: a common effect, a country-specific effect, and a variables-specific effect. Thus, our benchmark model can be formalized as follows:

$$y_{it} = \chi_{1t} \theta_{1t} + \chi_{2t} \theta_{2t} + \chi_{3t} \theta_{3t} + \zeta_t \tag{4}$$

where $\Xi_{11t} = \Sigma_{LA}\Sigma_g\Sigma_j y_{igt-j}$, $\Xi_{12t} = \Sigma_{NotLA}\Sigma_g\Sigma_j y_{igt-j}$ and θ_{1t} is a 2×1 vector of common factors; this factor distinguishes between common factors in (say) Latin America and in the countries belonging to a different geographic area (Africa for the banana market and Africa and Asia for the coffee market); $\Xi_{2it} = \Sigma_g\Sigma_j y_{igt-j}$ and θ_{2t} is a $n \times 1$ vector of country-specific factors for the countries used in the analysis; θ_{3t} is a $g\times1$ vector of variable-specific factors for the variables used in the analysis, where $\Xi_{3gt} = \Sigma_i\Sigma_j y_{igt-j}$; also $i = 1, ..., n$, and $g = 1, ..., g$. Following Canova and Ciccarelli (2009), we assume the factors evolve according to the following low of motion:

$$\theta_t = \theta_{t-1} + \eta_t \tag{5}$$

where $\eta_t \sim (0, B)$ and $B = diag\left(\bar{B}_1, \bar{B}_2, \bar{B}_3\right)$ and $\theta_t = (\theta'_{1t}, \theta'_{2t}, \theta'_{3t})'$.

Our framework includes also the presence of lagged interdependences as well as time varying coefficients. Following Canova and Ciccarelli (2009), we set loose proper priors to minimize their influence; in particular, we set $p(b_i^{-1}) = G(5, 0.5)$, where $i = 1, 2, 3$, $p(\Omega^{-1}) = W((z_1\Omega_{OLS})^{-1}, z_1)$, where the degrees of freedom are, in accordance with the sample size, $z_1 = ng+30$ and Ω_{OLS} and $\theta_{0|0}$ are OLS estimates obtained on the time-invariant version of the model.

The factor structure transforms the multi-country VAR into a seemingly unrelated regression (SUR) model. We are in presence of time-varying coefficients, so, given the likelihood of the SUR model, we estimate the model using Markov Chain Monte Carlo (MCMC) methods to obtain posterior distributions. The Kalman filter is used to get conditional posterior of $(\theta_1, .., \theta_T|Y_T, \psi_{-\theta_t})$. Following the literature (see, for example, Doan, Litterman and Sim, 1984; Kadiyala and Karlsson, 1997; Canova and Ciccarelli, 2009), we let E_t and u_t be correlated and use a variant of the Gibbs sampler to compute posterior distributions. Finally, our framework uses a Choleski system; also, a non-standard dynamic analysis, which allows to compute impulse response functions, recursive conditional forecast and conditional forecast is possible (see Canova and Ciccarelli (2009) for further details about inference, the model specification and identification).

We call this model our benchmark model because we assume this specification is more likely to reflect the dynamics of the commodity markets than alternative specifications. We formally test the framework we adopt against other alternative models in the empirical section. We will do this by using standard methods, such as the Chib's maximum likelihood method (Chib, 1995), the Schwartz approximation and the harmonic mean estimator (Newton and Raftery, 1994) and comparing the models using the Bayes factor.

3 Data and Model Selection

3.1 Data

We apply this framework to the banana and coffee markets. The data used in the analysis have monthly frequency and range from 2011:1 till 2015:12; this implies that the time series is of moderate length. Specifically, for the banana market, we collect data for the seven main exporting countries to the UK (Ecuador, Colombia, Costa Rica, Dominican Republic, Belize, the Ivory Coast and Cameroon).[4] They account for varying shares of exports to the UK: Colombia is the UK's main source of bananas (accounting for (using data for 2013) around 30 per cent of imports), the Dominican Republic (24 per cent), Costa Rica (14 per cent), Ecuador (13 per cent) with the other exporters accounting for between 5-7 per cent of the UK's supply. For the coffee market, we collect data for the exporters to the US market whose data were available (namely, Brazil, Ecuador, Guatemala, Mexico, Peru, Ethiopia and India). Other countries also export coffee to the US but

[4] In characterizing export supply, we focus only on the main producing countries and do not account for trade via other developed countries and which are subsequently re-exported. While this may affect the overall magnitudes, it will in principle have no impact on the issues we address in this paper.

the required data was not available for these countries.[5] For the countries covered in the model, they account for 55 per cent of the US's source of imports with Brazil being the main exporter (28 per cent of total supply), Guatemala (11 per cent) and Mexico (9 per cent) exporting countries.

For each exporting country, we have four endogenous variables: quantities exported to the relevant market (unit), prices for exports, exchange rates and domestic inflation. Data on exports and prices of exports are collected from the country data available at COMTRADE. For some countries (specifically with reference to the coffee market), multiple consecutive observations were not available, so we used consecutive years and assume a similar trend in order to interpolate the data. Also, the data do not allow to distinguish between different types of exports (e.g., fair trade versus non fair trade bananas) that have different price policies. Although this is a limitation of the work, it does not affect the main aim of the paper.

For each country across both markets, inflation is measured by the consumer price index (CPI), collected from the International Monetary Fund (IMF). Data on real exchange rates are also sourced from the IMF. The real exchange rate was not available for all the countries used for the coffee market: when this arose, we used the nominal currency per US dollar at the end of each period with the exception of Ecuador, for which we had to use the real effective exchange rate. While this is not desirable, the use of real or nominal variables for the analysis of shocks should not have too much of a bearing on the model particularly given that the period we are considering has not been affected by peaks to the inflation. Also, we use rates of growth which limits the impact of having to resort to nominal exchange rates in some cases. We compute growth rates for all the variables and the data are annualized; the data on prices and exports are seasonally adjusted. Finally, for the predetermined variable we use the (monthly) real

[5]Exporting countries where we had an incomplete data set to derive export unit values to the US market were Colombia, Indonesia and Vietnam. Colombia accounts for around 24 per cent of US coffee imports.

world oil price sourced from the World Bank.

3.2 Model Selection

We first of all address whether the multi-country VAR with the potential for cross-country interdependencies is an appropriate specification for the two commodity markets we apply the framework to. Our benchmark specification is therefore the model that encompasses include a common factor, variable-specific factors, country-specific factors as well as the presence of lagged interdependences and time-varying coefficients. We refer to this as Model 1 (M1) in Tables 1 and 2 (for the banana and coffee markets respectively). We test whether variants of this specification provides a better characterization of the data. We therefore estimate a model with no lagged interdependences, model 2 (M2), a model without country fixed effects, model 3 (M3), and a model without variables-specific factors, model 4 (M4).

Table 1 presents the results for the banana market. We estimate the model using ten different seeds and the likelihood statistics presented in Table 1 is the average of the likelihood obtained using the 10 seeds.

Table 1: Model Selection: Banana Market

	Model 1	Model 2	Model 3	Model 4
Chib	-2,097.80	-2,162.90	-2,255.96	-2,295.87
nse	9.42	10.09	18.03	8.88
Schwartz	-2,047.49	-1,988.14	-2,123.33	-2,201.83
nse	0.64	1.45	5.67	2.23
Harmonic Mean	-2,106.36	-2,128.12	-2,238.41	-2,197.18
nse	0.51	2.12	1.63	1.54
Parameters	409	409	408	408

Notes: The number of parameters is equal to the free elements in the variance-covariance matrix plus the free elements in B.

We follow the same procedure for the coffee market, the results of which are presented in Table 2. Looking at Table 1, the ranking of the model varies depending on the method used. Model 1 is the preferred specification according to the Chib and harmonic mean criteria and is ranked second according to the Schwartz approach. We select Model 1 as an appropriate characterization of the data and use this model in the rest of the empirical analysis for the study of the banana market.

Table 2 presents the results of the model selection process in relation to coffee exports to the US. Also in this case the ranking of the models vary depending on the method used. Model 1 is ranked first according to the harmonic mean, second according to the Chib's method and third for the Schwartz method. Although M1 is not always ranked first, none of the other models is always preferred to this model; so, on balance, we decide to use M1 for the rest of the analysis also for this market.

Table 2: Model Selection: Coffee Market

	Model 1	Model 2	Model 3	Model 4
Chib	-2,181.05	-2,380.55	-2,020.5	-2,429.15
nse	7.06	7.62	32.48	11.64
Schwartz	-2,117.66	-2,101.54	-2,114.77	2,201.83
nse	1.68	1.74	3.77	2.23
Harmonic Mean	-2,178.80	-2,218.42	-2,262.01	-2,318.41
nse	0.20	1.70	1.91	1.76
Parameters	409	409	408	408

Notes: The number of parameters is equal to the free elements in the variance-covariance matrix plus the free elements in B.

Taken together, the model selection criteria suggests that Model 1 which characterizes the network framework outlined in Figure 1 with three types of factors (country-specific and variable-specific factors, and a common factor) as well as time-varying coefficients and lagged interdependences is an appropriate specification in each case. With this specification, we therefore explore how shocks originating in one country/region propagate in each case.

4 Shocks Transmission and Spillovers

4.1 Price Transmission and Spillovers

The main motivation in specifying a multi-country panel VAR is not only that it presents an appropriate characterisation of commodity trade between exporting and importing countries but that it can be used to assess how shocks propagate in commodity markets. Shocks are often country or region-specific: commodity prices from one country may change due to weather, climate or changes in government policy. Alternatively, shocks may be region-specific: a change in climate may impact on export prices for a commodity from a group of neighboring countries. The effects of these shocks on the importing country will depend on the direct effect; but it will also depend on the spillover effect i.e. how other exporters change their prices to the importing country in response to the shock originating in a specific country. Depending on the lag structure, these spillover effects may vary over time and across countries. The combination of these effects gives an indication of the propagation of shocks in commodity markets.

We report a series of experiments for each commodity market. The first scenario consists in modeling a 1 percent increase in prices in all countries of the sample: we treat this as a benchmark scenario which we can compare with the source-specific shocks in the subsequent scenarios. While this exercise does not explicitly allow to disentangle spillover effects, it gives an idea about how commodity prices could change due to a 'global' shock that may spread worldwide.[6] The second set of experiments relates to changes in prices from the dominant (most powerful) exporter country. In a third and final set of experiments, we allow the shocks to originate in more than

[6] For instance, the framework used here allows to estimate the effect on, say, commodity prices of an increase of oil prices. We estimated the impact of changes in oil prices on commodity prices; the results, omitted for space reasons but available upon request, show that an increase in the growth rate of oil price would lead to an increase in commodity prices. This result confirms that our methodology is capable to predict the standard commodity market dynamics.

one country but not all exporting countries, which captures region-specific shocks.

(a) Shocks to the UK Banana Network

First of all, consider the impact of a 1 per cent temporary (one period) increase in export prices from all the countries of the sample (Figure 2). Figure 2 reports the median responses and the 68 per cent posterior bands. This represents a hypothetical 'global' shock and for each country, the resulting price effect will be a combination of direct and spillover effects that are embedded in the resulting change in prices. On average across all exporters, prices contemporaneously rise by 1.06 per cent. Even though the experiment relates to a 1 per cent shock, in some exporters, price changes 'over-shoot': prices rise by 3.6 per cent in Cameroon, 2 per cent in the Ivory Coast, while in Ecuador, prices rise by 0.67 per cent. In Colombia and the Dominican Republic, the price effects are lagged but with prices rising by 0.5 per cent and 0.471 per cent respectively. While it is not possible to specifically identify the role of spillover effects in this scenario, we can assess their role by considering the impact of the same shock, but circumscribed to fewer countries. In any case, these source-specific shocks are a more realistic characterization of the nature of price shocks that arise in commodity markets.

In Figure 3, we consider the impact of a 1 per cent temporary (one period) increase in export prices from Ecuador, this country being the largest exporter of bananas. The resulting change in prices from Ecuador to the UK is an increase of around 0.7 per cent. But prices also rise in other countries that were not the source of the shock. The impulse responses highlighting cross-country spillovers show a substantive increase in export prices in Colombia (approximately 0.4 per cent), Costa Rica (around 0.3 per cent), Dominican Republic (0.15 per cent), Belize (0.13 per cent) and with almost zero responses in prices in the two African exporters to the UK, the Ivory Coast (0.08) and Cameroon (0.10). Finally, comparing Figures 2 and 3, when the shock is imposed only on a single country (Figure 3),

Figure 2: Effects on Export Prices of a Contemporaneous Banana Price Shock in All UK Banana Export Countries

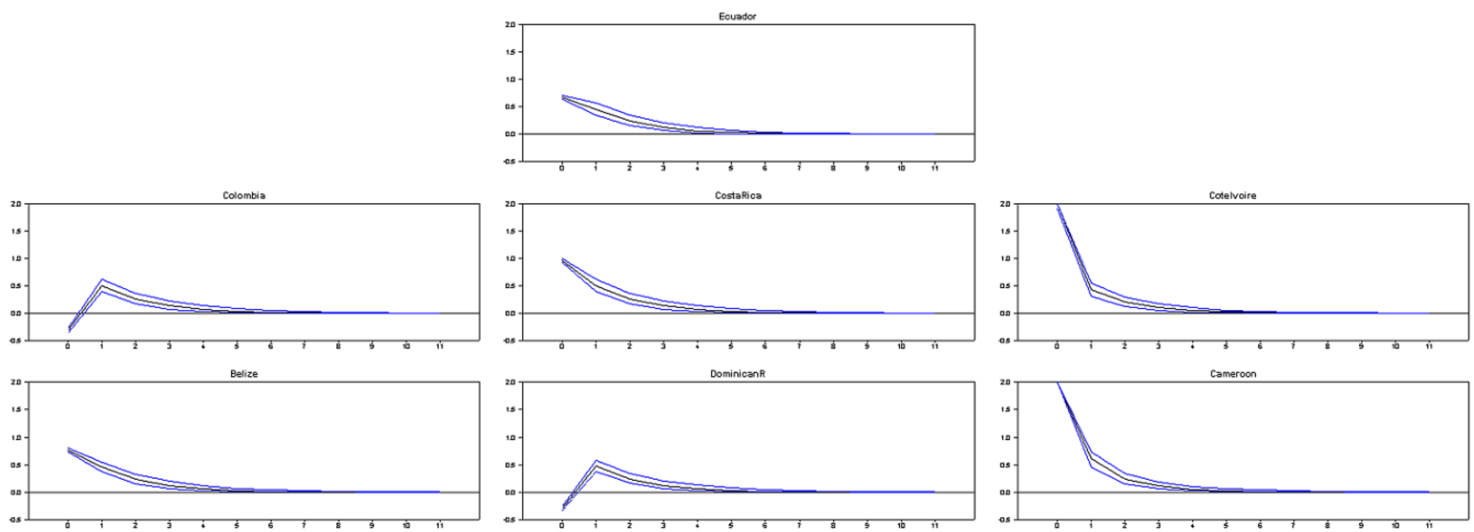
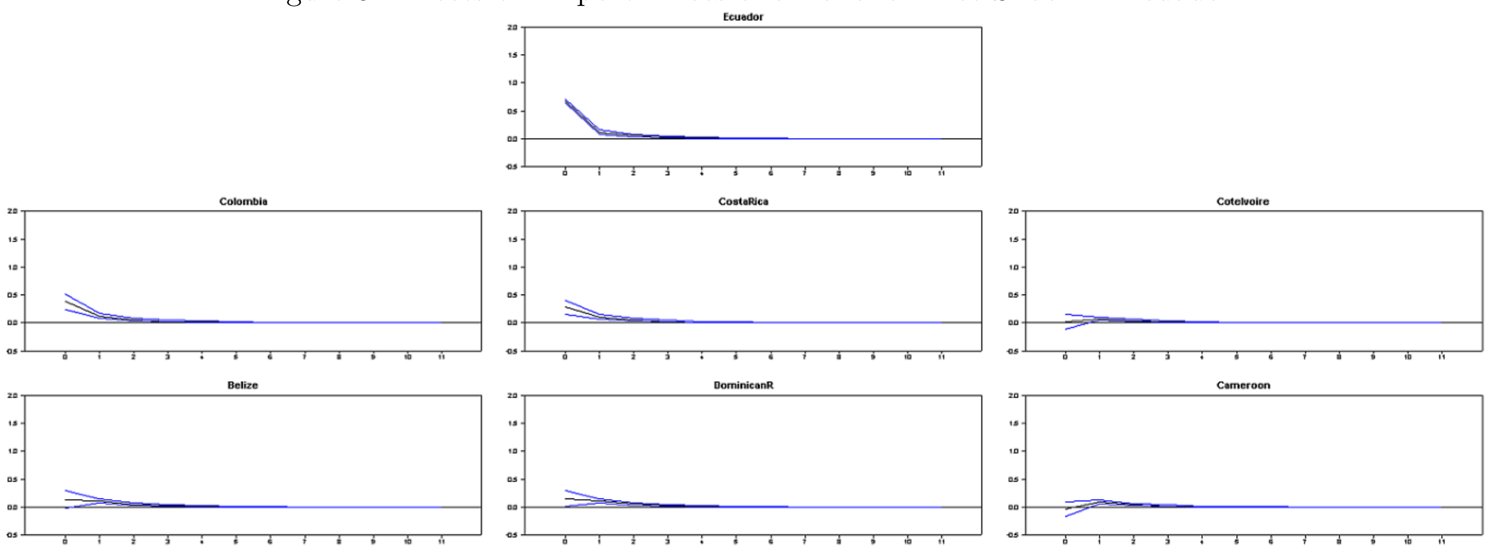


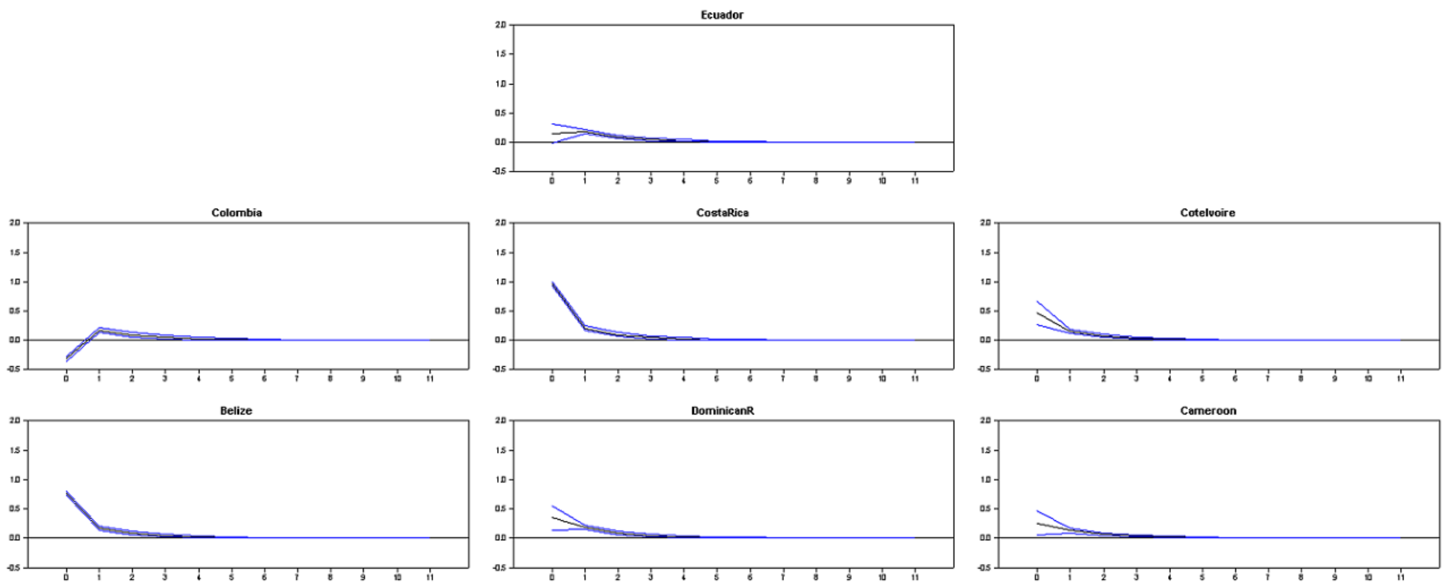
Figure 3: Effects on Export Prices of a Banana Price Shock in Ecuador



the impulse response functions are smaller in magnitude when the shock is imposed only on Ecuador than when the shock is imposed to all countries.

In the third scenario, we consider the effect of a shock that impacts on a limited number of countries simultaneously; we assume they are in the same region and therefore may be exposed to region-specific events, for example, adverse weather. In Figure 4, we consider the case where there is a temporary increase in prices in Belize, Colombia and Costa Rica, which are major exporters but not as dominant as Ecuador on the world banana market. Export prices rise in all the three countries, by 0.78, 0.17 and 0.96 per cent in Belize, Colombia and Costa Rica respectively. There are varying price responses throughout the network: Ecuador is the least affected country. Overall, all the countries of the network are affected by price shocks in these three countries and if we compare the results in Figure 4 and Figure 2, we observe that the more widespread the shock, the higher is the rise in prices, as expected. Ivory Coast and Cameroon, for instance, experience a rise in prices by 2 and 3.6 percent in Figure 2, a rise by 0.47 and 0.26 percent respectively in Figure 4 and a small increase when the shock occurs only in Ecuador. Scenarios 2 and 3 show that spillovers in price transmission matter and that the propagation of shocks across countries is an important dimension of price dynamics in this market.

Figure 4: Effects on Export Prices of a Banana Price Shock in Colombia, Costa Rica and Belize



(b) Shocks to the US Coffee Market

We consider a similar set of experiments in relation to coffee exports to the US. The first scenario, reported in Figure 5, shows the impact of a 1 per cent temporary increase in export prices in all exporting countries. The graph shows that this shock has an impact on export prices in all export countries: prices increase everywhere and while the two non-Latin American countries have a delayed reaction to the shock, all the Latin American countries experience an immediate reaction to the shock. Besides, for most countries the shock dies out in about 8 months. On average, across all 7 countries, the corresponding change in export prices is 0.4 per cent with the largest increases occurring in Ecuador (1.25 per cent), Mexico (0.657 per cent) and Brazil (0.62 per cent).

Figure 6 reports the same shock but limited to Brazil, the leading exporter to the US. Export prices rise by around 0.62 per cent but the spillover effects are sizeable. Export prices from Mexico rise by 0.55 per cent, from Guatemala by 0.49 per cent and from Peru by 0.5 per cent. As in the case of the banana market, Figure 6 provides clear evidence of the existence of spillover effects in prices across countries arising from the shock in a single country (Brazil). Once again, countries that are located outside the Latin American zone experience a delayed and minor increase in prices.

Finally, in Figure 7, we consider the case where there is a temporary price shock originating from other Latin American exporters of coffee to the US, namely Ecuador, Mexico and Peru. The direct price effects are substantive: export prices from Ecuador rise by 1.25 per cent, from Mexico by 0.66 per cent and Peru by 0.37 per cent. Figure 7 also shows that there still exist spillovers, most notably Brazil (0.41 per cent) though with lower price changes in Guatemala and even minor price effects in Ethiopia and India.

Figure 5: Effects on Export Prices of a Contemporaneous Coffee Price Shock in all US Coffee Export Countries

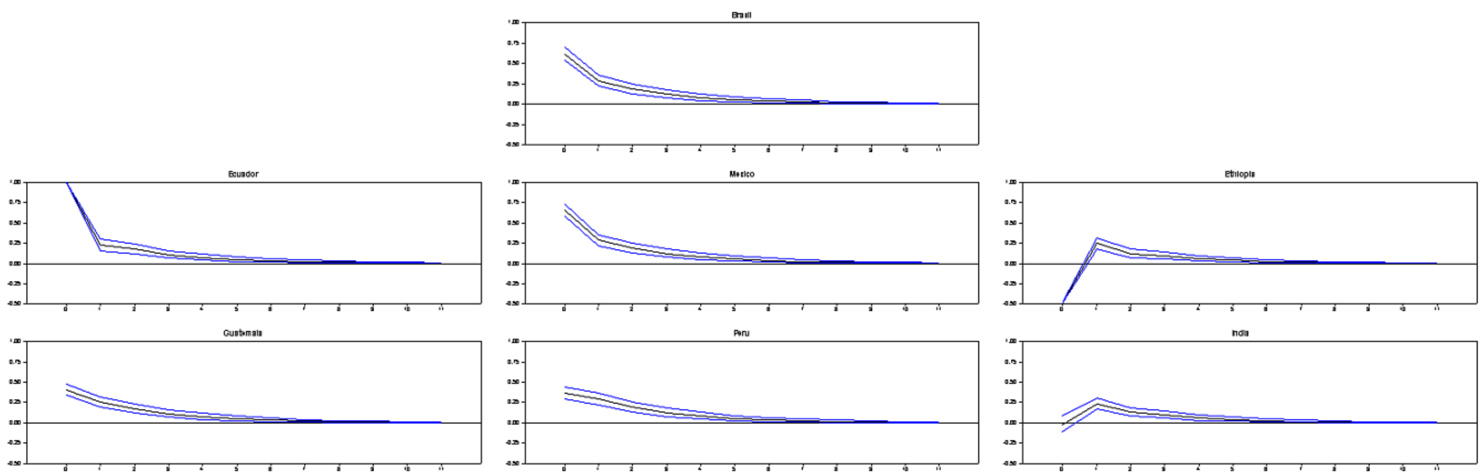


Figure 6: Effects on Export Prices of a Coffee Price Shock in Brazil

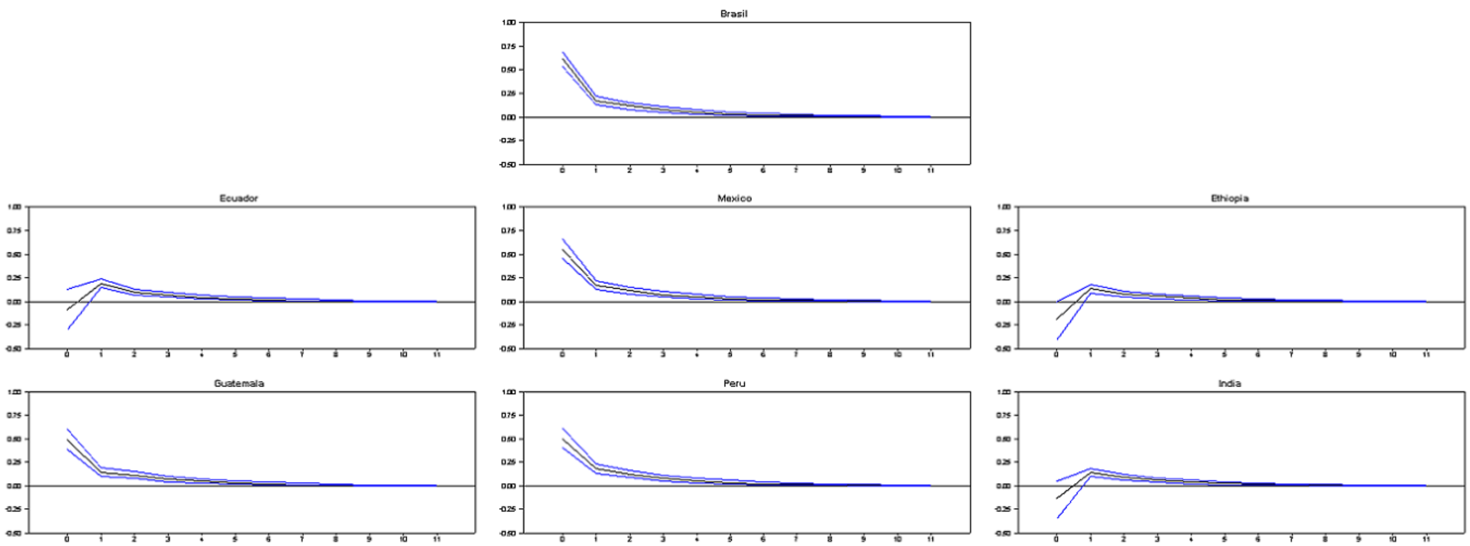
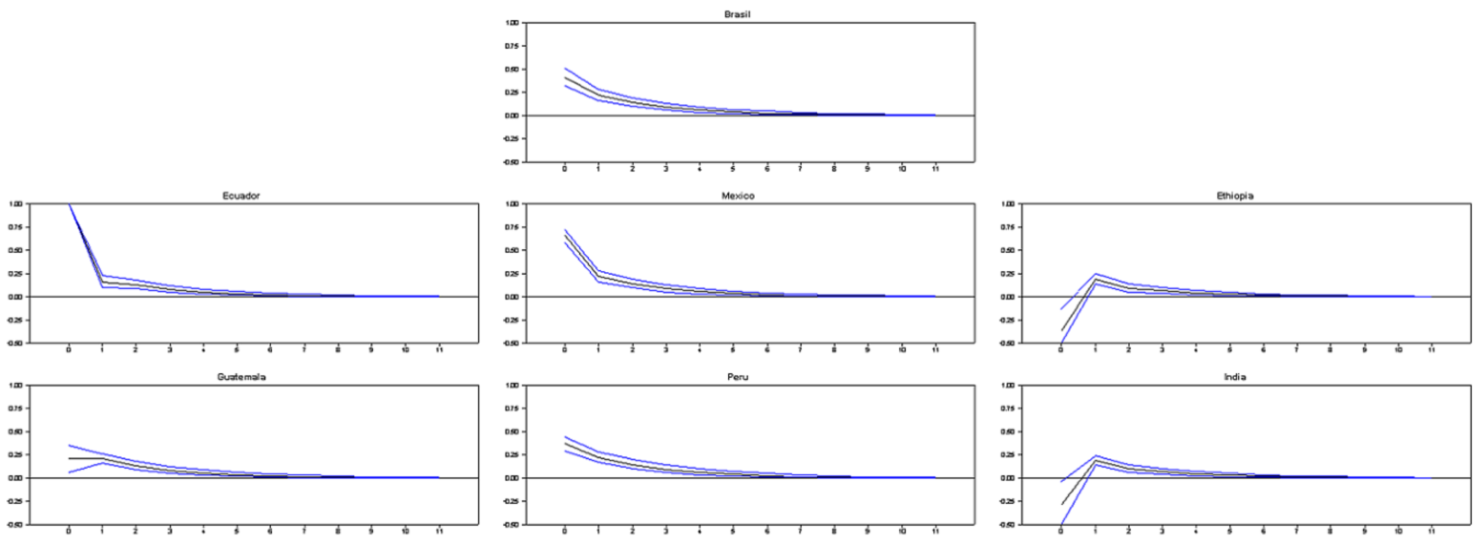


Figure 7: Effects on Export Prices of a Contemporaneous Coffee Price Shock in Ecuador, Mexico and Peru



(c) Summary

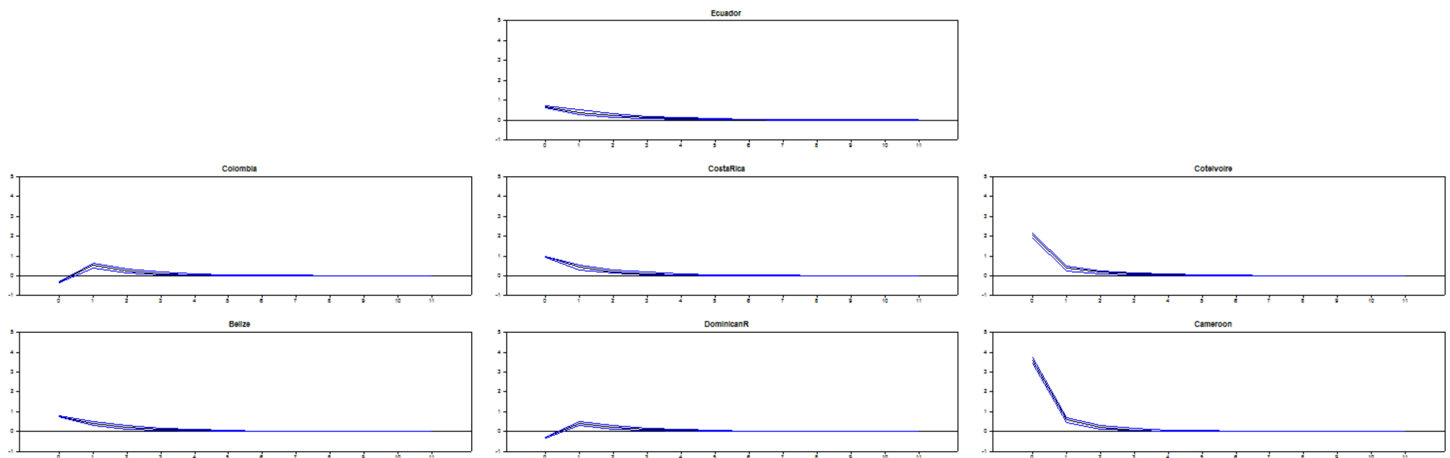
The above scenarios relating to both commodity markets show that a shock originating from specific sources not only has a direct effect on prices to the importing country but also has spillover effects. These spillover effects can vary; geography seems to matter. The extent of the spillover effects also appear to depend on the relative importance of the export country to a specific market and if the shock is sourced from more than one country. Source-specific shocks, whether at the country or regional level, result in lower price changes than if all countries faced a 'global' shock, but the spillover effects associated with the former highlight that the price effects across all countries are important and are certainly not zero. Taken together, the scenarios applied to the UK banana and US coffee markets indicate that the propagation of shocks can vary across trading networks and give a more nuanced insight into how shocks that arise in commodity markets work their way through to prices in importing countries.

4.2 Robustness Check

In this section, we present an additional scenario as a robustness check. We simulate the effect of a drop of all countries' production together with an increase in prices for one period: this scenario more directly exploits the properties of the econometric framework. Figure 8 reports the median responses and the 68 per cent posterior bands for the banana market, Figure 9 reports the results for the coffee market. The results support the evidence on price transmission presented in the previous section. Indeed, all these events are likely to generate a decrease in production together with an increase in prices, which is what we simulate in this last scenario.

Figure 8 shows that this scenario would produce an increase in prices for all the exporting countries. The pure responses vary across countries. While most of the countries would see an immediate answer to the shock, Colombia and Dominican Republic would experience a slightly delayed reaction. For

Figure 8: Effects on Export Prices of a Contemporaneous Banana Production and Price Shock in All UK Banana Export Countries



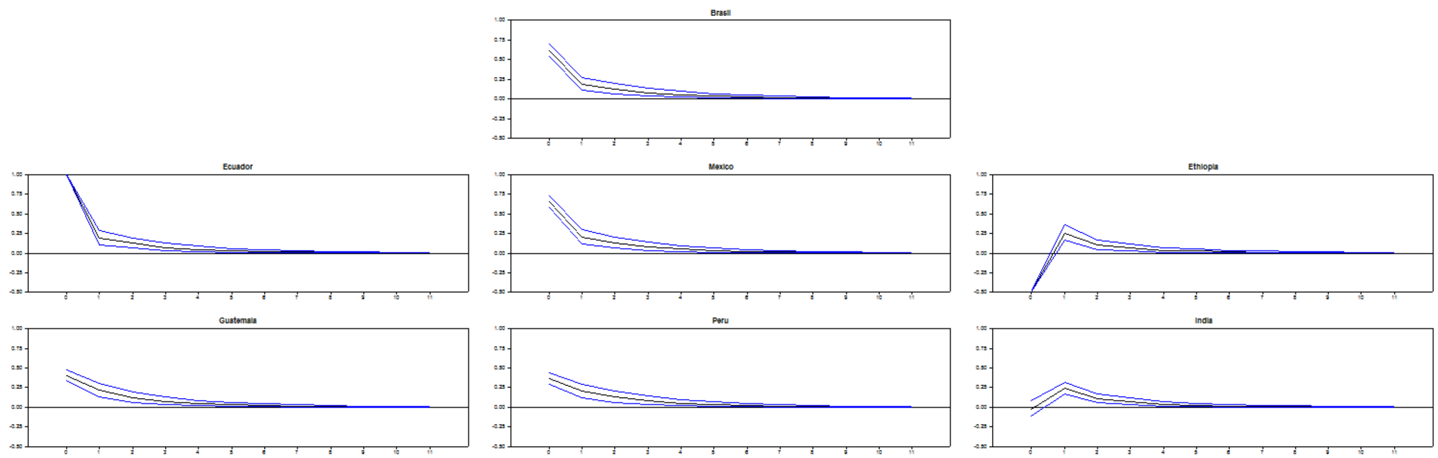
most of the countries the shock would die out in 6 periods. Belize and Costa Rica see their export prices increase by, respectively, 0.42 and 0.41 per cent, while Ivory Coast and Cameroon, the two countries with the highest increase in prices, experience a substantial increase in prices, that is, respectively, 2.03 and 3.57 per cent.

Figure 9 reports the results relative to the coffee market. Also for this commodity such a scenario would lead to an increase in prices for all the countries. The increase in prices vary depending on the exporting country and they range from about 0.20 per cent (Ethiopia experiences a 0.25 per cent increase and in India prices rise by a 0.24 per cent) to 1.25 per cent in Ecuador. The Figure shows also the presence of geographic effects: while in the Latin American countries the shock has an immediate effect on prices, in the two countries situated far away from the American continent, that is, Ethiopia and India, the effect is delayed one period.

We also replicated the other scenarios as in section IV of the paper and they reflect the previous findings and confirm the economic and statistical significance of the results and of the spillover effects when shocks are more region or country-specific. The respective Figures, omitted for space reasons, are available upon request.

Those results confirm that, once again, a shock to the production and prices of a commodity has a widespread effect across all the export prices of all countries and that the price dynamics reflect significant spillovers and depend on geography.

Figure 9: Effects on Export Prices of a Contemporaneous Coffee Production and Price Shock in All US Coffee Export Countries



5 Discussion and Conclusions

Understanding the dynamics of shocks transmission in commodity markets is a matter of general interest. It is relevant to macroeconomic policy in commodity exporting developing countries, in assessing the price transmission effects in importing countries and to firms throughout vertical chains involved in commodity trade. The econometric framework we have employed here addresses the propagation of commodity shocks and their impact on export prices to importing countries. The context for this is that most empirical research that addresses the impact of commodity price shocks use an aggregate measure of a commodity price (or commodity price index) that is referred to as a 'world' price. But much commodity trade is organized via the use of contracts and value chains with direct arrangements with the exporting countries and importing countries often import with a limited number of countries. Moreover, shocks due to weather, climate, pests and government policies are often source specific. Nevertheless, source-specific shocks have cross-country spillovers which determine the final price effect on the importing country.

We show that the characterization of a spatial network with the potential for cross-country linkages can be accommodated in an econometric framework. Specification tests indicate that a multi-country VAR that allows for cross-country interdependencies are appropriate characterizations of the two markets we apply the framework to (UK imports of bananas and US imports of coffee). By simulating shocks to prices in specific exporting countries or regions, we isolate the direct effect from the spillover effects. In the two applications we report here, the results indicate that the spillover effects are both statistically and economically important though they can vary across the countries in the network and they will depend on the source of the shock (i.e. whether it involves the leading exporter and whether it originates from more than a single source). We also provide robustness checks.

Acknowledging the network of commodity trade provides a more insightful characterization of commodity price dynamics that is pertinent to the management of commodity price shocks and the econometric approach applied here can be readily applied to other commodity markets. Further developments to directly accommodate weather and climate effects in specific countries as per recent research using climate data (see, for example, Dell, Jones and Olken, 2009, 2012) would provide further insights into the functioning of commodity markets and detailing commodity price dynamics.

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