How Important are Global Food Shocks?*

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Abstract

What are the sources and effects of global shocks that drive global food prices? We examine this question using a sign-restricted structural VAR model and rich data on domestic output and its components for 82 countries from 1980 to 2011. After identifying the relevant demand and supply shocks that explain fluctuations in real food prices, we quantify their dynamic effects on net food-importing and food-exporting economies. We find that negative global food shocks have contractionary effects on the domestic output of net food importers, and they are transmitted through deteriorating trade balances and declining household consumption. We document expansionary and shorter-lived effects for net food exporters. By contrast, positive global demand shocks that also increase real food prices stimulate the domestic output of both groups of countries. Our results indicate that identifying the source of a shock that affects global food prices is crucial to evaluating its domestic effects. The adverse effects of negative global food shocks on household consumption are larger for net food importers with relatively high shares of food expenditures in household budgets and those with relatively high food trade deficits as a share of total food trade. However, global food and energy shocks jointly explain only 8 to 14 percent of the variation in domestic output, leaving a large fraction unexplained by these commodity-specific shocks.

Keywords: Food prices, energy prices, global activity, business cycles, consumption, transmission mechanisms of global shocks

JEL Classification: E31, E32, F14, F32

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1 Introduction

The dramatic rise in international food prices during 2006–2008 and their elevated levels from 2008–2014 has renewed interest among policymakers and academics in understanding the underlying sources of increases in real food prices and their effects on macroeconomic indicators (Food and Agricultural Organization, 2008; The World Bank, 2009; Dillon and Barrett, 2015; Giordani et al., 2016). When global food prices increased rapidly over the 2006–2008 period, more than 30 countries around the world experienced food riots and protests (Food and Agricultural Organization, 2008), and civil conflicts have intensified (Arezki and Brueckner, 2014). In many inflation-targeting economies, the 2006–2008 surge in food commodity inflation led to widespread overshooting of inflation targets followed by undershooting of the targets when food prices dropped (De Gregorio et al., 2007). These consequences may not be surprising given the absence of easy substitutes for food, its large share of consumption baskets, and the fact that credit constraints may prevent consumption smoothing, particularly in developing countries. Despite a growing theoretical literature on the macroeconomic effects of global food prices (Anand and Prasad, 2012; Catao and Chang, 2015; De Gregorio, 2012), much less attention has been devoted to analyzing these effects empirically.

Fluctuations in real food prices may have very different effects on macroeconomic aggregates depending on their underlying sources (shocks to global demand/supply or shocks to commodity-specific demand/supply). On the one hand, a global food price surge driven by a rise in global economic activity may have expansionary effects on domestic output regardless of whether the country is a net exporter or importer of food commodities. On the other hand, a rise in global food prices stemming from adverse climate events that restrict the supply of food is likely to generate different impacts on domestic output depending on net food trade balance. Net food exporters may experience a positive spending effect to the extent that their net export earnings improve, while the opposite outcome may be observed for net food importers, generating a contraction not only in trade balance but also in household consumption. Moreover, a rapid rise in global oil prices may partially stimulate global food prices due to higher production costs of food, while both energy and food prices may simultaneously be driven by an expansion of global economic activity (Baumeister and Kilian, 2014). While a large body of empirical work on commodity markets has shown that not all oil price shocks are alike and that the effects of such shocks vary depending on their source (Charnavoki and Dolado, 2014; Kilian, 2009; Kilian et al., 2009; Lippi and Nobili, 2012; Kilian and Murphy, 2014), no research has examined whether the effects of international food prices differ depending on underlying sources.

Our paper provides the most comprehensive analysis to date of the relationship between global food prices and domestic output. We investigate the dynamic effects of global shocks driving international food prices on the domestic components of output in food-importing and food-exporting economies during the 1980–2011 period. We also examine changes in the importance of these shocks over time using historical decompositions and provide an analysis of variance decomposition to evaluate the average importance of these shocks for domestic output fluctuations. In addition, we compare the effects of these shocks to typical terms-of-trade shocks.

Our analysis departs from existing studies in many respects. First, we control for reverse causality from global economic activity to real food prices and differentiate among alternative sources of variation in real food prices. Using a sign-identified structural VAR (SVAR) model, we identify the global shocks driving international food prices. In particular, we consider four global-level macroeconomic variables: global economic activity, world real energy price index, world real food price index, and global inflation.[1] Our benchmark identification scheme utilizes sign restrictions and elasticity bounds and is accompanied by a recursive identification scheme as a sensitivity exercise. We examine four types of global shocks: global demand (GD) shocks, global energy (GE) shocks, global food (GF) shocks, and global supply (GS) shocks. Global expansions and contractions of economic activity are examples of positive and negative GD shocks. Negative GE shocks that are related to rising world energy prices capture geopolitical events that decrease global crude oil supply or increase oil market–specific demand due to anticipated future shortages or speculative trading. Examples of negative GF shocks that are associated with rising world food prices include climate shocks that may cause heat waves and droughts, resulting in a decrease in the food supply or an increase in food market–specific demand due to biofuel production or expansion of middle-income populations in emerging markets. Finally, positive GS shocks include improvements in productivity that decrease overall prices and whose origins range from innovations in information technology to technological upgrading in developing countries.

[1]The set of variables in our model differs slightly from those used in previous studies. As in Charnavoki and Dolado (2014), our model includes global inflation but lacks global commodity supply for the same reason: supply data for a range of primary commodities (including food commodities) are not easily accessed. Hence, our model differs from those of Kilian (2009) and Kilian et al. (2009), which include the global supply of crude oil. However, unlike that of Charnavoki and Dolado (2014), our model includes two separate commodity price indices, one for energy and one for food, instead of a single commodity price index. Therefore, shocks to global food and energy capture unexpected changes in the supply of and demand for food and energy in international markets, which are orthogonal to changes explained by shocks to global demand and (non-commodity) supply. However, this is not likely to restrict the analysis given that Kilian (2009) and Kilian et al. (2009) find that oil supply shocks explain only a small portion of variation in real oil prices.

Second, previous studies tended to focus predominantly on the pass-through effects of international food prices on domestic prices, without taking into account reverse causality or differentiating among sources of international food price fluctuations.[2] In this paper, we document the spending effects of global shocks driving international food prices, examining the channels through which these shocks have an impact on different components of domestic output. Using rich data from the Penn World Tables (PWT) 8.1, we analyze the dynamic effects on total output as well as its components, including household consumption, government consumption, investment, and trade balance in real terms for 82 countries. The existence of spending effects of oil price shocks has been documented by Kilian (2009) for the United States, by Peersman and Van Robays (2009) for the euro area economies, and by Baumeister et al. (2010) for industrialized countries broadly. Similarly, the presence of external balance effects of oil has been shown by Kilian et al. (2009) for oil exporters and importers, and Charnavoki and Dolado (2014) provided evidence for the existence of spending and external balance effects (among other effects) for a typical commodity exporter, Canada.[3] In this paper, we address a complementary question of whether there are systematic spending and external balance effects in response to global shocks that drive international food prices and to what extent these effects differ between net food exporters and importers. We also compare the magnitudes of these effects to the effects of energy market–specific shocks on net energy importers and exporters to gauge the relative importance of food market–specific shocks.

Third, previous studies focused on selected food-importing developing or advanced countries. In contrast, we examine a rich dataset of domestic output indicators for net food-importing and food-exporting economies, including both advanced and developing countries. In order to assess the channels through which global shocks are transmitted, we focus on heterogeneity among net food importers. In particular, we examine whether the household consumption response to negative GF shock is larger in absolute terms in countries where food expenditures represent a larger share of the household consumption baskets and where food trade deficits as a share of total food trade are

[2] Durevall et al. (2013) find that international food and goods prices have a long-run impact on domestic prices in Ethiopia. They also find that agricultural supply shocks had a significant impact on domestic food prices in the short run. Similarly, Ianchovichina et al. (2012) estimate the pass-through effects of international food prices to domestic food prices in Middle Eastern and North African countries and find that, on average, a 1-percent increase in world food prices increases domestic food prices by 0.2–0.4 percent. Minot (2011) finds similar results for 11 Sub-Saharan African countries. Dillon and Barrett (2015) examine the effects of global crude oil and maize prices on local maize prices in East African countries, finding that in 7 of 17 local markets, global oil prices have a larger impact on local maize prices than do global maize prices due to transportation costs. In addition, the welfare effects of domestic food price increases have been analyzed by Attanasio et al. (2013) in the context of Mexico. None of these studies takes into account reverse causality from global business cycles to global food prices, nor do they differentiate among underlying sources of changes in global food prices.

[3] The external balance effects of oil shocks have also been analyzed theoretically. See, for example, Bodenstein et al. (2011) and Backus and Crucini (2000), among others.

larger.

Fourth, a related body of literature focuses on the effects of terms-of-trade shocks on developing countries by assuming that such shocks are exogenous to small economies. While earlier studies generally find that terms-of-trade shocks explain a large share of the variation in output (approximately 30 percent) (Kose, 2002; Mendoza, 1995), more recent studies find that these shocks account for a much smaller share (about 10 percent) (Schmitt-Grohe and Uribe, 2015; Aguirre, 2011; Lubik and Teo, 2005).[4] Our empirical methodology has the advantage of capturing two sources of exogenous terms-of-trade shocks originating from energy and food markets, allowing us to shed more light onto how much of the variation in output is explained by these more exogenous components of terms-of-trade shocks.

Our findings can be summarized as follows. First, we find that international food prices are driven by a combination of global shocks rather than by a single shock. In particular, our results show that GD, GE, and GF shocks account for most of the variation in international food prices. This result is in line with the findings in the oil price literature.[5]

Second, our findings reveal that international food price fluctuations have very different impacts on domestic output depending on their source. A positive GD shock that increases global activity and international food prices has an expansionary impact on the domestic output of net food importers and exporters. On the other hand, a negative GF shock driving a surge in global food prices leads to a contraction in real domestic output among net food importers. This contraction is mainly explained by a decline in household consumption, a (relatively small) decline in government consumption, and a deterioration in the trade balance. By contrast, net food-exporting economies respond to a negative GF shock with an increase in investment and an improvement in trade balance, resulting in an expansion of domestic output. Compared to energy-related commodity shocks, the magnitude of the effect of a negative GF shock corresponds to approximately two-thirds of the effect of a negative GE shock.

Third, an examination of the heterogeneous effects of GF shocks on net food importers indicates

[4] Earlier studies find that terms-of-trade shocks explain approximately 30 percent of the variation in output (Kose, 2002; Mendoza, 1995). For oil-exporting countries, Spatafora and Warner (1999) find strong positive effects of terms-of-trade shocks on the components of aggregate demand, consumption, investment and government expenditures. In contrast, Schmitt-Grohe and Uribe (2015) find that terms-of-trade shocks explain only 10 percent of the variation in output using an SVAR model, which conflicts with previous findings that terms-of-trade shocks generally have large and important effects on business cycles in developing countries. Similarly, Aguirre (2011) finds that terms-of-trade shocks generate a smaller impact on macroeconomic aggregates in an SVAR model than in a business cycle model. Lubik and Teo (2005) find that interest rate shocks play a more important role as a source of business cycles compared to terms-of-trade shocks using a small open economy model.

[5] Kilian (2009) shows that a combination of shocks related to oil demand and supply drives global oil prices, and Charnavoki and Dolado (2014) shows that a combination of global shocks drives global commodity prices.

that the negative effects on household consumption are higher in absolute terms among countries where food expenditures represent a relatively high share of the household budget. In addition, we document that these effects are larger for countries that import a large share of their domestic food supply from abroad.

Finally, our findings are supportive of recent findings in the terms-of-trade literature. In particular, we find that approximately 8 to 14 percent of the share of the variation in output explained by the combination of GF shocks and GE shocks.[6] These commodity shocks also explain approximately 9 to 12 percent of the variation in investment and consumption and 14 to 21 percent of the variation in trade balance. Hence, although commodity-specific shocks explain a sizable portion of the variation in trade balance, the share of variation in domestic output explained by these shocks is modest.

The remainder of the paper is organized as follows. Section 2 presents the empirical methodology, including descriptions of the data, the estimation strategy, and the identification schemes for global shocks. Section 3 presents the empirical results. In particular, we report the dynamic responses of global and domestic economies to GF, GE, and GD shocks, focusing on the channels through which they are transmitted to net food-importing and food-exporting economies. Section 4 provides a robustness analysis of our results, and Section 5 concludes.

2 Empirical Methodology

2.1 Data

Our dataset is composed of two sets of variables. First, we use quarterly data from 1977:II to 2014:II for the international variables in the global SVAR model. Appendix A provides a list of variables, including descriptions, sources, and transformation codes. The non-stationary variables are stationarized by appropriate transformations (e.g., using growth rates and/or first differences). Our measure of global economic activity is the first principle component of eleven series representing real GDP; industrial production; volume of exports and imports for the world economy, the US, and the following large groups: OECD members, European Union members, and G7 members; and a global economic activity index constructed from dry cargo bulk freight rates by Kilian (2009).[7]

[6] The combination of GE shocks and GF shocks explains 8 percent of the variation in output among net food importers and net oil importers, 9 percent among net food exporters, and 14 percent among net oil exporters.

[7] In line with Charnavoki and Dolado (2014), we did not include GDP or industrial production data for individual country series because European countries are overrepresented, which makes the first principle component very similar to their real activity and, hence, a non-representative measure of world economic activity. In addition, quarterly GDP

We use the real price of crude oil as a measure of real energy prices by deflating the nominal crude oil price index provided by the IMF (a simple average of the Dated Brent, West Texas Intermediate, and Dubai Fateh prices) by the Manufacturing Unit Value (MUV) index provided by the World Bank[8] The real price of food is measured by a global food price index reported by the World Bank Global Economic Monitor (GEM) and deflated by the MUV index. The weights in the (nominal) global food price index is based on 2002-04 developing countries' export values, and the category with largest weights is grains, including rice, wheat, maize, barley, and soybeans.[9] Thus, our measure for real price of food largely reflects the weighted average of staple food commodity prices. Given that staple food commodities have the largest export shares, they are also the most integrated global food markets. Our measure of global inflation is the first principle component of implicit price deflators of GDP and consumer and producer prices for the OECD, European Union, G7 and the US.[10]

Second, we use annual data from 1980 to 2011 on domestic macroeconomic aggregates to assess the impacts of global shocks on individual countries based on their net import/export status. The data source is the PWT 8.1. Following standard country selection procedures from the empirical growth literature (Hausmann et al., 2005; Mankiw et al., 1992), we eliminate from our sample (i) all countries with populations of less than 1 million, (ii) all countries with fewer than 30 data points in the PWT, (iii) all countries with low-quality data (classified as poor data quality category "D" in the PWT 6.1), and (iv) all countries with designated outlier values in the PWT. These country selection criteria produce a sample of 82 countries. In Section 4, we examine the robustness of our results to the inclusion of different country groups in the sample.

We use annual data because international data on national accounts are available only at an annual frequency for most countries. In line with Kilian et al. (2009), in order to analyze the transmission of global shocks to individual countries in Section 3.2, we construct measures of an-

and industrial production data for fast-growing emerging markets are only available after the 1990s. However, the inclusion of world volume of trade allows us to capture the real activity of these economies.

[8]We use the real price of crude oil rather than a composite index of real energy prices that includes natural gas and coal for two reasons. First, oil is by far the most consumed source of energy worldwide; thus, any energy price index is very highly correlated with oil prices. Second, in the next stage of our analysis, we are interested in the effects of global shocks on the components of output, and the classification of net oil exporters and net oil importers is less prone to measurement error than a classification that includes a variety of traded energy sources. Appendix Figure A4 and Table A4 show that our results are robust to the use of a real energy price index that includes the prices of coal, natural gas, and crude oil.

[9]The World Bank Global Economic Monitor (GEM) database reports that grains have a total weight of 69%, while other food commodities such as meat, sugar, and oranges have a total weight of 31% in the global food price index.

[10]The availability of quarterly data for these series is the main reason for their inclusion, which is in line with Charnavoki and Dolado (2014). We take the first difference of these inflation series to eliminate the disinflationary trend throughout the world as we construct a global inflation factor.

nual global shocks by averaging quarterly structural innovations for each year. Next, we use a distributed lag model to estimate the effects of these annualized global shocks on individual countries' components of output. The data series we use from the PWT 8.1 are real GDP, real domestic absorption, real household consumption, real government consumption, real investment at constant 2005 national prices (in million 2005 US$) and trade balance as a share of GDP (as a percentage).[11]

As Figure 1 illustrates, there are large cross-country differences in net exports of oil and net exports of food (as shares of GDP), with little overlap between them. To account for these differences in specialization, our analysis focuses on two country classifications. First, we classify countries based on their food trade account: net food importers or net food exporters. A country is classified as a net food importer (exporter) if its average net food exports are negative (positive) over the 1980–2011 period. We calculate the net food exports of each country using FAOSTAT data as the difference between the export value of food and animal products and the import value of food and animal products. Among net food exporters, we exclude countries that are net exporters of tropical cash crops and net importers of grains because our index for global food prices is predominantly composed of grains rather than tropical cash crops. Second, we classify countries based on their oil trade account: net oil importers or net oil exporters. A country is classified as a net oil importer (exporter) if its average net fuel exports are negative (positive) over the 1980–2011 period. Appendix A includes a list of the countries included in each classification.

2.2 Empirical Model

In this section, we first provide an overview of our empirical strategy at the global level by introducing the SVAR model that allows for the identification of the main shocks driving global food and energy prices. Second, we present the distributed lag model at the country level that will be used to analyze the transmission of global shocks to domestic macroeconomic aggregates. Let the SVAR(8) model of 4×1 vector Y_t be written as follows:

$$B_o Y_t = B_1 Y_{t-1} + \cdots + B_p Y_{t-8} + \varepsilon_t, \tag{1}$$

where Y_t contains global economic activity, growth rate of real oil price, growth rate of real food price, and global inflation; $\varepsilon_t = (\varepsilon_{D,t}, \varepsilon_{E,t}, \varepsilon_{F,t}, \varepsilon_{S,t})' \sim (0, I_4)$ denotes the structural shocks with the

[11]The PWT also provide national income data in PPP terms. However, this might overstate the expansion or contraction of domestic output, which has a large component of non-tradables. In order for our results to be comparable with those of other studies, as well as to avoid overestimating the effects of global shocks, we use data measured at constant 2005 national prices (in million 2005 US$). Appendix A provides a list of the variables used in the analysis.

identity covariance matrix, and $\{B_o, \ldots, B_8\}$ are the structural coefficient matrices. The structural parameters and shocks cannot be estimated directly. However, if we multiply both sides of Equation (1) by B_o^{-1}, we obtain the reduced-form VAR model:

$$Y_t = A_1 Y_{t-1} + \cdots + A_p Y_{t-8} + e_t, \tag{2}$$

where $e_t \sim (0, \Sigma)$ denotes the reduced-form errors, and $\{A_1, \ldots, A_8\}$ are the reduced-form coefficient matrices, which can be estimated. The most common alternatives to estimate reduced-form parameters in (2) are Bayesian techniques and least-squares methods. In this paper, we use least-squares methods to avoid the complications arising from Bayesian estimations of SVAR models with sign restrictions. Baumeister and Hamilton (2015) show that in a standard sign-restriction setting, the prior and the number of variables in the VAR model play crucial role in Bayesian inference on structural parameters. In particular, asymptotically the height of the posterior for a parameter is simply a constant times the height of the prior, that is, priors implicitly influence the posteriors beyond the aim of the researcher.

The relation between the structural and reduced-form errors is $e_t = B_o^{-1}\varepsilon_t$, which implies that $\Sigma = B_o^{-1}B_o^{-1\prime}$. The least-squares estimation provides $\hat{e}_t$ and $\hat{\Sigma}$; however, they are not enough to recover structural parameters, particularly B_o^{-1}, without further restrictions on the model. One of the most common ways to identify B_o^{-1} is to use zero restrictions, particularly the Cholesky decomposition of $\hat{\Sigma}$. In this decomposition, one needs to assume that B_o^{-1} is lower triangular with unit diagonals such that $\hat{\Sigma} = \hat{B}_o^{-1}\hat{B}_o^{-1\prime}$. However, in this identification scheme, the ordering of global variables is crucial such that a variable is not affected on impact by the variables that are placed after itself. An alternative method, which we pursue in this paper, is to use sign restrictions combined with zero restrictions, which relies on the signs of the relationships between variables and shocks (Canova and Nicolo, 2002; Uhlig, 2005). Sign restriction identification is based on the fact that there are infinitely many ways to factorize Σ into $\Sigma = B_o^{-1}B_o^{-1\prime}$, but not all factorizations will comply with the sign restrictions imposed on B_o^{-1}. Note that given an orthonormal matrix Ξ, i.e., $\Xi\Xi'$ is the identity matrix, one can write $\Sigma = B_o^{-1}B_o^{-1\prime} = B_o^{-1}\Xi\Xi' B_o^{-1\prime} = (B_o^{-1}\Xi)(B_o^{-1}\Xi)' = \widetilde{B}_o^{-1}\widetilde{B}_o^{-1\prime}$. Hence, the idea of the identification lies is choosing Ξ such that $\widetilde{B}_o^{-1}$ satisfies the desired sign restrictions. As we explain in the next section and show in Table 1, we also need a zero restriction in the $(2, 3)$ position of B_o^{-1}, which corresponds to the contemporaneous effect of food shocks on real oil prices. For the zero restriction, we employ Givens rotation matrices on Ξ, following the steps in

Baumeister and Benati (2013). Moreover, we have elasticity restrictions imposing certain bounds on the elements of $\widetilde{B}_o^{-1}$, as explained in detail in the next section. The identification procedure is as follows:

1. Decompose the estimated covariance matrix $\hat{\Sigma} = \hat{B}_o^{-1}\hat{B}_o^{-1\prime}$ by the Cholesky decomposition.

2. Take the QR decomposition of a random (4×4) standard normal matrix W. That is, $W \sim \mathcal{N}(0, I_4)$, where I_4 is the (4×4) identity matrix, and $W = \Xi R$ with $\Xi\Xi' = I_4$. Define the candidate impact matrix as $\bar{B}_o^{-1} = \hat{B}_o^{-1}\Xi$. Note that $\bar{B}_o^{-1}$ does not necessarily satisfy any restrictions yet.

3. In this step, zero restrictions are imposed. Define the rotation angle $\xi = \arctan(\bar{B}_o^{-1}(2,3)/\bar{B}_o^{-1}(2,2))$, where arctan is the inverse tangent function, and $\bar{B}_o^{-1}(i,j)$ denotes the (i,j) element of the candidate contemporaneous effect matrix $\bar{B}_o^{-1}$. Next, generate the Givens rotation matrix:

$$G = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos(\xi) & -\sin(\xi) & 0 \\ 0 & \sin(\xi) & \cos(\xi) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

4. Define the final candidate matrix as $\widetilde{B}_o^{-1} = \bar{B}_o^{-1}G$, where $\widetilde{B}_o^{-1}$ has a zero in the $(2,3)$ position due to the Givens rotation matrix. Finally, if $\widetilde{B}_o^{-1}$ satisfies the required sign restrictions and its elements are within the elasticity bounds imposed by the researcher, then keep $\widetilde{B}_o^{-1}$; otherwise, discard it.

5. Repeat steps 2–4 many times, saving each $\widetilde{B}_o^{-1}$ matrix that satisfies the restrictions (sign, zero, and elasticity), and record the impulse response functions (IRFs) corresponding to each $\widetilde{B}_o^{-1}$.

As a result of the estimation, we have a collection of $\{\widetilde{B}_o^{-1}(m)\}_{m=1}^{M}$ matrices and M-many IRFs associated with each $\widetilde{B}_o^{-1}(m)$ matrix. In the global analysis, we will plot the equally tailed 68% credible set of IRFs along with the median IRF, where the median is taken at each time horizon.

Having estimated reduced-form residuals $\hat{e}_t$ and M-many draws for B_o^{-1} matrices, one can easily compute structural shocks by $\hat{\varepsilon}_t(m) = \widetilde{B}_o(m)\hat{e}_t$ for every m. Note that for the m^{th} accepted draw, $\hat{\varepsilon}_t(m) = \{\hat{\varepsilon}_{D,t}(m), \hat{\varepsilon}_{E,t}(m), \hat{\varepsilon}_{F,t}(m), \hat{\varepsilon}_{S,t}(m)\}$ contains 4 different structural shocks that are mutually orthogonal. Let X_t denote a stationary macroeconomic variable of a country. To compute the transmission of a global structural shock—say, the demand shock—to X_t, we will estimate the following distributed lag model M-many times:

$$X_t = \alpha_D + \beta_{D,0}\hat{\varepsilon}_{D,t}(m) + \cdots + \beta_{D,3}\hat{\varepsilon}_{D,t-3}(m) + u_t. \tag{3}$$

As a result, we obtain a collection of estimated dynamic multipliers $\{\hat{\beta}_D(m)\}_{m=1}^{M}$, where $\hat{\beta}_D(m) = \{\hat{\beta}_{D,0}(m), \ldots, \hat{\beta}_{D,3}(m)\}$, which indicates the transmission of a GD shock to an individual economy's X_t variable over four periods (the current period and three future periods). Note that because the structural shocks are orthogonal to each other, it would not create any bias in estimators to include only one structural shock and omit the other three shocks when estimating (3). The median pass-through effect in the country of interest is simply the median of $\hat{\beta}_D(m)$ over m. To compute the median response of a group of countries—say, food exporters—we take the median of each food exporter's median response. Finally, we repeat this analysis for 4 different groups of countries (food exporters, food importers, oil exporters, oil importers), 6 different macroeconomic variables, and each structural shock.

2.3 Identification of Structural Shocks

We focus on the identification of the four global structural shocks: (i) an unanticipated change in global demand (a GD shock), $\varepsilon_{D,t}$, (ii) an unanticipated change in the global price of energy (a GE shock), $\varepsilon_{E,t}$, (iii) an unanticipated change in the global price of food (a GF shock), $\varepsilon_{F,t}$, and (iv) a shock to global supply that is not related to commodity markets (a GS shock), $\varepsilon_{S,t}$. The second and third shocks aim to capture unexpected changes in the real prices of energy and food that are orthogonal to the other two innovations. Shocks can result from unanticipated changes in the supplies of energy and food, as well as demand shocks that are specific to these markets, such as changes in precautionary demand for energy or food commodities.

Our benchmark identification scheme relies on sign restrictions and some elasticity bounds. However, we also use a more traditional recursive ordering to present our results, which serves as a robustness check. In the next step, we examine the effects of these global shocks on domestic output and its components for individual countries, assuming that the rest of the world does not instantaneously respond to the domestic economic conditions in a single country.

Sign Restrictions: In the benchmark identification scheme, we impose sign restrictions on the IRFs of global variables to global shocks. Our identifying assumption is that IRFs in the first quarter after a shock have the signs presented in Table 1. A GD shock results in increased global activity, real energy and food prices, and inflation. A negative GE shock implies a rise in real energy prices, a rise in real food prices due to rising transportation costs, an increase in inflation and a fall in real activity. A negative GF shock results in rising real food prices, higher inflation, no contemporaneous effect on real energy prices, and decreasing real activity. Finally, a positive GS shock is associated with a decline in inflation, an increase in real activity, and increases in energy and food prices due to falling inflation.

One of the concerns with using sign restrictions in a VAR model is that these restrictions do not result in point estimates of the IRFs; they produce a set of IRFs in which the impulse responses have the specified signs. The set identification implies that there is a set of impact matrices satisfying the identifying assumptions rather than a unique impact matrix. This set of impact matrices implies different structural models related to each matrix, and therefore, the medians or quantiles of the IRFs are associated with different structural models, which complicates the interpretation of the results. To restrict this set, it is common to impose plausible elasticity restrictions on the IRFs (Charnavoki and Dolado, 2014; Kilian and Murphy, 2014). These extra restrictions reduce the set of admissible structural models by eliminating counterintuitive or unrealistic responses. In particular, we impose elasticity restrictions on the oil price elasticity of demand, the food price elasticity of demand, and the food price elasticity of oil prices. For the first two elasticity restrictions, we accept draws that satisfy $-14\% \leq B_o^{-1}(1,2) < 0$ and $-3\% \leq B_o^{-1}(1,3) < 0$, which after proper scaling, correspond to reported estimates of the short-run elasticity of advanced countries' GDP to real oil prices and real food prices reported in the literature (Galesi and Lombardi, 2009; Hamilton, 2008).[12] For the food price elasticity of oil prices, we already imposed a zero restriction on a contemporaneous response. In addition, to restrict the response of oil to food price shocks with a one-period lag, we impose a bound on the short-run elasticity of oil that corresponds to approximately $\pm 0.1\%$. One can compare this number to the demand elasticity of oil prices with one lag, which is approximately 5%.

Recursive identification: We provide an alternative scheme that relies on recursive ordering to

[12] Galesi and Lombardi (2009), using data 33 countries from January 1999 to December 2007, estimated a global VAR model to examine the responses of domestic inflation and industrial production to GF shocks and GE shocks. Their results indicate that the short-run elasticity of industrial production with respect to commodity shocks is small. A one-standard-error shock to global food prices (an approximately 2.7% increase within three months) leads to a 0.2 percent decline in U.S. industrial production within three months. However, they find that most European countries respond positively to GF shocks. The imprecisely estimated responses with mixed coefficients may result from not taking into account reverse causality from global demand to global food prices. Using data for 1967–1992, (Mork et al., 1994) find that a one-percent increase in oil price generates a decline in GDP of 0.015 percent in the U.S., 0.036 percent in Germany, 0.047 percent in the U.K., and 0.022 percent in Japan.

examine the robustness of the results from the benchmark identification scheme. In particular, we assume that the impact matrix of the global variables is lower triangular, as presented in Table 2. Global economic activity is ordered first, followed by the real energy price index, the real food price index, and global inflation. This ordering assumes that the GS shock does not have contemporaneous effects on global economic activity, real energy prices, or real food prices, while GE shocks and GF shocks affect global inflation on impact, as the latter series contain changes in the prices of these commodities by definition. We assume that a GE shock has a contemporaneous effect on the real price of food, as changes in transportation costs affect their real prices on impact, while a GF shock has no contemporaneous effect on real energy prices, as the cost of food is not a direct input in energy production. Finally, we allow a GD shock to affect all four variables contemporaneously.

3 Empirical Results

In this section, we present the empirical results from our SVAR model. First, we provide an overview of the time series of the four global variables and show their dynamic responses to global shocks, relying on the sign and recursive identification schemes described in the previous section. Second, using detailed data on the macroeconomic aggregates of individual countries, we present the dynamic effects of global shocks on domestic output and its components in real terms for different categories of countries based on their trade composition.

Table 3 displays the forecast error variance decomposition based on the sign-restricted identification scheme. The table shows that 96% and 95% of the variation in real prices of energy and food, respectively, are explained by GD, GE, and GF shocks. As GS shocks explain a very small percentage of the variation in commodity prices, for brevity, we focus on the transmission of the other three shocks to individual economies.[13]

3.1 Global Shocks

Figure 2 provides plots of the global variables for real activity, real price of energy, real price of food, and inflation. The global economic activity index captures the key global business cycles from 1977:II to 2014:II, including the recessionary episodes of the early 1980s, the European exchange rate mechanism crisis of the early 1990s, the East Asian crisis of 1997–1998, the collapse of the

[13] Table 4 shows that the FEVD estimates are similar under a recursive identification scheme.

dot-com bubble and the 9/11 attacks of the early 2000s, and the period from the Great Moderation to the Global Recession of 2007–2009. Real oil prices reflect major developments in the global energy market: the uncertainty following the Iranian revolution of 1978–1979 and the Iran-Iraq war of the early 1980s, the decline in prices with the East Asian crisis of 1997–1998, the rising industrialization and urbanization in emerging markets that boosted demand in the 2000s, and the collapse of prices during the Global Recession. Real food prices capture major supply shortages in food production, including the droughts in the Midwestern US and Russia of the early 1980s and mid-1990s, the Midwestern droughts of the late 1980s, the Australian droughts of the late 2000s, the Russian droughts and subsequent ban on grain of 2012, and the heatwave that led to the corn production shortfall of 2013. In addition, real food prices reflect rising demand for food commodities in the run-up to the Global Recession, as well as the collapse of this demand during the Global Recession of 2007–2009. Finally, the global inflation index reflects the inflationary episodes of the early 1980s, the relatively low levels of inflation of the 1990s due, in part, to positive productivity shocks, the rising inflation of the late 2000s as global commodity prices began to trend upward, and the subsequent deflation of the 2010s as commodity prices began to decline.

Figure 3 presents the IRFs of the global variables to one-standard-deviation shocks in the four global innovations, imposing the benchmark sign and elasticity restrictions (indicated by the shaded area representing the 68 percent error band around the median) and the recursive identification scheme (indicated by the solid line with the 68 percent confidence interval). The sign restriction and recursive identification schemes provide similar results. The initial response of a global variable to its own shock corresponds to the estimated standard deviation of that variable. A positive GD shock gives rise to a substantial increase in global economic activity, increases in real oil and food prices as large as half of their own standard deviations, and an increase in global inflation, with the largest effect taking place within the first two quarters. A negative GE shock pushes up the real price of oil and global inflation, reduces global economic activity and increases the real price of food with a secondary effect after half a year. A negative GF shock leads to higher real food prices, temporarily increases in global inflation, depressed real activity over the long run by almost one standard deviation (the decline is slightly smaller compared to a GE shock), and no significant impact on real energy prices. Finally, a positive GS shock results in an increase in real activity over both the short and long run, reduces inflation due to productivity improvements, and increases the real prices of energy and food with no significant long-run effects.

There are two differences between the sign restriction and recursive identification schemes. First, under the latter, the negative effects of GE shocks and GF shocks on real activity are delayed for two quarters. The identification scheme with sign restrictions avoids this puzzling result, which is also reported in Charnavoki and Dolado (2014) and Kilian (2009), by imposing a negative response of real activity to GE shocks and GF shocks contemporaneously.[14] Second, under the recursive identification scheme, the positive effects of the GS shock on real energy and food prices are delayed, very close to zero, and appear temporary. By imposing a positive response of the real commodity prices to a positive GS shock, the sign identification avoids these puzzling results.

Figure 4 illustrates the historical decompositions of global economic activity, real food and energy prices, and global inflation using the sign restriction scheme in Table 1. It reflects the extent to which each global shock has contributed to changes in the global variables during the period of analysis. Both identification schemes yield similar results, which can be summarized as follows. First, GE and GS shocks account for most of the changes in the global real activity throughout this period, while GD and GF shocks seem to have played smaller roles. Second, the volatility of global inflation has to be attributed to a combination of all four shocks, but the contributions of GD and GS shocks are larger than those of GE and GF shocks. Third, GE shocks contribute to a large portion of the changes in real energy prices, while GD shocks play a secondary role. Finally, a large portion of the volatility in real food prices is attributed to GE and GF shocks and, to a lesser extent, to GD shocks.[15]

3.2 Transmission of Global Shocks to Individual Economies

We use a distributed lag model to analyze the effects of global commodity price shocks to domestic output and its components for individual countries. In line with Kilian et al. (2009), because the domestic macro data are recorded annually, we construct measures of annualized global shocks by averaging the quarterly structural innovations in a given year in the following way. Let $\hat{\eta}_t(m)$ denote

[14] Due to the small elasticity bounds that we impose, the negative response of global activity to GE and GF shocks on impact is difficult to see in Figure 3, although it is present.

[15] The median variance decompositions for the four global variables shown in Tables 3 and 4 imply that the commodity-specific shocks – GE and GF shocks – explain most of the fluctuation in real energy and food prices (78 and 71 percent in the sign-identified model and 75 and 69 percent in the recursive model, respectively). GD shocks account for 12 percent of real energy and real food prices. Further, GE shocks explain 12 percent of the variation in real food prices. Finally, GS shocks explain the smallest amount of variation in commodity prices: 4 percent in the case of real energy prices and 5 percent in the case of real food prices.

annualized structural shocks, then:

$$\hat{\eta}_{j,t}(m) = \frac{1}{4}\sum_{q=1}^{4} \hat{\varepsilon}_{j,t,q}(m) \text{ for } j \in \{D, E, F\},$$

where $\hat{\varepsilon}_{j,t,q}(m)$ refers to the estimated j^{th} structural shock in the quarter q of the year t. Moreover, $m = 1, \ldots, M$ denotes the accepted m^{th} draw for the sign-restriction identification procedure (for the details, refer to Section 2.2). We treat these shocks as predetermined with respect to the domestic economies. We are interested in estimating the responses of domestic macroeconomic aggregates to annualized global shocks. For this purpose, we use a distributed lag model, with an impulse response horizon of 3 years[16] in the following pass-through equation:

$$X_t = \alpha_j + \beta_{j,0}\hat{\eta}_{j,t}(m) + \cdots + \beta_{j,3}\hat{\eta}_{j,t-3}(m) + u_t, \tag{4}$$

where X_t is a stationary country-specific macro variable, $\hat{\eta}_{j,t}(m)$ is the j^{th} structural shock for $j \in \{D, E, F\}$, and $\beta_{j,i}(m)$ is the dynamic multiplier for shock j lag $i = 0, \ldots, 3$. As a result, for the pass-through of the m^{th} global shock, we estimate M-many dynamic multipliers for 4 different horizons. The median pass-through is computed by taking the median of the collection of the estimated dynamic multipliers $\{\hat{\beta}_{j,0}(m), \ldots, \hat{\beta}_{j,3}(m)\}_{m=1}^{M}$ over m, denoted as $\overline{\hat{\beta}}_j$. Hence, a country-specific median impulse response $\overline{\hat{\beta}}_j$ is obtained. In order to compute the response of a group of countries—say, food exporters—we take the median of each food-exporting country's $\overline{\hat{\beta}}_j$, and refer to the resulting median impulse response as "the response of food exporters to global shock j". Note that we estimate regression (4) separately for each j, that is, for each GD, GE, and GF shock. Our approach relies on the assumption that these structural shocks are mutually uncorrelated. Since the structural shocks $\varepsilon_{j,t}$ in the SVAR model are martingale difference sequences and are mutually uncorrelated for each j, their annualized counterparts will also be mutually uncorrelated. Hence, including only one shock and omitting others will not create bias in the estimation.

3.2.1 Transmission of Global Shocks: Net Food Importers and Exporters

Figure 5 displays the responses of domestic output and its components to a GF shock that increases global real food prices by one standard deviation (4.07%) on impact in Panel (a) and a GD shock that

[16]Impulse responses at longer horizons are potentially of interest given that demand for commodities may adjust slowly to surges in prices. However, this is not feasible given the short span of the time series data that are available. Overall, the estimates are robust to the inclusion of two to three years of additional lags.

increases global economic activity by one standard deviation (0.32%) on impact in Panel (b). The plotted impulse responses are point-by-point medians of the impulse responses for net food exporters (indicated by dark solid lines) and for net food importers (indicated by gray dashed lines). For net food-importing countries, Panel (a) shows that a negative GF shock of one standard deviation generating an on-impact decline of 0.36% in domestic output in real terms, on average, is driven by declines in the trade balance (0.34%) and in domestic absorption (0.17%). The latter is explained by a strong and steady decline in household consumption (0.48%) and a much smaller decline in government consumption (0.07%), as one would expect given that higher food prices function are stronger constraints on household budgets. In year 2, the decline in household consumption peaks, and investment expenditures begin to fall in response to the continuing deterioration of domestic consumption. As food commodities are not major inputs into production, a negative GF shock has a negative impact on investment following a contraction in domestic demand.

We find opposite and shorter-lived effects of a GF shock on domestic output among net food-exporting economies. Panel (a) in Figure 5 indicates that a negative GF shock has a positive effect on trade balance on impact, resulting in higher domestic output and higher domestic absorption that peak in year 1. The increase in domestic absorption is mainly explained by a strong increase in investment on impact, which continues to increase in year 1. Household consumption and government consumption begin to increase in year 1, responding to the strong rise in investment expenditures. Government expenditures continue to rise in year 2, reflecting the increase in government revenue from windfall revenues in the export sector. Overall, a rise in global food prices generated by a negative GF shock is transmitted to net food exporters through the trade channel, which strongly stimulates investment activity. This results in lagged expansion of household and government consumption. The positive effect on domestic output peaks in year 1, subsequently fading away. The contrast with net food importers is interesting in that among countries that import food, the higher food prices generated by a negative GF shock result in the contraction of household expenditures, particularly in countries in which food expenditures represent larger shares of household budgets. When combined with a trade deficit, the result is a contraction in domestic output. Hence, while the primary channels of transmission for food-importing countries are the consumption and trade channels, for food-exporting countries, they are the trade and investment channels.[17]

By contrast, Panel (b) of Figure 5 shows that a positive GD shock has an expansionary impact

[17] We examine the robustness of these results in Section 4. The results are robust to the use of alternative restrictions in identification, alternative measures of global factors, and different country samples.

on the domestic output of both net food importers and net food exporters. Both groups experience increases in trade balances in response to higher global economic activity and international trade. This has large positive impacts on domestic output and domestic absorption, which are largely driven by a strong increase in investment expenditures and a rise in household consumption. For both groups, government consumption declines on impact, which might reflect countercyclical fiscal policy. This countercyclical stance persists for the rest of the period among food-importing countries, while it is reversed among food-exporting countries. The positive effect on domestic output in response to a positive GD shock peaks in year 1; it declines thereafter, although it remains positive throughout.

3.2.2 Transmission of Global Shocks: Net Oil Importers and Exporters

Figure 6 displays the effects of a negative GE shock and a positive GD shock on the different aggregate demand components of net oil-importing and oil-exporting economies. First, Panel (a) illustrates that a negative GE shock produces a contractionary effect on net oil importers with a one year lag, while it generates an immediate expansionary effect on net oil exporters that peaks in year 1. Among net oil importers, the negative GE shock has a negative and protracted effect on trade balances on impact and lagged negative effects on investment and household consumption that peaks in year 2. Government consumption responds positively to a rise in global energy prices resulting from a negative GE shock, which results from the fuel subsidies that many governments implement to reduce the contractionary effects of such shocks. However, this rise in government spending does not prevent the eventual decline in domestic output. This leads to a large negative effect on final domestic demand and domestic output in year 2. A GE shock of one standard deviation (corresponding to a 9.3% increase in global oil prices in real terms) generates a 0.56% decline in domestic output among net oil-importing economies in year 2. This is mainly explained by a decrease in investment expenditures of 2.89%, followed by a decrease in the trade balance of approximately 0.11% and a decline in household consumption of 0.55%. On the other hand, net oil-exporting economies experience a substantial improvement in their trade balance in response to a positive GE shock. The boost in net export earnings increases household consumption and government spending on impact, which remain high in year 1, and sharply increases investment in year 1. Hence, on average, governments spend windfall revenues from taxes in the export sector instead of implementing countercyclical fiscal policies. The total impact on domestic output is an immediate 0.37% increase, which remains high in year 1 and fades away thereafter.

By contrast, Panel (b) of Figure 6 illustrates that a positive GD shock generates similar effects on the aggregate demand components of net oil importers and net oil exporters. The increases in global economic activity and international trade driven by a positive GD shock improve the trade balances of both groups of countries, although the timing differs slightly. For oil importers, the effect is immediate and fades away in year 2; for oil exporters, it takes place in year 1 and remains positive in year 3. As a result, a positive GD shock has a strong expansionary impact on domestic output and final domestic demand, peaking in year 1. The expansion in the latter is mainly due to rising household consumption and investment for both groups of countries. A positive GD shock has a positive impact on the government expenditures of net oil exporters, while it has a roughly null effect on the government expenditures of net oil importers. The latter is likely an outcome of countercyclical fiscal policy among some net oil exporters.

Our results on the effects of global shocks on oil importers/exporters are similar to those documented in the literature. Kilian (2009), Peersman and Van Robays (2009), and Baumeister et al. (2010) find that the effects on the United States, the euro area economy, and industrialized countries vary substantially depending on the source of oil price fluctuations. Exogenous shocks to the supply of crude oil lead to a permanent fall in economic activity in net oil-importing economies, while they generate expansion in net oil exporters. On the other hand, positive GD shocks that also lead to a rise in global oil prices generate output expansion in both oil importers and oil exporters. Finally, these studies find that oil-specific demand shocks lead to a temporary decline in output in both groups of economies. In our framework, negative GE shocks capture the combined effect of oil supply shocks and oil-specific demand shocks in a reduced-form specification. Given that the effects of oil-specific demand shocks tend to be temporary, the negative GE shocks generally reflect oil supply shocks over time.

When we compare the results from this section to those from the previous section, we find that the peak effects of a (one-standard-deviation) negative GE shock on domestic output are roughly one and a half times as large as those of a (one-standard-deviation) negative GF shock for importing countries. While the former leads to a contraction in output of approximately 0.56% among net oil importers, the latter generates a contraction of approximately 0.36% among net food importers. Given that both shocks generate large declines in household consumption that are proportional to the fall in output observed among importing economies, these shocks have a large bearing on consumer welfare. To determine which countries suffer more from adverse GF shocks, in the next section, we compare household consumption effects based on the shares of food expenditures in household budgets and the food trade balance of net food-importing countries.

3.2.3 Heterogeneity among Net Food Importers by Share of Food Expenditures in Household Budgets and Net Food Trade Balance

We would expect the effects of a negative GF shock on household consumption to be larger in food-importing countries whose typical consumers spend relatively high shares of their household budgets on food. Figure 7 provides a scatter plot of the initial response of household consumption to a negative GF shock and the share of food expenditures in the household budget. We observe that countries with larger shares of household food expenditures have stronger responses, in absolute terms, to negative GF shock. For example, in low-income countries, such as Benin, Mali, and Nepal, where consumers spend close to one-half of their income on food, the response of household consumption to GF shocks is rather large. On the other hand, the high-income countries concentrated in the upper left-hand side of the graph have relatively small responses to GF shocks, on average. Middle-income countries are located in the middle range. Thus, the share of the average household budget spent on food is an important channel through which GF shocks affect aggregate demand.

Another channel through which the effects of GF shocks are transmitted is the extent to which countries import food from the rest of the world. If a country consumes mostly domestically produced food commodities, an increase in global food prices generated by a GF shock would have no impact on its domestic demand. Figure 8 shows that countries with higher food trade deficits as a share of their total food trade have stronger negative initial responses to GF shocks. This relationship also explains the existence of some of the outliers in Figure 7. For example, consumers in South Korea spend a relatively small share of their household budgets on food, but its net food deficit is over 70% of total food trade, resulting in a relatively large initial response of household consumption to a GF shock. Another example is Albania, which has a mid-range food share of approximately 26% but a net food deficit of over 80% of total food trade, resulting in a large response of household consumption to a GF shock. Hence, countries that produce a relatively large proportion of their food are better able to insulate themselves from the effects of GF shocks.

3.2.4 Variance Decomposition of Output and Household Consumption

One common way to assess the importance of a global shock to domestic output fluctuations is to examine the share of the variance of macroeconomic aggregates explained by the shock. Table 5 presents the fractions of domestic output and its components explained by global shocks. The first three columns report the variation explained by each shock and its three-period lags, as in Equation (3). The last column reports the variation explained by GE shocks and GF shocks combined, as well as their one-period lags. The latter represent the variation explained by external commodity shocks, which roughly corresponds to the estimated variation explained by terms-of-trade shocks in the literature. The estimates in Panel (b) show that, on average, these shocks explain 10 to 17 percent of the variation in output, depending on the country grouping. Several interesting insights emerge from the table. First, GF shocks explain a larger portion of the variance in output for net food exporters (17%) than for net food importers (10%). This results from the larger variations in investment and government consumption that are explained by GF shocks for net food-exporting economies. Specifically, GF shocks explain 11% (9%) of the variation in investment and 14% (10%) of the variation in government consumption for net food exporters (importers). Although a larger fraction of variation in trade balance is explained by GF shocks for net food importers (8% compared to 13% for net food exporters), this difference does not dominate the former difference in variation. Finally, Panel (c) shows that an equal fraction of the variation of household consumption (13%) is explained by GF shocks for both net food importers and exporters.

We also find that GE shocks explain more variation in output for net oil importers (15%) compared to net oil exporters (13%). This difference is due to the higher fractions of trade balance, household consumption, and investment explained by GE shocks for net oil importers than for net oil exporters. The differences in household consumption and investment on one hand and in government consumption on the other seem to offset each other, leaving the variation in domestic absorption explained by GE shocks the same. Hence, the difference seems to be explained by the higher portion of the trade balance that is explained by GE shocks for net oil importers than for exporters.

Finally, the combination of GE and GF shocks reported in column (4) of Table 5 indicates that commodity-specific shocks combined explain 8% of the variation in output for net food importers and net oil importers, 9% for net food exporters, and 14% for net oil exporters. These combined shocks also explain 9 to 12% of the variation in components of domestic demand and 14 to 21% of the variation in trade balance. Thus, although commodity-specific shocks explain a sizable portion of the variation in trade balance, the effects on domestic aggregate demand and final output are rather modest. This evidence is in line with recent findings documented by Schmitt-Grohe and Uribe (2015) that terms-of-trade shocks explain approximately 10% of variation in output among developing countries. If we restrict our sample to developing countries, our results for the median do not significantly change, as we include a large number of developing countries in our sample.[18]

3.2.5 Historical Decomposition of Output for Net Food Importers and Exporters

Figure 9 decomposes the median output of net food importers on the left-hand side (a) and that of net food exporters on the right-hand side (b) to examine the driving forces of large fluctuations in output among these economies. Actual denotes the median output growth rate, whereas the estimated effect denotes the median of the estimated output growth in a regression with a single global shock. It shows that a large portion of output expansion from 2003 to 2007 was driven by GD shocks for both groups. However, negative GF shocks that increased global food prices led to contractions of output among net food importers between 2005 and 2007, while they contributed to expansions of output among net food exporters during the same period. GF shocks appear to have had smaller and temporary effects on output during the 1980s for both groups, and negative GD shocks in the early 1980s explain a large portion of the contraction in output observed in these countries. On the other hand, positive GF shocks around 1997 decreased global food prices after the end of large-scale droughts led to reduced output among net food exporters, while the opposite effects can be observed for net food importers.

4 Robustness Analysis

In this section, we provide a robustness analysis of our results. Our analysis focuses on four main robustness checks: (i) alternative identification methods, including the use of the recursive identification scheme in the domestic-level analysis and removing or relaxing the bounds restrictions in the sign-identified SVAR model; (ii) alternative measures of global factors, including the replacement of the crude oil price index with a composite energy price index and the replacement of the global economic activity factor with Kilian's index of global economic activity; and (iii) alternative country samples. We present the results of the domestic IRFs and variance decomposition in Appendix B.

4.1 Alternative Identification Methods

We test whether our results are sensitive to two sets of changes in identification. First, we conduct a robustness analysis using recursive identification. We presented the robustness of our results

[18] We investigate the robustness of these results in Section 4. The results are robust to using alternative restrictions in identification, alternative measures of global factors, and different country samples.

to recursive identification in the global SVAR model. We now provide a robustness check of our main results in the domestic-level analysis by examining whether the transmission of GF and GD shocks to domestic economies vary and determining how much of the variation in domestic output is explained if we use a recursive identification. Figure A1 presents the median IRFs for net food exporters (darker solid red line) and net food importers (lighter dashed red line) using recursive identification. The black/gray lines represent our baseline results for sign identification. The effects of GF shocks estimated by recursive identification are very similar to those estimated by sign restrictions. The effects of GD shocks are also similar, but recursive identification estimates slightly larger effects on domestic output in response to GD shocks. This could be because recursive identification leaves out some of the contemporaneous feedback effects from other global variables to global economic activity. Moreover, Table A1 presents the share of variance of components of domestic output explained by global shocks using recursive identification. Similar patterns to Table 5 are evident. Individual GD, GE, and GF shocks explain 10 to 19 percent of the variation in domestic output. GF shocks explain a larger fraction of the variation in output for net food exporters than for importers, and GE shocks explain a larger fraction of the variation in output for net oil importers than for exporters. One difference we note is that with recursive identification, the combination of GE and GF shocks explains a larger fraction of the variation in output (15 to 25 percent) compared to the sign-identification results presented in Table 5 (8 to 14 percent). This is largely due to the larger response of household consumption in net food-exporting and net oil-exporting economies under the recursive identification.

Second, another concern with identification could be that the bounds restrictions that we impose on the elasticity of output with respect to commodity shocks may be too restrictive. In order to check the sensitivity of our results to bounds restrictions, Figure A2 and Table A2 present the results of removing the bounds restrictions completely, and Figure A3 and Table A3 present the results of relaxing the bounds restrictions. In the completely unbounded specification, the estimated effects of GD shocks on output are slightly higher, while those of GF shocks on output are slightly weaker for net food exporters but stronger for net food importers. In the less restricted specification, similar patterns are evident, but the differences in estimates are much smaller, as expected. These shocks explain similar fractions of output as the baseline specification.

4.2 Alternative Measures of Global Factors

We now examine the sensitivity of the results to the use of alternative measures of global variables by considering two versions of the model. First, we replace the real crude oil price with the real energy price index. The data for the nominal energy price index comes from the World Bank GEM Commodities database, which is composed of the prices of crude oil, coal, and natural gas weighted by their average export values over the 2002–2004 period. We deflate this nominal energy price index by the MUV index to construct a real energy price index. Not surprisingly, this index is highly correlated (98%) with the real crude oil price index used in our baseline estimates, as crude oil represents the highest export share of the global energy market. Thus, as Figure 3 shows, the estimates for the responses of domestic output components are very similar to those in the baseline results in Figure 5. The baseline results are generally more conservative compared to the results obtained from the real energy price index. Table A4 also shows that the variation in output explained by GE shocks declines slightly from 13–15 percent to 12 percent, and a larger fraction of output is explained by GD shocks (16–17 percent vs. 14–16 percent).

Second, we examine a version of the model that replaces our global economic activity factor with the Kilian (2009) global economic activity index. The latter index is constructed from dry cargo bulk freight rates. As a price-based index, its correlation with the global economic activity factor based on output and trade indicators is rather low. It also appears to be non-stationary; therefore, we use its growth rate to estimate its impact on domestic output indicators. Figure A5 shows that with Kilian's activity index, the effects of GF shocks on the domestic output of net food exporters are slightly more positive than the baseline. Those for net food importers are slightly more negative initially, but they recover more quickly after the initial impact. On the other hand, the effects of GD shocks appear muted, and Table A5 indicates that GD shocks explain a smaller share of the variation in output (11–12 percent) when this index is used compared to the baseline (14–16 percent).

4.3 Country Sample

Finally, we investigate the sensitivity of our estimates to changing the country sample used in the analysis. First, we examine the inclusion of countries with populations of less than one million in our sample.[19] Figure A6 indicates that the absolute magnitudes of the effects of GF shocks

[19] The countries with populations of less than one million are Antigua and Barbuda, Bahamas, Bahrain, Barbados, Belize, Bermuda, Bhutan, Botswana, Brunei Darussalam, Comoros, Costa Rica, Cyprus, Djibouti, Dominica, Equato-

on domestic output are slightly smaller; however, the directions of the impacts remain the same. The responses to GD shocks are, on average, the same for domestic output. Table A6 shows that individual global shocks account for similar shares of the variation in domestic output, ranging from 12 to 16 percent (compared to 10–17 percent in the baseline model).

Second, we test the sensitivity of our results to the inclusion of countries with fewer than 30 data points in our sample.[20] Figure A7 shows that the effects of GF shocks on domestic output are almost identical, while the effects of GD shocks are slightly larger when these countries are added to the sample. Table A7 indicates that GF shocks account for a smaller fraction of the changes in output (9–12 percent) compared to the baseline (10–17 percent), while GE shocks account for a larger fraction (15–20 percent compared to the baseline of 13–15 percent). This different could be due to the inclusion of transitional economies that are more sensitive to energy shocks than to food shocks.

Third, we examine whether the results are robust to the inclusion of countries with poor data quality, which we initially excluded.[21] The PWT 6.1 classifies the quality of the data for these countries as "D" category. As none of these countries is a net food exporter, our baseline results for net food exporters remain the same (a black solid line is superimposed on a red solid line). As illustrated in Figure A8, the inclusion of countries with unreliable data in the sample weakens the evidence of the negative effects of GF shocks on domestic output. The effects of GD shocks, on the other hand, appear larger when these countries are included. Table A8 shows that the share of variation in output explained by these shocks remain very similar (and identical in some categories) when these countries are included in the sample.

Finally, we include countries with outlier values that were identified by the PWT 8.1 to test the sensitivity of our results.[22] As none of these countries is a net food exporter, the results for this category do not change. For net food importers, the estimated effects of both GD and GF shocks remain almost identical, as Figure A9 shows. Table A9 also indicates that global shocks account

rial Guinea, Fiji, Gabon, Gambia, Grenada, Guinea-Bissau, Iceland, Jordan, Kuwait, Lesotho, Luxembourg, Macao, Maldives, Malta, Mauritania, Mauritius, Montenegro, Namibia, Oman, Panama, Qatar, Saint Kitts and Nevis, Saint Lucia, Sao Tome and Principe, St. Vincent and the Grenadines, Suriname, Swaziland, and Trinidad and Tobago.

[20] The countries with fewer than 30 data points are Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Croatia, Czech Republic, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Macedonia, Montenegro, Moldova, Russia, Serbia, Slovakia, Slovenia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan, and Yemen.

[21] The countries with poor data quality are Angola, Algeria, Belarus, Bhutan, Cambodia, Cape Verde, Central African Republic, Chad, Comoros, Congo, Cuba, Cyprus, Czechoslovakia, Djibouti, Equatorial Guinea, Eritrea, Guinea-Bissau, Guyana, Haiti, Iraq, Laos, Lesotho, Liberia, Malta, Mongolia, Mozambique, Myanmar, Namibia, Niger, Papua New Guinea, Puerto Rico, Sao Tome and Principe, Saudi Arabia, Seychelles, Somalia, Sudan, Suriname, Taiwan, Tajikistan, Togo, Turkmenistan, Uganda, United Arab Emirates, Uzbekistan, and Yemen.

[22] The countries with outlier values are Bermuda, Brunei Darussalam, Burundi, El Salvador, Guinea-Bissau, Mozambique, and Zimbabwe.

for almost identical shares of domestic output.

5 Conclusion

In this paper, we have provided the most comprehensive analysis to date of the effects of GF shocks on domestic output and its components at business cycle frequencies, focusing on net food exporters and importers. Using a sign-restricted SVAR model and rich data on the output components of 82 countries, we quantify the dynamic responses of domestic output, domestic absorption, household consumption, government consumption, investment, and trade balance to global structural shocks that drive real food prices. We then illustrate how these effects compare to the effects of the same shocks that drive real oil prices.

Our benchmark identification scheme using sign restrictions produces results that are in line with previous findings in the literature: the sources of global shocks driving international food prices have important effects on macroeconomic aggregates (e.g., Charnavoki and Dolado (2014) and Kilian (2009)). Specifically, we examine GD, GE, GF, and GS shocks. The first three shocks account for most of the changes in international food prices. Our findings indicate that negative GF shocks have contractionary effects on the domestic output of net food importers, which are transmitted through deteriorating trade balances and declining consumption. We document opposing and shorter-lived effects for net food exporters. By contrast, positive GD shocks that also increase real food prices stimulate domestic output among both groups of countries. Hence, the sources of shocks driving global food prices are crucial to evaluating their domestic effects. The magnitudes of the effects we estimate in response to GF shocks are roughly two-thirds of the magnitudes of the effects estimated in response to GE shocks. Among countries that are net importers of food, the adverse effects of negative GF shocks on household consumption are larger for countries with relatively high shares of household food expenditures and high food trade deficits. Finally, we find that the share of the variation in output explained by the combination of GF and GE shocks is modest (about 8 to 14 percent), which is similar to recent findings in the terms-of-trade literature. Although commodity-specific shocks explain a sizable portion of the variation in trade balance, a large portion of the variation in domestic output remains unexplained by such shocks.

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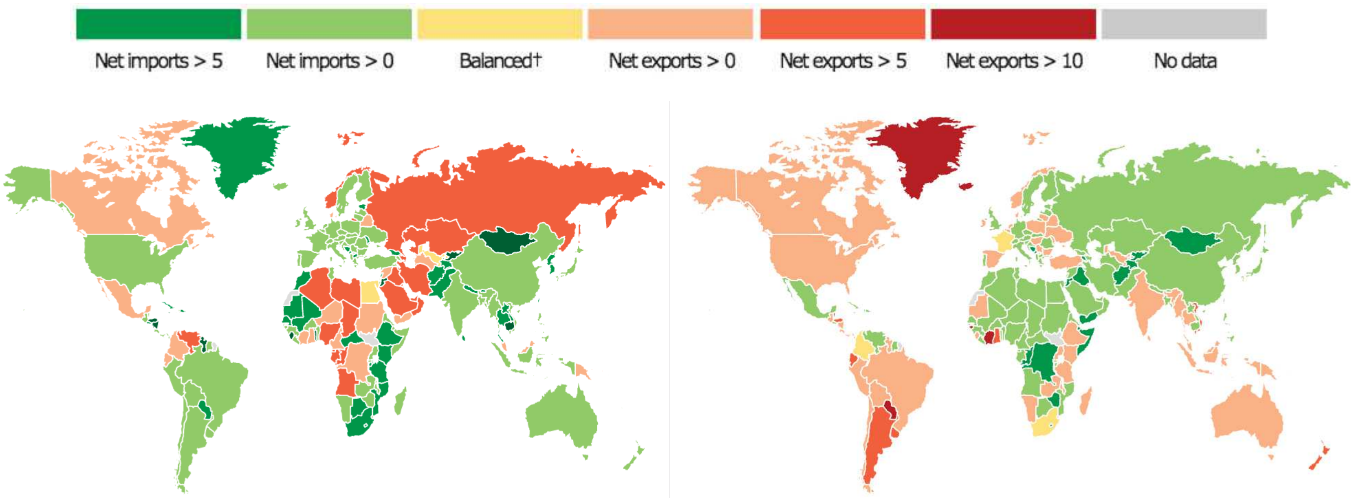
Figure 1: Net Imports/Exports as a Percentage of GDP, 2010–2013 Average

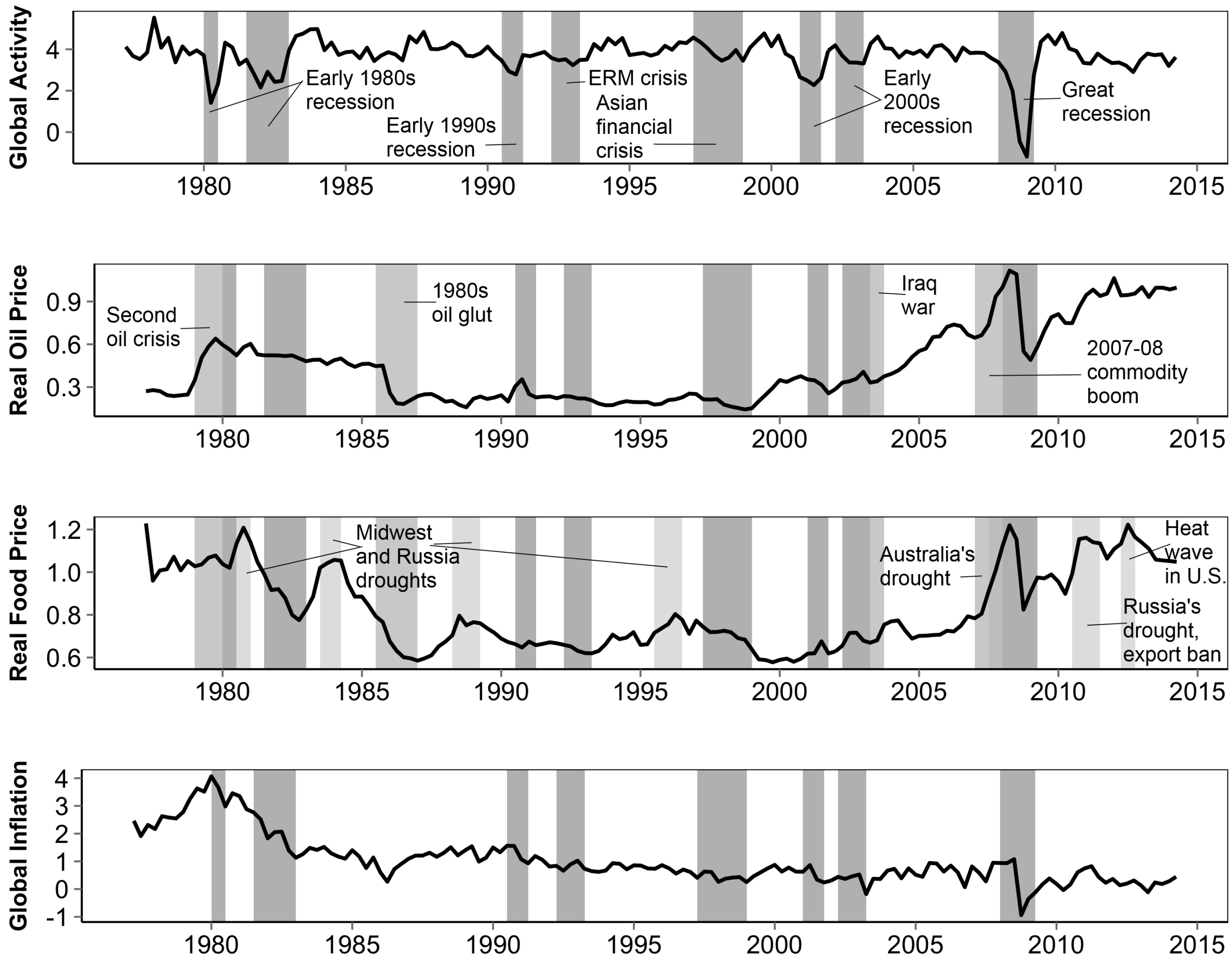


(a) Oil

(b) Food

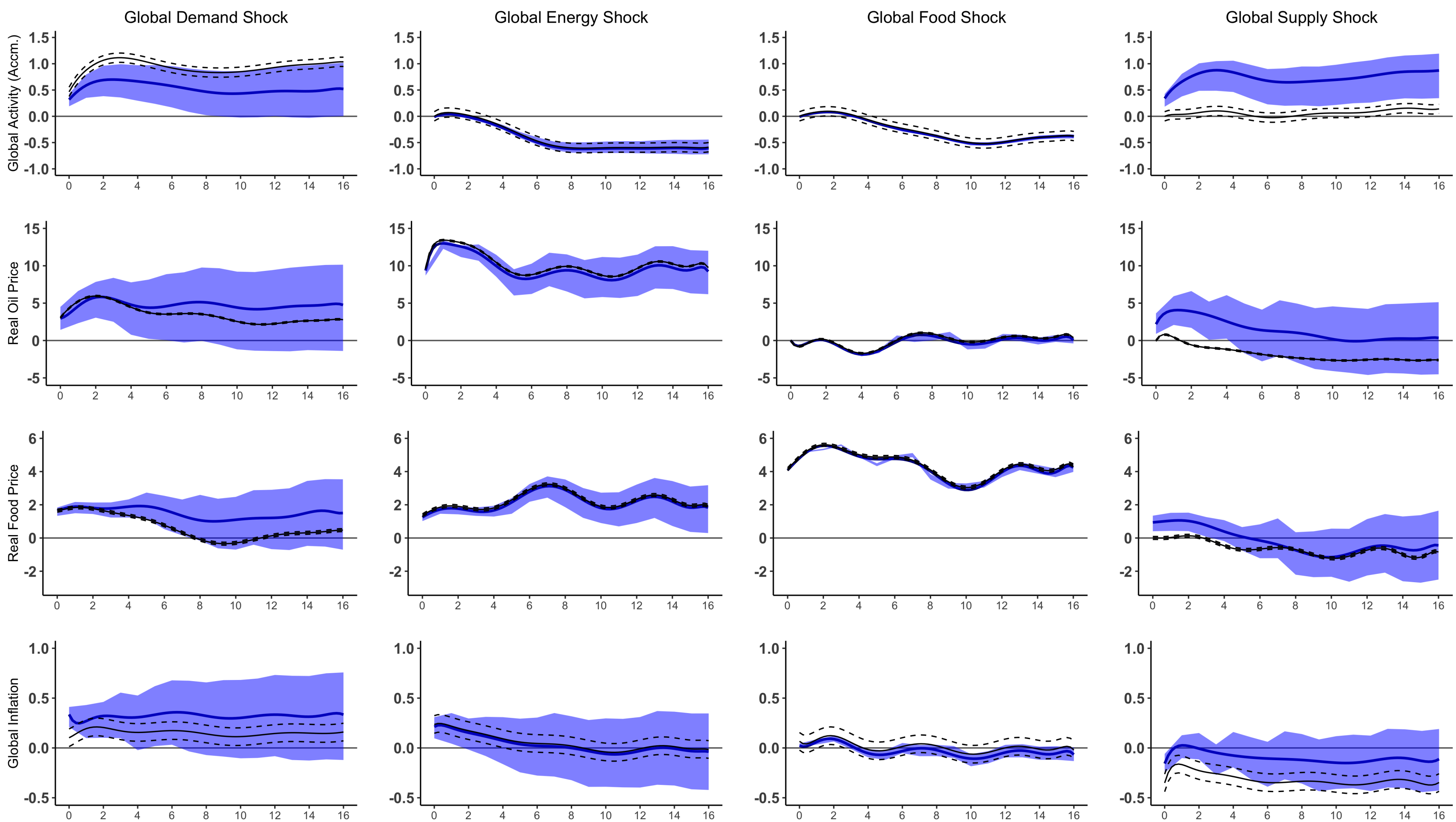
Notes: The data are from UNCTAD Statistics and the Economist (August 12, 2015). Accessed from http://www.economist.com/blogs/graphicdetail/2015/08/commodity-dependency on June 16, 2016.

Figure 2: Evolution of Global Variables in the SVAR Model



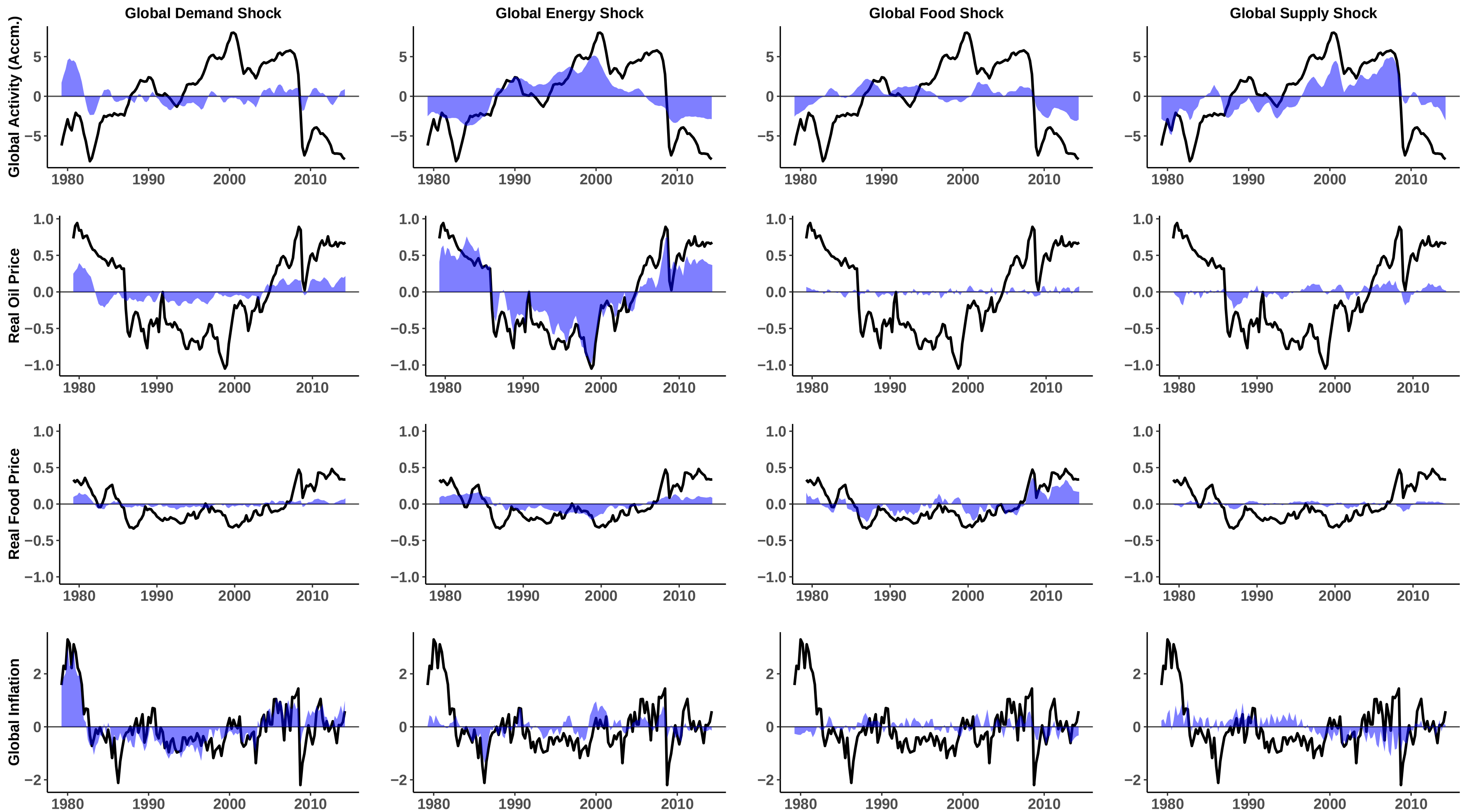
Note: Dark gray shaded areas represent major global recessions, medium gray shaded areas represent major events in global oil markets, and light gray shaded areas illustrate major events in global food markets, particularly periods of major crop shortages due to drought.

Figure 3: Impulse Responses of International Variables to Global Shocks



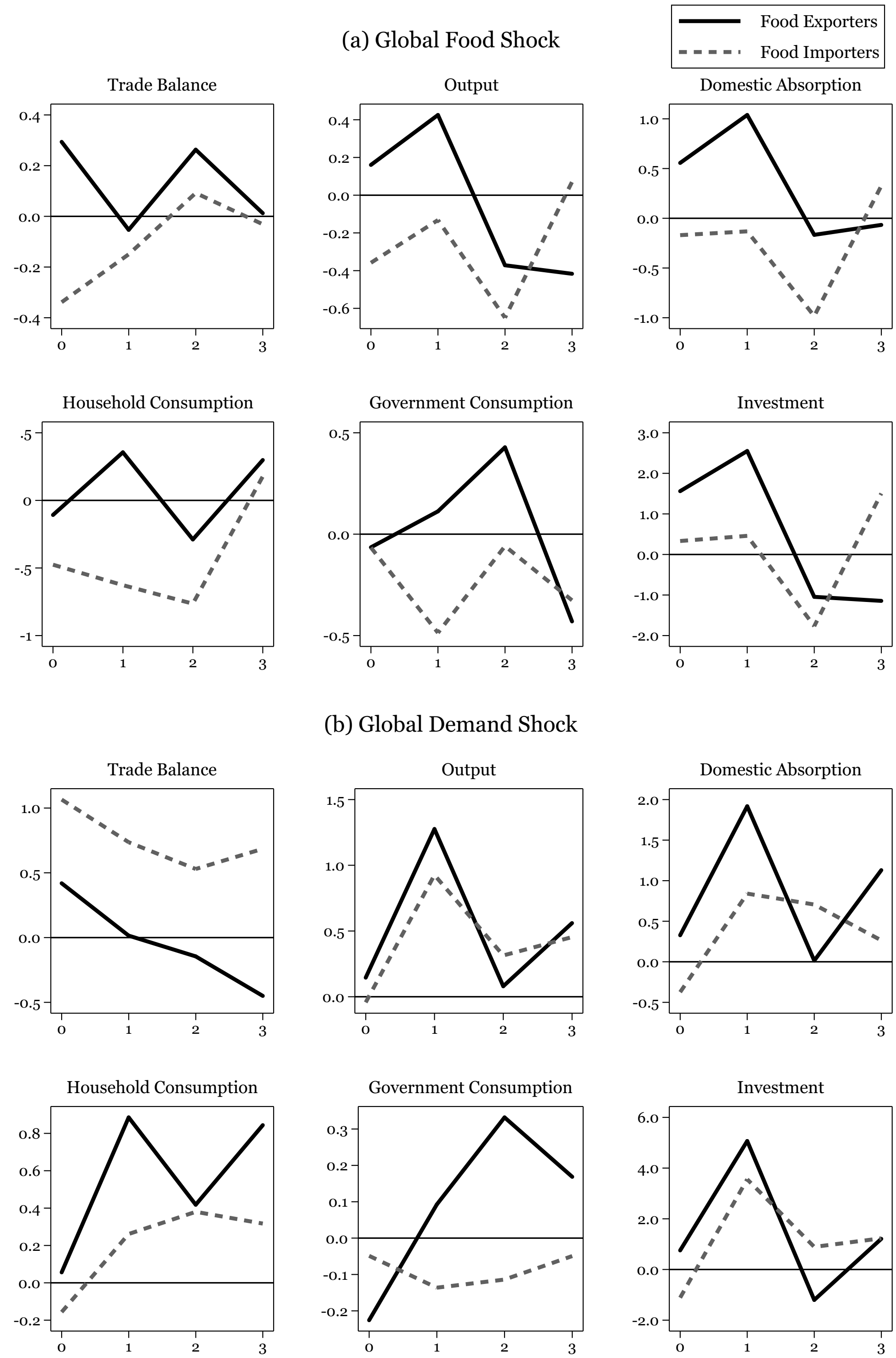
Note: Identification by sign restrictions is represented by the purple shaded area covering equally tailed 68 percent credible set, with the solid purple line representing the median. Recursive identification is represented by the median (black solid line) together with equally tailed 68 percent credible interval (black dashed lines).

Figure 4: Historical Decompositions of the Global Variables: 1977.II to 2014.II



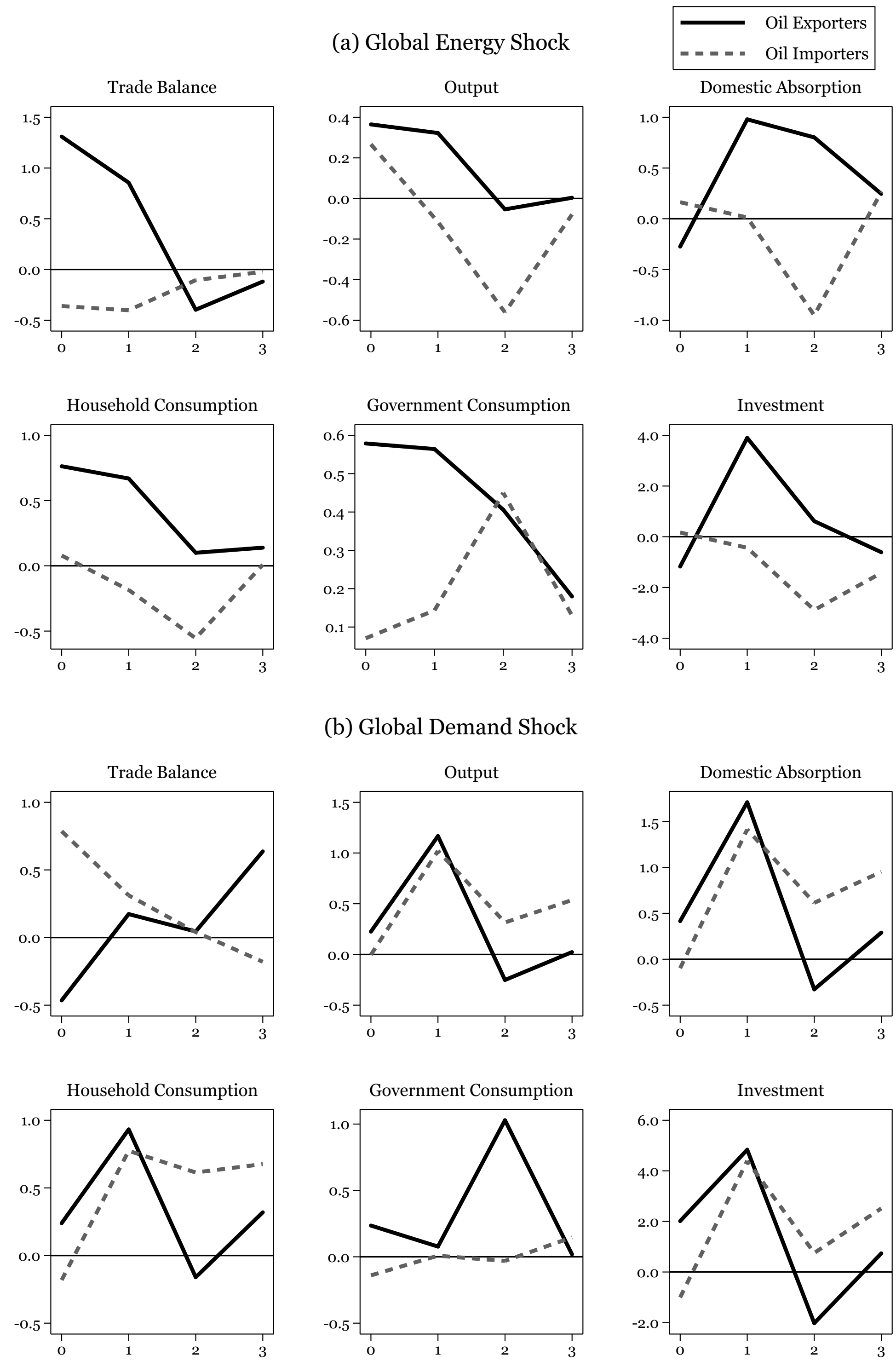
Note: Global variables are represented by thick solid lines, and identification by sign restriction is depicted by the shaded areas.

Figure 5: Transmission of Global Shocks: Net Food Importers and Exporters



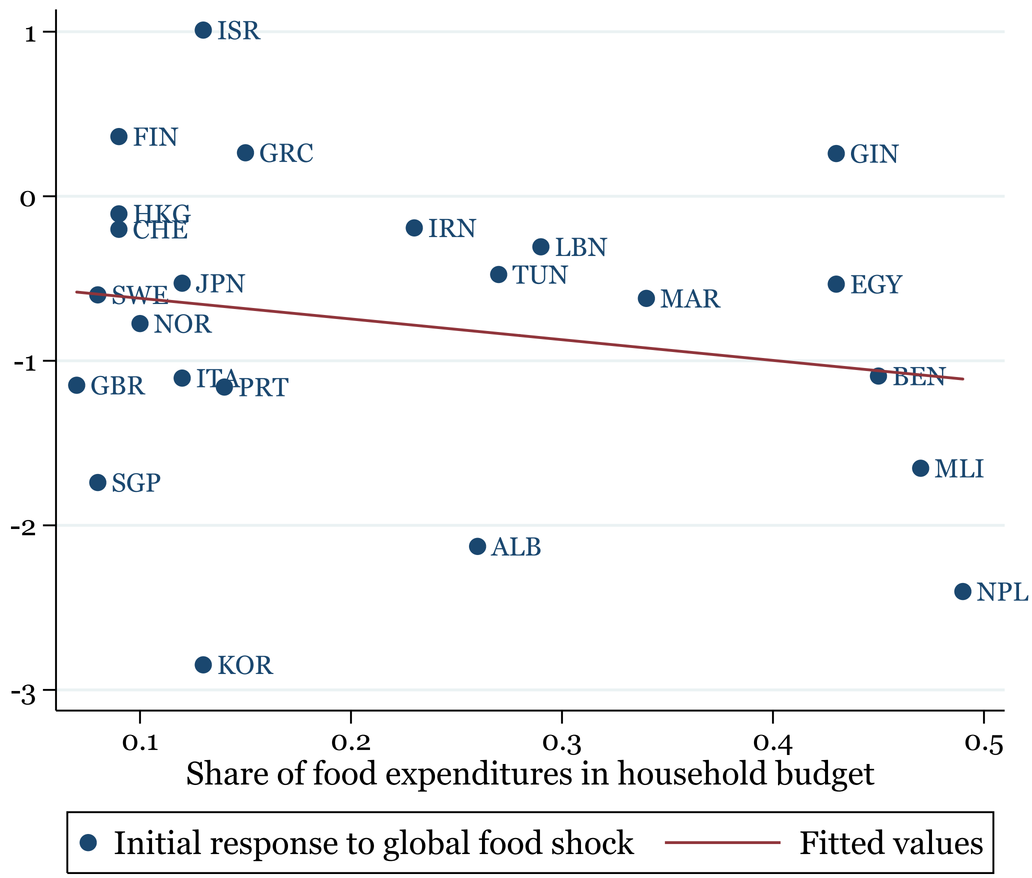
Note: The figure displays the median impulse responses to a global food shock in Panel (a) and a global demand shock in Panel (b) by net food exporters (in solid lines) and net food importers (in dashed lines). All variables are measured at constant 2005 national prices (in million 2005 US$). The trade balance is presented as a share of GDP, and all other variables are presented as growth rates.

Figure 6: Transmission of Global Shocks: Net Oil Importers and Exporters



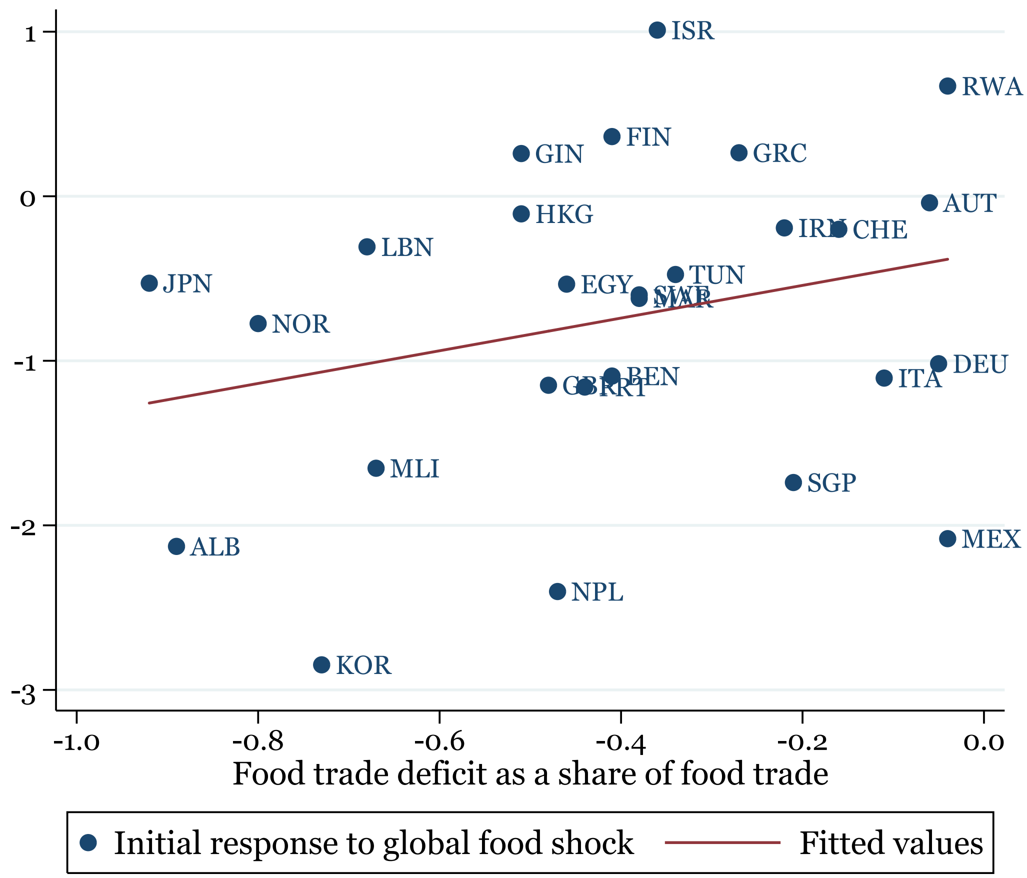
Note: The figure displays the median impulse responses to a global energy shock in Panel (a) and a global demand shock in Panel (b) by net oil exporters (in solid lines) and net oil importers (in dashed lines). All variables are measured at constant 2005 national prices (in million 2005 US$). The trade balance is presented as a share of GDP, and all other variables are presented as growth rates.

Figure 7: Initial Response of Household Consumption in Net Food Importers to Global Food Shocks by the Share of Food Expenditures in the Household Budget



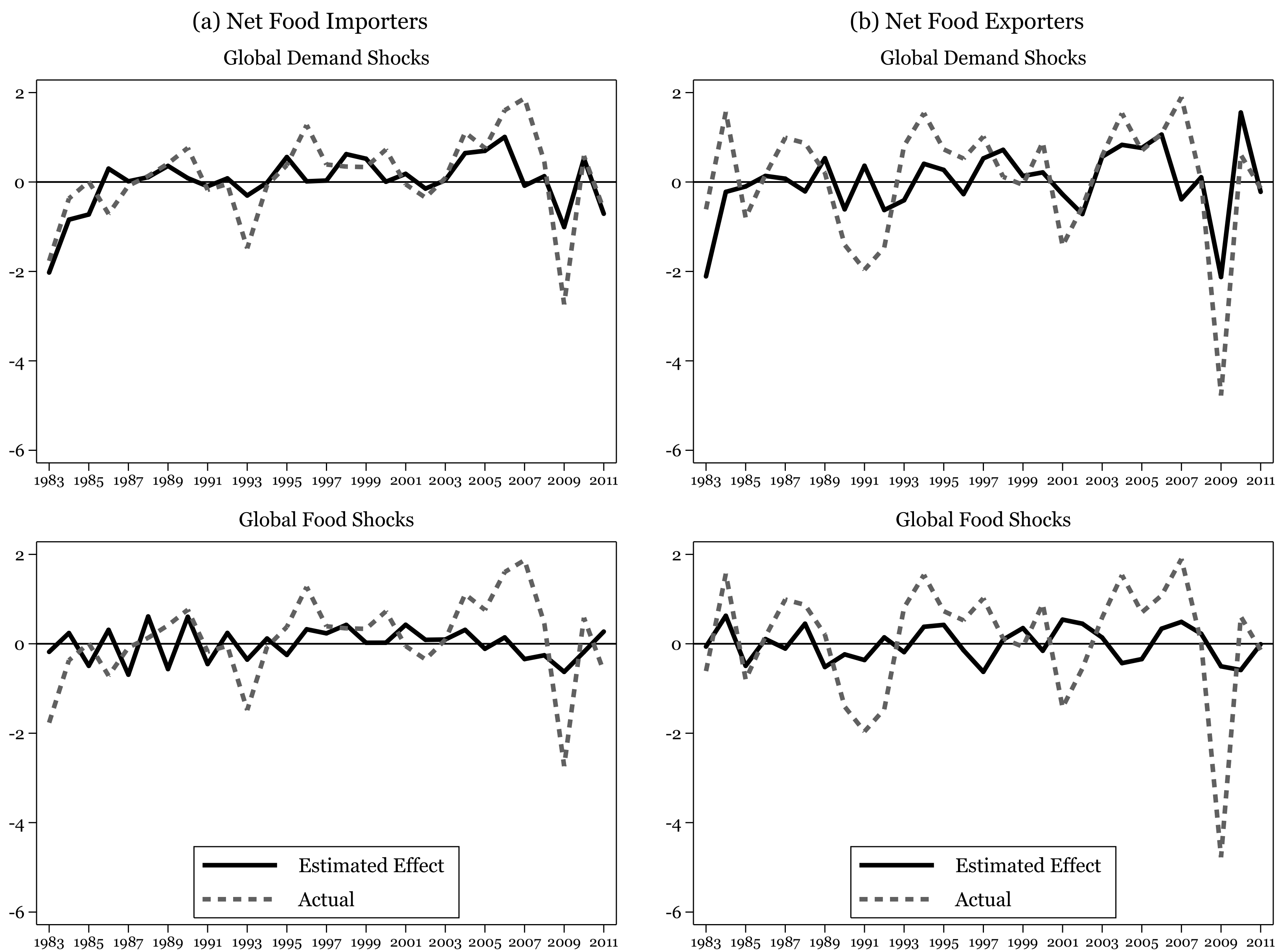
Note: The figure displays a scatter plot of the share of food expenditures in the average household budget of net food importing countries and the estimated initial response of household consumption in these countries to global food shocks. The line is a linear fit to the scatter plot. Identification by sign restrictions is used.

Figure 8: Initial Response of Household Consumption in Net Food Importers to Global Food Shocks by the Food Trade Deficit



Note: The figure displays a scatter plot of the food trade deficit as a share of total food trade of net food importing countries and the estimated initial response of household consumption in these countries to global food shocks. The line is a linear fit to the scatter plot. Identification by sign restrictions is used.

Figure 9: Historical Decomposition of Net Food Importer/Exporter Output by Global Shock



Note: This figure decomposes the combined effects on the GDP of net food importers in Panel (a) and the GDP of net food exporters in Panel (b) of global demand shocks and global food shocks. Each plot shows the estimated effect of one of the two shocks (solid lines) and the demeaned actual data (dashed lines).

Table 1: Sign restrictions on impulse response functions

	GD Shock, $\varepsilon_{D,t}$	GE Shock, $\varepsilon_{E,t}$	GF Shock, $\varepsilon_{F,t}$	GS Shock, $\varepsilon_{S,t}$
Global economic activity	+	−	−	+
Real energy price	+	+	0	+
Real food price	+	+	+	+
Global inflation	+	+	+	−

Notes: The table reports the sign restrictions imposed on the impulse response functions in the SVAR model.

Table 2: Recursive identification

	GD Shock, $\varepsilon_{D,t}$	GE Shock, $\varepsilon_{E,t}$	GF Shock, $\varepsilon_{F,t}$	GS Shock, $\varepsilon_{S,t}$
Global economic activity	x	0	0	0
Real energy price	x	x	0	0
Real food price	x	x	x	0
Global inflation	x	x	x	x

Notes: The table reports the ordering of the recursive identification used in the SVAR model as a robustness check.

Table 3: Forecast Error Variance Decomposition (Sign Restrictions)

	GD Shock, $\varepsilon_{D,t}$	GE Shock, $\varepsilon_{E,t}$	GF Shock, $\varepsilon_{F,t}$	GS Shock, $\varepsilon_{S,t}$
Global activity	0.75	0.13	0.09	0.03
Real energy price	0.12	0.78	0.06	0.04
Real food price	0.12	0.12	0.71	0.05
Global inflation	0.08	0.19	0.09	0.62

Notes: The table reports the forecast error variance decomposition obtained by the SVAR using the sign-restricted identification scheme shown in Table 1.

Table 4: Forecast Error Variance Decomposition (Recursive Identification)

	GD Shock, $\varepsilon_{D,t}$	GE Shock, $\varepsilon_{E,t}$	GF Shock, $\varepsilon_{F,t}$	GS Shock, $\varepsilon_{S,t}$
Global activity	0.80	0.09	0.07	0.03
Real energy price	0.13	0.75	0.05	0.07
Real food price	0.13	0.11	0.69	0.07
Global inflation	0.07	0.19	0.06	0.68

Notes: The table reports the forecast error variance decomposition obtained by the SVAR using the recursive identification scheme shown in Table 2.

Table 5: Share of Variance of Domestic Output and its Components Explained by Global Shocks

	GD Shock	GE Shock	GF Shock	GE and GF Shocks*
(a) Trade Balance	(1)	(2)	(3)	(4)
Food Exporters	0.10	0.17	0.08	0.14
Food Importers	0.14	0.27	0.13	0.21
Oil Exporters	0.09	0.19	0.14	0.14
Oil Importers	0.13	0.21	0.09	0.20
(b) Output				
Food Exporters	0.15	0.14	0.17	0.09
Food Importers	0.15	0.15	0.10	0.08
Oil Exporters	0.14	0.13	0.13	0.14
Oil Importers	0.16	0.15	0.12	0.08
(c) Domestic Absorption				
Food Exporters	0.17	0.15	0.13	0.09
Food Importers	0.17	0.16	0.08	0.09
Oil Exporters	0.15	0.15	0.09	0.16
Oil Importers	0.17	0.15	0.13	0.09
(d) Household Consumption				
Food Exporters	0.14	0.14	0.13	0.10
Food Importers	0.12	0.14	0.13	0.10
Oil Exporters	0.16	0.13	0.11	0.12
Oil Importers	0.12	0.15	0.14	0.11
(e) Government Consumption				
Food Exporters	0.13	0.12	0.14	0.12
Food Importers	0.11	0.13	0.10	0.11
Oil Exporters	0.09	0.13	0.09	0.11
Oil Importers	0.12	0.12	0.13	0.12
(f) Investment				
Food Exporters	0.19	0.12	0.11	0.10
Food Importers	0.14	0.17	0.09	0.11
Oil Exporters	0.13	0.11	0.09	0.12
Oil Importers	0.16	0.16	0.12	0.10

Notes: The table reports the median of the R^2 values obtained from the estimation of Equation (3) for countries listed in each group. GD shock represents global demand shocks, GE shock represents global energy shocks, and GF shock represents global food shocks, each of which is identified using the sign-restricted identification scheme in Table 1. The first three columns report the R^2 values using each global shock and its three period lags as in Equation (3). * denotes the R^2 values using the global energy and food shocks and their one-period lags jointly in the regression. As we explain in Section 3.2.4, this specification corresponds to the regressions used in the literature on terms-of-trade shocks.

Appendix A List of Countries and Variables

List of Countries:

Net Food Exporters: Argentina, Australia, Belgium, Bolivia, Brazil, Bulgaria, Canada, Chile, Denmark, France, Hungary, India, Indonesia, Malaysia, Netherlands, New Zealand, Paraguay, Peru, Poland, South Africa, Spain, Thailand, Turkey, United States, Uruguay.

Net Food Importers: Albania, Austria, Bangladesh, Benin, China, Democratic Republic Congo, Dominican Republic, Egypt, Finland, Germany, Greece, Guinea, Hong Kong, Iran, Ireland, Israel, Italy, Jamaica, Japan, Lebanon, Madagascar, Mali, Mexico, Morocco, Nepal, Nigeria, Norway, Pakistan, Portugal, Rwanda, Senegal, Sierra Leone, Singapore, South Korea, Sweden, Switzerland, Syria, Tanzania, Tunisia, United Kingdom, Venezuela.

Net Oil Exporters: Australia, Cameroon, Canada, Colombia, Democratic Republic Congo, Denmark, Ecuador, Indonesia, Iran, Malaysia, Mexico, Nigeria, Norway, Paraguay, South Africa, Venezuela.

Net Oil Importers: Albania, Argentina, Austria, Bangladesh, Belgium, Benin, Bolivia, Brazil, Bulgaria, Burkina Faso, Chile, China, Cote d'Ivoire, Dominican Republic, Egypt, Ethiopia, Finland, France, Germany, Ghana, Greece, Guatemala, Guinea, Honduras, Hong Kong, Hungary, India, Ireland, Israel, Italy, Jamaica, Japan, Kenya, Lebanon, Madagascar, Malawi, Mali, Morocco, Nepal, Netherlands, New Zealand, Pakistan, Peru, Philippines, Poland, Portugal, Romania, Rwanda, Senegal, Sierra Leone, Singapore, South Korea, Spain, Sri Lanka, Sweden, Switzerland, Syria, Tanzania, Thailand, Tunisia, Turkey, United Kingdom, United States, Uruguay, Vietnam, Zambia.

List of Variables:

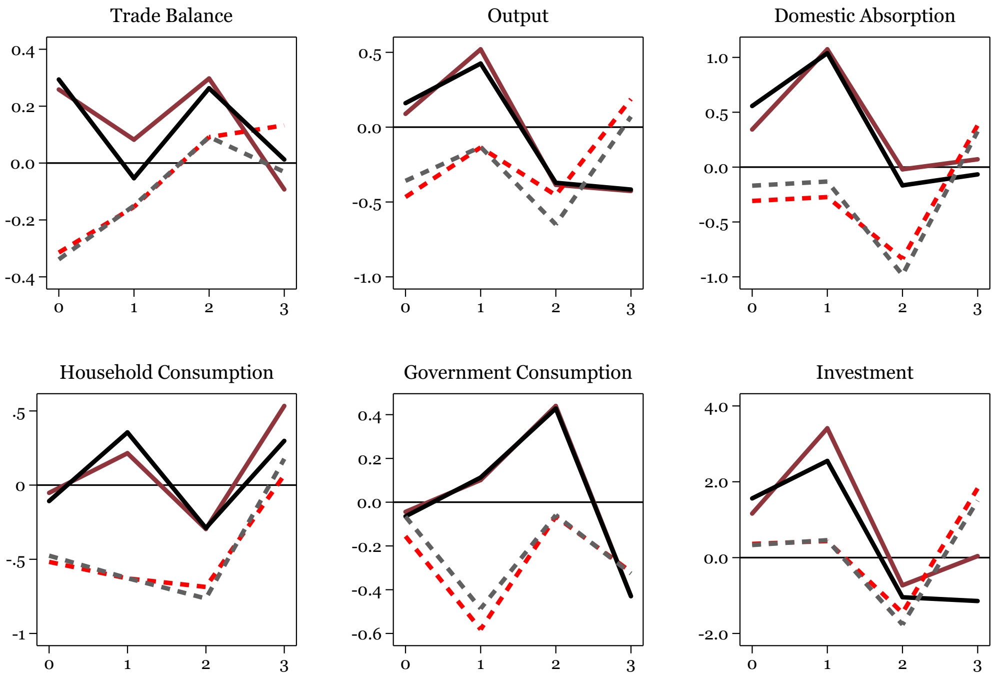
Variable	Series ID	Source	Code
(a) Global Economic Activity Series			
Real gross domestic product, OECD, SA	GDP-OECD	OECD	2
Real gross domestic product, G7, SA	GDP-G7	OECD	2
Real gross domestic product, USA, SA	GDP-USA	OECD	2
Industrial production index, G7, SA	INP-G7	OECD	2
Industrial production index, OECD Europe, SA	INP-EU	OECD	2
Industrial production index, USA, SA	INP-USA	OECD	2
Export volume, World, SA	EXP-WORLD	OECD	2
Export volume, OECD, SA	EXP-OECD	OECD	2
Import volume, World, SA	IMP-WORLD	OECD	2
Import volume, OECD, SA	IMP-OECD	OECD	2
Dry Cargo Bulk Freight Rates Index	ACT-INDEX	Kilian (2009)	4
(b) Commodity Price Indices			
Real crude oil price index, SA	P-OIL	IMF	2
Real food price index, SA	P-FOOD	WB, GEM	2
Real energy price index, SA	P-ENERGY	WB, GEM	2
(c) Global Inflation Series			
Deflator of gross domestic product, OECD, SA	DEF-OECD	OECD	3
Deflator of gross domestic product, G7, SA	DEF-G7	OECD	3
Deflator of gross domestic product, OECD Europe, SA	DEF-EU	OECD	3
Deflator of gross domestic product, USA, SA	DEF-USA	OECD	3
Consumer price index, all items, OECD, SA	CPI-OECD	OECD	3
Consumer price index, all items, G7, SA	CPI-G7	OECD	3
Consumer price index, all items, OECD Europe, SA	CPI-EU	OECD	3
Consumer price index, all items, USA, SA	CPI-USA	OECD	3
Consumer price index, all items, non-food, non-energy, OECD, SA	CPICORE-OECD	OECD	3
Consumer price index, all items, non-food, non-energy, G7, SA	CPICORE-G7	OECD	3
Consumer price index, all items, non-food, non-energy, OECD Europe, SA	CPICORE-EU	OECD	3
Consumer price index, all items, non-food, non-energy, USA, SA	CPICORE-USA	OECD	3
Total producer prices, manufacturing, USA, SA	PPIM-USA	OECD	3
Total producer prices, finished goods, USA, SA	PPIF-USA	OECD	3
(d) Domestic Economic Indicators			
Real household consumption at constant national 2005 prices (in mil. 2005 US$)	C	PWT 8.1	4
Real government consumption at constant national 2005 prices (in mil. 2005 US$)	G	PWT 8.1	4
Real domestic absorption at constant national 2005 prices (in mil. 2005 US$)	DA	PWT 8.1	4
Real investment at constant national 2005 prices (in mil. 2005 US$)	I	PWT 8.1	4
Real GDP at constant national 2005 prices (in mil. 2005 US$)	Y	PWT 8.1	4
Trade balance, % of GDP	TB	PWT 8.1	1
Share of food expenditures in household budget, percentage points	F-SHARE	WB - ICP	1
Food trade balance as a share of food trade, percentage points	F-TB	FAO	1

Notes: The table reports the variable description, series code reported in data file, source, and transformation code used in the analysis. The quarterly data in Panels (a)–(c) cover the period 1977Q2–2014Q2. The annual data in Panel (d) covers the period 1980–2011. The transformation codes are as follows: 1 – no transformation, 2 – log difference, 3 – first difference of log difference, and 4 – growth rate.

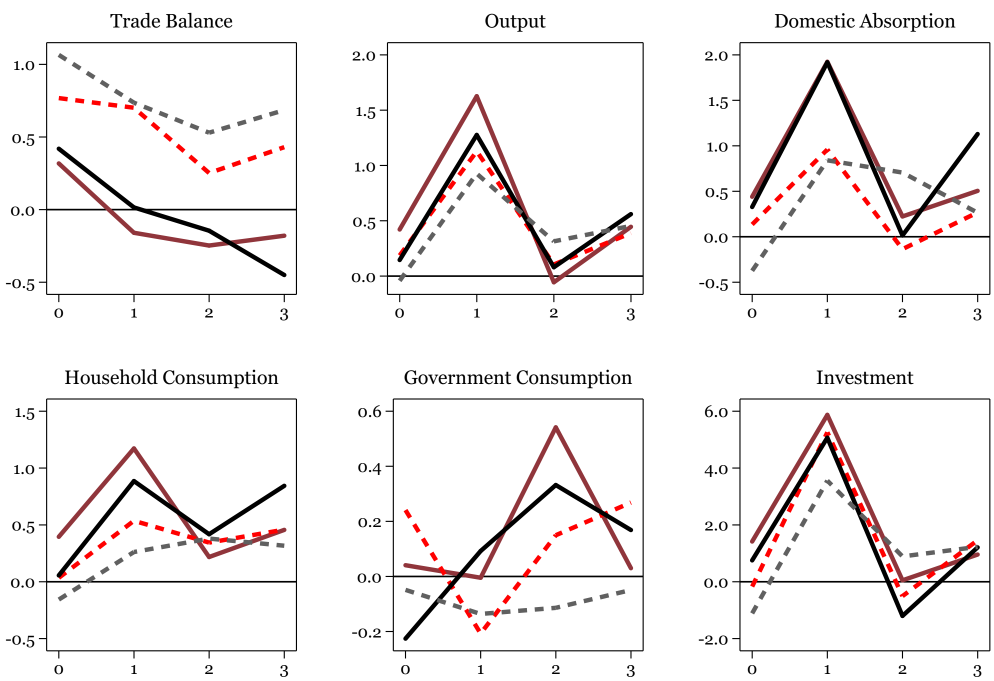
Appendix B Additional Figures and Tables (For Online Publication)

Figure A1: Robustness Analysis: Recursive Identification

(a) Global Food Shock

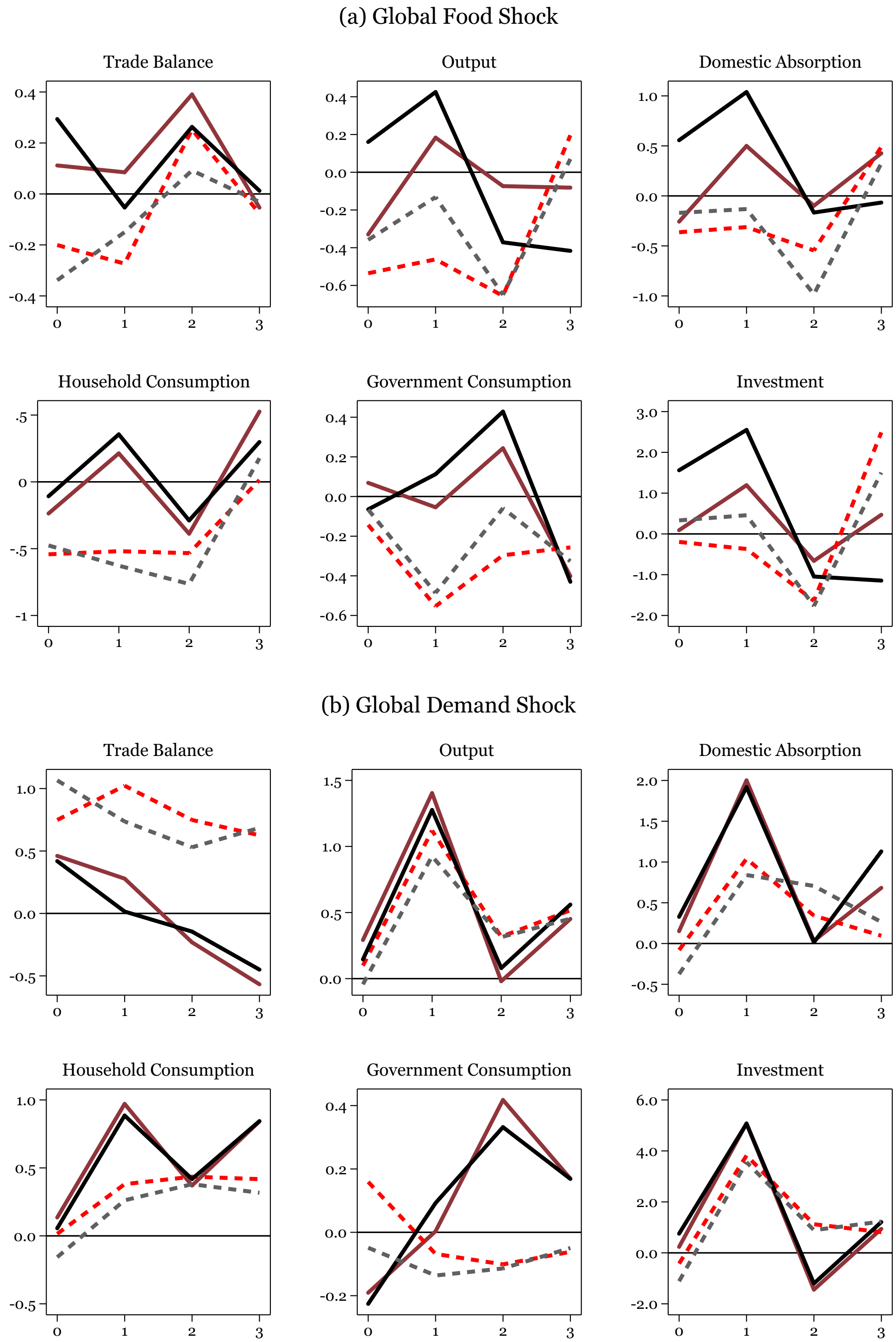


(b) Global Demand Shock



Note: This figure reproduces Figure 5 by comparing the baseline results to those of the robustness check of using the recursive identification scheme instead of sign identification. Baseline median impulse responses are represented by black/gray lines; robustness results are represented by red lines. In both cases, solid lines illustrate the median impulse responses for net food exporters, and dashed lines illustrate them for net food importers.

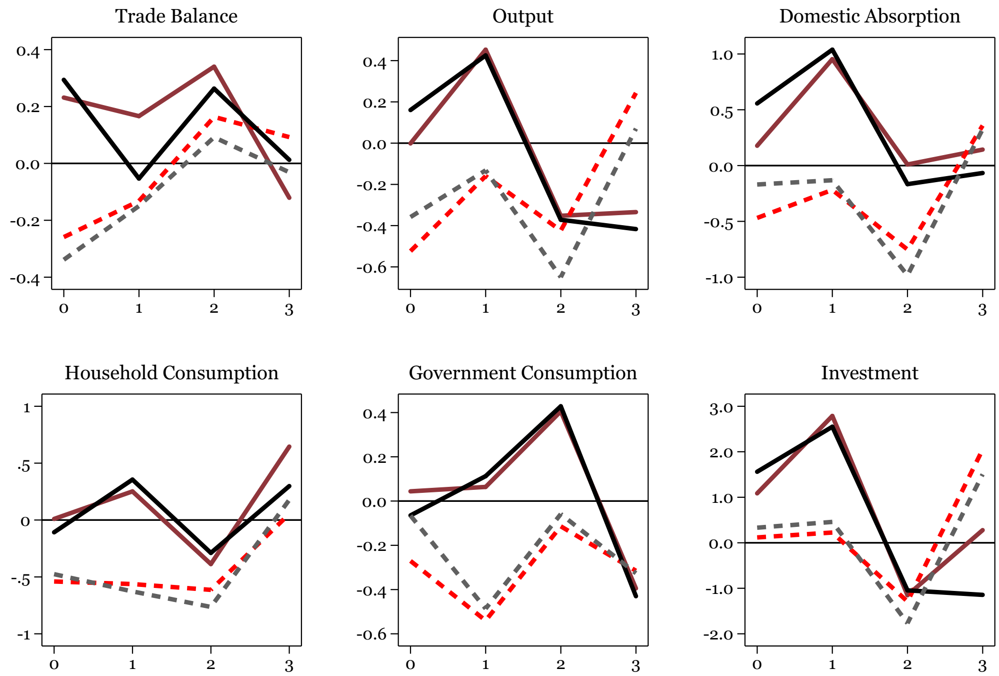
Figure A2: Robustness Analysis: Sensitivity to Removing Bounds Restrictions



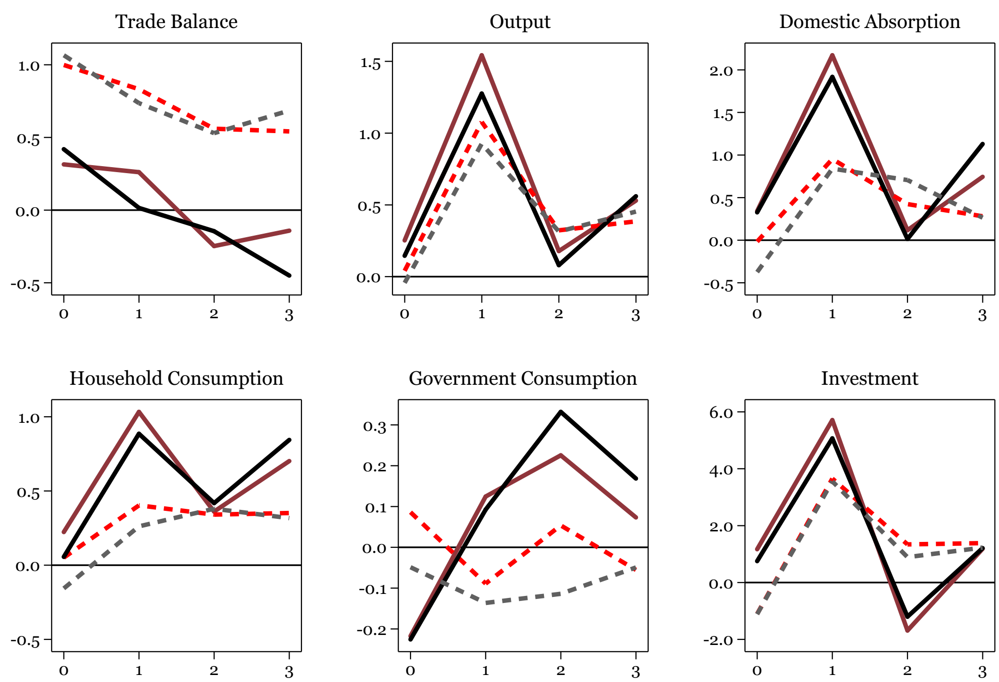
Note: This figure reproduces Figure 5 by comparing the baseline results to the robustness check of removing the bounds restrictions used in the sign identification. The shocks are identified by using sign restrictions. Baseline median impulse responses are represented by black/gray lines; robustness results are represented by red lines. In both cases, solid lines illustrate the median impulse responses for net food exporters, and dashed lines illustrate them for net food importers.

Figure A3: Robustness Analysis: Sensitivity to Relaxing Bounds Restrictions

(a) Global Food Shock



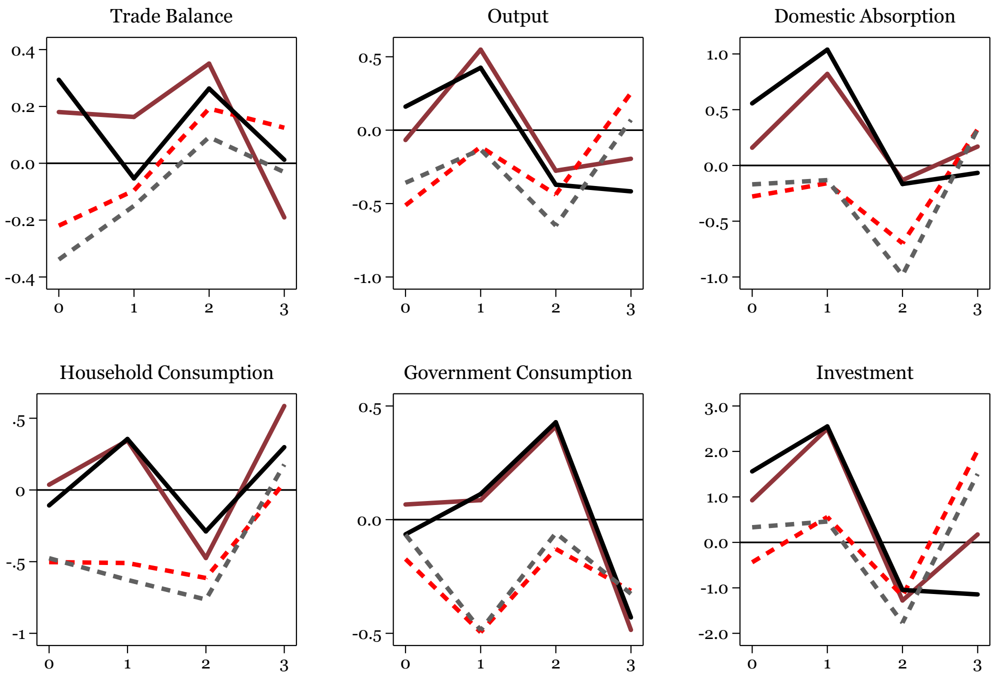
(b) Global Demand Shock



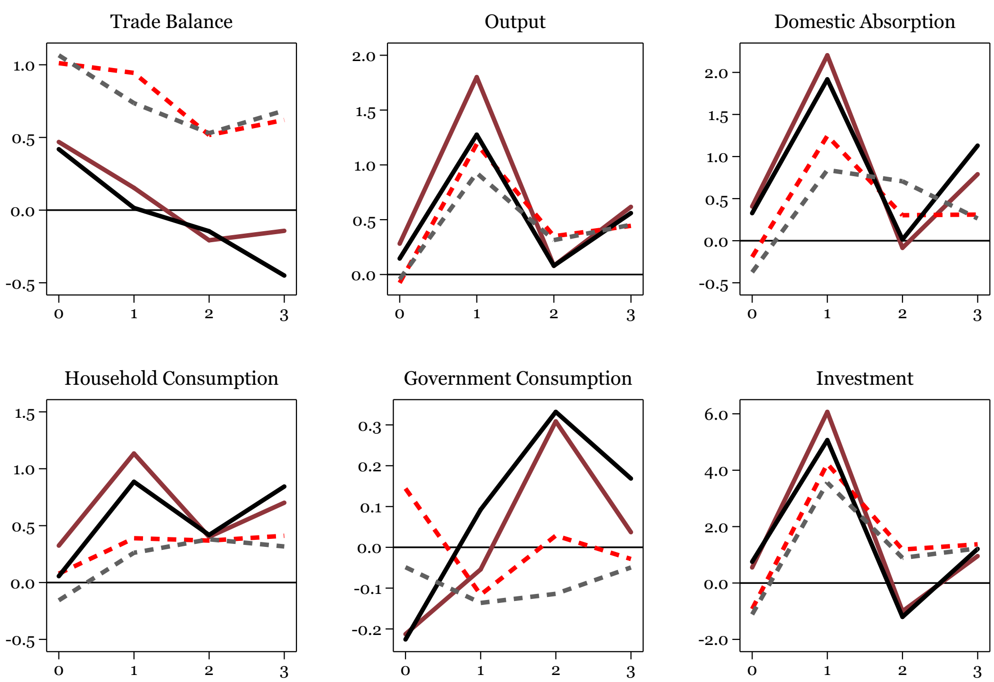
Note: This figure reproduces Figure 5 by comparing the baseline results to the robustness check of relaxing the bounds restrictions. In particular, we accept draws with the elasticity of global output with respect to real oil prices that are in the range of [-0.025, 0) and the elasticity of global output with respect to real food prices that are in the range of [-0.015, 0). The original elasticity restrictions were [-0.015,0) and [-0.0075,0), respectively. Baseline median impulse responses are represented by black/gray lines; robustness results are represented by red lines. In both cases, solid lines illustrate the median impulse responses for net food exporters, and dashed lines illustrate them for net food importers.

Figure A4: Robustness Analysis: Real Energy Prices

(a) Global Food Shock



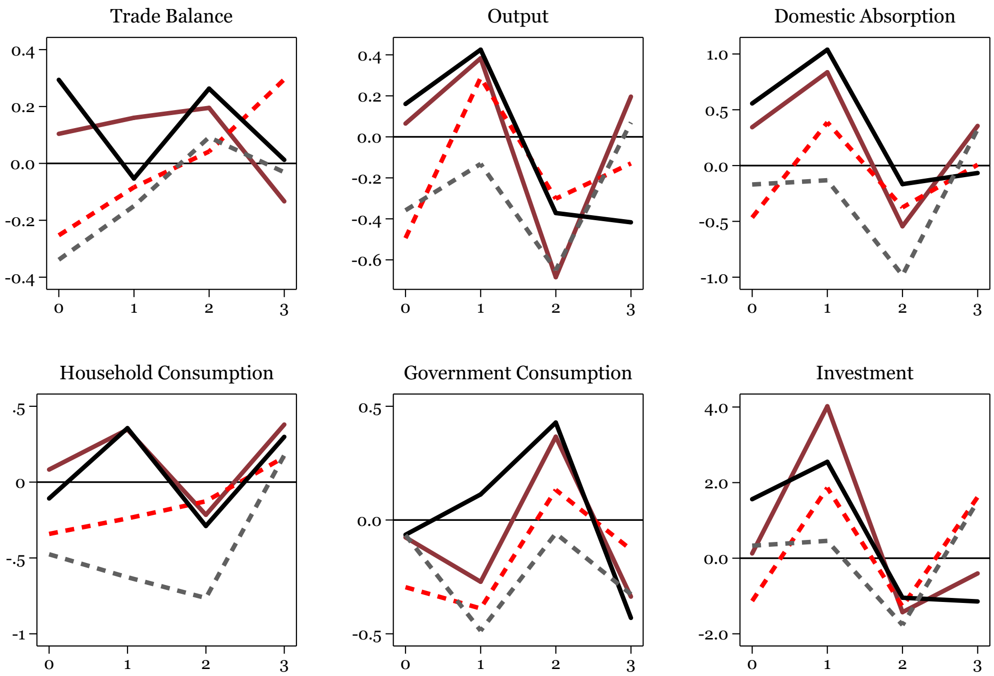
(b) Global Demand Shock



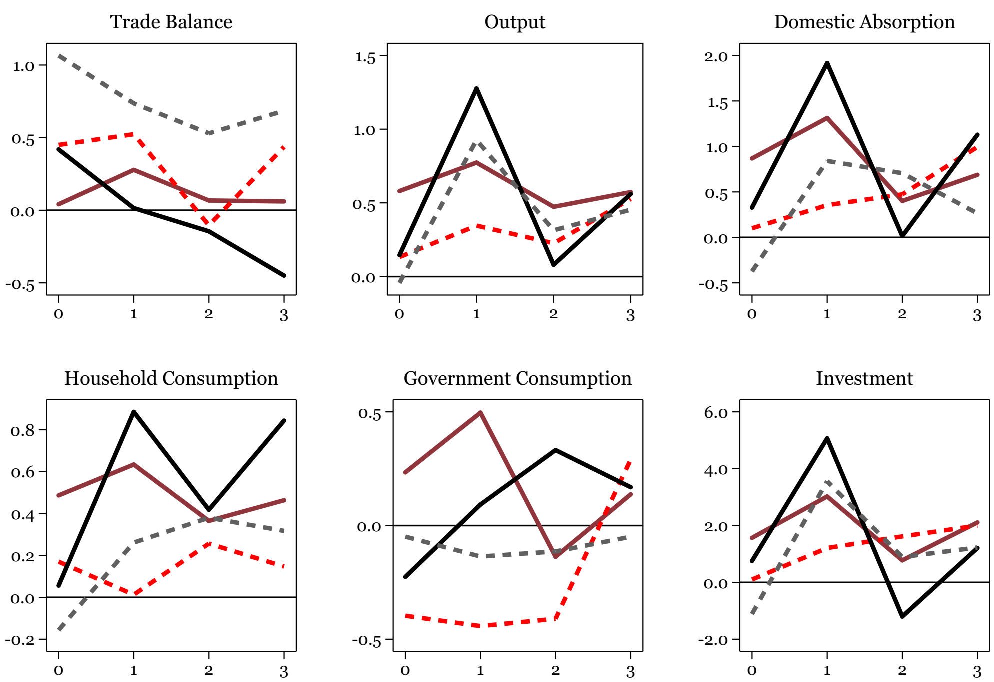
Note: This figure reproduces Figure 5 by comparing the baseline results to the robustness check of replacing real crude oil price index with real energy price index. The shocks are identified using sign restrictions. Baseline median impulse responses are represented by black/gray lines; robustness results are represented by red lines. In both cases, solid lines illustrate the median impulse responses for net food exporters, and dashed lines illustrate them for net food importers.

Figure A5: Robustness Analysis: Kilian Global Economic Activity Index

(a) Global Food Shock

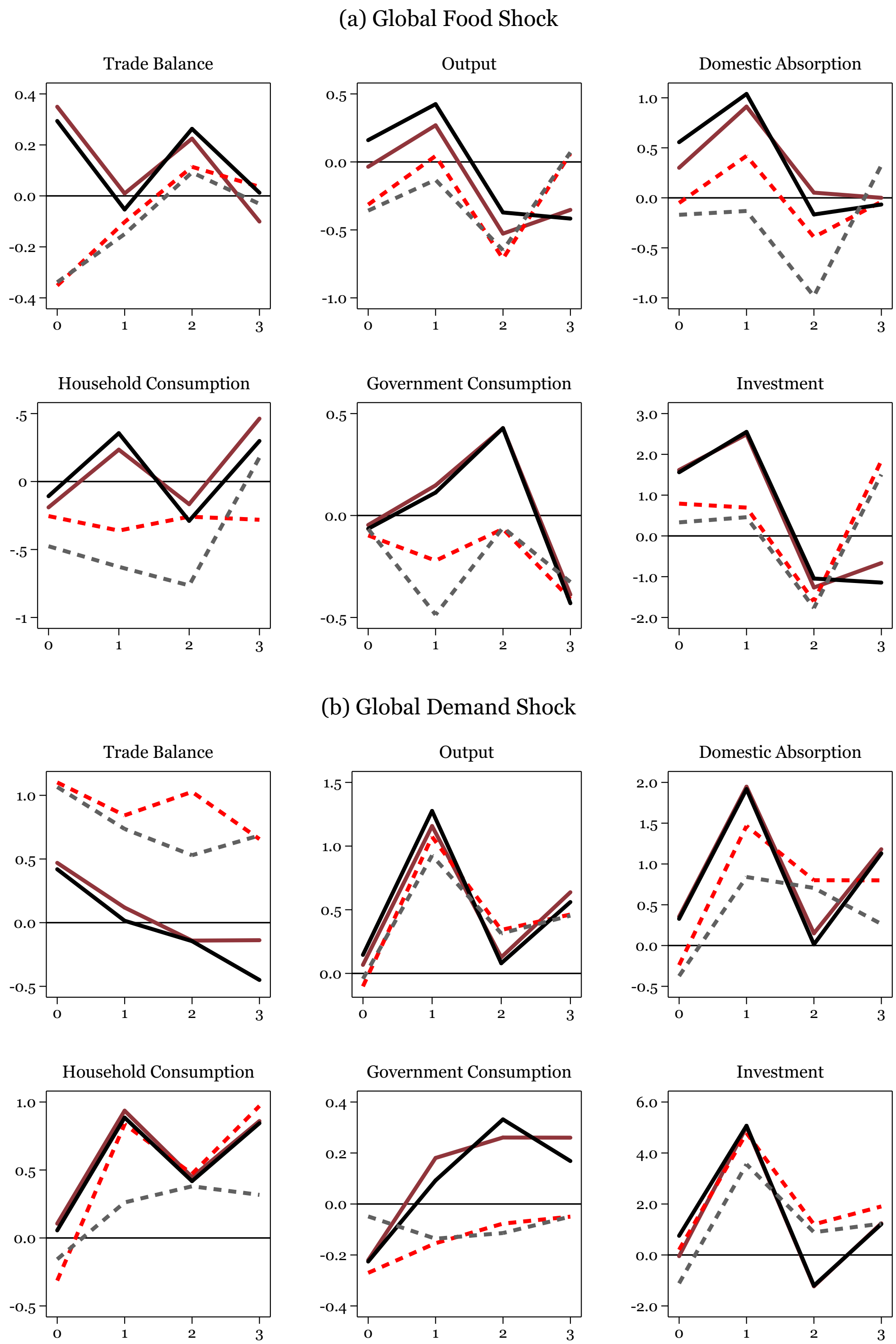


(b) Global Demand Shock



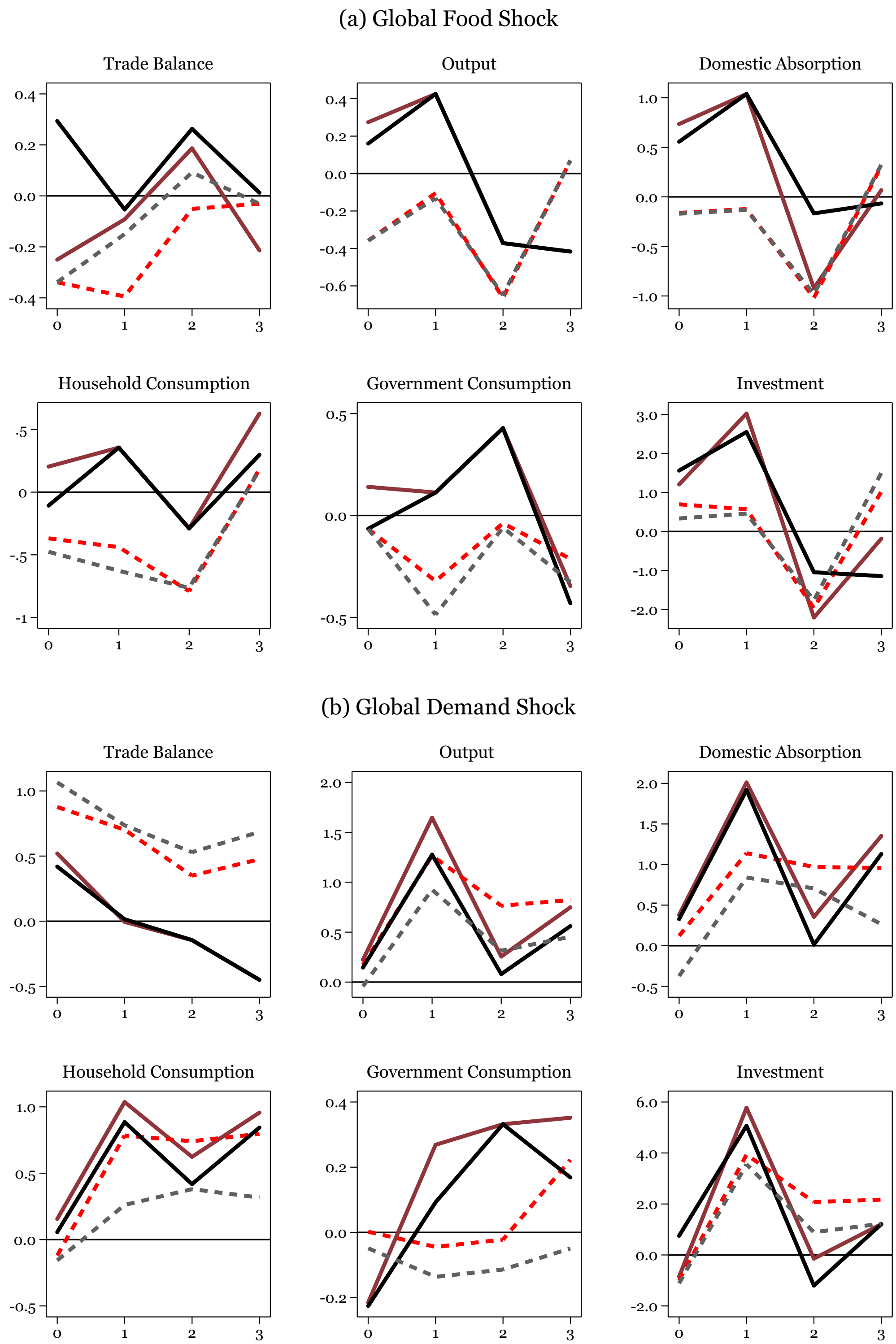
Note: This figure reproduces Figure 5 by comparing the baseline results to the robustness check of replacing global economic activity factor with the Kilian global economic activity index. The shocks are identified using sign restrictions. Baseline median impulse responses are represented by black/gray lines; robustness results are represented by red lines. In both cases, solid lines illustrate the median impulse responses for net food exporters, and dashed lines illustrate them for net food importers.

Figure A6: Robustness Analysis: Including Countries with a Population of Less than 1 Million



Note: This figure reproduces Figure 5 by comparing the baseline results to the robustness check including countries with a population of less than 1 million in the sample. The shocks are identified using sign restrictions. Baseline median impulse responses are represented by black/gray lines; robustness results are represented by red lines. In both cases, solid lines illustrate the median impulse responses for net food exporters, and dashed lines illustrate them for net food importers.

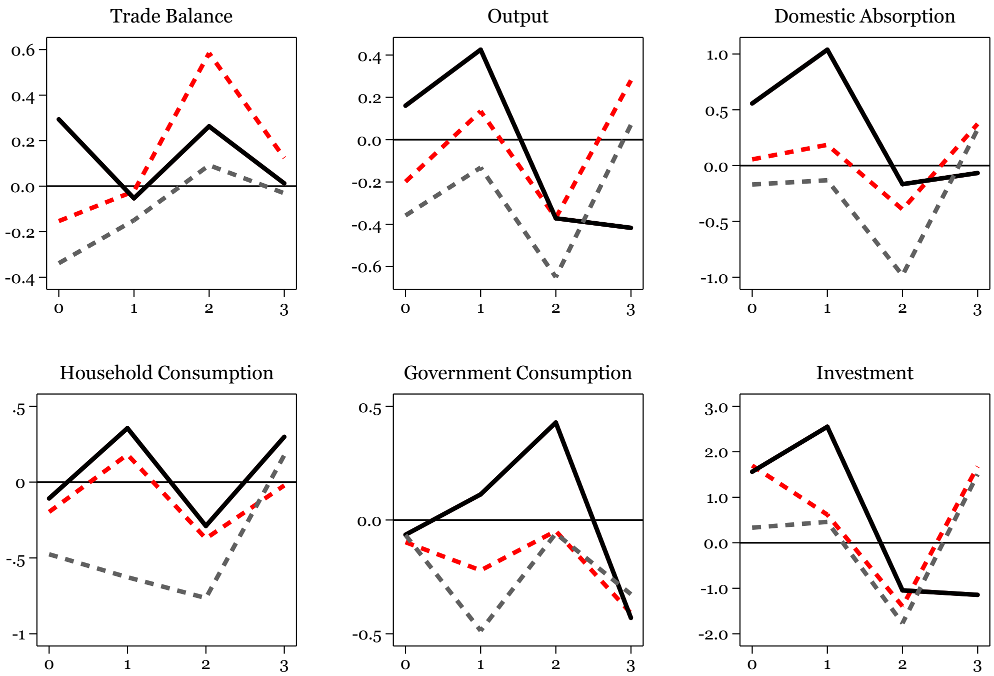
Figure A7: Robustness Analysis: Including Countries with Fewer than 30 Data Points



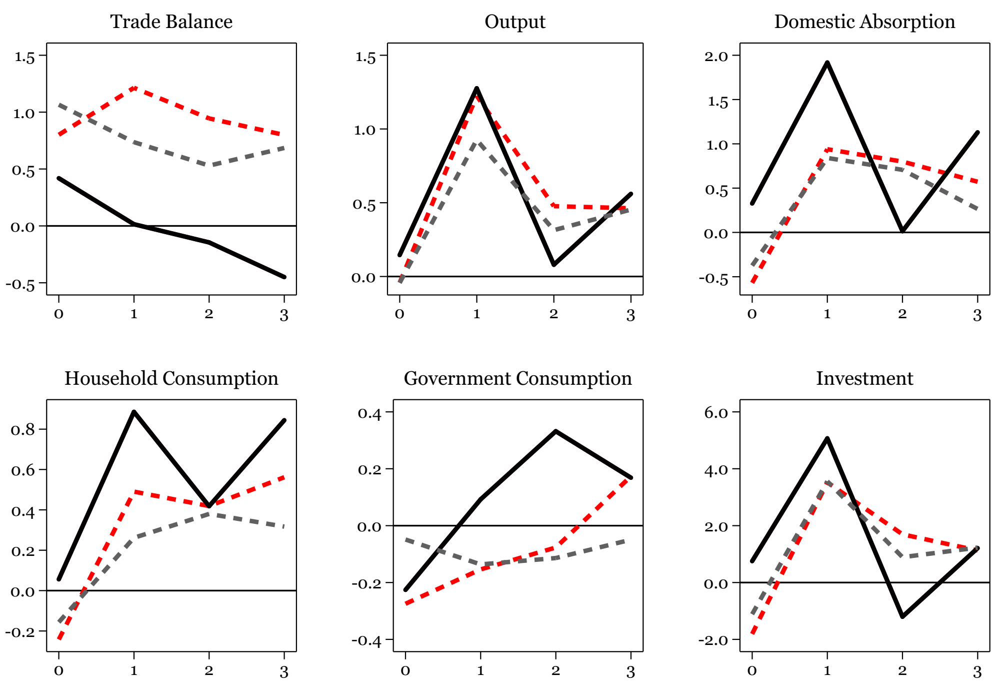
Note: This figure reproduces Figure 5 by comparing the baseline results to the robustness check including countries that have fewer than 30 data points in PWT in the sample. The shocks are identified using sign restrictions. Baseline median impulse responses are represented by black/gray lines; robustness results are represented by red lines. In both cases, solid lines illustrate the median impulse responses for net food exporters, and dashed lines illustrate them for net food importers.

Figure A8: Robustness Analysis: Including Countries with Poor Data Quality

(a) Global Food Shock

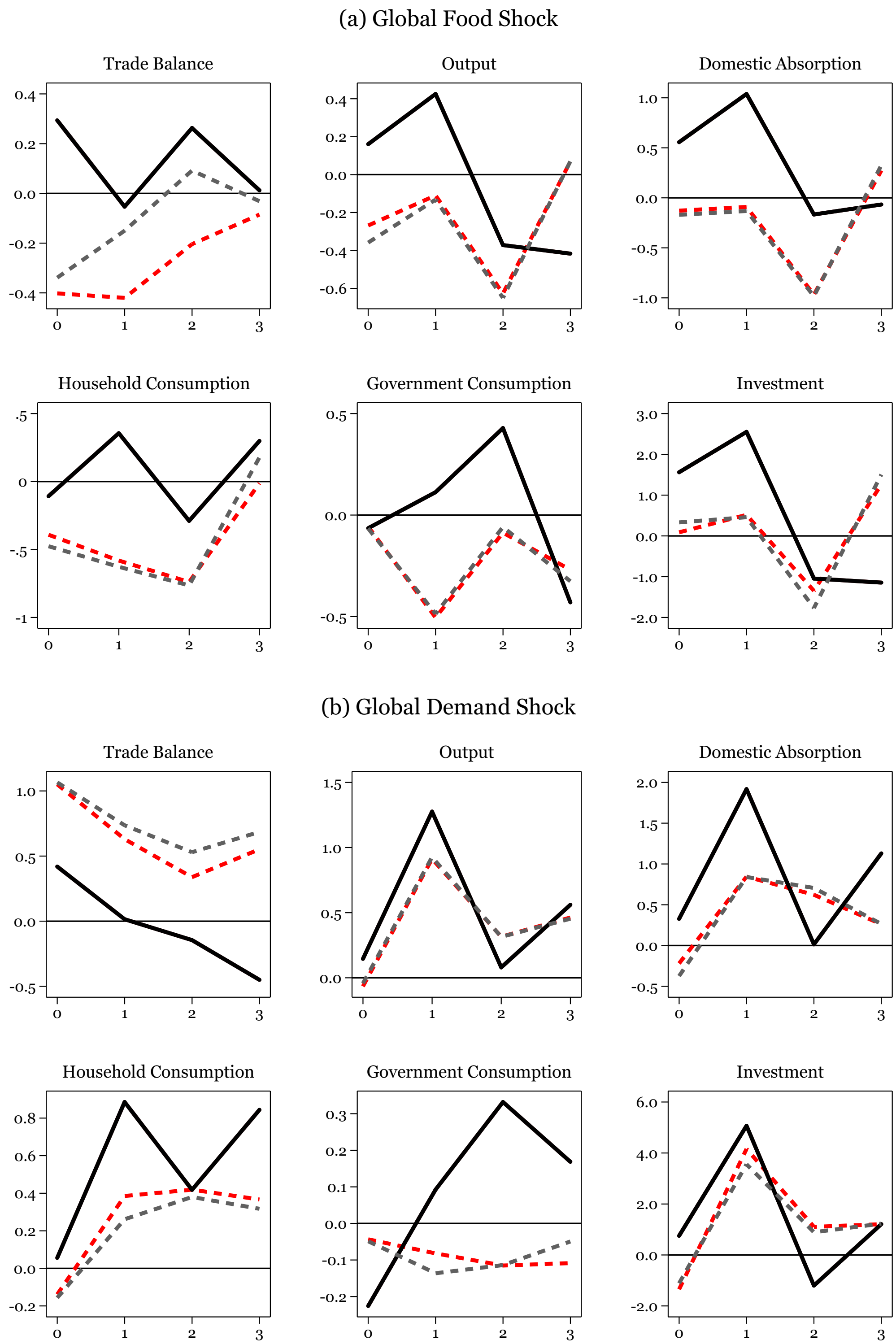


(b) Global Demand Shock



Note: This figure reproduces Figure 5 by comparing the baseline results to the robustness check of including countries with unreliable data. Countries with poor data quality category of "D" as listed in PWT 6.1 were included in the sample. The shocks are identified using sign restrictions. Baseline median impulse responses are represented by black/gray lines; robustness results are represented by red lines. In both cases, solid lines illustrate the median impulse responses for net food exporters, and dashed lines illustrate them for net food importers.

Figure A9: Robustness Analysis: Including Countries with Outlier Values Identified by the PWT



Note: This figure reproduces Figure 5 by comparing the baseline results to the robustness check of including countries with outlier values that are designated in PWT in the sample. The shocks are identified using sign restrictions. Baseline median impulse responses are represented by black/gray lines; robustness results are represented by red lines. In both cases, solid lines illustrate the median impulse responses for net food exporters, and dashed lines illustrate them for net food importers.

Table A1: Robustness Analysis: Recursive Identification

	GD Shock	GE Shock	GF Shock	GE and GF Shocks*
(a) Trade Balance	(1)	(2)	(3)	(4)
Food Exporters	0.11	0.19	0.08	0.16
Food Importers	0.17	0.10	0.15	0.24
Oil Exporters	0.09	0.18	0.14	0.17
Oil Importers	0.09	0.22	0.10	0.25
(b) Output				
Food Exporters	0.17	0.14	0.16	0.09
Food Importers	0.19	0.15	0.10	0.08
Oil Exporters	0.15	0.13	0.15	0.16
Oil Importers	0.16	0.14	0.12	0.09
(c) Domestic Absorption				
Food Exporters	0.21	0.16	0.13	0.10
Food Importers	0.17	0.15	0.09	0.10
Oil Exporters	0.14	0.16	0.10	0.19
Oil Importers	0.16	0.15	0.13	0.09
(d) Household Consumption				
Food Exporters	0.16	0.14	0.14	0.11
Food Importers	0.12	0.14	0.13	0.12
Oil Exporters	0.14	0.14	0.10	0.13
Oil Importers	0.14	0.14	0.14	0.10
(e) Government Consumption				
Food Exporters	0.13	0.13	0.13	0.13
Food Importers	0.11	0.13	0.10	0.13
Oil Exporters	0.11	0.14	0.09	0.11
Oil Importers	0.11	0.12	0.13	0.12
(f) Investment				
Food Exporters	0.20	0.13	0.11	0.10
Food Importers	0.17	0.17	0.10	0.10
Oil Exporters	0.15	0.12	0.10	0.12
Oil Importers	0.17	0.16	0.11	0.11

Notes: As a robustness check for Table 5, this table presents the share of variance of domestic output and its components explained by global shocks using recursive identification instead of sign identification in the SVAR model. It reports the median of the R^2 values obtained from the estimation of Equation (3) for countries listed in each group. GD shock represents a global demand shock, GE shock represents a global energy shock, and GF shock represents a global food shock. The first three columns report the R^2 values by using each global shock and its three period lags as in Equation (3). * indicates that the R^2 values use global energy and food shocks and their one-period lags jointly in the regression.

Table A2: Robustness Analysis: Sensitivity to Removing Bounds Restrictions

	GD Shock	GE Shock	GF Shock	GE and GF Shocks*
(a) Trade Balance	(1)	(2)	(3)	(4)
Food Exporters	0.11	0.15	0.10	0.16
Food Importers	0.15	0.21	0.15	0.25
Oil Exporters	0.11	0.18	0.13	0.19
Oil Importers	0.15	0.21	0.14	0.22
(b) Output				
Food Exporters	0.17	0.12	0.16	0.12
Food Importers	0.15	0.14	0.12	0.10
Oil Exporters	0.14	0.12	0.16	0.19
Oil Importers	0.16	0.13	0.12	0.10
(c) Domestic Absorption				
Food Exporters	0.18	0.13	0.12	0.12
Food Importers	0.13	0.16	0.11	0.10
Oil Exporters	0.17	0.15	0.12	0.16
Oil Importers	0.15	0.15	0.11	0.11
(d) Household Consumption				
Food Exporters	0.14	0.14	0.12	0.11
Food Importers	0.13	0.14	0.14	0.10
Oil Exporters	0.16	0.13	0.15	0.13
Oil Importers	0.12	0.15	0.13	0.11
(e) Government Consumption				
Food Exporters	0.14	0.14	0.09	0.10
Food Importers	0.10	0.13	0.09	0.11
Oil Exporters	0.09	0.15	0.10	0.13
Oil Importers	0.11	0.13	0.11	0.10
(f) Investment				
Food Exporters	0.19	0.14	0.08	0.12
Food Importers	0.14	0.18	0.10	0.11
Oil Exporters	0.14	0.09	0.12	0.14
Oil Importers	0.14	0.16	0.09	0.11

Notes: As a robustness check for Table 5, this table presents the share of variance of domestic output and its components explained by global shocks after removing the bounds restrictions used in the sign identification of the SVAR model. It reports the median of the R^2 values obtained from the estimation of Equation (3) for countries listed in each group. GD shock represents the global demand shock, GE shock represents the global energy shock, and GF shock represents the global food shock, each of which is identified using the sign-restricted identification scheme in Table 1. The first three columns report the R^2 values by using each global shock and its three period lags as in Equation (3). * denotes the R^2 values using the global energy and food shocks and their one-period lags jointly in the regression.

Table A3: Robustness Analysis: Sensitivity to Relaxing Bounds Restrictions

	GD Shock	GE Shock	GF Shock	GE and GF Shocks*
(a) Trade Balance	(1)	(2)	(3)	(4)
Food Exporters	0.10	0.18	0.08	0.17
Food Importers	0.13	0.27	0.13	0.26
Oil Exporters	0.08	0.17	0.14	0.20
Oil Importers	0.12	0.22	0.12	0.24
(b) Output				
Food Exporters	0.18	0.14	0.16	0.11
Food Importers	0.16	0.15	0.10	0.09
Oil Exporters	0.15	0.12	0.15	0.17
Oil Importers	0.16	0.14	0.12	0.09
(c) Domestic Absorption				
Food Exporters	0.19	0.14	0.13	0.11
Food Importers	0.14	0.16	0.09	0.09
Oil Exporters	0.15	0.16	0.10	0.16
Oil Importers	0.15	0.15	0.13	0.10
(d) Household Consumption				
Food Exporters	0.14	0.15	0.13	0.10
Food Importers	0.13	0.14	0.14	0.10
Oil Exporters	0.16	0.13	0.11	0.12
Oil Importers	0.12	0.15	0.14	0.11
(e) Government Consumption				
Food Exporters	0.12	0.13	0.12	0.12
Food Importers	0.09	0.13	0.09	0.12
Oil Exporters	0.09	0.14	0.09	0.11
Oil Importers	0.12	0.12	0.12	0.12
(f) Investment				
Food Exporters	0.18	0.13	0.11	0.10
Food Importers	0.14	0.16	0.11	0.10
Oil Exporters	0.13	0.10	0.10	0.12
Oil Importers	0.16	0.15	0.11	0.10

Notes: As a robustness check for Table 5, this table presents the share of variance of domestic output and its components explained by global shocks after relaxing the bounds restrictions. In particular, we accept draws with the elasticity of global output with respect to real oil prices that are in the range of [-0.025, 0) and the elasticity of global output with respect to real food prices that are in the range of [-0.015, 0). The original elasticity restrictions were [-0.015,0) and [-0.0075,0), respectively. The table reports the median of the R^2 values obtained from the estimation of Equation (3) for countries listed in each group. GD shock represents the global demand shock, GE shock represents the global energy shock, and GF shock represents the global food shock, each of which is identified using the sign-restricted identification scheme in Table 1. The first three columns report the R^2 values by using each global shock and its three period lags as in Equation (3). * denotes the R^2 values using the global energy and food shocks and their one-period lags jointly in the regression.

Table A4: Robustness Analysis: Real Energy Prices

	GD Shock	GE Shock	GF Shock	GE and GF Shocks*
(a) Trade Balance	(1)	(2)	(3)	(4)
Food Exporters	0.10	0.18	0.09	0.18
Food Importers	0.11	0.25	0.14	0.27
Oil Exporters	0.11	0.19	0.13	0.21
Oil Importers	0.11	0.24	0.12	0.26
(b) Output				
Food Exporters	0.17	0.12	0.17	0.12
Food Importers	0.16	0.12	0.11	0.09
Oil Exporters	0.17	0.12	0.15	0.18
Oil Importers	0.16	0.12	0.14	0.09
(c) Domestic Absorption				
Food Exporters	0.22	0.14	0.13	0.12
Food Importers	0.14	0.16	0.09	0.10
Oil Exporters	0.14	0.16	0.10	0.16
Oil Importers	0.14	0.15	0.12	0.11
(d) Household Consumption				
Food Exporters	0.15	0.13	0.11	0.09
Food Importers	0.12	0.15	0.14	0.10
Oil Exporters	0.16	0.12	0.12	0.11
Oil Importers	0.12	0.14	0.15	0.11
(e) Government Consumption				
Food Exporters	0.11	0.15	0.11	0.12
Food Importers	0.10	0.13	0.10	0.12
Oil Exporters	0.11	0.16	0.08	0.12
Oil Importers	0.11	0.12	0.11	0.12
(f) Investment				
Food Exporters	0.18	0.14	0.09	0.12
Food Importers	0.15	0.16	0.09	0.10
Oil Exporters	0.13	0.13	0.10	0.12
Oil Importers	0.16	0.15	0.10	0.10

Notes: As a robustness check for Table 5, this table presents the share of variance of domestic output and its components explained by global shocks after replacing real crude oil price index with real energy price index in the SVAR model. It reports the median of the R^2 values obtained from the estimation of Equation (3) for countries listed in each group. GD shock represents the global demand shock, GE shock represents the global energy shock, and GF shock represents the global food shock, each of which is identified using the sign-restricted identification scheme in Table 1. The first three columns report the R^2 values by using each global shock and its three period lags as in Equation (3). * denotes the R^2 values using the global energy and food shocks and their one-period lags jointly in the regression.

Table A5: Robustness Analysis: Kilian Global Economic Activity Index

	GD Shock	GE Shock	GF Shock	GE and GF Shocks*
(a) Trade Balance	(1)	(2)	(3)	(4)
Food Exporters	0.13	0.17	0.09	0.11
Food Importers	0.24	0.17	0.08	0.14
Oil Exporters	0.17	0.19	0.11	0.16
Oil Importers	0.22	0.16	0.08	0.13
(b) Output				
Food Exporters	0.11	0.13	0.16	0.12
Food Importers	0.11	0.14	0.13	0.10
Oil Exporters	0.12	0.20	0.15	0.20
Oil Importers	0.11	0.13	0.13	0.10
(c) Domestic Absorption				
Food Exporters	0.11	0.12	0.13	0.11
Food Importers	0.10	0.14	0.12	0.09
Oil Exporters	0.16	0.19	0.12	0.19
Oil Importers	0.12	0.11	0.13	0.10
(d) Household Consumption				
Food Exporters	0.12	0.15	0.15	0.12
Food Importers	0.12	0.14	0.13	0.08
Oil Exporters	0.16	0.21	0.13	0.15
Oil Importers	0.12	0.11	0.14	0.10
(e) Government Consumption				
Food Exporters	0.10	0.11	0.11	0.09
Food Importers	0.14	0.11	0.10	0.11
Oil Exporters	0.13	0.11	0.09	0.09
Oil Importers	0.11	0.11	0.12	0.11
(f) Investment				
Food Exporters	0.11	0.13	0.14	0.12
Food Importers	0.10	0.14	0.13	0.12
Oil Exporters	0.12	0.19	0.11	0.17
Oil Importers	0.11	0.13	0.12	0.11

Notes: As a robustness check for Table 5, this table presents the share of variance of domestic output and its components explained by global shocks after replacing the global economic activity factor with the Kilian global economic activity index in the SVAR model. It reports the median of the R^2 values obtained from the estimation of Equation (3) for countries listed in each group. GD shock represents the global demand shock, GE shock represents the global energy shock, and GF shock represents the global food shock, each of which is identified using the sign-restricted identification scheme in Table 1. The first three columns report the R^2 values by using each global shock and its three period lags as in Equation (3). * denotes the R^2 values using the global energy and food shocks and their one-period lags jointly in the regression.

Table A6: Robustness Analysis: Including Countries with a Population of Less than 1 Million

	GD Shock	GE Shock	GF Shock	GE and GF Shocks*
(a) Trade Balance	(1)	(2)	(3)	(4)
Food Exporters	0.11	0.16	0.08	0.14
Food Importers	0.14	0.20	0.13	0.20
Oil Exporters	0.10	0.25	0.13	0.20
Oil Importers	0.14	0.19	0.12	0.19
(b) Output				
Food Exporters	0.15	0.14	0.16	0.09
Food Importers	0.14	0.16	0.12	0.10
Oil Exporters	0.14	0.15	0.12	0.16
Oil Importers	0.14	0.15	0.13	0.09
(c) Domestic Absorption				
Food Exporters	0.16	0.13	0.13	0.10
Food Importers	0.16	0.16	0.11	0.10
Oil Exporters	0.17	0.16	0.13	0.18
Oil Importers	0.16	0.15	0.13	0.09
(d) Household Consumption				
Food Exporters	0.13	0.14	0.14	0.10
Food Importers	0.13	0.15	0.13	0.10
Oil Exporters	0.13	0.13	0.11	0.12
Oil Importers	0.13	0.15	0.13	0.10
(e) Government Consumption				
Food Exporters	0.13	0.12	0.15	0.12
Food Importers	0.11	0.13	0.11	0.12
Oil Exporters	0.10	0.13	0.10	0.12
Oil Importers	0.12	0.13	0.12	0.12
(f) Investment				
Food Exporters	0.19	0.11	0.12	0.10
Food Importers	0.14	0.16	0.11	0.12
Oil Exporters	0.14	0.16	0.12	0.16
Oil Importers	0.14	0.14	0.11	0.11

Notes: As a robustness check for Table 5, this table presents the share of variance of domestic output and its components explained by global shocks after including countries that have a population of less than 1 million in the sample. It reports the median of the R^2 values obtained from the estimation of Equation (3) for countries listed in each group. GD shock represents the global demand shock, GE shock represents the global energy shock, and GF shock represents the global food shock, each of which is identified using the sign-restricted identification scheme in Table 1. The first three columns report the R^2 values by using each global shock and its three period lags as in Equation (3). * denotes the R^2 values using the global energy and food shocks and their one-period lags jointly in the regression.

Table A7: Robustness Analysis: Including Countries with Fewer than 30 Data Points

	GD Shock	GE Shock	GF Shock	GE and GF Shocks*
(a) Trade Balance	(1)	(2)	(3)	(4)
Food Exporters	0.10	0.17	0.08	0.15
Food Importers	0.13	0.24	0.13	0.20
Oil Exporters	0.10	0.21	0.13	0.16
Oil Importers	0.12	0.20	0.11	0.20
(b) Output				
Food Exporters	0.15	0.15	0.12	0.10
Food Importers	0.15	0.17	0.09	0.10
Oil Exporters	0.14	0.20	0.12	0.17
Oil Importers	0.17	0.15	0.10	0.10
(c) Domestic Absorption				
Food Exporters	0.18	0.16	0.13	0.11
Food Importers	0.17	0.17	0.09	0.10
Oil Exporters	0.13	0.16	0.09	0.17
Oil Importers	0.17	0.16	0.12	0.10
(d) Household Consumption				
Food Exporters	0.14	0.15	0.11	0.11
Food Importers	0.13	0.15	0.12	0.11
Oil Exporters	0.14	0.14	0.10	0.13
Oil Importers	0.13	0.15	0.13	0.12
(e) Government Consumption				
Food Exporters	0.12	0.15	0.15	0.13
Food Importers	0.11	0.15	0.10	0.12
Oil Exporters	0.11	0.17	0.09	0.12
Oil Importers	0.12	0.14	0.12	0.12
(f) Investment				
Food Exporters	0.19	0.13	0.11	0.10
Food Importers	0.13	0.17	0.10	0.11
Oil Exporters	0.12	0.14	0.10	0.14
Oil Importers	0.15	0.16	0.13	0.10

Notes: As a robustness check for Table 5, this table presents the share of variance of domestic output and its components explained by global shocks after including countries that have fewer than 30 data points in PWT in the sample. It reports the median of the R^2 values obtained from the estimation of Equation (3) for countries listed in each group. GD shock represents the global demand shock, GE shock represents the global energy shock, and GF shock represents the global food shock, each of which is identified using the sign-restricted identification scheme in Table 1. The first three columns report the R^2 values by using each global shock and its three period lags as in Equation (3). * denotes the R^2 values using the global energy and food shocks and their one-period lags jointly in the regression.

Table A8: Robustness Analysis: Including Countries with Poor Data Quality

	GD Shock	GE Shock	GF Shock	GE and GF Shocks*
(a) Trade Balance	(1)	(2)	(3)	(4)
Food Exporters	0.10	0.17	0.08	0.14
Food Importers	0.14	0.20	0.11	0.20
Oil Exporters	0.10	0.23	0.13	0.16
Oil Importers	0.14	0.19	0.11	0.20
(b) Output				
Food Exporters	0.15	0.14	0.17	0.09
Food Importers	0.15	0.14	0.10	0.09
Oil Exporters	0.13	0.13	0.12	0.16
Oil Importers	0.15	0.14	0.12	0.09
(c) Domestic Absorption				
Food Exporters	0.17	0.15	0.13	0.09
Food Importers	0.16	0.15	0.10	0.10
Oil Exporters	0.15	0.15	0.13	0.18
Oil Importers	0.16	0.15	0.13	0.10
(d) Household Consumption				
Food Exporters	0.14	0.14	0.13	0.10
Food Importers	0.13	0.14	0.12	0.10
Oil Exporters	0.15	0.13	0.11	0.13
Oil Importers	0.13	0.14	0.13	0.10
(e) Government Consumption				
Food Exporters	0.13	0.12	0.14	0.12
Food Importers	0.11	0.13	0.09	0.10
Oil Exporters	0.09	0.13	0.09	0.11
Oil Importers	0.11	0.12	0.12	0.11
(f) Investment				
Food Exporters	0.19	0.12	0.11	0.10
Food Importers	0.14	0.16	0.11	0.11
Oil Exporters	0.14	0.17	0.13	0.12
Oil Importers	0.15	0.15	0.12	0.10

Notes: As a robustness check for Table 5, this table presents the share of variance of domestic output and its components explained by global shocks after including countries with unreliable data. Countries with poor data quality of category of "D" as listed in PWT 6.1 were included in the sample. It reports the median of the R^2 values obtained from the estimation of Equation (3) for countries listed in each group. GD shock represents the global demand shock, GE shock represents the global energy shock, and GF shock represents the global food shock, each of which is identified using the sign-restricted identification scheme in Table 1. The first three columns report the R^2 values by using each global shock and its three period lags as in Equation (3). * denotes the R^2 values using the global energy and food shocks and their one-period lags jointly in the regression.

Table A9: Robustness Analysis: Including Countries with Outlier Values Identified by the PWT

	GD Shock	GE Shock	GF Shock	GE and GF Shocks*
(a) Trade Balance	(1)	(2)	(3)	(4)
Food Exporters	0.10	0.17	0.08	0.14
Food Importers	0.14	0.25	0.13	0.21
Oil Exporters	0.10	0.16	0.13	0.14
Oil Importers	0.13	0.20	0.12	0.20
(b) Output				
Food Exporters	0.15	0.14	0.17	0.09
Food Importers	0.15	0.15	0.10	0.09
Oil Exporters	0.13	0.13	0.12	0.16
Oil Importers	0.16	0.14	0.12	0.08
(c) Domestic Absorption				
Food Exporters	0.17	0.15	0.13	0.09
Food Importers	0.16	0.15	0.08	0.09
Oil Exporters	0.16	0.15	0.09	0.15
Oil Importers	0.16	0.15	0.13	0.09
(d) Household Consumption				
Food Exporters	0.14	0.14	0.13	0.10
Food Importers	0.13	0.14	0.13	0.11
Oil Exporters	0.18	0.14	0.11	0.12
Oil Importers	0.12	0.15	0.14	0.11
(e) Government Consumption				
Food Exporters	0.13	0.12	0.14	0.12
Food Importers	0.11	0.13	0.10	0.11
Oil Exporters	0.09	0.12	0.10	0.11
Oil Importers	0.12	0.12	0.13	0.12
(f) Investment				
Food Exporters	0.19	0.12	0.11	0.10
Food Importers	0.14	0.16	0.09	0.11
Oil Exporters	0.14	0.10	0.10	0.11
Oil Importers	0.15	0.16	0.12	0.10

Notes: As a robustness check for Table 5, this table presents the share of variance of domestic output and its components explained by global shocks after including countries with outlier values that are designated in PWT in the sample. It reports the median of the R^2 values obtained from the estimation of Equation (3) for countries listed in each group. GD shock represents the global demand shock, GE shock represents the global energy shock, and GF shock represents the global food shock, each of which is identified using the sign-restricted identification scheme in Table 1. The first three columns report the R^2 values by using each global shock and its three period lags as in Equation (3). * denotes the R^2 values using the global energy and food shocks and their one-period lags jointly in the regression.