U.S. Agricultural Export Competitiveness and Export Market Diversification

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Abstract

This paper examines the structural relationship between U.S. agricultural exports, foreign GDP growth, and real exchange rate volatility, and the impact of exogenous shocks on the evolution of export growth to examine the sector's international competitiveness and opportunities for export extensification. The long- and short-run dynamics of export demand are analyzed within the structural cointegrating vectorautoregressive framework. Principal findings are that: 1. Exports of high-value processed agricultural products are more sensitive to changes in foreign income and exchange rate fluctuations than exports of low-value grains and bulk commodities. Specifically, a 10% growth in trade-adjusted GDP across all importing countries leads to a 7.8% increase in U.S. exports of bulk commodities compared to 33% increase in exports of high-value processed commodities. Similarly, a 10% increase in the value of the trade-weighted exchange rate (*i.e.*, an appreciation of the U.S. dollar) reduces bulk exports by 8.4% compared to a whopping 35% decline in high-value processed food exports; 2. In response to exogenous shocks, deviations from the predicted equilibrium level of exports are corrected at a much faster rate for grains and other bulk commodity exports than export of high value commodities. For example, more than 75% of the disequilibrium in aggregate bulk commodity exports is corrected within one year; less than 15% of the disequilibrium in high-value processed exports is corrected within a year. 3. The present concentration of U.S. agricultural commodity exports to a few developed countries is increasingly problematic, U.S. agricultural exports may benefit not only from policies intended to increase trade with existing developing country importers but also from policies that aim to export agricultural commodities to emerging markets. Our paper also highlights the importance of including the long-run relationship when modeling the short-run dynamics.

JEL Classification: Q17, O11, O41, O51, F14, F41, F62, C22, C32

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1 Introduction

Economic growth in developing countries has been accompanied by a dramatic rise in developing countries' share of world trade [World Trade Organization, 2014]. Growth in world food demand, pulled by rising incomes and the rising opportunity cost of household member time, is changing the composition as well as destination of U.S. agricultural exports.

The expansion of U.S. agricultural exports along the extensive margin is plotted in figure 1. The upper segment of the bars represents the fraction of countries that do not import agricultural commodities from the U.S: thus, in 2010 U.S. agricultural exports reached 85% of the 219 countries in the sample compared to 65% in 1967, indicative of the expansion of agricultural exports along the extensive margin. However, inspection of the intensive margin of U.S. agricultural exports (figure 2) reveals that for every year in the sample, 25 countries have accounted for at least 80% of all agricultural exports. While the countries in the top-25 list have changed remarkably[1], U.S. agricultural exports have remained concentrated in a handful of countries. Thus, expansion of agricultural trade along the extensive margin has not been a major factor in the growth of U.S. agricultural exports.

The evolution of U.S. agricultural exports can be further refined by classifying importers as developing, transition, developed, or oil-exporting countries. Figure 3 depicts the evolution of commodity export shares (by volume), averaged over the 1967-1970 and 2006-2010 periods. Developing countries remain a major importer of bulk exports, whereas horticulture and produce exports remain highly concentrated, with at least 80% of fruits and vegetable exports accruing to developed countries. Note also the substantial increase in developing countries' demand for meat and meat products (pork, red meat, lamb, poultry, and turkey). Developing country markets are, thus, increasingly important for U.S. agricultural exports.

Additionally, the evolution of trade-weighted index of per capita income of importing countries (figure 4) indicates that developed countries with high per-capita incomes are associated with imports of high-value processed commodities, while low- and middle-income developing countries primarily import low-value grains and bulk commodities. This suggests that economic growth in developing countries will create new possibilities for expansion of U.S. exports of higher value-added

[1]Tables of descriptive statistics are available from the authors upon request.

commodities to heretofore untapped markets.

A rigorous analysis of factors affecting demand for U.S. agricultural exports will allow us to determine the impact of changes in global economic growth on volume of trade with the rest of the world and identify opportunities for U.S. agricultural export market diversification. Shane, Roe, and Somwaru [2008] use a dynamic maximizing framework to derive the demand for U.S. agricultural exports as a function of partners' income and real exchange rate. The authors find that episodes of rising U.S. agricultural exports are associated with growth in importing countries' income, whereas episodes of declining exports tend to be dominated by an appreciation of U.S. trade-weighted exchange rate.

This paper extends the Shane et al. [2008] work to examine the short- and long-run structural relationship between volume of exports, economic growth, and real exchange rate volatility, and the impact of exogenous shocks on the evolution of export volume, foreign income, and real exchange rate. The framework is applied to examine U.S. agricultural sector's international competitiveness and opportunities for export extensification.

Modeling economic time series data is riddled with several statistical challenges. First, nonstationary data are not amenable to standard statistical methods of estimation and inference. Moreover, statistical analysis requires econometric methods that account for the potential cointegration among macroeconomic variables. The econometric framework in this paper uses the bounds test, developed by Pesaran, Shin, and Smith [2001], which alleviates the problem of modeling potentially cointegrated variables when there is uncertainty about the unit root properties of the underlying regressors. The bounds test is used to test if the data accepts the long-run relationship posited by the theoretical framework; if the relationship exists, the long-run multipliers associated with foreign GDP and exchange rate are computed.

Interactions among variables in a macroeconomic model are, however, far more complex than what is captured by the posited long-run equilibrium relationship alone; studying the short-run transition dynamics provides a richer understanding of the underlying structure. Our paper uses the error correction framework as it is "an excellent framework within which it is possible to apply both the data information and the information obtainable from economic theory" [Hylleberg and Mizon, 1989]. Economic theory provides the basis to formulate a structural export demand relationship; thereafter, we use impulse response analysis and forecast error variance decomposition within an error correction model to study the short-run transition dynamics of the export demand system in response to exogenous shocks.

Our major findings are as follows: (i) An increase (decrease) in importing countries' trade-adjusted GDP leads to an increase (decrease) in U.S. agricultural exports; (ii) A real appreciation (depreciation) of the U.S. dollar results in a decline (increase) in U.S. agricultural exports; and (iii) Exports of high-value processed agricultural products are more sensitive to changes in foreign income and exchange rate fluctuations than exports of low-value grains and bulk commodities. Specifically, a 10% growth in trade-adjusted GDP across all importing countries leads to a 7.8% increase in U.S. exports of bulk commodities compared to 33% increase in exports of high-value processed commodities. Similarly, a 10% increase in the value of the trade-weighted exchange rate (*i.e.*, an appreciation of the U.S. dollar) reduces bulk exports by 8.4% compared to a whopping 35% decline in high-value processed food exports; and (iv) In response to exogenous shocks, deviations from the predicted equilibrium level of exports are corrected at a much faster rate for grains and other bulk commodity exports than export of high value commodities. For example, more than 75% of the disequilibrium in aggregate bulk commodity exports is corrected within one year; less than 15% of the disequilibrium in high-value processed exports is corrected within a year.

Our paper makes three main contributions to the literature. First, we provide a comprehensive analysis of the long- and short-run dynamics of U.S. agricultural export demand, using data on 32 commodities and commodity categories, for the period 1967 - 2010. Second, our paper shows that disequilibrating shocks to agricultural exports are rather costly to low-income countries with relatively high export shares for food, resulting in a speedy convergence to pre-shock long-run equilibrium levels of imports. Third, our paper highlights the importance of including the long-run relationship when modeling the short-run dynamics, which has not received sufficient attention in the literature. Our framework begins with an explicit statement of the underlying macroeconomic theory; *a priori* identification restrictions used to draw structural inference, therefore, relate to the long-run properties of the macroeconomic variables, thus avoiding Sims's critique of the ad-hoc use of 'incredible identifying restrictions' [Sims, 1980].

In the following sections, the theoretical model and econometric framework are presented, followed by a discussion of the long-run export demand multipliers and short-run dynamics of the export demand model.

2 Conceptual Framework

The basic setup of the analytical model follows that of Senhadji and Montenegro (1998). Consider a two-country world: a home country (exporter) and a foreign country (importer). Following the typical growth model structure (e.g. Barro and Sala-i-Martin, 2004), households consist of finitely lived agents, behaving altruistically: they provide transfers to their future generations, whose welfare they discount, who in turn provide transfers to their future generations, and so on.

At each point in time, households, as owners of the country's resources, consume a portion of their domestic production and export the rest. In addition, households spend part of their income on imported goods. Using * superscripts to identify the foreign country, let e_t^* and d_t^* denote the foreign country's endowment and consumption of the domestically produced good, respectively. Let x_t^* denote the quantity of domestic good exported to the 'home' country, at the numeraire price. Let m_t^* denote foreign country's consumption of the good imported from the 'home' country, at a price of p_t. Expressed this way, p_t is the price of the imported good relative to the numeraire price of the domestically produced good; accordingly, p_t can be interpreted as the 'real exchange rate' between the two countries' currencies. Further, household earnings consist of factor payments, the sum of which equals the value of domestic production at the numeraire price, e_t^*, and the stock of (risk-less) bonds, b_t^*, which are traded freely at world interest rate, r.

The optimization problem facing the representative agent in the foreign country is to maximize the discounted present value of inter-temporal utility

$$\max_{\{d_t^*, m_t^*\}_{t=0}^{\infty}} \int_0^{\infty} u(d_t^*, m_t^*)\, exp(-\rho t)\, dt, \tag{1}$$

subject to the budget constraint

$$b_{t+1}^* = (1+r)\, b_t^* + (e_t^* - d_t^*) - p_t\, m_t^*, \tag{2}$$

Here, $u(d_t^*, m_t^*)$ is the felicity function, and ρ is the consumer's rate of time-preference, assumed to be constant to ensure that the discount rate is the same across generations. If b_{t+1}^* is positive, the foreign country holds a stock of home bonds in the next period; conversely, if b_{t+1}^* is negative, the home country holds a stock of foreign bonds in the next period.[2]

In addition, we assume that $\lim_{\tau \to \infty} exp(-\rho\tau)\, b^*_\tau \geq 0$, which implies that the net present value of assets is asymptotically negative. This is the familiar 'no-Ponzi games' condition to prevent households from running Ponzi schemes by accumulating debts forever. Furthermore, to ensure that the felicity function is strongly separable, we assume that $u(\cdot)$ is addilog[3] and satisfies

$$u\left(d^*_t, m^*_t\right) = \frac{A_t \left(d^*_t\right)^{1-\alpha}}{1-\alpha} + \frac{B_t \left(m^*_t\right)^{1-\beta}}{1-\beta}; \quad \alpha > 0,\ \beta > 0, \tag{3}$$

where A_t and B_t are scale parameters, and α and β are curvature parameters.

We can solve this optimization problem by setting up the present-value Hamiltonian

$$H = u(d^*_t, m^*_t)\, e^{-\rho t} + \lambda_t \left[b^*_t r + (e^*_t - d^*_t) - p_t\, m^*_t\right] \tag{4}$$

and taking partial derivatives with respect to the choice variables, d^*_t and m^*_t, and the co-state variable, λ_t. Solving for m^*_t and taking log on both sides, we can express foreign country's demand for home country's goods as

$$\log\left(m^*_t\right) = -\frac{1}{\beta}\,\frac{A_t}{B_t} + \frac{\alpha}{\beta}\,\log d^*_t - \frac{1}{\beta}\log p_t \tag{5}$$

The two-country set-up implies that the foreign country's imports are equal to the home country's exports: $m^*_t = x_t$. In addition, using gross domestic product, gdp^*_t– national income from factor payments to households– to measure the value of domestic supply, the value of the foreign country's exports can be expressed as the difference between the endowment (gdp^*_t) and consumption of the domestic good, valued at numeraire price: $x^*_t = e^*_t - d^*_t = gdp^*_t - d^*_t$. Substituting for m^*_t and d^*_t in (5), we can express the foreign country's demand for home country's exports as

$$\log\left(x_t\right) = c_0 + \frac{\alpha}{\beta}\,\log\left(gdp^*_t - x^*_t\right) - \frac{1}{\beta}\log p_t, \tag{6}$$

[2] Note that in (2), replacing x^*_t with $(e^*_t - d^*_t)$, and rearranging terms yields the *flow* budget constraint, or the equation of motion of assets, $\dot{b}^* = b^* r + (e^* - d^*) - p\, m^*$.

[3] Separability allows imports and domestic goods to be imperfect substitutes. While strong separability is necessary for the model to be compatible with available data, the choice is in line with such studies on import and export demand elasticities as Ceglowski (1991), Ogaki (1992), Clarida (1991), Senhadji (1998), and Senhadji and Montenegro (1998). For properties of the addilog function, see Houthakker (1960).

where $c_0 = -\frac{1}{\beta}\frac{A}{B}$. Thus, the importing country's demand for the exporting country's good is a function of the importing country's *trade-adjusted GDP* $(gdp_t^* - x_t^*)$, and the relative price of the imported good, or the exchange rate (p_t).

Next, to implement the above export demand function in a multi-country, multi-commodity framework, we construct commodity-specific indexes[4] for importers' trade-adjusted GDP and real exchange rate. The aggregate foreign demand for home country's exports of the i'th commodity $(i = 1, 2, \ldots N)$ can be expressed as

$$\log\left(x_{i,t}\right) = \mu_i + \delta_i \,\log\left[\sum_{k=1}^{K} \omega_{i,t}^{k}\left(gdp_t^{k*} - x_t^{k*}\right)\right] + \gamma_i \,\log\left[\sum_{k=1}^{K} \omega\,_{i,t}^{k}(rer\,_{i,t}^{k})\right] + \varepsilon_{i,t} \tag{7}$$

where the commodity-specific weights, $\omega_{i,t}^k = x_{i,t}^k / \sum_{k=1}^K x_{i,t}^k$, are defined as the share of home country's exports of the i'th commodity accruing to the k'th importing country $(k = 1, 2, \ldots K)$.

Finally, using $X_{i,t}$, $GDP_{i,t}^*$, and $RER_{i,t}$ to denote, respectively, aggregate exports of commodity i, and commodity-export weighted indexes of importers' trade-adjusted GDP and real exchange rate to simplify notation, the structural export demand equation has the form

$$X_{i,t} = \mu_i + \delta_i \, GDP_{i,t}^* + \gamma_i \, RER_{i,t} + \varepsilon_{i,t} \tag{8}$$

Equation (8) is the commodity-specific *structural export demand equation* for home country's exports: it represents the long-run relationship underlying the movements in exports, foreign incomes and real exchange rates[5].

[4]Trade-weighted indices are an average measure, where each country is weighted by its importance in trade. The list of countries accounting for the largest share of U.S. agricultural exports varies across commodities. For instance, the five countries with the largest shares (average 2003–05) of U.S. bulk commodity exports are China (29.2%), Turkey (12.5$), Mexico (12.2%), Indonesia (6.6%), and Thailand (4.5%). In contrast, the largest importers of U.S. high-value processed commodity exports are Mexico (20.7%), Canada (17.1%), Japan (13.3%), Hong Kong (9.9%), and the Netherlands (6.2%). Evolution of broad macroeconomic series varies substantially across the two sets of countries. The advantage of using trade-weighted indices is that these variations across commodities are embodied in commodity-trade weighted indices of GDP and exchange rate. See documentation on Agricultural Exchange Rate Data Set, Economic Research Service, U.S. Department of Agriculture.

[5]We construct a three-year moving average sequence of country export shares to reduce the impact of year-to-year volatility on trade-weights (Esfahani *et al.*, 2014). Furthermore, we use a fixed weight scheme, using the average 2003–05 share of U.S. exports to construct the commodity trade weighted indices of foreign GDP and exchange rate.

3 Econometric Methodology

The principal steps in the research methodology consist of: first, establishing the order of integration of variables in the export demand equation; second, selecting an appropriate error correction specification of export demand that passes model diagnostic tests (serial correlation, normally distributed errors, dynamic stability); third, testing for the presence of a long-run relationship underlying the core variables; and, finally, conditional on the null of no long-run relationship being rejected, estimating parameters of the export demand model and examining short-run dynamics.

3.1 Unit Root Properties of the Variables

Because standard asymptotic distribution theory does not apply to estimation procedures with non-stationary data, the first task is to establish the order of integration of variables in the export demand equation. It is often difficult to distinguish between borderline stationary, trend stationary and difference stationary processes. In such cases, selecting the appropriate method for eliminating the trend is tricky: de-trending a difference stationary process does not eliminate the stochastic portion of the trend from the series, and differencing a trend stationary process unwittingly introduces a non-invertible unit root component to the series [Enders, 2004].

We use the generalized least squares version of the popular augmented Dickey-Fuller (ADF) test of non-stationarity. The null hypothesis is that the series has a unit root. The Dickey-Fuller generalized least squares (DF-GLS) test performs considerably better in small samples and has greater power than the ADF test, particularly in the presence of an unknown mean or trend. Baum [2005] comments that the DF-GLS test is more robust than the "first generation" ADF test, and recommends it as the "unit root test of choice."

We also apply the Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test of stationarity, which is a more conservative testing strategy because the hypothesis of interest is the alternate hypothesis Kwiatkowski, Phillips, Schmidt, and Shin [1992]. Failure to reject the null hypothesis of the KPSS test indicates that the evidence in favor of a unit root is insufficient. If the DF-GLS test simultaneously suggests the presence of a unit root, it is prudent to go with the verdict of the more conservative test, and conclude that the series does not possess a unit root. Clearly, if the verdicts of the two tests concur, the integration properties of the variables can be determined conclusively.

3.2 A Long-Run Model of Export Demand

To keep notation simple, commodity subscripts are suppressed. Assuming that the structural export demand equation (7) can be well-approximated by a log-linear vector autoregression (VAR) model, let $y_t = (X_t,\ GDP^*_t,\ RER_t)'$ be the vector of endogenous variables: quantity exported by the home country, index of importing countries' trade-adjusted GDP, and index of importing countries' trade-weighted real exchange rate, respectively, all expressed in natural logs.

This VAR model can be rewritten in its *conditional* vector error correction (VECM) form as:

$$y_t = a + \vartheta t + \sum_{i=1}^{p} \mathbf{\Phi}_i y_{t-i} + \varepsilon_t, \quad t = 1, 2, \ldots, T. \tag{9}$$

Here, a is a vector of constant terms, ϑ is a vector of trend coefficients, $\mathbf{\Phi}_i$ is a matrix of VAR parameters for the i'th lag, and ε_t is a vector of error terms, $\varepsilon_t \sim IN(0, \Omega),\ \Omega$ is positive definite.

The unrestricted vector error correction model has the following representation

$$\Delta y_t = b + \theta t + \mathbf{\Pi}\, y_{t-1} + \sum_{i=1}^{p-1} \mathbf{\Gamma}_i \Delta y_{t-i} + u_t, \tag{10}$$

where $y_t = (X_t,\, GDP^*_t,\, RER_t)'$ is the vector of endogenous variables, $\mathbf{\Pi}$ and $\mathbf{\Gamma}_i$ are matrices of long-run multipliers and i'th-lag short-run response parameters, respectively:

$$\mathbf{\Pi} = (\pi_x,\, \pi_g,\, \pi_r)' = \begin{pmatrix} \pi_{x,x} & \pi_{x,g} & \pi_{x,r} \\ \pi_{g,x} & \pi_{g,g} & \pi_{g,r} \\ \pi_{r,x} & \pi_{r,g} & \pi_{r,r} \end{pmatrix}, \quad \mathbf{\Gamma}_i = (\gamma_{x,i},\, \gamma_{g,i},\, \gamma_{r,i})' = \begin{pmatrix} \gamma_{x,x;\,i} & \gamma_{x,g;\,i} & \gamma_{x,r;\,i} \\ \gamma_{g,x;\,i} & \gamma_{g,g;\,i} & \gamma_{g,r;\,i} \\ \gamma_{r,x;\,i} & \gamma_{r,g;\,i} & \gamma_{r,r;\,i} \end{pmatrix},$$

Δ is the difference operator, $b = (b_x,\, b_g,\, b_r)'$ is a vector of intercepts; $\theta = (\theta_x,\, \theta_g,\, \theta_r)'$ is a vector of trend coefficients; p is the number of lagged differences of the endogenous variables; and $u_t = (u_{x,t},\, u_{g,t},\, u_{r,t})'$ is a vector of serially-uncorrelated zero-mean stationary errors. Thus, the VECM form of the export demand equation can be expressed as

$$\begin{aligned} \Delta X_t \;&=\; b_x + \theta_x t \\ &+\; \pi_{x,x}\, X_{t-1} + \pi_{x,g}\, GDP^*_{t-1} + \pi_{x,r}\, RER_{t-1} \\ &+\; \sum_{i=1}^{p-1} \gamma_{x,x;\,i}\, \Delta X_{t-i} + \sum_{i=1}^{p-1} \gamma_{x,g;\,i}\, \Delta GDP^*_{t-i} + \sum_{i=1}^{p-1} \gamma_{x,r;\,i}\, \Delta RER_{t-i} + u_{x,\,t} \end{aligned} \tag{11}$$

The Akaike Information Criterion [Akaike, 1998], the Schwarz-Bayesian Information Criterion [Schwarz, 1978], and the Hannan-Quinn Information Criterion [Hannan and Quinn, 1979] (AIC, SBC, and HQIC respectively)[6] are used to determine the optimal number of lags, p, in the VECM. Each criterion penalizes over-fitting, while also rewarding goodness of fit, with the SBC and HQIC imposing a heavier penalty for additional parameters relative to the AIC. Thus, the AIC tends to overestimate the 'true' lag order; in contrast, the SBC and HQIC provide consistent estimates of the true lag order, and may be preferred from a theoretical point of view [StataCorp, 2013].

The chosen model should satisfy two additional requirements: first, the error terms, u_t in (11) must be serially independent. We use Durbin's [1970] Lagrange multiplier test to test for presence of residual serial correlation.

Due to the autoregressive structure, interpretation of the VECM requires the model to be dynamically stable. This is the second requirement. Dynamic stability ensures that the cumulative effect of a shock does not cause a series to have an explosive time-path: this is critical if the model is used for forecasting. To illustrate, let $y_t = \gamma_1 y_{t-1} + \gamma_2 y_{t-2} + \cdots + \gamma_p y_{t-p} + \varepsilon_t$ be an autoregressive process of order p, where $\{\varepsilon_t\}_{t=1}^{\infty} \sim i.i.d.(0, \sigma^2)$ is the vector of error terms. For this AR(p) process to be dynamically stable, all inverse roots of the corresponding characteristic equation, $z^p - \gamma_1 z^{p-1} - \gamma_2 z^{p-2} - \cdots - \gamma_p = 0$, must lie strictly outside the unit circle.

After an appropriate model is selected, we test the existence of a long-run export demand equation, which is a test of the null hypothesis that the long-run multipliers $\pi_{x,x}$, $\pi_{x,g}$, and $\pi_{x,r}$ are jointly zero. The resulting F-statistic is compared with the critical value bounds provided by Pesaran et al. [2001]: they provide lower and upper bounds on the critical values for the distribution

[6] Each criterion measures the relative quality of statistical models that are used to represent the data generating process, and represents the trade-off between goodness of fit and parsimony. For a particular model with a sample size of T and k parameters, the AIC value is $AIC = -2LL/T + 2(k/T)$, the SBC value is $SBC = -2LL/T + \ln T(k/T)$, and the HQIC value is $HQIC = -2LL/T + 2\ln(\ln T)(k/T)$; LL is the log-likelihood of the model. The optimal lag order is one that minimizes the value of the criterion.

of the F-statistic in the presence of a mix of $I(0)$ and $I(1)$ variables. If the test statistic falls below the lower critical bound, the test fails to reject the null hypothesis of no long-run relationship; if the test statistic falls above the upper critical bound, it is evidence that a long-run relationship exists. Inference is inconclusive if the test statistic falls between these bounds. The Bounds F-test is also performed under different restrictions on the intercept and trend coefficients[7].

3.3 Long-Run Estimates

If the data accepts the structural model, we can extract the long-run GDP and exchange-rate multipliers from the conditional VECM (11). The long-run relationship between exports, importers' trade-adjusted income, and real exchange rate can then be expressed as

$$X_t = \alpha_0 \; + \; \xi_{x,gdp^*} \text{ (Foreign GDP) } + \; \xi_{x,rer}\text{(Real exchange rate) } + \; v_t \tag{12}$$

where $\xi_{x,gdp^*} = -\pi_{x,g}/\pi_{x,x}$ is the long-run multiplier between home country's exports and foreign countries' trade-adjusted GDP, and $\xi_{x,rer} = -\pi_{x,r}/\pi_{x,x}$ is the long-run multiplier between home country's exports and real exchange rate.

Economic interpretation of the estimated multipliers is somewhat tricky. For example, interpreting ξ_{x,gdp^*} as the long-run effect of a unit increase in foreign countries' GDP on home country's exports ignores the dynamic effects captured by, for example, the lagged differences of the real exchange rate. An understanding of interrelationships among the variables in the VECM (11) requires examination of the short-run dynamics of the system to which we now turn.

3.4 Short-Run Dynamics

To examine the short-run transition dynamics of fluctuations in foreign GDP and exchange rate, we formulate a *restricted* VECM as

$$\Delta X_t \;=\; b_x + \theta_x t + \psi\, \hat{v}_{t-1} + \sum_{i=1}^{p-1} \gamma_{x,x;\,i}\, \Delta X_{t-i} + \sum_{i=1}^{p-1} \gamma_{x,g;\,i}\, \Delta GDP^*_{t-i} + \sum_{i=1}^{p-1} \gamma_{x,r;\,i}\, \Delta RER_{t-i} + u_{x,\,t} \tag{13}$$

[7] A Bounds t-test of the hypothesis that $\pi_{x,x} = 0$ can be used to reaffirm the conclusions of the F-test: if the t-statistic falls above the upper critical bound, the null of no cointegration can be rejected. As before, rejection of the null hypothesis provides evidence that the posited structural export demand equation is accepted by the data.

where the error correction term, $\hat{\upsilon}_{t-1}$, is the one-period lagged disequilibrium error, computed from the long-run export demand equation as $\hat{\upsilon}_t = X_t - \hat{\alpha}_0 - \hat{\xi}_{x,gdp^*}\ (GDP_t) - \hat{\xi}_{x,rer}(RER_t)$. This specification of the short-run behavior ensures that long-run predictions of export demand and deviations of actual exports from the level predicted by the long-run relationship are embodied in the error correction form of the structural export demand equation.

Speed of Adjustment

The coefficient on the error-correction term, ψ, is the adjustment parameter. It measures the speed at which deviations from long-run equilibrium are corrected to restore long-run equilibrium. For example, $\psi = 0.3$ implies that roughly 30% of the disequilibrium between actual and predicted exports is corrected within one time period. The requirement of dynamic stability implies that the value of the adjustment parameter must be negative[8]. A negative value of ψ implies that if actual exports, for example, exceeds the predicted long-run equilibrium level, exports will subsequently grow slower than the long-run rate to restore the level of exports to the long-run mean. This is the 'error correction' process: when the variables are out of long-run equilibrium, economic forces, by adjusting upwards (in response to negative disequilibrium error) or downwards (in response to positive disequilibrium error), act to restore the long-run equilibrium[9].

Impulse Response Function

The dynamic nature of this system allows us to conduct impulse response analysis to trace the effect of an exogenous shock to one variable on other variables [Lütkepohl, 2005]. For example, we can trace the impact of a one standard deviation disturbance in commodity-trade weighted real exchange rates on the evolution of foreign demand for U.S. exports of a particular commodity.

[8] By implication, a positive-valued adjustment parameter ($\psi > 0$) is representative of an explosive and divergent adjustment process: positive deviations from long-run equilibrium are followed by ever larger positive deviations, so that shocks cumulate over time, moving the system further away from long-run equilibrium. Clearly, $\psi < -1$ indicates overshooting.

[9] Examination of the dynamic stability of the VECM also provides insights into the process by which the system converges to (or, diverges from) the long-run equilibrium. Using roots of the characteristic equation of an AR(2) process, Zellner [1971] provides a diagram of characteristic roots plotted on the complex plane [Giles, 2013]. Depending on where the roots of the auxiliary equation of the autoregressive part of the VECM lie, the process of convergence to (or divergence from) equilibrium is expected to be either explosive and non-oscillatory, explosive and oscillatory, non-explosive and non-oscillatory, or non-explosive and oscillatory.

Consider an n-dimensional mean-centered VAR(p) model

$$x_t = \mu + \sum_{i=1}^{p} A_i \, x_{t-i} + \varepsilon_t \tag{14}$$

where μ is a vector of means, and ε_t is a vector of jointly-determined, serially-uncorrelated white noise disturbances with a multivariate normal distribution: $\varepsilon_t \sim MVN(0, \Sigma)$. Assuming that x_t is stationary, it has an infinite moving average representation

$$x_t = \mu + \sum_{i=0}^{\infty} \phi_i \, \varepsilon_{t-i} \tag{15}$$

The ϕ_i represents the simple impulse response function (IRF): the element $\phi_{jk}(i)$ of the ϕ_i matrix measures the impact of a one-time shock to ε_k on the evolution of ε_j after i periods, *ceteris paribus*. A plot of, say, $\phi_{12}(i)$ against i traces the i-period impact of an exogenous shock to ε_{zt} on the evolution of $\{y_t\}$. In addition, $\phi_{jk}(0)$ are the *impact multipliers*, which measure the instantaneous impact of a one-unit change in ε_{zt} on y_t.

However, because of contemporaneous correlation among the variables, shocks to one variable may be accompanied by shocks to (several) other variables. Therefore, IRFs derived from reduced-form disturbances are not amenable to structural interpretation, and are helpful only for short-term forecasts. Economically meaningful inference about the underlying structure requires identifying restrictions on parameters. The strength of our structural cointegrating VAR framework is that *a priori* restrictions used to identify structural shocks are well-defined and relate to the long-run properties of the macroeconomic variables. Being grounded in economic theory, this strategy avoids Sims's [1980] critique of the ad-hoc use of incredible identifying restrictions.

The focus being analysis of macroeconomic dynamics governing foreign demand for U.S. agricultural exports, we assume that foreign GDP and real exchange rate are *long-run forcing* for agricultural exports [Pesaran et al., 2001, p.4]. To illustrate, assume that the long-run structural VAR form of the export demand system is: $y_t = Ae_t$, where $y_t = \{X_t,\, GDP_t^*,\, RER_t\}$ is the vector of endogenous variables, and e_t is a vector of independently and identically distributed disturbances. With three endogenous variables, 3 restrictions are needed to identify structural shocks. We adopt the restriction that unexpected changes in U.S. exports have no long-run effects on changes in foreign GDP or real exchange rate[10]. In addition, we assume that the long-run level of exchange rates is not affected by disturbances in foreign GDP[11]. Thus, the implied A matrix is $\begin{pmatrix} a_{11} & a_{12} & a_{13} \\ 0 & a_{22} & a_{23} \\ 0 & 0 & a_{33} \end{pmatrix}$. We also report confidence intervals generated from a bootstrap procedure using 1000 replications.

Forecast Error Variance Decomposition

Forecast error variance decomposition (FEVD) measures the proportion of the movement in one endogenous variable due to (orthogonalized) shocks to itself or to other endogenous variables. In the context of the $VAR(p)$ model (equation 14), the error of the n-step-ahead forecast is

$$x_{t+n} - E_t(x_{t+n}) = \sum_{i=0}^{n-1} \phi_i \, \varepsilon_{t+n-i} \tag{16}$$

where x_{t+n} is the value observed at time $t+n$ and $E_t(x_{t+n})$ is the $n-$step-ahead predicted value for x_{t+n} that was made at time t [StataCorp, 2013]. Variance decomposition is the decomposition of the n-step-ahead forecast error variance into proportions attributable to shocks to $\{\varepsilon_t\}$ sequence. Thus, the fraction of total forecast error variance in U.S. exports (X_t) that is attributable to shocks to importers' trade-adjusted GDP is $\frac{\sigma^2_{gdp}\left[\phi_{12}(0)^2+\phi_{12}(1)^2+\ldots\phi_{12}(n-1)^2\right]}{\sigma_x(n)^2}$.

As with impulse response functions, causal interpretation of variance decomposition requires the imposition of identifying restrictions so that the structural shocks can be identified from the reduced form model. We use the same exclusion restrictions as with the IRFs to identify structural shocks, and report confidence intervals generated from a bootstrap procedure using 1000 replications.

4 Aggregate Analysis: U.S. agricultural exports to all countries

To allow comparison of regression estimates across models with varying lag structures, we begin our analysis with the sample from 1971 to 2010, *i.e.*, 40 observations. The rationale is that the lag order of the underlying VAR should be sufficient to remove residual serial correlation without sacrificing too many degrees of freedom due to over-parametrization. One rule of thumb is to start with the maximum lag order p, such that $p = \sqrt[4]{T}$, where T is the sample size [Baum, 2006, p.140]. Having

[10] Note that this does not preclude exports from being 'Granger-causal' for importers' GDP and exchange rate in the short-run; these effects are captured by the short-run response parameters in the restricted VECM.

[11] Heuristically, exchange rates are more likely to be determined by trade, quantitative easing, domestic and international monetary policies than by the level of GDP.

44 observations (1967 – 2010), our analysis begins with a maximum lag length of 3 ($\approx \sqrt[4]{44}$). The first observation is used to construct first differences of the variables, the next three, to construct the lagged series. This leaves a uniform sample with 40 observations.

4.1 Unit Root Properties of the Variables

The DF-GLS and KPSS unit root tests are computed for the 1971–2010 period, and are applied to the variables in levels and in first differences, both with and without a deterministic trend.[12] Tables 1 and 2 report, respectively, the results of application of the DF-GLS and KPSS tests to the natural log of levels of the variables. Results for higher order of integration are reported in table 3.

In models without trend, both tests provide evidence in favor of the export and foreign GDP series being stationary around a constant. When a linear trend is included, the KPSS test's results diverge significantly from the DF-GLS test's results for all three core variables, and it is unclear whether the series are $I(0)$ or $I(1)$. In contrast, the KPSS test show no evidence in favor of the view that the export and real exchange rate series are $I(2)$. The same is true for the foreign GDP series when a linear trend in first differences is included.

4.2 A Long-run Model of Export Demand

The AIC, SBC, and $HQIC$ values reported in table 5 suggest that for most commodities and commodity categories, a VAR with two lags, or equivalently, a VECM with one lag, is sufficient. Table 6 reports the $F-$ and $t-$statistics for testing the existence of the long-run export demand equation for models with and without a deterministic linear trend, and alternate lag specifications. Overall, a structural export demand equation can be established for 21 out of 32 commodities and commodity groups[13]. A trend in the cointegrating relationship is selected for total value of agricultural exports, soybean, tobacco, and vegetable juices; for all others, an error correction

[12] Including a trend in unit root tests applied to first differenced variables implies that there are quadratic trends in the levels of the variables, *i.e.*, exports, GDP, and real exchange rates have been increasing at an increasing rate over the sample time period. Time series plots of the variables do not substantiate this assertion; see, for example, figures 4, 5, **??**, and **??**.

[13] Qualitative differences among commodities partly explains the absence of a (statistically) valid long-run foreign demand equation for most perishable commodities, *i.e.*, fruit and vegetable products. Port-of-entry barriers, such as absence of refrigeration, delays in clearing customs all raise the effective cost of exporting perishable fruit and vegetable products. exports to proximate destinations may be the efficient alternative. Indeed, fifteen countries in North America, Central America, and the Caribbean accounted for 46% – 95% of all exports of perishable fruit and vegetable products.

specification with unrestricted intercept and no deterministic trend is selected.

Diagnostic tests applied to the reduced-form error correction specifications of commodity export demand are reported in table 9. All equations have reasonable explanatory power, with R^2 values ranging from 0.21 veal and high-value processed exports to 0.64 for soyoil exports. Model diagnostics are satisfactory for tests of residual serial correlation With three exceptions, the assumption of normally distributed errors cannot be rejected. Figure 6 suggests that the error correction specifications are dynamically stable: eigenvalues for all equations are strictly within the unit circle. Lastly, actual and fitted values of the error correction specifications (figure 10) indicate that the model does a reasonable job of capturing the underlying patterns in commodity exports; this is also true for models with low R^2 values.

4.3 Long-Run Estimates

Where a statistically significant long-run export demand equation exists, long-run multipliers of U.S. agricultural exports with respect to importers' trade-adjusted GDP and trade-weighted exchange rate are summarized in table 7. Standard errors are reported in parentheses[14].

Three observations stand out: in the long run, (i) an increase (decrease) in importing countries' trade-adjusted GDP leads to an increase[15] in U.S. agricultural exports; (ii) a real appreciation (depreciation) of the U.S. dollar results in a decline (increase) in U.S. agricultural exports; and (iii) exports of high-value processed agricultural products are more sensitive to changes in foreign income and exchange rate fluctuations than exports of low-value grains and bulk commodities.

Thus, equal growth across all importing countries leads to a smaller increase in U.S. exports of bulk commodities than high-value processed commodities. For example, a 10% growth in trade-adjusted GDP across all importing countries leads to a 7.8% increase in U.S. exports of bulk commodities compared to 33% increase in exports of high-value processed commodities.[16] Similarly,

[14]Standard errors for the long-run elasticity estimates are calculated using the *delta* method, which uses a Taylor-series expansion to approximate the variance of the parameter. Standard errors for the intercept term are not reported because in VECMs with unrestricted intercept, the intercept in the cointegrating equation is not estimated directly. Instead, it is backed out from the estimate of a model-wide intercept. Consider, for instance, a VECM with unrestricted intercept and no deterministic trend $\Delta y_t = \alpha(\boldsymbol{\beta} y_{t-1}+\mu)+\sum_{i=1}^{p-1}\boldsymbol{\Gamma}_i\Delta y_{t-i}+\delta+u_t$, where the variables have the usual definition. Under certain conditions, an equivalent representation is $\Delta y_t = \alpha\boldsymbol{\beta} y_{t-1}+\sum_{i=1}^{p-1}\boldsymbol{\Gamma}_i\Delta y_{t-i}+b+u_t$, where $b = \alpha\mu + \delta$ is a vector of unrestricted, equation-wide intercept terms. To obtain an estimate of μ, first the parameter $\hat{b}$ is estimated; thereafter, $\hat{\mu}$ is extracted from $\hat{b}$ as $\hat{\mu} = (\hat{\alpha}^{'}\hat{\alpha})^{-1}\hat{\alpha}^{'}\hat{b}$. For a detailed exposition, see Stata documentation for the `-vec-` command [StataCorp, 2013].

[15]There are exceptions, but none statistically significant at conventional levels of significance.

[16]A 10% increase in trade-adjusted GDP multiplies U.S. bulk exports by $e^{0.788\ln(1.1)} = 1.077997$; so, a 10% increase

real appreciation of the dollar leads to a more than proportionate decline in U.S. exports of processed meats and vegetables relative to bulk exports. Specifically, a 10% increase in the value of the trade-weighted exchange rate (*i.e.*, an appreciation of the U.S. dollar) reduces bulk exports by 8.4% compared to a whopping 35% decline in high-value processed food exports.

The difference in the magnitude of GDP and exchange rate elasticities between bulk and processed commodities is not surprising. Engel's law contends that the budget share of necessities declines as incomes rise. At low levels of income grains comprise a large share of an average household's diet[17]; demand for 'necessities' is relatively invariant to income and price shocks. Higher income allows for diversification of diet to include more processed meats, fruits and vegetables. Magnitude of the exchange rate elasticity increases (in absolute terms) as we move away from primary commodities towards value-added items, with a 10% appreciation of the U.S. dollar leading to a 30% decline in U.S. lamb exports.

Foreign-income elasticities of U.S. agricultural export demand have striking empirical regularities with historical data and the literature on income-and-price elasticities. Krugman [1989] suggests that countries with high-rates of growth have low income-elasticity of import demand, whereas countries with slow growth rates have high income elasticity for imports. Thus, high rates of economic growth in developing and emerging market economies explain the low long-run income elasticity of demand for U.S. bulk commodity exports. Similarly, high income elasticity of demand for value-added processed U.S. agricultural exports is explained by the slow-growing economies of high-income developed countries.

4.4 Short-Run Dynamics

Speed of Convergence The short-run dynamics of the export demand system are characterized by the reduced-form error-correction specification reported in table 8. The speed of adjustment estimates are highly statistically significant, which substantiates the existence of a stable structural export demand equation for exports of the listed commodities; see Kremers, Ericsson, and Dolado [1992] and Banerjee, Dolado, and Mestre [1998]. More importantly, the high statistical significance

in trade-adjusted GDP increases US bulk exports by 7.8%. Similarly, a 10% increase in trade-adjusted GDP multiplies U.S. high-value processed exports by $e^{2.929 \ln(1.1)} = 1.322023$, a 32.2% increase.

[17] In a survey of 1529 rural households in Bihar in India, Christian (2014) finds that households spent 33% of their food budget on the staple food (rice, wheat, or maize); rice alone accounted for more than 25% of food expenditure.

of the error correction coefficient highlights the importance of including the long-run relationship when modeling the short-run dynamics [Garratt, Lee, Pesaran, and Shin, 1998]. This is one of our contributions to the literature, as the joint determination of long- and short-run dynamics has not received sufficient attention in the agricultural economics literature.

Comparison of the estimates of the speed of adjustment across commodities reveals that, on average, exports of grains and bulk commodities converge to long-run equilibrium at a faster rate than exports of high-value processed commodities. For example, more than 75% of the disequilibrium in aggregate bulk commodity exports is corrected within one year. By comparison, less than 15% of the disequilibrium in high-value processed exports is corrected within one year. Thus, in response to exogenous shocks, deviations from the equilibrium level of exports predicted by the structural export demand equation are corrected at a much faster rate for grains and other bulk commodity exports than export of high value commodities.

This finding has significant implications for U.S. agricultural policy. Disequilibrating shocks are rather costly in low-income countries with relatively high export shares for food, resulting in a speedy convergence to pre-shock long-run equilibrium levels of imports[18]. The faster speed of convergence to long-run equilibrium for commodities that are mainly exported to developing countries suggests that U.S. agricultural exports may benefit not only from policies intended to increase trade with existing developing country importers (expanding exports along the intensive margin) but also from policies that aim to export agricultural commodities to hitherto unexplored emerging markets (expanding exports along the extensive margin).

Impulse Response Analysis Structural impulse response functions of agricultural exports due to one percentage shocks to foreign GDP and real exchange rate are presented in figures 7 and 8. The solid lines in figure 7, for instance, trace the response of rate of growth of exports to a one percent shock to rate of growth of importers' trade-adjusted GDP. The dashed lines plot the 95% confidence interval for the impulse response function, generated from a bootstrap procedure using 1000 replications.

Observe that a shock to rate of growth of foreign GDP (figure 7) does not produce a permanent

[18] A similar argument is presented by Esfahani, Mohaddes, and Pesaran [2014] in the context of oil exports. Major oil exporters, such as Venezuela, have faster speed of convergence relative to developed countries, such as Switzerland. The authors contend that well-developed financial markets may "act as shock absorbers," causing a "more sluggish response to shocks" [Esfahani et al., 2014, p.19].

change in export growth rates, and disequilibrium due to a shock to foreign GDP dissipates after two years for most commodities. Export growth rate of soybean, tobacco, veal, poultry, red meat, vegetable juices, dried vegetables, and total export value display somewhat prolonged convergence, with disequilibrium due to a GDP shock lasting up to 4 years. The same is true of a one percent shock to the index of trade-weighted real exchange rate (figure 8), where the effect of the shock may linger for 2 to 4 years.

For several commodities, the pattern of convergence to equilibrium is complex, indicative of the complex short-run dynamics and dynamic feedback between the endogenous variables causing the effects of shocks to die out more slowly. Indeed, the oscillating pattern of convergence is suggested by the presence of multiple conjugate pairs of complex roots in the characteristic equation corresponding to the reduced form error correction models for these commodities [Giles, 2013].

Forecast Error Variance Decomposition Analysis Structural FEVDs showing the decomposition of variance in export growth due to shocks to growth of foreign GDP and exchange rate are presented in figure 9. Exogenous shocks to agricultural exports account for the largest share of forecast error variance in export growth. Even though shocks to foreign GDP and real exchange rate account for successively larger proportions of the forecast error variance of most commodity exports, the largest proportion of forecast error variance in exports continue to arise from effects within the agricultural sector [Chambers, 1984].

Notable exceptions are bulk commodity exports and cotton, where exchange rate fluctuations account for 30% - 40% of the forecast error variance in exports; for soybean and dried vegetable exports, shocks to foreign GDP account for slightly more than 40% of the forecast error variance in export growth.

5 Conclusion

We develop a structural model of foreign demand for U.S. agricultural exports, foreign GDP, and real exchange rate volatility to examine the sectors international competitiveness and opportunities for export extensification.

Estimates of long-run multipliers suggest that exports of high-value processed agricultural products are more sensitive to changes in foreign income and exchange rate fluctuations than exports of low-value grains and bulk commodities. Thus, equal growth across all importing countries leads to a smaller increase in U.S. exports of bulk commodities than high-value processed commodities, and real appreciation of the dollar leads to a more than proportionate decline in U.S. exports of processed meats and vegetables relative to bulk exports.

Analysis of short-run dynamics substantiates the existence of a stable structural export demand equation for exports of 21 out of 32 commodities in our sample. We also find that, on average, exports of grains and bulk commodities converge to long-run equilibrium at a faster rate than exports of high-value processed commodities. This has (substantively and statistically) significant implications for U.S. agricultural policy: U.S. agricultural exports may benefit not only from policies intended to increase trade with existing developing country importers but also from policies that aim to export agricultural commodities to emerging markets (*i.e.*, export market diversification along both intensive and extensive margins).

Finally, our modeling framework highlights the importance of including the long-run relationship when modeling the short-run dynamics. Our results suggest that, first, long-run elasticity estimates by themselves are insufficient to track and explain the complex short-run dynamics of innovations in endogenous variables. Second, even though the mechanics of the equilibrating process are not precisely captured, the cointegrating vector autoregressive framework incorporates insights from economic theory and both short- and long-run parameter estimates, accounting for the complex interrelationships among the core macroeconomic variables.

Two caveats deserve mention. First, high income elasticity for high-value processed exports and low income elasticity for bulk exports should not be used to conclude that economic growth in high-income countries benefits U.S. agricultural sector more than economic growth in low-income countries. Similarly, low (absolute) exchange rate elasticity for bulk exports and high exchange rate elasticity for processed food exports should not be used to conclude that the magnitude of the increase in bulk exports due to depreciation against currencies of developing countries is smaller than the increase in processed meat and vegetable exports associated with a commensurate depreciation against developed countries' currencies.

We caution against such premature and potentially fallacious interpretations. First, long-run elasticity estimates may be substantively biased due to aggregation across vastly diverse export destinations. A more appropriate strategy to address this question will be to model developing and developed countries separately, especially so if the rise in developing countries' demand for U.S. agricultural products– fueled by rapid economic growth in developing countries– outweighs the high income elasticity of agricultural exports to developed countries.

Finally, interactions among variables in a macroeconomic model are often far more complex than what is captured by long-run equilibrium relations alone; studying the short-run transition dynamics provides a richer understanding of the underlying structure of the model. For example, while depreciation of developed countries' currencies may produce a larger increase in exports of processed foods relative to grains, we have shown that relative to developed countries, developing countries are more resilient to exogenous shocks and disequilibrium errors are corrected quickly.

Figure 1: Share of countries in sample importing U.S. agricultural products

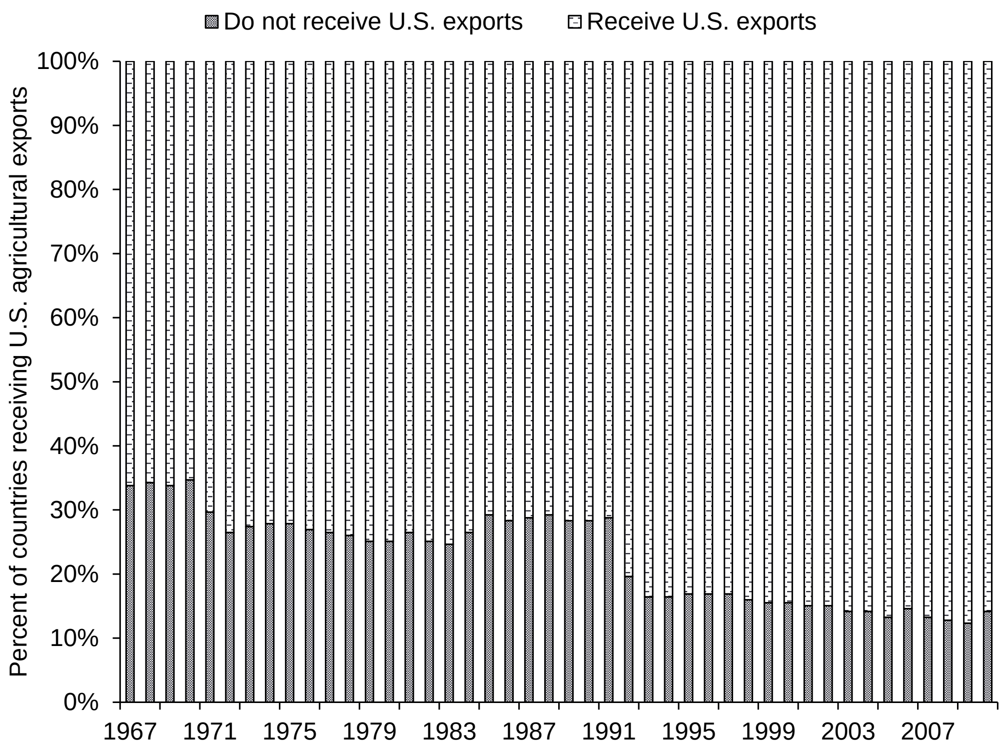


Figure 2: Decomposing U.S. agricultural export value by shares accruing to top 25 importers.

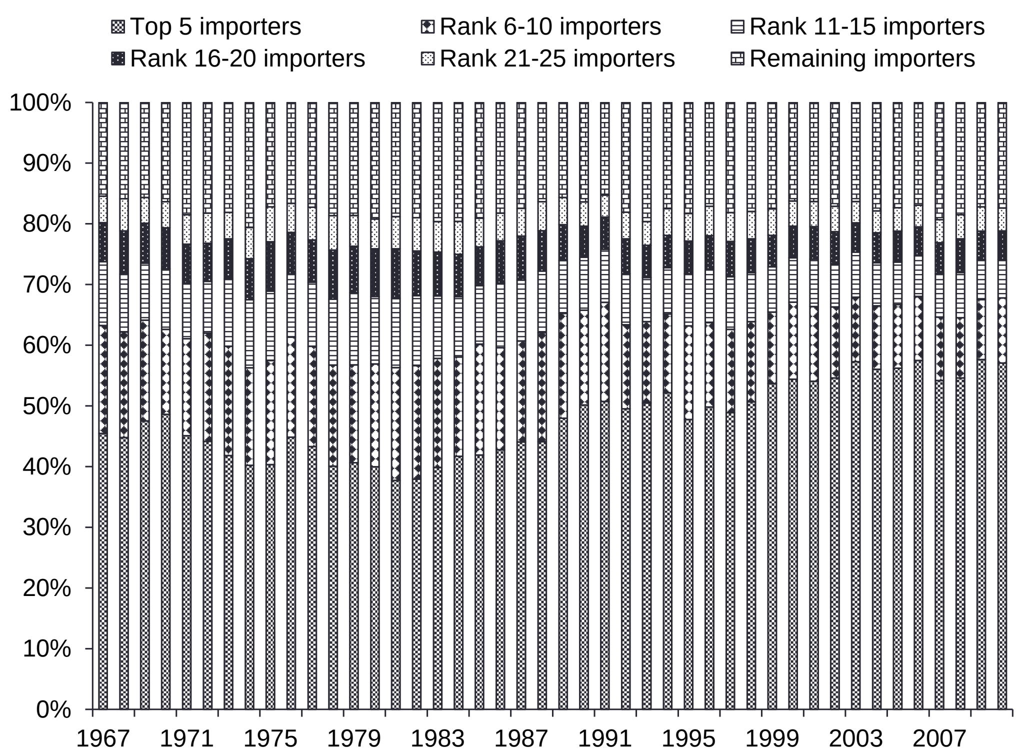
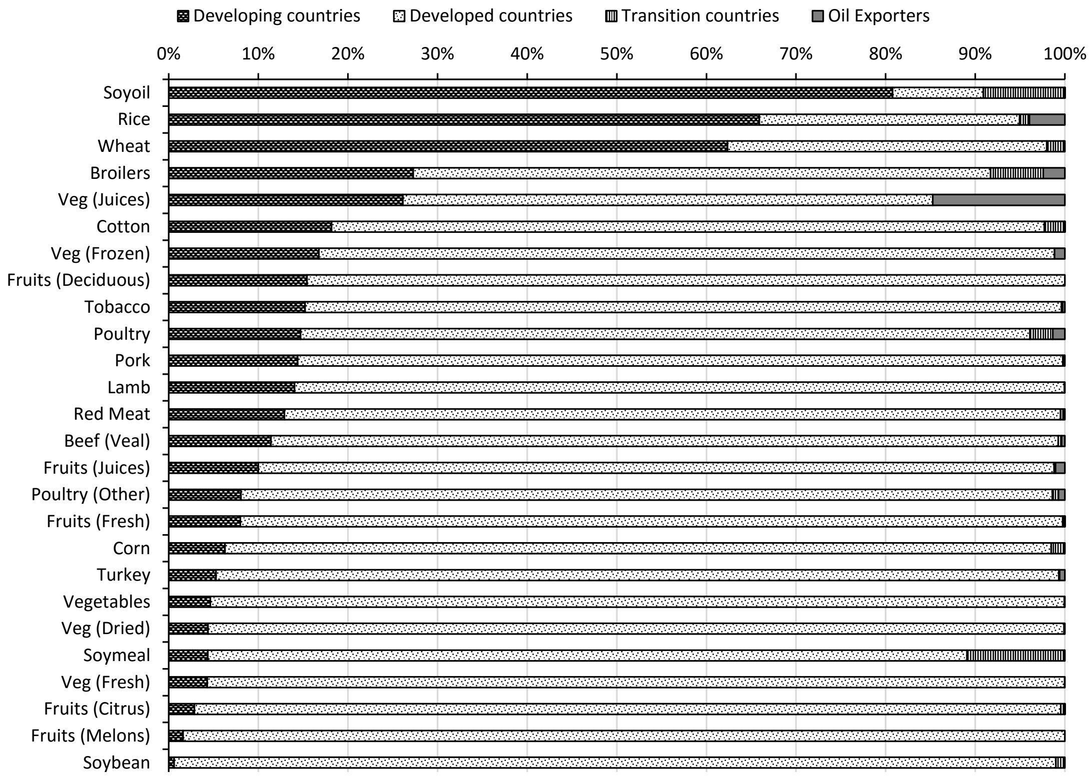
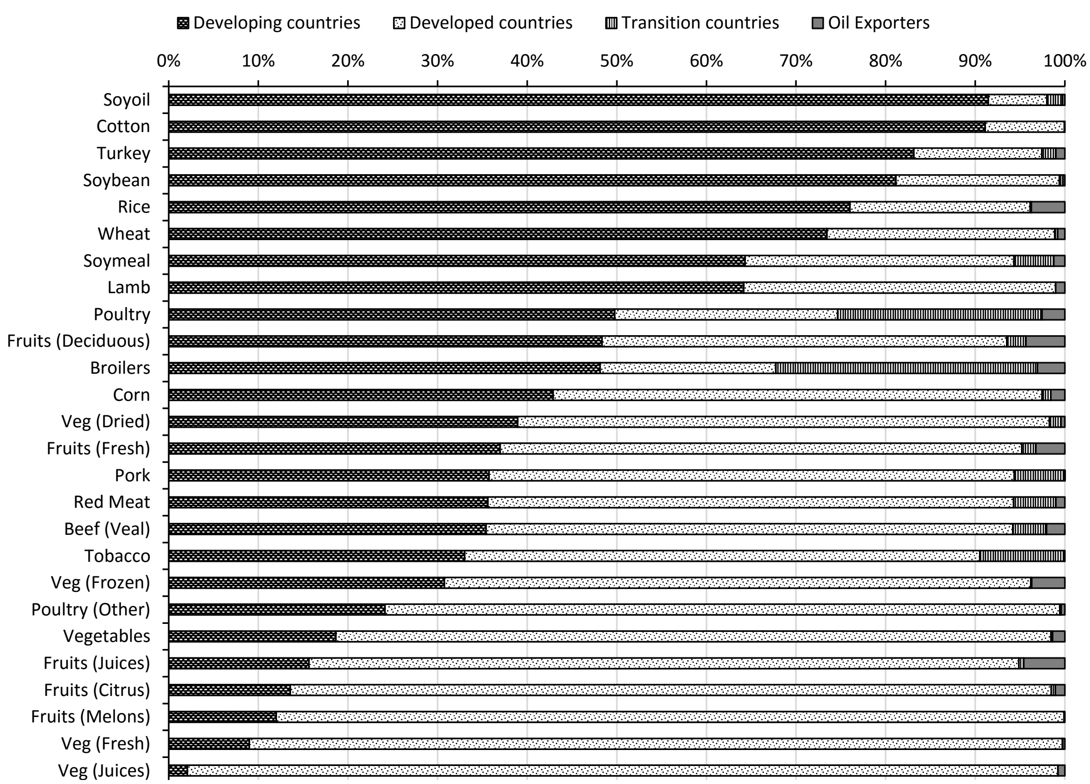


Figure 3: Change in distribution of U.S. agricultural exports from 1967 to 2010



(a) Export share in 1967



(b) Export share in 2010

Figure 4: Commodity trade-weight indices of importing countries' per capita income.

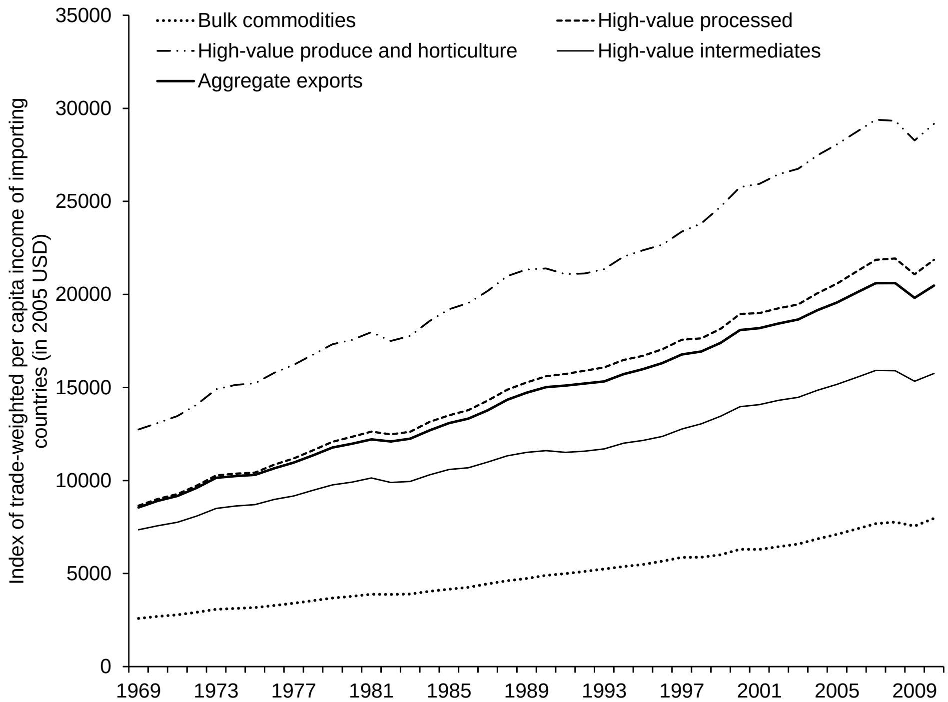


Figure 5: Deviations from mean real trade-weighted exchange rate indices.

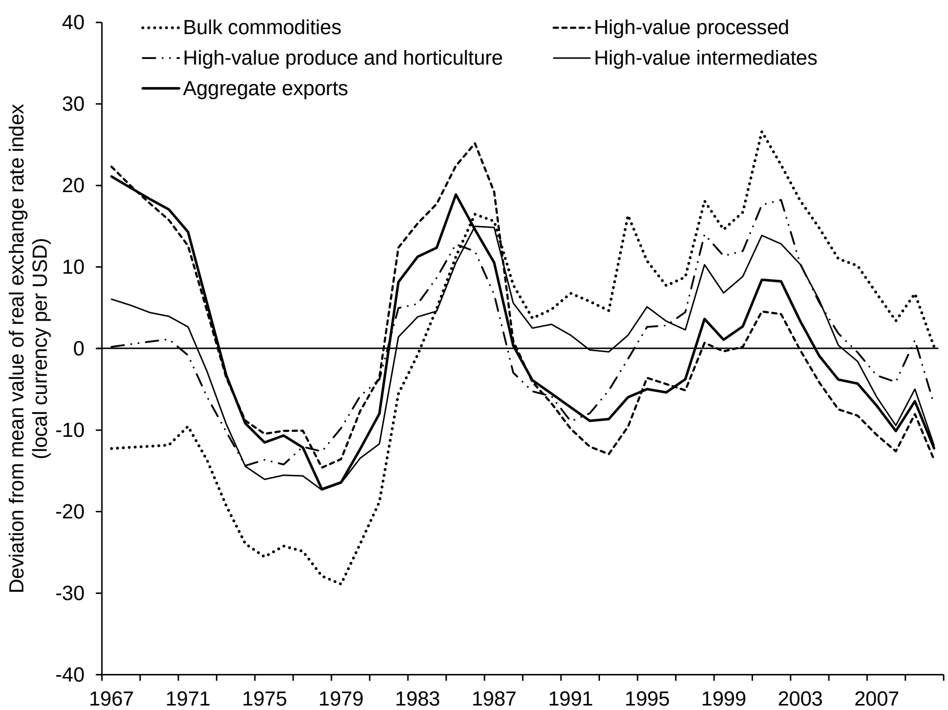
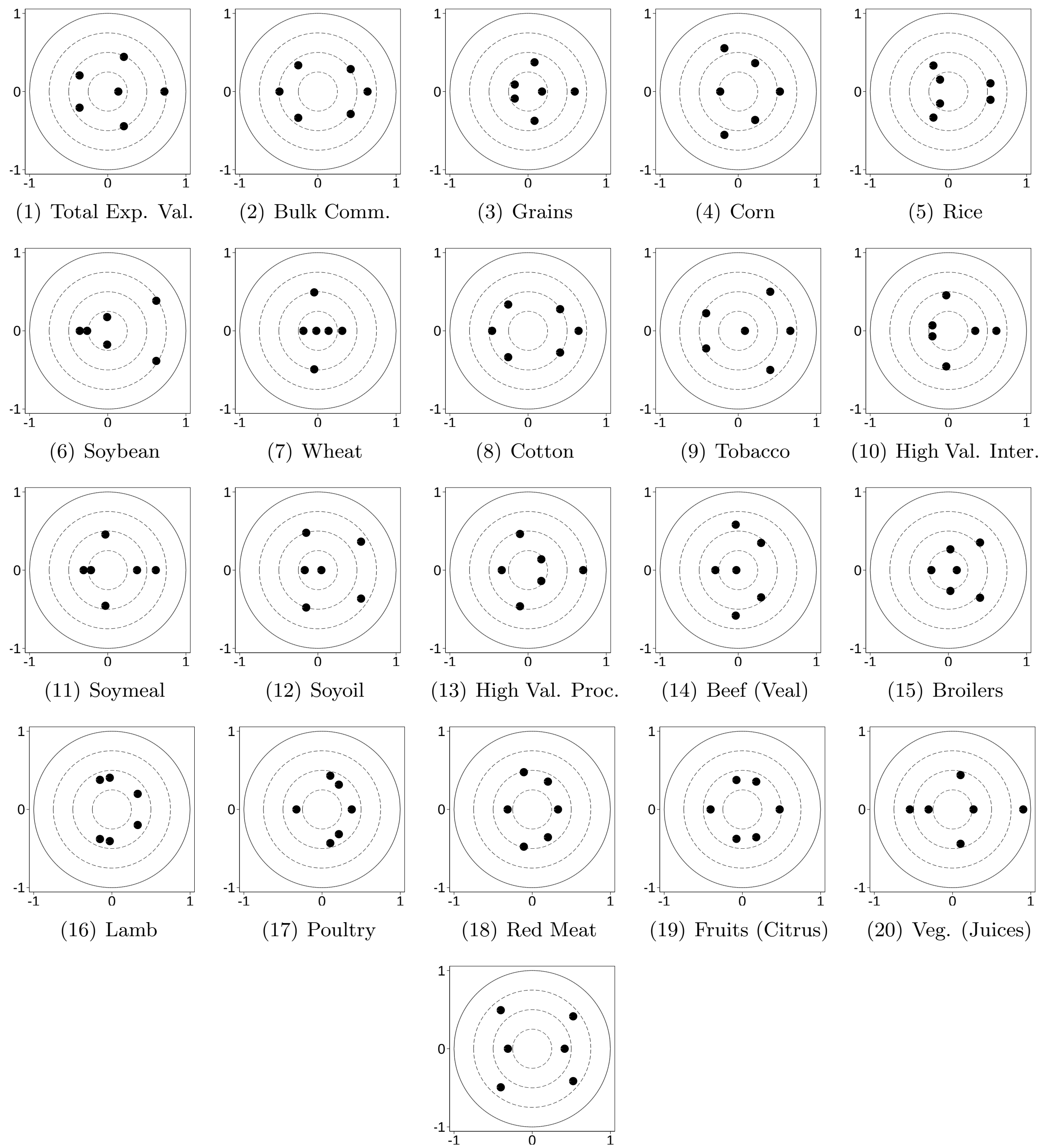


Figure 6: Dynamic stability of the vector error correction models



(1) Total Exp. Val. (2) Bulk Comm. (3) Grains (4) Corn (5) Rice

(6) Soybean (7) Wheat (8) Cotton (9) Tobacco (10) High Val. Inter.

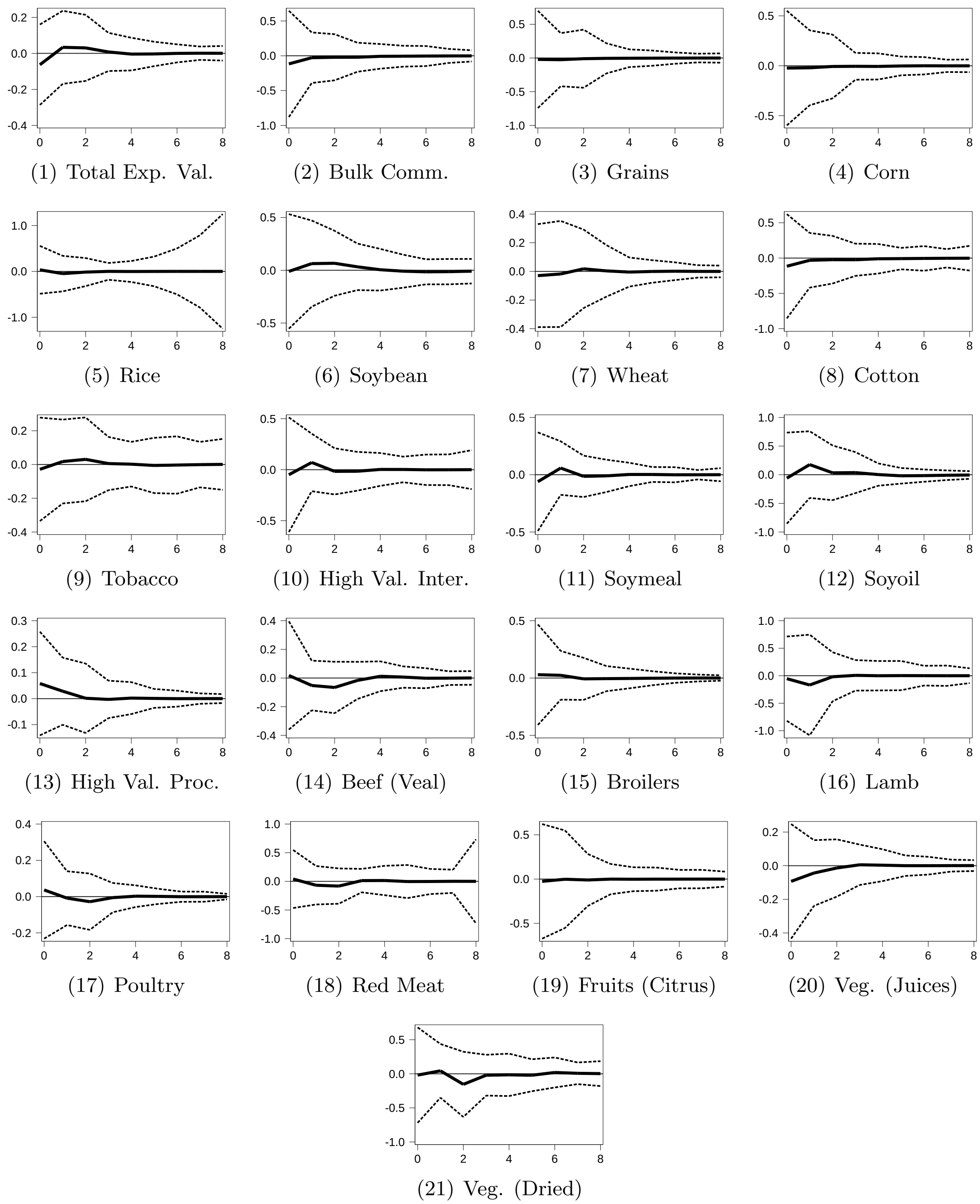
(11) Soymeal (12) Soyoil (13) High Val. Proc. (14) Beef (Veal) (15) Broilers

(16) Lamb (17) Poultry (18) Red Meat (19) Fruits (Citrus) (20) Veg. (Juices)

(21) Veg. (Dried)

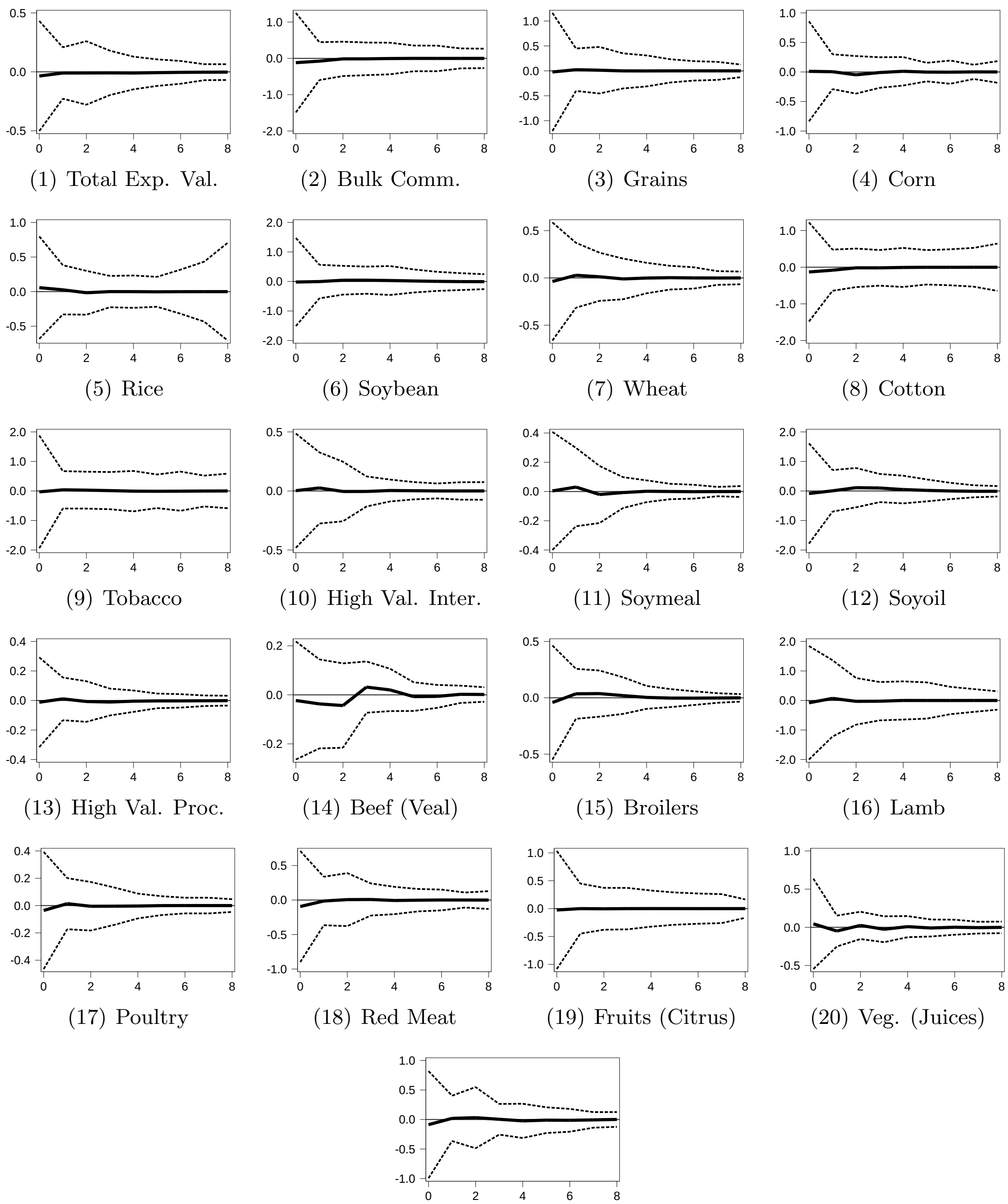
Note: The black dots represent the modulii of the eigenvalues of the characteristic equation corresponding to the VECM, with the real part of the eigenvalue measured along the $x-$axis and the complex part along the $y-$axis. A given VECM is dynamically stable if all eigenvalues lie within the unit circle (Lütkepohl, 2005; StataCorp, 2013).

Figure 7: Structural impulse response of rate of growth of U.S. agricultural exports to a one percent change in the rate of growth of importing countries' trade-adjusted GDP



Note: The solid line traces the response of rate of growth of exports to a one percent shock to rate of growth of importers' trade-adjusted GDP. The dashed lines plot the 95% confidence interval for the impulse response function, generated from a bootstrap procedure using 1000 replications.

Figure 8: Structural impulse response of rate of growth of U.S. agricultural exports to a one percent change in the rate of growth of importing countries' commodity-trade weighted real exchange rate



(1) Total Exp. Val. (2) Bulk Comm. (3) Grains (4) Corn

(5) Rice (6) Soybean (7) Wheat (8) Cotton

(9) Tobacco (10) High Val. Inter. (11) Soymeal (12) Soyoil

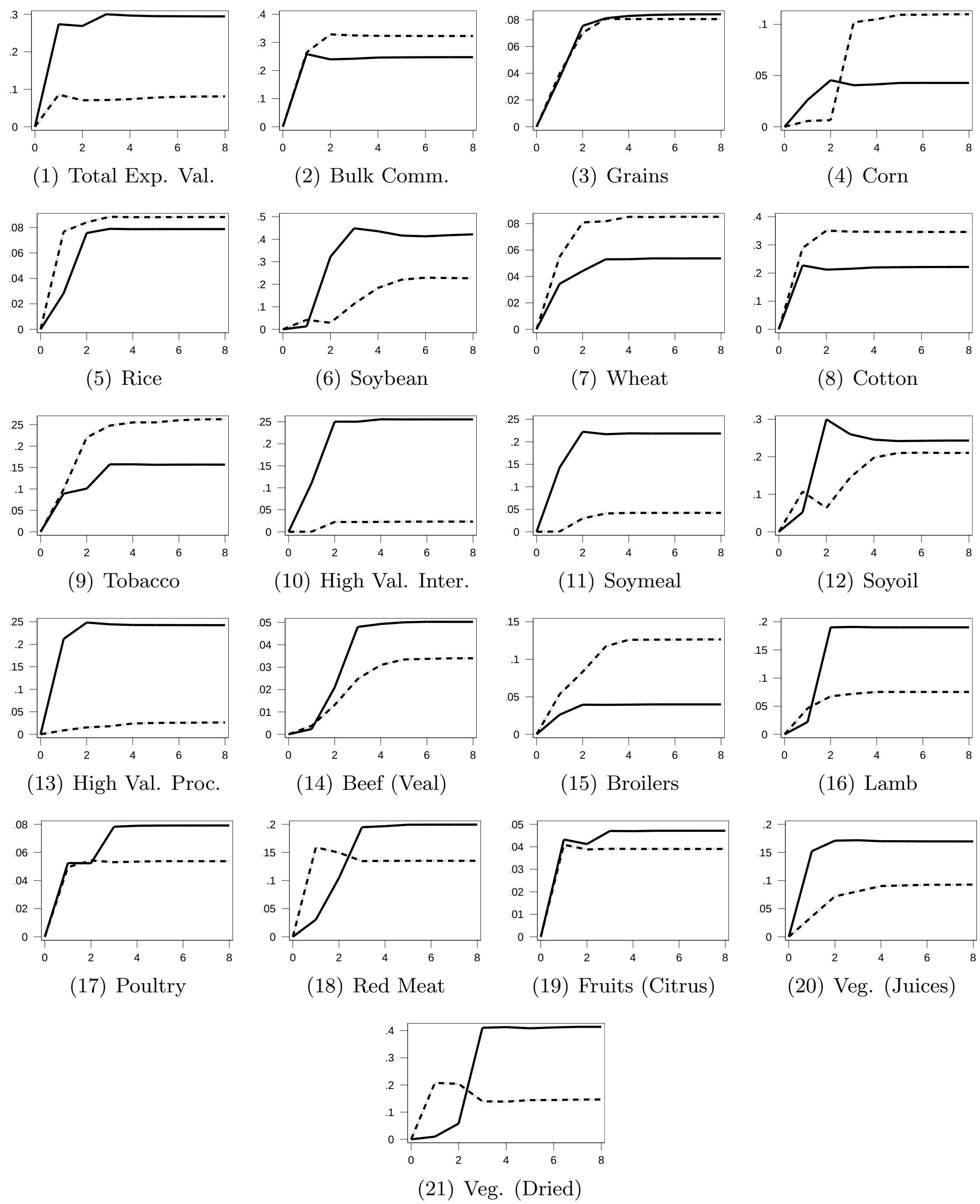
(13) High Val. Proc. (14) Beef (Veal) (15) Broilers (16) Lamb

(17) Poultry (18) Red Meat (19) Fruits (Citrus) (20) Veg. (Juices)

(21) Veg. (Dried)

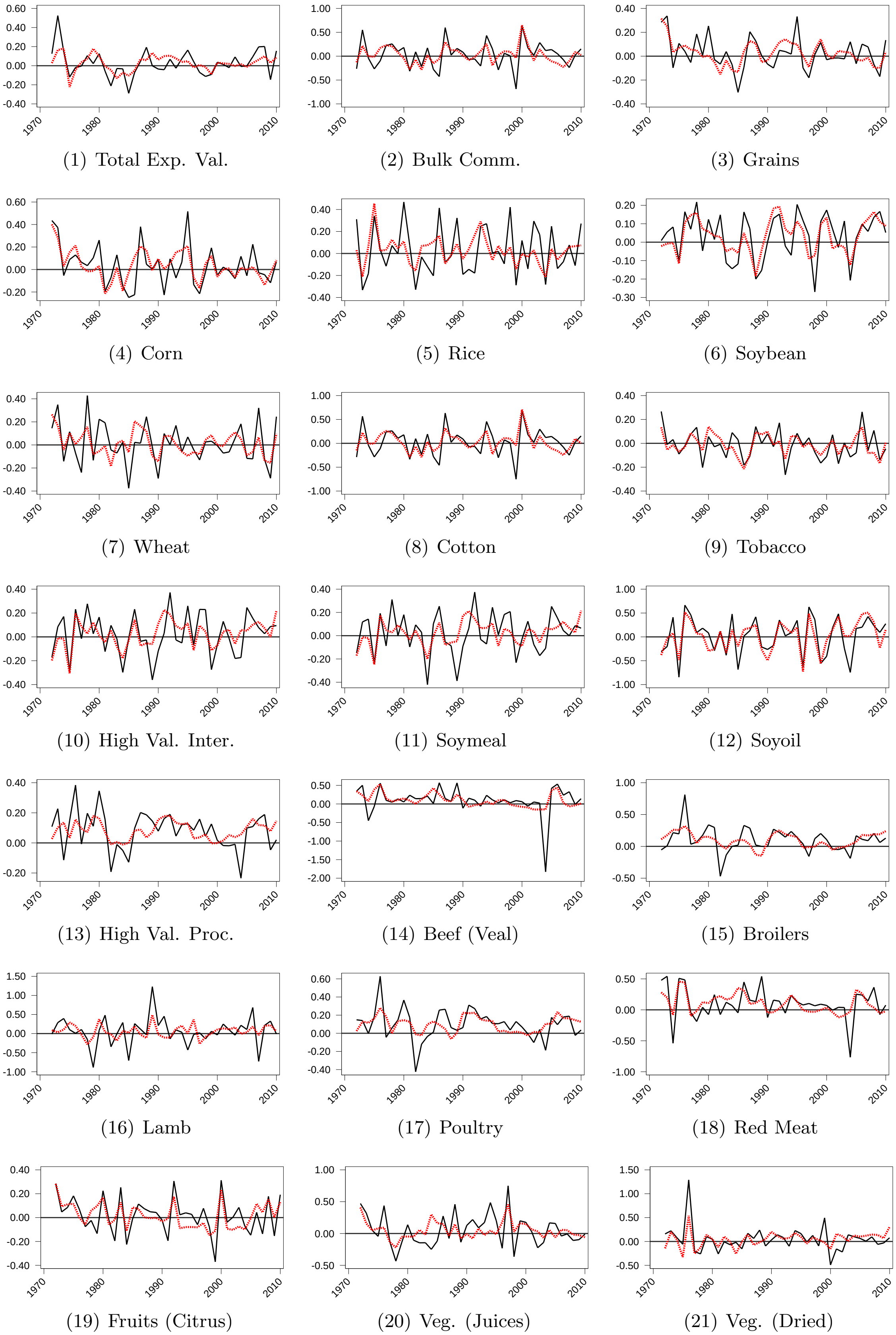
Note: The solid line traces the response of rate of growth of exports to a one percent shock to rate of growth of commodity-trade weighted real exchange rate. The dashed lines plot the 95% confidence interval for the impulse response function, generated from a bootstrap procedure using 1000 replications.

Figure 9: Variance decomposition of U.S. agricultural export growth



Note: The solid and dashed lines plot the share of variance in U.S. agricultural exports attributable to structural innovations in importers' trade-adjusted GDP and real exchange rate, respectively.

Figure 10: Actual (solid) and fitted (dashed) values for the export demand reduced form ECM equation



(1) Total Exp. Val.
(2) Bulk Comm.
(3) Grains
(4) Corn
(5) Rice
(6) Soybean
(7) Wheat
(8) Cotton
(9) Tobacco
(10) High Val. Inter.
(11) Soymeal
(12) Soyoil
(13) High Val. Proc.
(14) Beef (Veal)
(15) Broilers
(16) Lamb
(17) Poultry
(18) Red Meat
(19) Fruits (Citrus)
(20) Veg. (Juices)
(21) Veg. (Dried)

Table 1: Dickey–Fuller generalized least squares test applied to levels of the core variables. Subscript denotes lag order chosen by the modified Akaike Information criterion

	With deterministic trend (5% critical value: −3.19)			Without deterministic trend (5% critical value: −1.95)		
Commodity	Exports	Foreign GDP	RER	Exports	Foreign GDP	RER
Total Export Value	-2.75_1	-0.58_1	-2.42_1	-2.57_1*	0.59_3	-1.64_1
Bulk Commodities	-3.38_1*	-2.64_1	-1.75_1	-0.91_2	1.30_2	-1.33_1
Grains	-2.00_2	-0.21_1	-2.05_1	-0.92_1	0.16_3	-0.48_1
High Value Intermediates	-2.56_1	-0.69_1	-1.65_1	-0.36_1	0.16_3	-1.54_1
High Value Processed	-2.16_1	-0.39_1	-2.58_1	0.28_1	0.39_3	-1.64_1
Produce & Horticulture	-1.81_1	-1.27_2	-2.13_1	-0.36_2	0.13_3	-2.06_1*
Beef (Veal)	-1.75_1	-1.03_1	-1.74_2	-0.24_1	0.18_3	-1.51_2
Broilers	-2.41_1	-1.10_1	-2.59_2	0.33_1	0.85_3	-0.25_2
Corn	-1.80_2	-0.19_1	-2.24_1	-0.48_2	0.07_3	-1.18_1
Cotton	-2.84_2	-2.70_1	-1.72_1	-0.96_2	1.28_2	-1.28_1
Fruits (Citrus)	-2.01_1	-0.28_1	-2.57_1	-1.15_1	0.16_3	-1.81_1
Fruits (Deciduous)	-1.78_1	-1.37_1	-1.90_1	-0.37_2	0.33_3	-1.52_1
Fruits (Fresh)	-1.99_1	-0.96_2	-2.21_1	-0.09_1	0.23_3	-2.07_1*
Fruits (Juices)	-1.52_1	-0.48_1	-2.75_1	-0.43_2	0.09_3	-2.00_1*
Fruits (Melons)	-1.42_1	-1.51_1	-1.87_1	-0.14_1	0.07_2	-1.80_1
Lamb	-2.18_1	-1.50_2	-1.55_2	-0.81_1	0.56_1	-1.30_2
Pork	-1.41_2	-0.22_1	-2.32_1	0.42_1	0.14_3	-1.29_1
Poultry	-2.61_1	-1.37_1	-2.29_2	0.17_1	0.78_3	-1.02_2
Poultry (Other)	-1.50_3	-2.81_1	-2.14_1	-0.51_1	1.21_2	-1.60_1
Red Meat	-1.60_2	-0.86_3	-2.38_1	0.45_1	0.11_3	-1.74_1
Rice	-2.82_2	-0.42_1	-1.90_1	-0.46_2	0.08_3	-1.08_1
Soybean	-1.31_3	-2.09_1	-2.25_1	0.74_1	1.23_2	-1.79_1
Soymeal	-2.58_1	-1.31_3	-1.51_1	-0.38_1	0.09_3	-1.49_1
Soyoil	-3.54_1*	-1.25_1	-2.28_1	-1.49_3	0.58_3	-0.36_1
Tobacco	-1.88_3	-0.42_1	-2.48_2	-0.42_1	0.04_2	-1.68_2
Turkey	-1.49_1	-1.63_1	-1.61_2	-0.24_1	0.74_1	-1.37_2
Vegetables	-1.87_1	-0.96_2	-2.20_1	0.10_1	0.16_3	-1.99_1*
Vegetables (Dried)	-2.12_1	-0.37_1	-2.26_1	-0.53_1	0.06_3	-1.94_1
Vegetables (Fresh)	-1.94_1	-1.62_2	-2.06_1	-0.30_1	0.18_2	-2.04_1*
Vegetables (Frozen)	-1.34_1	-0.27_1	-2.28_1	-0.33_2	0.32_3	-1.43_1
Vegetables (Juices)	-1.69_1	-1.67_1	-1.96_1	-0.62_1	0.04_2	-1.95_1*
Wheat	-2.09_2	-0.29_1	-2.08_1	-1.59_2	0.53_3	-0.00_1

Notes: The DF-GLS test is applied to the natural log of levels of the core variables: U.S. agricultural exports, by commodities and category (X_t), commodity trade-weighted (adjusted) GDP of importing countries (GDP_t^*), and commodity trade-weighted real exchange rate of U.S. agricultural exports (RER_t). The null hypothesis of the DF-GLS test is that the series contains a unit root. The alternative hypothesis, when the model contains a linear trend, is that the series is stationary around a linear trend; in the absence of a linear trend, the alternate hypothesis is that of level stationarity, *i.e.* the series is stationary around a constant. The subscripts denote the optimal lag order of the DF-GLS regression chosen using Ng and Perron's (2001) *modified* Akaike Information criterion (MAIC), with a maximum lag order of three. The lower critical value bounds for the DF-GLS test with a linear trend are -3.77, -3.19, and -2.89 at 1%, 5%, and 10% levels of significance, respectively. In the absence of a linear time trend, the lower critical value bounds are -2.63 (1%), -1.95 (5%), and -1.608 (10%)

Table 2: Kwiatkowski, Phillips, Schmidt, and Shin test applied to levels of the core variables. Rejection of the null hypothesis indicates that the variable contains a unit root, or is $I(1)$. Optimal lag order selected is 2, unless otherwise noted.

	With deterministic trend (5% critical value: 0.146)			Without deterministic trend (5% critical value: 0.463)		
Commodity	Exports	Foreign GDP	RER	Exports	Foreign GDP	RER
Total Export Value	0.12	0.38*	0.09	0.34	1.72*	0.18
Bulk Commodities	0.10	0.06	0.17*	1.30*	1.75*	1.14*
Grains	0.22*	0.40*	0.17*	1.10*	1.66*	1.02*
High Value Intermediates	0.11	0.38*	0.15*	1.17*	1.69*	0.31
High Value Processed	0.18*	0.40*	0.08	1.70*	1.70*	0.32
Produce & Horticulture	0.13	0.37*	0.09	1.62*	1.69*	0.43
Beef (Veal)	0.33*	0.36*	0.22*	1.55*	1.66*	0.63*
Broilers	0.23*	0.34*	0.07	1.66*	1.72*	1.24*
Corn	0.20*	0.40*	0.19*	1.18*	1.65*	0.55*
Cotton	0.11	0.08	0.18*	1.28*	1.75*	1.17*
Fruits (Citrus)	0.27*	0.40*	0.15*	1.07*	1.68*	0.25
Fruits (Deciduous)	0.15*	0.29*	0.15*	1.66*	1.70*	0.94*
Fruits (Fresh)	0.18*	0.39*	0.09	1.62*	1.70*	0.45
Fruits (Juices)	0.27*	0.39*	0.11	1.58*	1.68*	0.18
Fruits (Melons)	0.23*	0.24*	0.12	1.54*	1.66*	0.61*
Lamb	0.13	0.27*	0.27*	1.32*	1.60*	0.71*
Pork	0.26*	0.40*	0.16*	1.45*	1.66*	0.59*
Poultry	0.10	0.32*	0.09	1.69*	1.72*	0.63*
Poultry (Other)	0.17*	0.07	0.24*	1.64*	1.74*	1.04*
Red Meat	0.23*	0.40*	0.09	1.69*	1.66*	0.21
Rice	0.15*	0.40*	0.17*	1.46*	1.67*	0.19
Soybean	0.16*	0.17*	0.12	1.41*	1.75*	0.87*
Soymeal	0.11	0.38*	0.16*	1.19*	1.68*	0.61*
Soyoil	0.06	0.31*	0.10	0.63*	1.71*	1.15*
Tobacco	0.24*	0.37*	0.11	1.39*	1.63*	0.30
Turkey	0.24*	0.29*	0.24*	1.44*	1.63*	0.69*
Vegetables	0.12	0.39*	0.09	1.65*	1.69*	0.13
Vegetables (Dried)	0.18*	0.40*	0.09	1.35*	1.69*	0.09
Vegetables (Fresh)	0.12	0.33*	0.10	1.57*	1.68*	0.36
Vegetables (Frozen)	0.35*	0.40*	0.17*	1.62*	1.68*	0.36
Vegetables (Juices)	0.19*	0.19*	0.14	1.33*	1.64*	0.47*
Wheat	0.25*	0.40*	0.14	0.58*	1.70*	1.36*

Notes: The KPSS test is a Lagrange multiplier (LM) test of stationarity, either around a level or around a linear time trend. The test statistic's denominator is an estimate of the variance of the series. The test is applied to the natural log of levels of the core variables: U.S. agricultural exports, by commodities and category (X_t), commodity trade-weighted (adjusted) GDP of importing countries (GDP_t^*), and commodity trade-weighted real exchange rate of U.S. agricultural exports (RER_t). Unless otherwise noted, two lags are selected based on a combination of the Quadratic Spectral kernel and an automatic bandwidth selection routine, and a maximum lag order of three. The QS and automatic bandwidth selection combination is known to perform well in small samples; see Baum and Sperling (2000). When a trend is included in the model, the null hypothesis of the KPSS test is that the series is stationary around a linear time trend. In models without trend, the null hypothesis is that the series is stationary around a constant. The alternative hypothesis is that the series contains a unit root. The lower critical value bounds for the KPSS test with a linear trend are 0.216, 0.146, and 0.119 at 1%, 5%, and 10% levels of significance, respectively. In the absence of a linear time trend, the lower critical value bounds are 0.729 (1%), 0.463 (5%), and 0.347 (10%)

Table 3: Dickey–Fuller generalized least squares test and Kwiatkowski, Phillips, Schmidt, and Shin test applied to the core variables in *first differences*, and no deterministic trend.

	DF-GLS test (5% critical value: −1.95)			KPSS test (5% critical value: 0.463)		
Commodity	Exports	Foreign GDP	RER	Exports	Foreign GDP	RER
Total Export Value	-1.99_2*	-1.78_2	-2.37_2*	0.09	0.73∗	0.10
Bulk Commodities	-3.87_2*	-3.30_1*	-2.20_3*	0.04	0.10	0.14
Grains	-5.58_1*	-1.22_2	-2.18_2*	0.14_3	1.01∗	0.17
High Value Intermediates	-5.34_1*	-1.31_2	-2.16_2*	0.06	0.79∗	0.15
High Value Processed	-2.30_2*	-1.49_2	-2.44_2*	0.09	0.90∗	0.09
Produce & Horticulture	-1.46_2	-1.68_2	-2.32_2*	0.10	0.68∗	0.10
Beef (Veal)	-3.38_2*	-2.02_2*	-3.38_2*	0.19_3	0.60∗	0.08
Broilers	-4.50_1*	-2.28_2*	-2.89_2*	0.09	0.48∗	0.06
Corn	-3.22_3*	-1.19_2	-2.81_2*	0.19_3	1.03∗	0.14
Cotton	-3.89_2*	-3.35_1*	-2.20_3*	0.04	0.11	0.15
Fruits (Citrus)	-1.08_2	-1.49_2	-2.94_2*	0.12	0.92∗	0.10
Fruits (Deciduous)	-1.54_3	-2.57_2*	-2.54_2*	0.09	0.33	0.11
Fruits (Fresh)	-1.06_2	-1.61_2	-2.30_2*	0.10	0.80∗	0.09
Fruits (Juices)	-2.30_2*	-1.71_2	-2.33_3*	0.16	0.80∗	0.09
Fruits (Melons)	-1.92_3	-2.27_1*	-3.17_1*	0.17	0.28	0.16
Lamb	-3.04_2*	-3.06_2*	-2.93_3*	0.09	0.27	0.09
Pork	-1.16_3	-1.24_2	-2.87_2*	0.10_3	1.00∗	0.13
Poultry	-2.36_3*	-2.75_2*	-2.74_2*	0.07	0.37	0.06
Poultry (Other)	-1.76_3	-3.77_1*	-2.00_2*	0.14	0.08	0.16
Red Meat	-1.98_3*	-1.13_2	-2.72_2*	0.14	1.03∗	0.09
Rice	-6.51_1*	-1.25_2	-2.43_2*	0.07	0.97∗	0.20
Soybean	-2.29_3*	-3.22_1*	-2.71_2*	0.10_1	0.11	0.11
Soymeal	-5.10_1*	-1.23_2	-2.14_2*	0.07	0.82∗	0.17
Soyoil	-6.14_1*	-2.29_2*	-2.60_2*	0.06	0.41	0.11
Tobacco	-5.71_1*	-2.71_1*	-2.62_3*	0.09	0.76∗	0.09
Turkey	-2.38_2*	-2.94_2*	-2.82_3*	0.18	0.31	0.09
Vegetables	-2.36_3*	-1.49_2	-2.37_2*	0.10	0.81∗	0.10
Vegetables (Dried)	-2.36_3*	-1.36_2	-2.48_2*	0.13	0.92∗	0.09
Vegetables (Fresh)	-2.87_2*	-1.80_2	-2.49_2*	0.08_3	0.54∗	0.12
Vegetables (Frozen)	-2.67_3*	-1.40_2	-2.83_2*	0.30	0.94∗	0.14
Vegetables (Juices)	-1.95_3*	-2.38_1*	-3.35_1*	0.09_3	0.18	0.16
Wheat	-3.60_2*	-1.39_2	-2.42_2*	0.08	0.92∗	0.14

Notes: Subscripts in the DF-GLS columns denote the optimal lag order of the DF-GLS regression; for the KPSS test, a lag order of 2 is selected, unless otherwise noted in the subscript. The DF-GLS and KPSS tests are applied to the *first difference* of natural log of the core variables: U.S. agricultural exports, by commodities and category (ΔX_t), commodity trade-weighted (adjusted) GDP of importing countries (ΔGDP_t^*), and commodity trade-weighted real exchange rate of U.S. agricultural exports (ΔRER_t). The null hypothesis of the DF-GLS test is that the series contains *two* unit root; the alternate hypothesis is that the *first difference* of the series is stationary around a constant. The optimal lag order in the DF-GLS regression is chosen using Ng and Perron's (2001) modified Akaike information criterion (MAIC), with a maximum lag order of three. The lower critical value bounds for the DF-GLS test without a trend are -2.63 (1%), -1.95 (5%), and -1.608 (10%). The null hypothesis of the KPSS test is that the *first-difference* of the series is stationary around a constant. The alternative hypothesis is that the series contains *two* unit roots. The optimal lag order is selected based on a combination of the Quadratic Spectral kernel and an automatic bandwidth selection routine, and a maximum lag order of three. In the absence of a trend, the lower critical value bounds are 0.729 (1%), 0.463 (5%), and 0.347 (10%)

Table 4: Kwiatkowski, Phillips, Schmidt, and Shin test applied to the *first difference* of commodity-weighted foreign GDP, with and without a deterministic trend. Two lags are chosen by the Quadratic Spectral kernel and an automatic bandwidth selection routine, unless otherwise noted in the subscript.

	ΔGDP_t^* with deterministic trend (5% critical value: 0.146)		ΔGDP_t^* without deterministic trend (5% critical value: 0.463)	
Commodity	AICc Value	KPSS (2)	AICc Value	KPSS (2)
Total Export Value	−218.46	0.07	−209.41	0.73∗
Bulk Commodities	−200.57	0.09	−202.59	0.10
Grains	−203.73	0.06	−184.96	1.01∗
High Value Intermediates	−221.46	0.10	−209.99	0.79∗
High Value Processed	−215.58	0.06	−202.25	0.90∗
Produce & Horticulture	−219.67	0.09	−211.04	0.68∗
Beef (Veal)	−183.96	0.07	−177.47	0.60∗
Broilers	−210.88	0.11	−208.23	0.48∗
Corn	−200.53	0.06	−180.84	1.03∗
Cotton	−199.47	0.09	−201.29	0.11
Fruits (Citrus)	−205.79	0.06	−190.58	0.92∗
Fruits (Deciduous)	−207.85	0.12	−207.20	0.33
Fruits (Fresh)	−220.74	0.07	−209.78	0.80∗
Fruits (Juices)	−210.48	0.06	−198.67	0.80∗
Fruits (Melons)	−200.98	0.13	−200.70	0.28
Lamb	−138.68	0.07	−138.15	0.27
Pork	−201.89	0.06	−183.56	1.00∗
Poultry	−192.97	0.11	−191.88	0.37
Poultry (Other)	−155.60	0.08	−157.74	0.08
Red Meat	−205.55	0.05	−186.24	1.03∗
Rice	−219.29	0.05	−201.16	0.97∗
Soybean	−199.20	0.08	−201.00	0.11
Soymeal	−221.67	0.09	−209.04	0.82∗
Soyoil	−206.11	0.13	−204.40	0.41
Tobacco	−203.34	0.06	−193.74	0.76∗
Turkey	−146.72	0.07	−145.64	0.31
Vegetables	−218.72	0.07	−206.26	0.81∗
Vegetables (Dried)	−219.21	0.05	−203.74	0.92∗
Vegetables (Fresh)	−214.79	0.10	−208.82	0.54∗
Vegetables (Frozen)	−201.96	0.06	−186.49	0.94∗
Vegetables (Juices)	−192.08	0.14	−193.61	0.18
Wheat	−211.26	0.06	−196.69	0.92∗

Notes: The KPSS test is applied to the *first difference* of natural log of the commodity trade-weighted (adjusted) GDP of importing countries (ΔGDP_t^*). Unless otherwise noted, two lags are selected based on a combination of the Quadratic Spectral kernel and an automatic bandwidth selection routine, and a maximum lag order of three. The QS and automatic bandwidth selection combination is known to perform well in small samples; see Baum and Sperling (2000). When a trend is included in the model, the null hypothesis of the KPSS test is that the series is stationary around a linear time trend. In models without trend, the null hypothesis is that the series is stationary around a constant. The alternative hypothesis is that the series contains a unit root. The lower critical value bounds for the KPSS test with a linear trend are 0.216, 0.146, and 0.119 at 1%, 5%, and 10% levels of significance, respectively. In the absence of a linear time trend, the lower critical value bounds are 0.729 (1%), 0.463 (5%), and 0.347 (10%)

Table 5: Statistics for selecting the lag order of the aggregate U.S. agricultural export demand equation

		With deterministic trends				Without deterministic trends			
Commodity	Lags	*AIC*	*SBC*	$\chi^2_{SC}(1)$	$\chi^2_{SC}(4)$	*AIC*	*SBC*	$\chi^2_{SC}(1)$	$\chi^2_{SC}(4)$
	2	−10.18	−9.42	5.15	13.08	−10.23	−9.51	3.90	15.01*
Total Export Value	3	−10.06	−8.92	16.00*	10.95	−9.99	−8.89	10.63	14.00
	4	−10.00	−8.48	13.53	8.92	−9.85	−8.37	17.66**	8.62
	2	−7.55	−6.79	4.96	10.52	−7.47	−6.75	6.45	11.77
Bulk Commodities	3	−7.33	−6.19	11.31	7.03	−7.22	−6.12	12.28	11.45
	4	−7.24	−5.72	7.77	7.79	−7.18	−5.70	14.45	9.79
	2	−9.08	−8.32	7.79	6.09	−9.10	−8.38	11.68	6.39
Grains	3	−8.73	−7.59	15.46*	6.65	−8.70	−7.61	16.59*	6.47
	4	−8.74	−7.22	9.14	6.28	−8.79	−7.31	8.63	6.08
	2	−9.53	−8.77	5.95	8.53	−9.39	−8.67	1.52	9.66
High Value Intermediates	3	−9.31	−8.17	4.89	4.37	−9.05	−7.95	10.02	9.58
	4	−9.24	−7.72	5.38	8.41	−9.16	−7.69	5.64	7.80
	2	−9.63	−8.87	2.70	10.48	−9.65	−8.93	2.28	8.63
High Value Processed	3	−9.39	−8.25	9.30	10.39	−9.33	−8.23	7.43	9.24
	4	−9.23	−7.71	11.23	9.33	−9.15	−7.67	10.54	7.42
	2	−10.66	−9.90	4.92	10.44	−10.56	−9.84	4.64	8.24
Produce and Horticulture	3	−10.34	−9.20	8.23	9.91	−10.28	−9.18	7.10	6.53
	4	−10.26	−8.74	2.60	3.12	−10.22	−8.74	2.39	3.48
	2	−5.69	−4.93	2.91	6.67	−5.71	−4.99	3.64	7.29
Beef (Veal)	3	−5.36	−4.22	2.88	7.43	−5.40	−4.30	5.27	7.38
	4	−5.08	−3.56	5.97	6.37	−5.13	−3.65	5.58	6.21
	2	−8.19	−7.43	2.16	7.76	−8.15	−7.43	1.83	6.07
Broilers	3	−7.90	−6.76	3.31	12.71	−7.93	−6.83	2.59	9.52
	4	−7.83	−6.31	11.56	12.38	−7.81	−6.34	7.01	11.18

Continued

Table 5 – continued

Commodity	Lags	With deterministic trends				Without deterministic trends			
		AIC	*SBC*	$\chi^2_{SC}(1)$	$\chi^2_{SC}(4)$	*AIC*	*SBC*	$\chi^2_{SC}(1)$	$\chi^2_{SC}(4)$
	2	−8.29	−7.53	8.93	12.68	−8.24	−7.52	14.55	11.50
Corn	3	−8.06	−6.92	21.62^{**}	12.97	−8.07	−6.97	18.68^{**}	12.51
	4	−7.93	−6.41	27.45^{***}	13.52	−7.96	−6.48	27.88^{***}	13.88
	2	−7.36	−6.60	5.34	10.78	−7.29	−6.57	6.39	12.05
Cotton	3	−7.17	−6.03	11.60	7.16	−7.04	−5.94	12.58	11.81
	4	−7.08	−5.56	7.01	8.46	−7.02	−5.54	15.84^{*}	9.88
	2	−8.90	−8.14	8.06	9.21	−8.80	−8.09	6.27	9.80
Fruits (Citrus)	3	−8.71	−7.57	8.12	10.34	−8.53	−7.43	4.93	9.08
	4	−8.62	−7.10	7.14	10.44	−8.58	−7.11	4.24	8.60
	2	−9.45	−8.69	10.34	11.16	−9.25	−8.53	4.44	12.17
Fruits (Deciduous)	3	−9.33	−8.19	11.85	11.02	−8.96	−7.87	5.66	10.86
	4	−9.30	−7.78	7.13	13.19	−9.04	−7.56	9.11	12.46
	2	−10.47	−9.71	3.65	11.63	−10.51	−9.79	3.56	10.61
Fruits (Fresh)	3	−10.14	−9.00	5.04	10.60	−10.19	−9.09	4.86	9.84
	4	−10.04	−8.52	5.67	7.00	−10.01	−8.54	4.58	7.04
	2	−9.65	−8.89	4.37	14.17	−9.70	−8.98	4.37	14.46
Fruits (Juices)	3	−9.43	−8.29	7.40	7.67	−9.48	−8.38	6.99	7.70
	4	−9.39	−7.87	17.15^{**}	8.22	−9.41	−7.93	19.25^{**}	8.04
	2	−9.83	−9.07	7.92	3.15	−9.54	−8.82	8.16	4.84
Fruits (Melons)	3	−9.60	−8.46	2.84	3.25	−9.39	−8.30	4.58	4.24
	4	−9.24	−7.72	6.42	2.88	−9.13	−7.65	9.21	3.70
	2	−4.79	−4.03	5.77	5.90	−4.84	−4.12	5.66	5.93
Lamb	3	−4.55	−3.41	12.48	4.37	−4.57	−3.47	12.54	5.34
	4	−4.52	−3.00	4.31	5.72	−4.56	−3.08	3.16	6.09

Continued

Table 5 – continued

Commodity	Lags	With deterministic trends				Without deterministic trends			
		AIC	*SBC*	$\chi^2_{SC}(1)$	$\chi^2_{SC}(4)$	*AIC*	*SBC*	$\chi^2_{SC}(1)$	$\chi^2_{SC}(4)$
	2	−6.99	−6.23	3.14	17.30**	−6.80	−6.08	4.91	16.19*
Pork	3	−6.67	−5.53	4.01	14.96*	−6.50	−5.40	2.71	15.06*
	4	−6.43	−4.91	11.50	12.90	−6.40	−4.92	16.09*	18.98**
	2	−8.04	−7.28	6.76	4.28	−8.06	−7.34	2.99	5.01
Poultry	3	−7.86	−6.72	3.73	5.07	−7.72	−6.62	10.78	8.14
	4	−7.81	−6.29	7.38	7.13	−7.67	−6.20	7.51	10.28
	2	−7.47	−6.71	9.11	11.66	−7.42	−6.70	3.76	11.33
Poultry (Other)	3	−7.31	−6.17	9.09	13.63	−7.10	−6.00	10.67	11.54
	4	−7.28	−5.76	11.50	13.79	−7.12	−5.65	16.98**	13.76
	2	−7.07	−6.31	2.68	12.02	−7.11	−6.40	3.47	13.40
Red Meat	3	−6.91	−5.77	3.08	10.20	−6.95	−5.86	3.18	9.84
	4	−6.81	−5.29	15.97*	9.33	−6.86	−5.38	15.63*	8.97
	2	−8.66	−7.90	1.64	15.49*	−8.66	−7.94	1.79	6.81
Rice	3	−8.41	−7.27	15.89*	12.72	−8.34	−7.24	4.33	12.29
	4	−8.36	−6.84	4.76	7.64	−8.05	−6.58	9.85	17.84**
	2	−9.00	−8.24	11.10	14.87*	−9.00	−8.28	6.27	19.37**
Soybean	3	−8.93	−7.79	10.56	10.55	−8.79	−7.69	5.27	17.41**
	4	−8.91	−7.39	7.14	7.51	−8.65	−7.17	14.96*	12.26
	2	−9.41	−8.65	6.70	9.32	−9.24	−8.53	1.67	9.15
Soymeal	3	−9.17	−8.03	8.02	4.77	−8.89	−7.80	9.05	9.18
	4	−9.08	−7.56	6.39	11.35	−8.98	−7.50	6.67	7.80
	2	−7.21	−6.45	10.00	5.01	−7.25	−6.53	9.99	4.03
Soyoil	3	−7.27	−6.13	4.23	3.83	−7.32	−6.22	3.35	3.54
	4	−7.19	−5.67	3.91	4.82	−7.21	−5.73	3.26	4.34

Continued

Table 5 – continued

Commodity	Lags	With deterministic trends				Without deterministic trends			
		AIC	*SBC*	$\chi^2_{SC}(1)$	$\chi^2_{SC}(4)$	*AIC*	*SBC*	$\chi^2_{SC}(1)$	$\chi^2_{SC}(4)$
	2	−8.59	−7.83	5.53	10.85	−8.31	−7.59	9.86	12.34
Tobacco	3	−8.56	−7.42	5.39	7.65	−8.35	−7.26	5.86	4.32
	4	−8.39	−6.87	12.23	8.96	−8.15	−6.67	13.98	9.71
	2	−5.53	−4.77	10.12	7.51	−5.51	−4.79	11.72	9.60
Turkey	3	−5.49	−4.35	17.13^{**}	7.40	−5.37	−4.27	13.48	11.74
	4	−5.86	−4.34	4.79	3.43	−5.35	−3.87	7.42	11.60
	2	−10.07	−9.31	4.08	13.04	−10.00	−9.28	5.66	11.75
Vegetables	3	−9.90	−8.76	15.59^{*}	6.93	−9.75	−8.65	6.34	7.54
	4	−9.99	−8.47	2.39	8.47	−9.74	−8.26	6.62	9.09
	2	−7.97	−7.21	10.37	18.19^{**}	−7.99	−7.27	10.08	17.10^{**}
Vegetables (Dried)	3	−8.17	−7.03	14.74^{*}	8.87	−7.95	−6.85	10.92	12.78
	4	−8.42	−6.90	3.54	7.90	−8.07	−6.59	9.63	7.28
	2	−9.85	−9.09	4.10	6.63	−9.61	−8.89	5.68	5.87
Vegetables (Fresh)	3	−9.52	−8.38	6.45	6.00	−9.41	−8.31	6.08	3.59
	4	−9.33	−7.81	6.17	1.69	−9.35	−7.87	4.95	3.36
	2	−8.19	−7.43	10.16	4.94	−8.16	−7.44	24.23^{***}	3.04
Vegetables (Frozen)	3	−8.28	−7.14	1.85	5.09	−8.21	−7.12	3.08	3.18
	4	−8.04	−6.52	27.33^{***}	7.58	−8.03	−6.56	13.32	6.40
	2	−8.20	−7.44	10.49	4.64	−8.00	−7.28	12.85	5.72
Vegetables (Juices)	3	−8.11	−6.97	3.94	7.36	−7.99	−6.89	3.65	7.08
	4	−7.75	−6.23	8.59	7.11	−7.66	−6.19	3.83	7.32
	2	−8.44	−7.68	5.69	10.14	−8.47	−7.76	6.27	12.63
Wheat	3	−8.13	−6.99	19.64^{**}	7.08	−8.14	−7.04	21.39^{**}	8.39
	4	−8.53	−7.01	4.15	8.52	−8.57	−7.10	3.96	8.47

Notes: Lag order p corresponds to an underlying $VAR(p)$ model, which is equivalent to $p-1$ lags in the VECM. For a particular model with a sample size of T and k parameters, $AIC = -2LL/T + 2k/T$ denotes Akaike's Information Criterion for the given lag order; $SBC = -2LL/T + \ln(T)k/T$ is the Schwarz's Bayesian Information Criterion; LL is the maximized log-likelihood of the model. The preferred model is the one with the *lowest* information criterion value. $\chi^2_{SC}(1)$ and $\chi^2_{SC}(4)$ are the statistics for the Lagrange Multiplier test of serial non-correlation against the alternate hypothesis of residual serial correlation at lags 1 and 4, respectively.

Table 6: $F-$ and $t-$ statistics for testing the existence of a long-run export demand equation.

		With deterministic trends		Without deterministic trends	
Commodity	Lags	F_{IV}	t_{V}	F_{III}	t_{III}
	2	5.62^{**}	-2.37	2.55	-1.60
Total Export Value	3	17.71^{**}	-4.21^{**}	4.93^{*}	-2.22
	4	12.91^{**}	-3.59	2.40	-1.55
	2	16.73^{**}	-4.09^{**}	16.75^{**}	-4.09^{**}
Bulk Commodities	3	1.75	-1.32	9.46^{**}	-3.08
	4	3.94	-1.98	9.85^{**}	-3.14
	2	15.06^{**}	-3.88^{*}	14.86^{**}	-3.85^{**}
Grains	3	6.22^{**}	-2.49	9.01^{**}	-3.00
	4	1.43	-1.20	1.02	-1.01
	2	24.90^{**}	-4.99^{**}	16.38^{**}	-4.05^{**}
High Value Intermediates	3	12.11^{**}	-3.48	9.10^{**}	-3.02
	4	19.86^{**}	-4.46^{**}	6.95^{**}	-2.64
	2	3.50	-1.87	6.87^{**}	-2.62
High Value Processed	3	1.02	1.01	8.72^{**}	-2.95
	4	0.22	0.47	3.85	-1.96
	2	0.03	-0.18	0.97	-0.99
Produce & Horticulture	3	0.03	-0.18	0.95	-0.97
	4	0.03	-0.18	0.16	0.40
	2	4.78^{*}	-2.19	6.90^{**}	-2.63
Beef (Veal)	3	7.05^{**}	-2.65	8.47^{**}	-2.91
	4	14.15^{**}	-3.76^{*}	14.46^{**}	-3.80^{**}
	2	10.92^{**}	-3.31	12.49^{**}	-3.53^{**}
Broilers	3	0.50	-0.70	3.05	-1.75
	4	0.42	0.65	0.00	-0.04
	2	18.69^{**}	-4.32^{**}	11.06^{**}	-3.33^{*}
Corn	3	6.86^{**}	-2.62	3.82	-1.95
	4	4.95^{*}	-2.23	2.38	-1.54
	2	16.36^{**}	-4.04^{**}	17.49^{**}	-4.18^{**}
Cotton	3	0.71	-0.84	9.57^{**}	-3.09
	4	1.13	-1.06	9.49^{**}	-3.08
	2	15.36^{**}	-3.92^{*}	11.23^{**}	-3.35^{*}
Fruits (Citrus)	3	12.30^{**}	-3.51	4.20	-2.05
	4	16.45^{**}	-4.06^{**}	4.37	-2.09

Continued

Table 6 – continued

Commodity	Lags	With deterministic trends F_{II}	With deterministic trends t_{I}	Without deterministic trends F_{III}	Without deterministic trends t_{III}
Fruits (Deciduous)	2	0.01	0.11	2.77	−1.66
	3	0.66	−0.81	4.20	−2.05
	4	0.00	0.05	2.00	−1.41
Fruits (Fresh)	2	1.72	−1.31	2.45	−1.56
	3	0.94	−0.97	1.36	−1.17
	4	0.09	0.30	0.01	0.09
Fruits (Juices)	2	3.55	1.89	3.90	1.98
	3	0.28	−0.53	0.28	−0.53
	4	13.18**	−3.63*	13.51**	−3.68**
Fruits (Melons)	2	1.08	1.04	0.07	0.26
	3	0.76	0.87	0.80	0.90
	4	1.13	1.06	0.40	0.63
Lamb	2	2.95	−1.72	3.24	−1.80
	3	0.47	−0.69	2.01	−1.42
	4	3.38	−1.84	6.41**	−2.53
Pork	2	12.02**	−3.47	2.91	−1.71
	3	5.49**	−2.34	1.73	−1.31
	4	0.04	0.20	1.34	−1.16
Poultry	2	1.24	−1.11	8.52**	−2.92
	3	0.31	−0.56	4.01	−2.00
	4	0.01	0.08	0.60	−0.78
Poultry (Other)	2	1.99	−1.41	0.81	−0.90
	3	1.51	−1.23	0.00	0.03
	4	0.15	−0.39	0.03	0.16
Red Meat	2	10.62**	−3.26	9.94**	−3.15
	3	10.44**	−3.23	11.00**	−3.32*
	4	6.41**	−2.53	6.58**	−2.56
Rice	2	11.95**	−3.46	9.12**	−3.02
	3	1.77	−1.33	4.72*	−2.17
	4	3.29	−1.81	2.87	−1.70
Soybean	2	22.69**	−4.76**	14.46**	−3.80**
	3	27.51**	−5.24**	17.33**	−4.16**
	4	16.71**	−4.09**	7.49**	−2.74
Soymeal	2	22.08**	−4.70**	11.55**	−3.40*
	3	10.58**	−3.25	4.71*	−2.17
	4	18.92**	−4.35**	6.06**	−2.46

Continued

Table 6 – continued

Commodity	Lags	With deterministic trends F_{II}	With deterministic trends t_{I}	Without deterministic trends F_{III}	Without deterministic trends t_{III}
	2	19.17**	−4.38**	20.78**	−4.56**
Soyoil	3	28.92**	−5.38**	30.10**	−5.49**
	4	4.19	−2.05	3.47	−1.86
	2	23.27**	−4.82**	2.84	−1.68
Tobacco	3	14.99**	−3.87*	1.69	−1.30
	4	16.95**	−4.12**	0.70	−0.84
	2	0.76	−0.87	0.16	−0.40
Turkey	3	0.45	−0.67	0.85	−0.92
	4	2.13	−1.46	0.00	0.02
	2	0.01	0.11	0.11	−0.33
Vegetables	3	0.53	0.73	3.73	−1.93
	4	0.88	0.94	0.02	0.14
	2	7.84**	−2.80	8.37**	−2.89
Vegetables (Dried)	3	8.29**	2.88	16.46**	−4.06**
	4	6.22**	−2.49	1.19	−1.09
	2	0.02	−0.13	0.20	−0.45
Vegetables (Fresh)	3	0.01	−0.11	0.44	−0.66
	4	0.25	−0.50	0.11	0.33
	2	0.77	−0.88	0.50	0.70
Vegetables (Frozen)	3	0.16	−0.40	0.66	−0.81
	4	0.69	−0.83	0.98	−0.99
	2	8.93**	−2.99	0.60	0.77
Vegetables (Juices)	3	5.02*	−2.24	0.18	0.43
	4	6.16**	−2.48	0.06	0.25
	2	10.74**	−3.28	5.97**	−2.44
Wheat	3	9.40**	−3.07	2.49	−1.58
	4	4.97*	−2.23	4.90*	−2.21

Notes: $\Delta y_t = (\Pi y_{t-1} + \mu + \rho t) + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \delta + \tau t + u_t$ (Eq. 10), where $y_t = (X_t,\ GDP_t^*,\ RER_t)$, is the vector of core variables; $\Pi = (\pi_x,\ \pi_g,\ \pi_r)'$ is the matrix of long-run multipliers; $\Gamma_i = (\gamma_{x,\,i},\ \gamma_{g,\,i},\ \gamma_{r,\,i})'$ is the matrix of short-run response parameters; μ and δ are vectors of intercepts; ρ and τ are vectors of trend coefficients, and u_t is a vector of zero-mean stationary errors. F_{IV} is the $F-$statistic for testing the joint hypothesis that $\pi_{x,x} = 0$, $\pi_{x,g} = 0$, $\pi_{x,r} = 0$, and $\tau = 0$, and F_{III} is the $F-$statistic for testing the additional restriction that $\rho = 0$. The $t-$statistics are the $t-$ratios for testing $\pi_{x,x} = 0$ with and without a deterministic linear trend. If the test statistic falls above the 95% upper critical value bound, the null is rejected in favor of the existence of the posited long-run relationship. If the statistic falls below the lower critical bound, the null hypothesis of no long-run relationship can not be rejected. Inference is inconclusive if the statistic lies in between. Small-sample upper and lower critical value bounds for the $F-$statistic for models with two regressors are [Narayan, 2005, pp. 1987-90]: F_{IV}: 95% – (4.360, 5.138), 90% – (3.663, 4.378); F_{III}: 95% – (4.133, 5.260), 90% – (3.373, 4.377). Upper and lower critical value bounds for the $t-$ statistic in models with two regressors are [Pesaran et al., 2001, tables C2.i, C2.iii and Table C2.v, pp T4–T5]: t_{V}: 95% – (-3.41, -3.95), 90% – (-3.13, -3.63); t_{III}: 95% – (-2.86, -3.53), 90% – (-2.57, -3.21). The symbols * and ** denote that the test statistic falls above the 90% and 95% upper critical value bound, respectively.

Table 7: Long-run foreign income and exchange rate multipliers for U.S. agricultural exports

Commodity	Foreign GDP	Exchange Rate	Intercept	Trend	Commodity	Foreign GDP	Exchange Rate	Intercept	Trend
Total Export Value	−0.439 (1.029)	-3.404^{***} (0.658)	35.56	0.030 (0.030)	High Val. Interm.	1.502^{***} (0.232)	-1.791^{**} (0.645)	14.56	
Bulk Commodities	0.779^{***} (0.128)	-0.842^{*} (0.377)	20.47		High Val. Proc.	3.319^{***} (0.256)	-3.487^{***} (0.879)	9.418	
Grains	0.236 (0.139)	−0.332 (0.369)	18.05		Beef (Veal)	0.596 (0.962)	1.984 (1.677)	0.331	
Corn	0.353^{*} (0.163)	−0.114 (0.507)	15.64		Broilers	1.979^{***} (0.388)	-2.547^{**} (0.855)	13.89	
Rice	0.697^{***} (0.208)	−0.694 (0.494)	13.67		Lamb	2.714^{***} (0.197)	-3.013^{***} (0.337)	5.820	
Soybean	−1.084 (0.901)	-1.211^{***} (0.280)	−38.14	0.078^{*} (0.036)	Poultry	2.659^{***} (0.249)	-2.429^{**} (0.782)	9.791	
Wheat	0.138 (0.323)	0.938 (0.590)	11.86		Red Meat	2.524^{***} (0.321)	0.396 (0.882)	−6.631	
Cotton	0.785^{***} (0.130)	-0.861^{*} (0.378)	20.50		Fruits (Citrus)	0.140 (0.127)	−0.473 (0.370)	15.01	
Tobacco	0.645^{**} (0.233)	-0.600^{***} (0.124)	39.41	-0.030^{***} (0.004)	Vegetables (Juices)	-11.82^{***} (2.207)	-3.605^{*} (1.629)	−281.9	0.313^{***} (0.053)
Soymeal	1.849^{***} (0.313)	-1.889^{*} (0.755)	12.72		Vegetables (Dried)	0.451 (0.373)	-2.041^{*} (0.949)	18.32	
Soyoil	0.320 (0.295)	−1.081 (0.738)	16.47						

Notes: $\Delta y_t = (\Pi y_{t-1} + \mu + \rho t) + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \delta + \tau t + u_t$ (Eq. 10), where $y_t = (X_t,\, GDP_t^*,\, RER_t)$, is the vector of core variables; $\Pi = (\pi_x,\, \pi_g,\, \pi_r)'$ is the matrix of long-run multipliers; $\Gamma_i = (\gamma_{x,\,i},\, \gamma_{g,\,i},\, \gamma_{r,\,i})'$ is the matrix of short-run response parameters; μ and δ are vectors of intercepts; ρ and τ are vectors of trend coefficients; u_t is a vector of zero-mean stationary errors; and $p \geq 2$ is the lag order. Conditional on the existence of a long-run export demand equation, the long-run multipliers can be extracted from the estimated VECM. The long-run foreign GDP multiplier is $\hat{\xi}_{x,\,gdp^*} = -\hat{\pi}_{x,g}/\hat{\pi}_{x,x}$, and the long-run real exchange rate multiplier is $\hat{\xi}_{x,\,rer} = -\hat{\pi}_{x,r}/\hat{\pi}_{x,x}$. Standard errors are in parenthesis. The symbols ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

Table 8: [§]Reduced-form error correction specification of the U.S. agricultural export demand equation.[†]

Commodity	Speed of Adjustment	Intercept	ΔX_{t-1}	ΔGDP_{t-1}	ΔRER_{t-1}	ΔX_{t-2}	ΔGDP_{t-2}	ΔRER_{t-2}	ΔX_{t-3}	ΔGDP_{t-3}	ΔRER_{t-3}
Total Export Value	-0.185^{*}	-0.010	0.237	3.521^{**}	0.326						
	(0.0802)	(0.043)	(0.181)	(1.092)	(0.593)						
Bulk Commodities	-0.768^{***}	0.019	0.113	-1.211	-1.147						
	(0.193)	(0.094)	(0.163)	(1.679)	(0.629)						
Grains	-0.687^{***}	-0.020	0.320^{*}	-0.718	0.791						
	(0.126)	(0.025)	(0.150)	(0.750)	(0.436)						
Corn	-0.556^{***}	-0.025	0.137	-0.928	0.262						
	(0.122)	(0.034)	(0.145)	(1.012)	(0.541)						
Rice	-0.454^{**}	0.001	-0.104	-3.137	-0.614						
	(0.158)	(0.055)	(0.164)	(1.713)	(0.775)						
Soybean	-0.520^{**}	-0.009	0.197	2.113^{**}	-0.520						
	(0.108)	(0.035)	(0.135)	(0.768)	(0.108)						
Wheat	-0.367^{**}	-0.016	-0.0753	-0.655	0.531						
	(0.121)	(0.043)	(0.169)	(1.359)	(0.463)						
Cotton	-0.789^{***}	0.021	0.112	-1.522	-1.238						
	(0.195)	(0.099)	(0.162)	(1.730)	(0.654)						
Tobacco	-0.789^{***}	-0.002	0.0828	0.930	0.659^{**}						
	(0.161)	(0.019)	(0.145)	(0.719)	(0.232)						
High Value Intermediates	-0.377^{***}	0.015	0.0895	3.707^{**}	1.519^{*}						
	(0.0878)	(0.045)	(0.145)	(1.366)	(0.657)						
Soymeal	-0.313^{***}	0.014	0.0614	3.206^{*}	1.341						
	(0.0854)	(0.046)	(0.152)	(1.442)	(0.703)						
Soyoil	-0.777^{***}	0.007	0.206	6.492^{*}	2.560^{*}						
	(0.171)	(0.098)	(0.154)	(2.638)	(1.133)						
High Value Processed	-0.140^{*}	0.005	-0.0109	1.514	0.284						
	(0.0591)	(0.040)	(0.166)	(1.069)	(0.497)						
Beef (Veal)	-0.161^{*}	0.003	-0.0453	-2.821	-1.081						
	(0.0675)	(0.101)	(0.160)	(2.836)	(0.956)						

Continued

Table 8 – continued from previous page

Commodity	Speed of Adjustment	Intercept	ΔX_{t-1}	ΔGDP_{t-1}	ΔRER_{t-1}	ΔX_{t-2}	ΔGDP_{t-2}	ΔRER_{t-2}	ΔX_{t-3}	ΔGDP_{t-3}	ΔRER_{t-3}
Broilers	-0.285^{***}	0.002	0.186	0.452	0.826						
	(0.0821)	(0.057)	(0.144)	(1.491)	(0.512)						
Lamb	-0.582^{**}	−0.006	0.158	-6.334^{**}	−1.422	0.113	−2.407	−0.700	0.196	−3.537	-1.983^{*}
	(0.216)	(0.108)	(0.219)	(2.225)	(0.850)	(0.185)	(2.348)	(0.881)	(0.170)	(2.159)	(0.864)
Poultry	-0.251^{**}	0.007	0.185	−0.522	0.140						
	(0.0940)	(0.050)	(0.155)	(1.177)	(0.479)						
Red Meat	-0.330^{**}	0.0001	−0.003	−3.207	−0.680						
	(0.106)	(0.068)	(0.170)	(2.130)	(0.652)						
Fruits (Citrus)	-0.588^{***}	−0.014	−0.208	−0.497	−0.179						
	(0.149)	(0.030)	(0.141)	(0.952)	(0.423)						
Vegetables (Juices)	-0.308^{**}	−0.008	−0.0928	1.039	−0.845						
	(0.0972)	(0.064)	(0.156)	(1.740)	(1.043)						
Vegetables (Dried)	-0.381^{***}	−0.026	−0.0621	1.894	0.700	−0.0961	-8.292^{***}	-1.570^{*}			
	(0.0868)	(0.067)	(0.124)	(1.778)	(0.687)	(0.121)	(1.708)	(0.688)			

Notes: The reduced-form vector error correction model with p lags and no intercept terms is $\Delta y_t = b + \psi\,\hat{v}_t + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + u_t$, where for a given time period t, y_t is the vector of core variables, namely volume of exports (X_t), importers' trade-adjusted GDP (GDP_t^*), and real commodity trade-weighted real exchange rate (RER_t); $\Gamma_i = (\gamma_{x,i}, \gamma_{g,i}, \gamma_{r,i})'$ is the matrix of short-run response parameters; b is a vector of deterministic intercept terms; u_t is a vector of stationary errors; and $p \geq 2$ is the lag order of the VECM; see text for details. Additionally, $\hat{v}_t$ is the error correction term (ECT), which represents the deviation of (observed) exports from the level predicted by the long-run export demand equation. The coefficient on the ECT, ψ is known as the *speed of adjustment* parameter, whose magnitude measures the speed at which deviations from predicted long-run equilibrium are corrected to restore long-run equilibrium: $|\hat{\psi}| = 0.3$ implies that roughly 30% of the disequilibrium between actual and predicted exports is corrected within one time period. Standard errors are in parenthesis. The symbols ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

Table 9: Model diagnostics of reduced form error correction specifications of the export demand equations

Commodity	$\chi^2_{SC}(1)$	$\chi^2_{SC}(4)$	χ^2_N	R^2	AIC	SBC
Total Export Value	6.03	14.63	8.25^{**}	0.37	-10.00	-8.98
Bulk Commodities	10.07	10.91	1.52	0.43	-7.25	-6.22
Grains	7.72	6.62	2.60	0.49	-9.08	-8.05
Corn	6.91	13.87	2.25	0.51	-8.41	-7.39
Rice	4.56	9.59	4.44	0.31	-8.31	-7.29
Soybean	6.62	10.91	4.43	0.54	-8.97	-7.95
Wheat	6.33	11.46	3.22	0.35	-8.28	-7.25
Cotton	9.83	11.23	1.37	0.44	-7.07	-6.04
Tobacco	12.04	14.48	4.24	0.50	-8.54	-7.52
High Value Intermediates	7.44	9.49	2.78	0.43	-9.09	-8.07
Soymeal	9.75	9.30	2.85	0.34	-8.93	-7.91
Soyoil	5.91	4.98	1.39	0.64	-7.27	-6.25
High Value Processed	5.68	8.35	3.25	0.21	-9.33	-8.31
Beef (Veal)	4.24	7.23	129.9^{***}	0.21	-5.43	-4.41
Broilers	7.91	5.76	1.49	0.32	-7.75	-6.73
Lamb	11.10	5.52	1.39	0.22	-4.57	-3.54
Poultry	7.96	6.77	1.76	0.26	-7.72	-6.69
Red Meat	12.62	10.68	9.94^{***}	0.34	-6.97	-5.94
Fruits (Citrus)	8.83	10.49	4.46	0.48	-8.58	-7.56
Vegetables (Juices)	2.38	7.48	1.52	0.28	-8.22	-7.20
Vegetables (Dried)	14.36	11.19	0.95	0.59	-8.07	-7.05

Notes: Akaike's and Schwarz's Bayesian Information Criteria are denoted, respectively, by AIC and SBC. $\chi^2_{SC}(1)$ and $\chi^2_{SC}(4)$ are the statistics for the Lagrange Multiplier test of serial non-correlation against the alternate hypothesis of residual serial correlation at lags 1 and 4, respectively. χ^2_N is the test statistic for the Jarque-Bera test non-normal errors. Finally, R^2 is the coefficient of multiple determination measuring goodness of fit.

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