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ABSTRACT

Although food aid may have important medium- to long-term effects, there is a glaring absence of empirical research on food aid dynamics. This paper applies structural vector autoregression and dynamic structural equations modeling methods to a panel of production, trade, and food aid data from eighteen countries over the period 1961-95. We find evidence of a J-curve effect of food aid on recipient country commercial food imports, but only modest effects on food production. The implication is that food aid primarily serves donor goals of export market development.

Key words: agricultural development, commercial trade, dynamic estimation, food aid, structural vector autoregression
THE DYNAMIC EFFECTS OF U.S. FOOD AID ON RECIPIENT COUNTRY AGRICULTURE*

The effects of United States food aid on recipient country agriculture have been heatedly debated since the Cochrane-Schultz debate of 1959-60 (Cochrane 1959; Schultz 1960). Does food aid depress producer incentives, thereby retarding output growth? Does it substitute for food that would otherwise be imported commercially from the donor, thereby providing balance of payments relief? Does food aid have long-run stimulative effects on recipient country commercial imports, thereby developing markets for donors? Although food aid may have important medium- to long-term effects, there is a glaring absence of empirical research on these questions using dynamic modeling techniques. This paper addresses that void by applying structural vector autoregression and dynamic structural equations modeling methods to a panel of production, trade, and food aid data from eighteen countries over the period 1961-95.

Now is an especially opportune time to investigate the linkages between food aid and agricultural development in recipient countries. In the wake of disappointing growth performance in the 1970s and 1980s, and under pressure in recent years from external creditors and donors, many low-income countries have vigorously renewed their commitment to agriculture-led economic development. Policymakers in low-income countries must thus consider carefully the economic effects of prospective food aid receipts on domestic food production and trade.

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Meanwhile, food aid is inextricably linked to the agricultural trade promotion and surplus disposal objectives of wealthy donor countries that built up substantial farm support programs in the half century following World War II. Foreign consumers, especially in presently low-income countries, are the growth markets of the future for food exporters. However, recession and renewed emphasis on domestic production in low-income countries has led to slowed growth in international food commodity trade since the early 1980s, making donor country surplus disposal and export market development tasks more difficult and competitive. Moreover, potentially dramatic revisions to farm support and agricultural trade policies in the context of budget deficit reduction and trade treaties (e.g., GATT, NAFTA) are forcing serious reexamination of the efficacy of food aid in promoting donor countries’ multiple objectives.

1. The Issues

The Food and Agriculture Organization of the United Nations (FAO) defines food aid as the transfer of food commodities from donor to recipient economies on a full grant basis or on highly concessional terms. Food aid, which began with massive commodity shipments to western Europe under the Marshall plan, was formalized in the United States in 1954 under Public Law 480 (PL 480), the Agricultural Trade Development and Assistance Act (later renamed Food for Peace).¹ Title I of PL 480 extends credit to recipient countries to buy food on concessional terms. The recipient government earns revenue (counterpart funds) by selling this food in its domestic market. Title II (emergency) aid is distributed for humanitarian purposes through nongovernmental organizations (NGOs). Title III consists of barter of agricultural products for strategic materials and

¹See Maxwell and Singer (1979) and Ruttan (1993) for excellent surveys.
for retiring Title I debts. Title II now falls under the direction of the U.S. Agency for International Development (USAID), while the Department of Agriculture (USDA) retains control of Titles I and III.

Although assistance in the wake of natural and social disasters perhaps draws the most attention, humanitarian food aid historically represents 10% or less of global volumes and enjoys relatively broad-based political support in the U.S., in large measure because of its clear, humanitarian objective. A more spirited debate surrounds nonemergency (program) food aid, which represents the lion’s share of food aid shipments, historically about 80% of direct, bilateral food aid, although this proportion has been falling with decreasing surplus stocks in donor countries. Program food aid is more fungible and most commonly used for broader development purposes by recipients and for trade promotion purposes by donors. Historically, it has been far more subject to distribution according to political criteria (Ruttan 1993; Ball and Johnson 1996) and its effectiveness and desirability is more contested. We study program food aid (PL 480 Titles I and III) in this paper, hereafter referring to it simply as “food aid.”

The multiple, sometimes conflicting, objectives of food aid have sparked heated debate over its efficacy in promoting either agricultural development in recipient economies or trade development for donors. Particularly intense debates have surrounded the questions of whether food aid (1) is “additional” to commercial trade volumes, as the international food aid convention insists, (2) establishes distribution channels and fosters consumer taste for donor country products, thereby stimulating long-term commercial trade, or (3) depresses or stimulates recipient country food production. There are no unambiguous analytical answers to these questions; they demand empirical

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2 The empirical material in this paragraph is drawn from information available in various issues of the FAO’s *Food Aid in Figures* and the World Food Program’s *Food Aid Monitor.*
investigation. While there are other conceptual debates in the literature—and many over operational details—data considerations restrict our inquiry to these three fundamental issues.  

The primary question to donor country agricultural producers is whether food aid creates additional commercial export opportunities. Under international aid agreements, food aid recipient countries are obliged to maintain a “normal” volume of commercial food imports (the “usual marketing requirement” or UMR) so as to ensure the “additionality” of food aid. That is, aid must be in addition to customary commercial import volumes. If the additionality principle is honored, Acker (1989, p. 165) observes that “food aid programs provide an opportunity to empty granaries and warehouses, build up taste preferences for US commodities, and through the economic development consequences of our PL 480 programs, build purchasing power for future commercial sales of US agricultural commodities.” Yet, there is considerable evidence that the additionality principle is widely violated and food aid does substitute for commercial imports (Abbott and McCarthy 1982; Von Braun and Huddleston 1988). This has caused concern among agricultural groups in the United States, inducing opposition by some farm lobbies to food aid and agricultural development assistance (Ruppel and Kellogg 1991).

Additionality also concerns those interested primarily in recipient country development. Additional foreign food may indeed build up taste preferences for foreign products, obstructing attainment of national food self-sufficiency goals set (for right or wrong) by most developing countries. Pure additionality also implies a restriction to recipient substitution opportunities. As with any grant in kind, recipients would generally be better off if they could use the grant to increase consumption in each of several classes of goods, perhaps including capital equipment for

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3In particular, the effects of food aid on the nutritional status of the poor is one of the most fundamental questions, but one for which there is no good longitudinal data.
investment. Moreover, violations of additionality imply relaxation of balance of payments constraints, which may be crucial to macroeconomic stabilization efforts central to long-run economic growth and development.

If trade maintenance and promotion are the key issues to donor country producers, the crucial issue to recipient countries is whether food aid depresses or stimulates domestic output. Schultz (1960) claimed that food aid augments domestic supply, thereby depressing prices and creating disincentives for local producers. Others argue, however, that recipient economies are price takers in international markets, restricting the price reducing effects of food aid. Bounded output price reductions might then be overshadowed by the stimulative effects of increased intermediate goods (e.g., fertilizer, machinery) imports made possible by prospective violations of additionality, which could have analogous price lowering effects in agricultural factor markets. Or nutritional improvements fostered by food aid might increase labor productivity. And food aid deliveries might help stimulate more efficient distribution channels, reducing trader margins, to the advantage of recipient country producers. Even in relatively simple models, the crucial incentive effects of food aid are ambiguous and complex (Mohapatra et al. 1996).

Perhaps some of the disagreement over food aid reflects unstated differences in the time frames commentators have in mind. For instance, while additionality might not hold, thereby depressing donor commercial exports in the short-run, food aid might nonetheless generate long-run increases in recipient country food imports. This hypothesis suggests a J-curve response of commercial food trade to food aid shocks, with a short-term decrease in commercial transactions followed by long-run net increases. Similarly, food aid might generate immediate, Schultzian output price disincentives that lead to a short-run decrease in recipient country food production, while
improved nutrition and increased intermediate imports generate lagged positive effects that mitigate or offset the product market disincentive effects of food aid. Although the key questions surrounding food aid concern multiyear horizons, and conflicting claims may be reconcilable in ways like those just hypothesized, no study to date has considered the dynamics of food aid’s effects on production and trade in recipient economies.

2. Methods

Given the dynamic relationship between food aid, production, and commercial imports, the logical way to proceed is with a dynamic structural econometric model (DSEM). Traditional structural models use *a priori* theoretical restrictions on both contemporaneous relationships and dynamics to achieve identification. However, there is not always theoretical justification for specifying dynamics *a priori*. Moreover, traditional simultaneous equation models are subject to criticism for imposing arbitrary and 'incredible' restrictions (Sims 1980). Given the considerable dispute over the relationship between food aid, trade, and production, one would like to impose as few restrictions as possible in statistical estimation. Multivariate time-series analysis based on vector autoregression (VAR) techniques offer an appropriate blend of dynamic structure and statistical robustness (Sims 1980; Blanchard 1989; Lütkepohl 1993). The VAR is essentially a reduced form model of an unknown, general DSEM. However, although VAR models were developed to ease the dependence on (often arbitrary) theoretical restrictions, pure VAR itself can be excessively atheoretical. We therefore employ the intermediate technique of structural vector autoregression (SVAR), which summarizes the dynamics of the vector of dependent variables combining both minimal restrictions on parameter estimates with a theoretical basis for interpreting the statistical results (Hamilton 1994; Enders 1995). As a check on the SVAR estimation, we also
directly estimate a DSEM using three-stage least squares to address potential simultaneity and inefficiency problems. A DSEM model, estimated in either of several ways and accompanied by innovation accounting methods like impulse response functions and variance decomposition, seems an appropriate tool for understanding of the dynamic effects of food aid.

We thus consider the joint behavior of food aid, commercial imports and production in the following general DSEM specification,

\[ AX = BX(L) + Ce \]  
\[ E(e) = 0, \quad E(e_t e_s^t) = 0 \quad t \neq s; E(e e^t) = \Omega \]

where \( X \) is the dependent variable vector comprised of food aid, \( F \), commercial food imports, \( M \), and food production, \( P \), and \( e \) is the mutually orthogonal white noise structural innovation vector \((e_F, e_M, e_P)\). \( X(L) \) is a matrix polynomial of order \( p \) in the lag operator \( L \) (for a \( p^{th} \) order autoregressive structure). Matrices \( A \) and \( C \) capture the contemporaneous feedback interactions in the system. \( B \) represents system dynamics.

The indeterminacy of the system is eliminated by normalizing the diagonal elements of \( A \) and \( C \) to unity. This allows standard representation of the model with unit coefficients for both the dependent variables and the associated error term. The normalization on \( C \) does not allow direct effects of innovations on variables other than the associated dependent variable of the equation.

Premultiplication by \( A^{-1} \) yields the reduced form of the DSEM

\[ X = A^{-1}BX(L) + A^{-1}Ce \]  
\[ X = RX(L) + \epsilon \]

where

\[ E(\epsilon \epsilon^t) = A^{-1}CC'(A^{-1})' = A^{-1}(A^{-1})' = \Sigma \]

\(^4C \) is specified as an identity matrix. Since restrictions imposed on \( A \) imply restrictions on \( C \), it is irrelevant if a covariate shock to a pair of dependent variables enters through \( A \) or through \( C \) (Fackler 1988).
R is the reduced form parameter matrix \((A^{-1}B)\), and \(\varepsilon\) is the reduced form innovation vector \((A^{-1}Ce)\). Assuming the primitive \(\varepsilon\) vector was white noise, it follows that the reduced form stochastic disturbance terms \((\varepsilon_F, \varepsilon_M, \varepsilon_P)\) have zero means and are individually serially uncorrelated (Hamilton, 1994; Enders 1995). If the dynamics of the system are unrestricted and lags are specified appropriately, then equation [3] represents a standard VAR process.

Standard VAR methods obtain identification by a Choleski decomposition of the covariance matrix of reduced form errors, restricting \(A\) to be lower triangular, i.e., a current period shock to the first dependent variable in the vector does not affect subsequent dependent variables. VAR methods are often criticized as being devoid of economic information when this recursive structure is imposed atheoretically (Cooley and Leroy 1985), since the results vary with changes in the ordering of the variables in the system. The aim of structural vector autoregression (SVAR), however, is to use economic theory to select the appropriate identifying restrictions to allow recovery of the structural innovations, \(\varepsilon\), from the reduced form residuals, \(\varepsilon\) (Bernanke 1986; Sims 1986; Hamilton 1994). We thus use theory to restrict the contemporaneous coefficient matrix, \(A\), so as to exactly identify the system of equations in [1].

There are three steps to model specification in SVAR modeling. First, we choose the relevant variables to include in each process. Second, based on the theoretical relation between those variables, we restrict \(A\) so as to permit recovery of the primitive innovations, \(\varepsilon\), from the reduced form residuals. Third, we determine an appropriate lag structure for the \(X(L)\).

The first task is quite straightforward in this case. We are interested in the relationship between food aid shipments (i.e., concessionary food imports), commercial food imports, and
domestic food production in economies given program food aid by the U.S. We therefore include those three variables in each process.

The set of identifying restrictions on the A matrix is drawn from an understanding of the theory and practice of program food aid. Program food aid (perhaps unlike humanitarian aid) is requisitioned nine or so months prior to delivery and thus is effectively exogenous to contemporaneous production or import shocks. Commercial imports, in contrast, can be affected by contemporaneous shocks to both production and food aid deliveries since commercial trade requires considerably less lead time than does program food aid transfer. Production, meanwhile, could well be affected by contemporaneous shocks to food aid deliveries since these are known in advance and can affect the availability of imported inputs insofar as aid mitigates binding balance of payments constraints. Shocks to commercial food imports, on the other hand, tend not to be known ahead of time and are thus unlikely to affect production volumes, given the biological lags involved in food production. This logic dictates the restrictions we impose on matrix A:

\[
A = \begin{bmatrix}
1 & 0 & 0 \\
\alpha_{21} & 1 & \alpha_{23} \\
\alpha_{31} & 0 & 1
\end{bmatrix}
\]

This corresponds to the innovation model

\[
\epsilon_{ft} = \epsilon_{ft} \\
\epsilon_{mt} = \alpha_{21} \epsilon_{ft} + \epsilon_{mt} + \alpha_{23} \epsilon_{pt} \\
\epsilon_{pt} = \alpha_{31} \epsilon_{ft} + \epsilon_{pt}
\]

these restrictions permit recovery of the structural parameters of equation [1] through VAR estimation of the reduced form relationship in [3].
We would expect $\alpha_{21}$ to be nonpositive, since it is unlikely that food aid stimulates contemporaneous commercial food imports by recipient nations, but it could reduce those imports (i.e., violate the additionality principle), as signalled by $\alpha_{21} < 0$. We would also expect contemporaneous production ($\alpha_{23}$) to be negatively associated with commercial imports, since increased domestic output reduces excess domestic food demand. The contemporaneous effect of food aid on domestic production, given by $\alpha_{31}$, would be negative if Schultzian product market effects dominate and positive if balance of payments and factor market effects prevail (Mohapatra et al. 1996). Theory does not yield a clear prediction of the relationship between food aid and recipient country food production.

While VAR models are often specified with identical lag structures both within and across equations, thereby permitting efficient estimation by ordinary least squares, we select lag lengths so as to minimize the number of parameters estimated without misspecifying the model. Toward this end, we performed block exogeneity tests—a multivariate generalization of the Granger causality test (Hamilton 1994)—to establish which lagged variables Granger cause other dependent variables in equation (1). We used five annual lags of each variable (i.e., sixteen total regressors, including a constant, in each equation) as the unrestricted system against which we tested more parsimonious specifications. We found that neither food imports nor food production Granger cause food aid deliveries, which also provides statistical support to our earlier specification of the A

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5The block exogeneity test uses the likelihood ratio statistic, where $T$ is the number of observations, $c$ is the “Sims correction,” equal to the number of estimated parameters in the unrestricted system, and $\Sigma_r$ and $\Sigma_u$ are the covariance matrices of the restricted and unrestricted systems, respectively. That is, the test statistic is $(T-c)(\log|\Sigma_r|-\log|\Sigma_u|)$, which has an asymptotic $\chi^2$ distribution with degrees of freedom equal to the number of restrictions imposed.
matrix. Food aid deliveries likewise do not Granger cause food production. The block exogeneity test suggest the most parsimonious appropriate specification for the reduced form model in [3] is:

\[
F_{it} = \mu_0 + \sum_{l=1}^{5} \mu_l F_{i,t-l},
\]

\[
M_{it} = \gamma_0 + \sum_{l=1}^{4} \gamma_l F_{i,t-l} + \sum_{l=1}^{5} \phi M_{i,t-l} + \sum_{l=1}^{3} \psi P_{i,t-l}
\]

\[
P_{it} = \lambda_0 + \sum_{l=1}^{5} \lambda P_{i,t-l} + \sum_{l=1}^{5} \pi M_{i,t-l}
\]

Since the regressors are not identical across the three equations, we estimated the resulting SVAR by the seemingly unrelated regressions (SUR) method to ensure efficiency.

3. The Data

While it makes sense to distinguish between program and humanitarian food aid, published data that disaggregate flows by recipient country do not routinely separate the two. USDA generously provided the food aid flows data of Suarez (1994), disaggregated by commodity, recipient country, year, and source (PL 480 Titles I, II, or III). From these data we constructed time series of (Titles I and III) cereals program food aid delivery volumes to each country, 1961-95. Cereals food aid accounts for more than 90% of world food aid, so cereals serve as a reasonable proxy for overall trends in food aid. 7 We use data from the eighteen countries that most frequently received program food aid from the United States over this period: Bangladesh, Bolivia, Dominican

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6 The block exogeneity test statistic is 8.21, which has a p-value of 0.98 against the \( \chi^2(18) \) distribution with a null hypothesis that the two models are statistically equivalent.

7 We aggregated volumes (metric tons) across the following commodities: barley, bulgur wheat (0.96), corn, cornmeal (0.56), corn-soy-milk (0.88), mixed feed grains, oats, rice, rye, sorghum, wheat, wheat flour grain equivalent, and wheat-flour-soy (0.80). The numbers in parentheses are the grain equivalent conversion factors under the food aid convention.
Republic, Egypt, Ghana, Guinea, Indonesia, Israel, Jamaica, Republic of Korea, Morocco, Peru, Pakistan, Sri Lanka, Sierra Leone, Sudan, Tunisia, and Zaire. Commercial cereals import volume data come from the FAO's *Trade Yearbook* and data on cereals production volumes are from the FAO's *Production Yearbook*. All volume figures were converted to a *per capita* basis using annual population data reported in the latter publication. All the estimation results are thus on a real, per capita basis.

Figure 1 displays a plot of the cross-sectional annual mean per capita volumes for cereals production, commercial imports, and food aid deliveries in the eighteen recipient economies. While per capita production has remained fairly constant at about 140 kilograms per capita, program food aid volumes have declined sharply, from almost 20 kg per capita in the 1960s to less than 10 in the 1990s. Commercial cereals imports, meanwhile, have risen from less than 50 kg per capita in the early 1960s to nearly 100 kg per capita in the 1990s. Clearly trade is replacing aid in these nations, but do past food aid distributions help account for any of the growth in cereals trade volumes?

The VAR literature is divided over whether it is important to test and potentially adjust for stationarity in the dependent variables (Sims 1980; Doan 1992; Lütkepohl 1993; Hamilton 1994; Enders 1995). This proved not to be an issue with these data, as both augmented Dickey-Fuller and Phillips-Perron tests rejected the null hypothesis of a unit root in the dependent variables. The relationships in equations [6]-[8] are therefore estimated in levels.

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8The results of the unit root tests are as follows (the null hypothesis is nonstationarity):

<table>
<thead>
<tr>
<th></th>
<th>ADF Statistic</th>
<th>Phillips-Perron Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food aid</td>
<td>-56.41</td>
<td>-60.84</td>
</tr>
<tr>
<td>Commercial imports</td>
<td>-11.54</td>
<td>-3.10</td>
</tr>
<tr>
<td>Production</td>
<td>-82.07</td>
<td>-50.70</td>
</tr>
</tbody>
</table>
Figure 1:

Mean annual cereals production, imports, and food aid volumes

4. Estimation Results

While we are interested in the coefficients of the structural relationship represented in equation [1], the real motivation of this work focuses on the dynamic effects of food aid on recipient country food production and commercial imports. Does food aid retard or stimulate recipient country food production and does it make or take away commercial markets for the donor? We therefore follow up estimation of the dynamic system in equations [6]-[8] with innovation accounting. The Wold decomposition theorem enables the representation of the vector autoregressive process as a vector moving average process, which offers some insights on the time
path of dependent variables' responses to shocks to the system. Impulse response functions enable us to trace the effect of an innovation in one variable on the others. Variance decomposition offers complementary information on the relative importance of shocks to one variable on the forecast errors of the other dependent variables.

Since we are using panel data, it is also important to consider whether there may be country-specific unobserved heterogeneity. Toward this end, we tested for both fixed effects and cross-sectional heteroscedasticity. An F-test fails to reject the null hypothesis that the intercepts are identical across countries in equations [6]-[8]. On the other hand, likelihood ratio tests for groupwise heteroscedasticity consistently reject the null hypothesis of homoscedasticity. In recognition that the autoregressive specification of equations [6]-[8] might not have removed all autocorrelation, we also tested for serial correlation using the Kolmogorov-Smirnov test. The food aid equation still evinces autocorrelation. In recognition of the ubiquitous heteroscedasticity and occasional serial correlation in the errors of equations [6]-[8], we use the Newey-West (1987) estimator to derive a positive, semidefinite, heteroscedasticity, and autocorrelation consistent covariance matrix for the parameter estimates.

<table>
<thead>
<tr>
<th>Equation</th>
<th>F-Statistic</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food aid</td>
<td>0.364</td>
<td>0.991</td>
</tr>
<tr>
<td>Imports</td>
<td>0.760</td>
<td>0.740</td>
</tr>
<tr>
<td>Production</td>
<td>1.059</td>
<td>0.392</td>
</tr>
</tbody>
</table>

9The test statistics are as follows (the null hypothesis is no fixed effects):

10The p-values on the Kolmogorov-Smirnov test statistics are less than 0.01 for [6], but greater than 0.10 for [7] and [8], when testing the null hypothesis of white noise.

11The full diagnostic test results are available from the authors by request.
A. Structural Vector Autoregression

SVAR estimation proceeds in a two-step fashion. Initially, the reduced form parameters are estimated efficiently by SUR. The estimated covariance matrix from the SUR estimation is then used to recover estimates of the structural parameters of equation [1], to formulate impulse response functions, and to compute the variance decompositions.

The structural parameter estimates are reported in Table 1.\textsuperscript{12} The results are consistent with theory. Program food aid clearly violates the additionality principle, as the partial correlation between a ton of aid and contemporaneous commercial food imports is -0.8. Contemporaneous production increases likewise decrease commercial imports, as one would expect, although the parameter estimate is not statistically significantly different from zero. Interestingly, the partial correlation between food aid inflows and contemporaneous food production in recipient economies is positive, although this parameter estimate is statistically insignificant. Given the substantial apparent balance of payments effects of food aid, as manifest in its substitution for commercial imports, perhaps this signals that factor market price effects dominate output market price effects in recipient country food agriculture.

Figure 2 depicts the impulse response functions of both commercial food imports and food production to a shock to food aid. The J-curve effect of food aid on commercial food imports is clear in this graphic. An increase in food aid volumes initially reduces commercial food trade volumes, violating the additionality principle, but ultimately yields a net increase in commercial imports, thanks most likely to induced shifts in consumer tastes, income effects, and reduced transactions costs caused by the development of distribution channels. In the short-run, program

\textsuperscript{12}The reduced form model estimates are available from the authors by request.
Table 1:

SVAR Estimates of Contemporaneous Food Aid-Production-Commercial Trade Relations

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Regressors</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[F]</td>
<td>[M]</td>
<td>[P]</td>
</tr>
<tr>
<td>Food aid [F]</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Commercial imports</td>
<td>-0.847</td>
<td>1</td>
<td>-0.113</td>
</tr>
<tr>
<td>[M]</td>
<td>(-0.128)</td>
<td></td>
<td>(-0.078)</td>
</tr>
<tr>
<td>Production [P]</td>
<td>0.179</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>(0.128)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Newey-West standard errors in parentheses.

Figure 2:

Impulse response functions following a 1-ton shock to food aid (SVAR)
food aid indeed takes away U.S. export markets abroad, but in the longer run it fosters market development.

Although the partial correlation between food aid and food production is positive, once all the effects are accounted for in the impulse response function, a food-aid shock of one ton decreases contemporaneous production by almost 2 tons. These negative effects dissipate over time, with production ultimately stabilizing at a level below that prevailing prior to the shock to food aid. Thus, there appear to be Schultzian effects, albeit more severe in the short run than in later periods. Combined, the two impulse response functions in Figure 2 support an interpretation that food aid serves donor country trade development objectives far more so than recipient country agricultural development objectives.

It is important, however, to note that food aid accounts for relatively little of the forecast error variance in either commercial food imports or food production. This likely reflects primarily the considerable difference in magnitudes of these volumes. The mean aid volume in sample (12.5 kg per capita) is only 9 and 17 percent of mean production and commercial import volumes, respectively. This is likely a major reason why food aid never accounts for more than 2 percent of forecast error variance in either commercial cereals imports or cereals production (Table 2). This suggests that while the conditional expectation of food aid’s effects on commercial imports and recipient country output may follow the J-curve and Schultzian patterns depicted in Figure 1, respectively, food aid is not a driving variable behind recipient country production or trade patterns.

B. Dynamic Structural Econometric Model

As a check on the robustness of the SVAR results, we supplemented SVAR modeling with direct estimation of a DSEM. In SVAR estimation we had restricted the A matrix of
contemporaneous interactions among the dependent variables so as to be able to recover the structural parameters from the reduced form estimates, and we had specified lag lengths in the SVAR model using a block exogeneity test so as to minimize the number of estimated parameters. In recognition that this parsimony might waste information on the relationships among the variables, we also directly estimated a DSEM of the form

\[ F_{it} = \mu_0 + \alpha_t \beta_{it} + \alpha_i M_{it} + \sum_{l=1}^{5} \mu_l F_{it-l} \]  \[ M_{it} = \beta_0 + \gamma_t F_{it-l} + \sum_{l=1}^{4} \phi_l M_{it-l} + \sum_{l=0}^{3} \psi_l P_{it-l} \]  \[ P_{it} = \lambda_0 + \sum_{l=1}^{5} \lambda_{it-l} + \sum_{l=1}^{4} \pi_l M_{it-l} + \sum_{l=0}^{5} \delta_l F_{it-l} \]  

The principal concern about estimating the less restrictive system found in equations [9]-[11] is the considerable likelihood of both simultaneity and cross-equation correlation of errors in this system. Thus we instrument for the contemporaneous variables in the system, using a standard, symmetric

\[ ^{13} \text{We did not include the contemporaneous commercial imports volumes on the right-hand side of the food production equation because of multicollinearity between that variable and contemporaneous food aid deliveries.} \]
VAR of F, M and P as instruments, following the principles of Fair (1970) and Hayashi and Sims (1983), and then use those instruments in three-stage least squares estimation (3SLS).  

Table 3 displays the parameter estimates on the contemporaneous variables in equations [9]-[11], equivalent to the A matrix of the SVAR. There remains a negative partial correlation between food aid deliveries and commercial imports, suggesting violation of the additionality principle, but the most striking feature of these estimates is that none are statistically significantly different from zero. The innovation accounting is, again, of greater interest.

As in the SVAR model, food aid has a J-curve effect on commercial trade, causing a short-run decrease in commercial imports which then recover by about the fifth year, yielding a net increase in commercial imports thereafter (Figure 3). Also as in the SVAR, food aid's impact on

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Regressors</th>
<th>[F]</th>
<th>[M]</th>
<th>[P]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food aid [F]</td>
<td>1</td>
<td>0.006</td>
<td>-0.007</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.006)</td>
<td>(0.007)</td>
<td></td>
</tr>
<tr>
<td>Commercial imports [M]</td>
<td>-0.005</td>
<td>1</td>
<td>0.045</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.831)</td>
<td></td>
<td>(0.222)</td>
<td></td>
</tr>
<tr>
<td>Production [P]</td>
<td>-0.071</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3.032)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Newey-West standard errors in parentheses.

14The adjusted $r^2$ on the instrumenting equations were 0.85, 0.96, and 0.81 for food aid, commercial imports, and production, respectively. Full estimation results and diagnostics from the instrumenting equations are available from the authors by request.
production appears to be negative in the short-run, with later recovery, in the DSEM case to mildly positive long-run output effects. This pattern would be consistent with short-run Schultzian output price disincentives that are subsequently offset by the stimulative effects of services from increased intermediate capital goods imports enabled by the balance of payments effects of food aid, or of improved worker nutrition.

The forecast error variance decomposition (Table 4) again suggests that food aid shocks are not driving variables behind recipient country food production or trade patterns. Food aid shocks have a limited impact, albeit increasing over time, on commercial import forecast variance, but negligible effect on production variance. Again, given the relative magnitudes of the variables (Figure 1), it is little surprise that food-aid shocks do not account for much of the movement in the
Table 4:
DSEM Variance Decomposition Percentages of Forecast Errors at Different Leads

<table>
<thead>
<tr>
<th>Lead (years)</th>
<th>Commercial Food Imports</th>
<th>Food Production</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F  M  P</td>
<td>F  M  P</td>
</tr>
<tr>
<td>1</td>
<td>0.0 99.5 0.5</td>
<td>0.1 22.6 77.3</td>
</tr>
<tr>
<td>5</td>
<td>1.2 97.8 1.0</td>
<td>0.2 22.7 77.1</td>
</tr>
<tr>
<td>10</td>
<td>1.6 97.6 0.8</td>
<td>0.3 24.1 75.6</td>
</tr>
<tr>
<td>15</td>
<td>3.3 95.6 1.1</td>
<td>0.4 25.1 74.5</td>
</tr>
</tbody>
</table>

other two variables. So just as we found in SVAR estimation, direct estimation of the DSEM system suggests a J-curve relationship between food aid and commercial trade, and short-run Schultzian effects on recipient country production that are mitigated or offset in later periods, but these relationships are not the primary forces behind movements in recipient country food production or trade.

Given the similarity in qualitative results between the SVAR and the more general DSEM estimated by 3SLS, it is natural to wonder whether the two specifications are in fact equivalent. Since the SVAR specification is simply a more restricted version of the DSEM, we again employed the block exogeneity test to investigate this hypothesis. The test statistic is 4.72, which has a p-value of 0.86 against the $\chi^2(9)$ distribution. Statistically, the restrictions imposed to enable SVAR estimation do not seem to introduce any misspecification bias.

5. Discussion and Conclusions

In this paper we estimated the dynamic relationship between U.S. program food aid, commercial food trade, and recipient country food production using 35 years’ data from 18 recipient
countries. Despite the enormous literature devoted to food aid, this is the first effort at modeling these dynamic relationships statistically. Several important findings emerge.

The traditional justification for program food aid is twofold: first, that it facilitates income growth, improved nutrition, and economic development in recipient economies; and, second, that it creates foreign markets for donors’ commercial sales. Call the former development objectives and the latter a trade objective. While our data do not properly measure each of the development objectives, we find no evidence that U.S. program food aid (P.L. 480, Titles I and III) significantly stimulates food production in recipient economies. If anything, the data support the Schultzian critique, that food aid discourages recipient country production in the short run. We find no statistically robust answer to the logically subsequent question of whether food production per capita ultimately recovers or not in the wake of an increase in food aid per capita.

With respect to the trade objective, it is clear that program food aid generally violates the principle of additionality. The contemporaneous relationship between food aid deliveries and a recipient’s commercial food import volumes is consistently negative. However, there is a lagged positive response of commercial food shipments to food aid distribution as recipient country tastes change, donor country distribution networks in the recipient economy expand and improve, and recipient country incomes grow. Cumulatively, this generates what we describe as a J-curve relationship between these variables, evident in the innovation accounting from both the SVAR and DSEM estimation. While shocks to food aid volumes have limited impact on commercial trade volumes, they appear to decrease commercial transactions initially, then increase them over longer horizons of ten to fifteen years. This can also be seen in Table 5, which presents the expected internal rates of return (IRR) to a ton of distributed food aid, as computed from the commercial
import volume flows in the impulse response functions. No matter which estimation method one employs, SVAR or DSEM, program food aid shows nonpositive commercial returns in the first eight years. In the short run, program food aid clearly costs the donor export markets. At longer horizons, however, the story is markedly different. The IRR at a ten-year horizon is in the neighborhood of 10 percent and at a fifteen-year horizon the IRR is greater than 20 percent under either estimation method. The apparent wisdom of food aid as an investment strategy (in future commercial markets development) thus turns largely on one’s horizon. Program food aid offers strong commercial returns to the donor having a long-term perspective, negative returns to those with a short-term view.

Finally, while the expected time path of food aid’s effects on recipient country food production and commercial food imports suggests interesting relationships, as depicted by the impulse response functions in Figures 2 and 3, it is clear from the variance decompositions that food aid shocks are not the driving force behind either output or trade. They have significant effects at the margin on commercial trade, but modest aggregate effects. While program food aid might not

Table 5:

<table>
<thead>
<tr>
<th>Period</th>
<th>SVAR</th>
<th>DSEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Until year 9</td>
<td>negative</td>
<td>negative</td>
</tr>
<tr>
<td>10 years</td>
<td>11.2</td>
<td>7.5</td>
</tr>
<tr>
<td>15 years</td>
<td>22.4</td>
<td>20.1</td>
</tr>
</tbody>
</table>
have considerable favorable impacts on recipient country food production, as development specialists might hope, it also cannot be defensibly blamed for the declining per capita food output evident in many low-income countries, especially in Sub-Saharan Africa. It does appear, however, that program food aid helps make long-term markets for U.S. food producers.
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