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THE DYNAMIC EFFECTS OF U.S. FOOD AID

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Right Running Head: BARRETT, MOHAPATRA & SNYDER: FOOD AID DYNAMICS

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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 vector autoregression methods to data from 18 countries over the period 1961-95. We find evidence that food aid has a pronounced J-curve effect on recipient country per capita commercial food imports, but only negligible negative effects on recipient country per capita food production. The commercial export gains are primarily enjoyed, however, by the donors' competitors, revealing heretofore unrecognized positive pecuniary trade externalities associated with foreign assistance.

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# I. INTRODUCTION

The effects of United States food aid on recipient country agriculture have been heatedly debated for years. 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? Are there pecuniary commercial trade externalities caused by food aid, wherein the donor captures either more or less than the marginal increase in recipient country commercial food imports that food aid induces? 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. We apply vector autoregression methods to a 1961-1995 panel of data on food production, food trade and program food aid shipments from the United States—by far the world's largest bilateral food aid donor—for the 18 countries that have most benefitted from U.S. food aid over the past 40+ years. This analysis uncovers important, intuitive multiyear patterns not previously identified in the vast literature on food aid.

# II. THE ISSUES

Food aid was formalized in the United States in 1954 under Public Law 480 (PL480), the Agricultural Trade Development and Assistance Act (later renamed Food for Peace).[1] Title II (emergency) aid is distributed for humanitarian purposes through charities. Titles I and III, program food aid, provide food on concessional terms that recipient governments then sell to earn revenue (counterpart funds). Program (nonemergency) food aid represents the lion's share of food aid shipments, historically about 80% of direct, bilateral food aid. Compared to Title II, program food

aid is more fungible, more commonly used for broader development purposes by recipients and for trade promotion purposes by donors, and its effectiveness and desirability is more contested. We study program food aid in this paper, hereafter referring to it simply as "food aid" for the sake of brevity.

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 investigation. While there are other conceptual debates in the literature—and many over operational details—we restrict our attention 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. If the additionality principle is honored, Acker [1989, 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." However, as researchers such as Abbott and McCarthy [1982] and Von Braun and Huddleston [1988] note, food aid commonly seems to

2

substitute in part for commercial imports, violating the additionality principle. Producer groups' and legislators' concerns revolve around whether food aid offers a reasonable rate of return on investment, and whether it implicitly subsidizes trade promotion for competitors (e.g., the European Community) who sell similar products on world markets.

Additionality also affects recipient country development since 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. Another concern for most recipient countries is whether food aid depresses or stimulates domestic output. Schultz [1960] argued 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 induce real exchange rate appreciation and thereby lower imported input prices. Mohapatra et al. [1996] show that even in relatively simple models, food aid's incentive effects on factor and product markets are ambiguous.

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 because of substitution effects, thereby depressing donor commercial exports in the short run, food aid might nonetheless generate long-run increases in recipient country food imports through habit-formation and the development of distribution channels. 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

3

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.  This too would generate a J-curve pattern in the time path of food production response to food aid deliveries.  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.

## III.  METHODS

Given the dynamic but unknown relationship between food aid, production, and commercial imports, the logical way to proceed is with dynamic estimation imposing as few restrictions as possible, i.e., with vector autoregression (VAR).[2]  A VAR represents the reduced form of a general dynamic structural econometric model of the form:

$$AX = BX(L) + Ce \tag{1}$$

$$E(e) = 0; \ E(e_t e_s') = 0 \ \forall \ t \neq s; \ E(ee') = \Omega$$

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.  The reduced form of [1] is

$$X = RX(L) + \epsilon \tag{2}$$

where R is the reduced form parameter matrix($A^{-1}B$), and $\epsilon$ is the reduced form innovation vector ($A^-$

[1]Ce), with variance $\Sigma$.  Assuming the primitive e vector was white noise, it follows that the reduced form stochastic disturbance terms ($\epsilon_F$, $\epsilon_M$, $\epsilon_P$) have zero means  and are individually serially uncorrelated.  With unrestricted dynamics and appropriately specified lags, equation [2] represents a standard VAR process.

Rather than obtaining identification by a Choleski decomposition of the covariance matrix of reduced form errors, we use the theory and practice of program food aid to restrict the contemporaneous coefficient matrix, A, and exactly identify the system of equations in [1].  Program food aid (perhaps unlike humanitarian aid) is typically 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 in food production.  This logic dictates the restrictions we impose on matrix A:

$$A = \begin{bmatrix} 1 & 0 & 0 \\ \alpha_{21} & 1 & \alpha_{23} \\ \alpha_{31} & 0 & 1 \end{bmatrix} \qquad [3]$$

We expect $\alpha_{21}$ to be nonpositive, reflecting contemporaneous substitution of food aid for commercial food imports (i.e., violation of the additionality principle).  We likewise 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, $\alpha_{31}$, could be either positive or negative.

The restrictions imposed in [3] correspond to the innovation model

$$\epsilon_{Ft} = e_{t\,Ft} \qquad\qquad [4]$$

$$\epsilon_{Mt} = \alpha_{21}\epsilon_{Ft} + e_{Mt} + \alpha_{23}\epsilon_{Pt}$$

$$\epsilon_{Pt} = \alpha_{31}\epsilon_{Ft} + e_{Pt}$$

Using initial estimates of the reduced form coefficients and $\epsilon$, we generate full information maximum-likelihood estimates of A and $\Omega$, then trace the expected time paths of variables using the relationship $e = A\epsilon$.

We selected 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 — to establish which lagged variables Granger cause other dependent variables in [1].[3] We used five annual lags of each variable (i.e., sixteen total regressors per equation, including a constant) as the unrestricted system against which we tested more parsimonious specifications. Candidate specifications were generated through application of the Akaike Information Criterion to each regression. From among these, a block exogeneity test suggests a more parsimonious and statistically equivalent specification for the reduced form model in [3] is:[4]

$$F_{it} = \mu_0 + \sum_{l=1}^{5} \mu_l F_{it-1} + \sum_{l=1}^{4} \delta_l M_{it-1} \qquad\qquad [5]$$

$$M_{it} = \gamma_0 + \sum_{l=1}^{5} \gamma_l F_{it-1} + \sum_{l=1}^{5} \phi_l M_{it-1} + \sum_{l=1}^{3} \psi_l P_{it-1} \qquad\qquad [6]$$

6

$$P_{it} = \lambda_0 + \sum_{1=1}^{5} \lambda_1 P_{it-1} + \sum_{1=1}^{5} \pi_1 F_{it-1} \; + \; \sum_{1=1}^{2} \theta_1 M_{it-1} \qquad\qquad [7]$$

We estimated the resulting VAR by the seemingly unrelated regressions (SUR) method.[5]

## IV. THE DATA

USDA generously provided the food aid flows data of Suarez [1994], disaggregated by commodity, recipient country, year and source (PL480 Titles I, II or III). From these data we constructed time series of cereals program food aid (Titles I and III) delivery volumes to each country, 1961-1995. 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.[6] We use data from the eighteen countries that most frequently received program food aid from the United States over this period: Bangladesh, Bolivia, Dominican 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.

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 more than replacing aid in these nations, but do past food aid distributions help account for any of the growth in cereals trade volumes?

V.  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 [5]-[7] with innovation accounting.  The Wold decomposition theorem enables representation of the VAR process as a vector moving average process that offers some insights on dependent variables' dynamic responses to shocks to the system. Impulse response functions 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 heteroskedasticity.  An F test fails to reject the null hypothesis that the intercepts are identical across countries in equations [5]-[7].  On the other hand, likelihood ratio tests for groupwise heteroskedasticity consistently reject the null hypothesis of homoskedasticity.  In recognition that the autoregressive specification of equations [5]-[7] might not have removed all autocorrelation, we also tested for serial correlation using the Kolmogorov-Smirnov test.  The food aid equation still evinces autocorrelation.  We therefore use the Newey-West (1987) estimator to derive a positive, semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix for the parameter estimates.[7]

The structural parameter estimates recovered from SUR estimation of the VAR are reported

in Table I.[8]  The results are consistent with theory.  Program food aid clearly violates the full

additionality principle, as the partial correlation between a ton of aid per capita and contemporaneous

commercial food imports per capita is -0.86.  This suggests that, on average, food aid adds yields

little additional food consumption.  The implied aggregate marginal propensity to consume food out

of a food aid transfer is in the range of consensus microeconometric estimates of Engel curves.[9]

Contemporaneous production increases likewise decrease commercial imports, as one would expect.

Interestingly, the estimated partial correlation between food aid  inflows and contemporaneous food

production in recipient economies is positive, although statistically insignificant.  Given the apparent

balance of payments effects of food aid reflected in $\alpha_{21}$, perhaps this signals that contemporaneous

factor market price effects dominate contemporaneous output market price effects in recipient

country food agriculture.[10]

Figure 2 depicts the impulse response functions of commercial food imports, food production

and U.S. food aid to a one kilogram per capita shock to U.S. food aid shipments.  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 full additionality principle, but

ultimately (by the fifth year) 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 food aid indeed takes away donor export markets

abroad, but in the longer run it appears to foster market development for food exporters.

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 kilogram per

capita decreases contemporaneous production, but these negative effects dissipate over time, with

production ultimately stabilizing at a level modestly below that prevailing prior to the shock to food aid. Thus, there appear to be Schultzian effects, albeit never especially serious and dissipating over time. Finally, food aid shows considerable persistence; the half life on food aid flows is better than seven years in these data.[11] Combined, the impulse response functions in Figure 2 support an interpretation that food aid impacts primarily trade, fostering greater food import reliance by recipient countries, both through further food aid flows in the short term and commercial imports in the medium-to-long term. Given that consumption equals production plus net imports, assuming no change in stocks, the impulse response functions suggest that food aid stimulates increased food consumption in recipient economies, albeit entirely through aid and trade, not local production.

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 (Table II), reflecting the considerable difference in magnitudes of these volumes. The mean aid volume in sample (12.5 kg per capita) is only 9% and 17% of mean production and commercial import volumes, respectively. So while the conditional expectations of food aid's effects on commercial imports and recipient country output follow the J-curve and Schultzian patterns, respectively (Figure 2), food aid does not drive recipient country production or trade patterns.

## VI.  DO U.S. EXPORTERS BENEFIT FROM FOOD AID?

The estimation results above suggest that the primary effects of food aid on recipient country food agriculture are to stimulate further food aid in the near-term (roughly five years) and to stimulate commercial imports in the longer run (beyond five years, after passing through the trough of the J curve effect).  However, that analysis uses aggregate commercial trade volumes; it does not necessarily follow that U.S. food aid promotes U.S. exports.  The impulse response functions in Figure 2 may mask pecuniary externalities associated with food aid and trade.  For example, perhaps food aid somehow ties a recipient to the donor, thereby inducing substitution of commercial imports from the donor for commercial imports from the rest of the world (i.e., negative externalities).  Alternatively, it could be that food aid—a form of income transfer—stimulates demand for other products, including other cereals, thereby stimulating demand for commercial food imports from the rest of the world (a positive externality).  There is no *a priori* theoretical reason why there must be an externality, or one of any particular sign; again, this is an empirical question.

We employ the same method to study this question, now dividing the commercial cereals imports data into two series: commercial imports from the United States ($M_{US}$) and from the rest of the world ($M_{ROW}$).  The economic logic behind the earlier restrictions imposed on the A matrix carry over, but there is no particular reason to expect $M_{ROW}$ to influence $M_{US}$ unidirectionally, nor vice versa.  As it turns out, we estimated the VAR under both specifications and found qualitatively identical and statistically insignificantly different results.  So here we report the results derived using a specification for A that allows contemporaneous, unidirectional effects from $M_{US}$ to $M_{ROW}$.  We use the same lag structure as before; the prior specification was chosen so as to yield parsimony and white noise residuals and to pass the block exogeneity test for this system of equations as well.

The structural estimation results for the estimated A matrix are found in Table III. These again show negative partial correlations between food aid and contemporaneous trade, signaling a violation of the principle of additionality, although the estimate is statistically significantly different from zero only for $M_{ROW}$. As before, however, our principal interest concerns the dynamic effects of food aid, and thus in the impulse response functions derived from the estimated model. Figure 3 shows precisely the sort of food aid persistence and quite modestly negative effects on food production we found before. By splitting the commercial imports series into $M_{US}$ and $M_{ROW}$, however, we find evidence of strong positive externality effect of U.S. food aid on ROW commercial food exports to recipient countries. An increase in food aid continues to have a J-curve effect on U.S. commercial food shipments to the recipient country, but we estimate that it takes better than twenty years to recover from the initial violation of additionality. U.S. program food aid appears to substitute for U.S. commercial sales for quite some time.

Meanwhile, foreign food exporters face only short-term losses from U.S. food aid shipments. From the fifth year on, the impulse response of commercial imports from ROW is consistently positive. In the medium-term (3-10 years), U.S. food aid shipments beget mainly further food aid from the U.S., at significant commercial cost. Over the decade following a positive food aid shock, annual U.S. commercial food export volumes to the recipient country fall by an expected 55% of the amount of the initial food aid shock (i.e., food aid replaces exports at almost a 2:1 rate), while annual food aid flows continue at 69% of the level of the initial shock. American largesse appears to stimulate recipient country demand for commercial food shipments from the donor's trade competitors. Over the decade following a positive shock to U.S. food aid, ROW commercial food exports to the recipient country increase by 18% of the shock volume, on average. As a

12

consequence, U.S. investments in program food aid yield a negative internal rate of return, measured in terms of real effects on U.S. commercial exports (Table IV).[12]  For the world as a whole, however—i.e., looking at U.S. food aid's effects on aggregate commercial food export volumes to the recipient, not just on U.S. commercial exports— the internal rate of return is reasonably attractive at horizons of 20 years or longer: 7-10% per annum, on average.  This suggests the presence of significant bilateral food aid externality effects, wherein trade promotion gains to temporary investments in food aid are enjoyed broadly, while the trade-displacing costs of aid flows are borne primarily by the donor.  This may help explain why OECD nations deliver only a fraction of their common and longstanding bilateral aid targets.  It also suggests an important role for multilateral efforts to internalize these externalities, i.e., replacing bilateral program food aid with multilateral distribution through the World Food Programme, as has gradually occurred for donors other than the United States.

This is a novel and potentially important result.  Our interpretation of the trade externality effect of food aid is that there are two forces at work.  First, donor and competitor cereals are not perfect substitutes (i.e., they have finite Armington elasticities), so the implicit income transfer in food aid induces expanded demand for competitors' cereals exports.  Second, PL480 food aid shipments exhibit considerable persistence.  Aid flows fall only 3% over the subsequent three years and have a half-life of seven years, consistent with Barrett's [1998] finding that the probability of a PL480 recipient receiving further food aid shipments, conditional on the number of years' delivery to date, is greater than 0.9 at all horizons out to 25 years.  Since food aid partly substitutes for contemporaneous commercial food imports from the donor, the persistence of food aid translates into persistent substitution of aid for trade in the donor-recipient relationship.

## VII. CONCLUSION

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. This is the first attempt at modeling these relationships statistically yields several suggestive findings having implications for international food aid and trade policy.

We find no evidence that U.S. program food aid (PL480 Titles I and III) significantly stimulates food production in recipient economies. Given that agricultural output expansion is central to the agrarian transformation of most low- and middle-income countries, this seems an indicator that perhaps program food aid offers little if any stimulus to recipient country development. If anything, the data support the Schultzian critique that food aid discourages recipient country production in the short run.

Like most previous researchers, we find a negative and statistically significant contemporaneous relationship between per capita food aid deliveries and recipients' per capita commercial food import volumes. However, there is a lagged positive response of per capita commercial food shipments to food aid deliveries, yielding a J-curve relationship between these variables, as evident in the estimated impulse response functions. Shocks to per capita food aid volumes appear to decrease per capita commercial transactions initially, then increase them over longer horizons of five to 20 years.

Although this aggregate J-curve delivers an attractive internal rate of return to world commercial exports at the twenty year horizon, the return to the United States exclusively is negative throughout the period of our analysis due to significant (and heretofore unrecognized) positive externality effects of U.S. program food aid on commercial food shipments from other countries.

14

U.S. food aid shipments persist at high levels for many years after a positive shock to food aid flows and have the effect of significantly reducing commercial exports over the ensuing decade. It is nonetheless also clear from the variance decompositions that program food aid shocks are not the driving force behind either output or trade patterns, because food aid volumes are tiny relative to recipient country production or trade volumes. In summary, we find that U.S. program food aid does not contribute significantly to either recipient country development or donor commercial exports.

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FOOTNOTES

1.   See Maxwell and Singer [1979], Ruttan [1993], or Barrett [forthcoming] for surveys.

2.   Sims [1980], Blanchard [1989], Lütkepohl [1993], Hamilton [1994], and Enders [1995] provide excellent summaries of VAR methods and motivations.

3.   See Hamilton [1994] or Enders [1995] for technical details on the block exogeneity test.

4.   The block exogeneity test statistic is 14.78, which has a p-value of 0.54 on the $\chi^2$ distribution, with a null hypothesis that the two models are statistically equivalent.

5.   Both augmented Dickey-Fuller and Phillips-Perron tests rejected the null hypothesis of a unit root in the dependent variables.  So equations [5]-[7] are estimated in levels.

6.   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 (.80).  The numbers in parentheses are the grain equivalent conversion factors under the food aid convention.

7.   The full suite of diagnostic test results are available from the authors by request.

8.   The reduced form model estimates are available from the authors by request, as are complementary, direct three stage least squares estimates of [1].  The latter, reported in Barrett, Mohapatra, and Snyder [1998] yield qualitatively identical results.

9.   Strauss and Thomas [1995] and Barrett [forthcoming] discuss this literature in more detail.

10.  Mohapatra et al. [1996] demonstrate that substitution of food aid for commercial food imports may reduce the price of imported intermediate inputs due to endogenous real exchange rate appreciation.

11.  See also Barrett [1998] on food aid dependency dynamics.

12.  We treat this as if the initial violation of additionality were an investment expected to yield a stream of future payoffs for which the internal rate of return is a function of the sequence of annual impulse responses in commercial trade per capita.

Table I

Estimated Contemporaneous Food Aid-Production-Commercial Trade Relations

| | Regressors | | |
| Dependent Variables | [F] | [M] | [P] |
| --- | --- | --- | --- |
| Food Aid [F] | 1 | 0 | 0 |
| Commercial Imports [M] | -0.860<br>(0.111) | 1 | -0.100<br>(0.059) |
| Production [P] | 0.194<br>(0.130) | 0 | 1 |

Standard errors in parentheses.

Table II

Variance Decomposition Percentages of Forecast Errors at Different Leads

| Lead (years) | Commercial Food Imports | | | Food Production | | |
| --- | --- | --- | --- | --- | --- | --- |
| | F | M | P | F | M | P |
| 5 | 0.4 | 49.9 | 49.7 | 0.4 | 0.1 | 99.5 |
| 10 | 0.7 | 51.2 | 48.1 | 0.4 | 0.2 | 99.4 |
| 15 | 1.6 | 52.4 | 46.0 | 0.4 | 0.5 | 99.2 |

Table III

Contemporaneous Food Aid-Production—U.S. and ROW Commercial Trade Relations

| Dependent Variables | Regressors | | | |
| --- | --- | --- | --- | --- |
| | [F] | [$M_{ROW}$] | [P] | [$M_{US}$] |
| F | 1 | 0 | 0 | 0 |
| $M_{ROW}$ | -0.295 (0.108) | 1 | 0.137 (0.149) | 1.412 (0.151) |
| P | 0.138 (0.149) | 0 | 1 | 0 |
| $M_{US}$ | -0.296 (0.375) | 0 | 0.286 (0.112) | 1 |

Standard errors in parentheses.

Table IV

Expected Internal Rates of Return on U.S. Program Food Aid
(Change in commercial export volume as percent return on initial investment in food aid)

| Period | Aggregate Returns* | Returns to the U.S. |
|---|---|---|
| Up to 10 years | Negative | Negative |
| 15 years | 0.2% | Negative |
| 20 years | 7.1% | Negative |
| 25 years | 9.6% | Negative |
| 30 years | 10.6% | Negative |

*Sum of impulse responses of commercial imports from ROW and United States.

Figure 1

Mean Annual Cereals Production, Imports and Food Aid Volumes

## Annual Mean Cereals Volumes
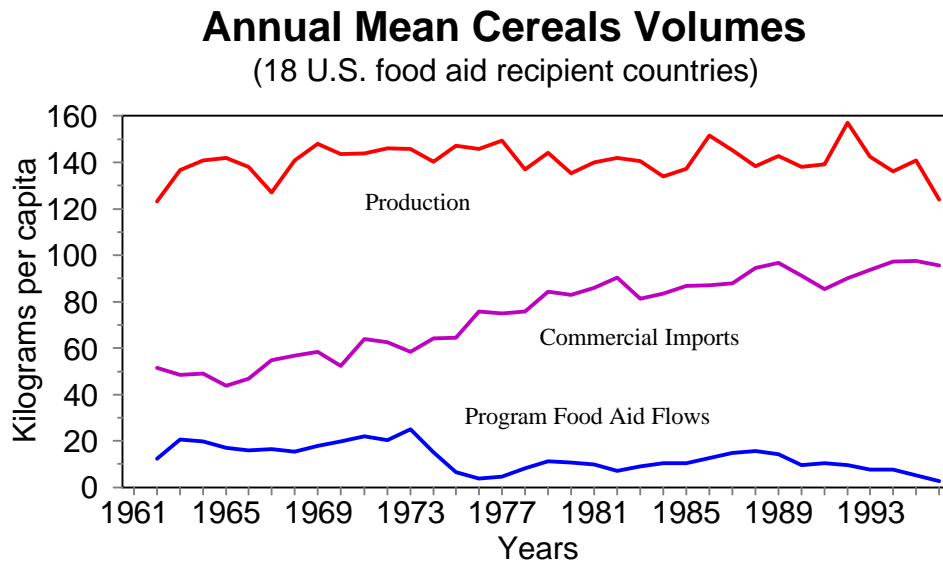(18 U.S. food aid recipient countries)

Figure 2

Impulse Response Functions Following a One Kilogram Per Capita Shock to Food Aid
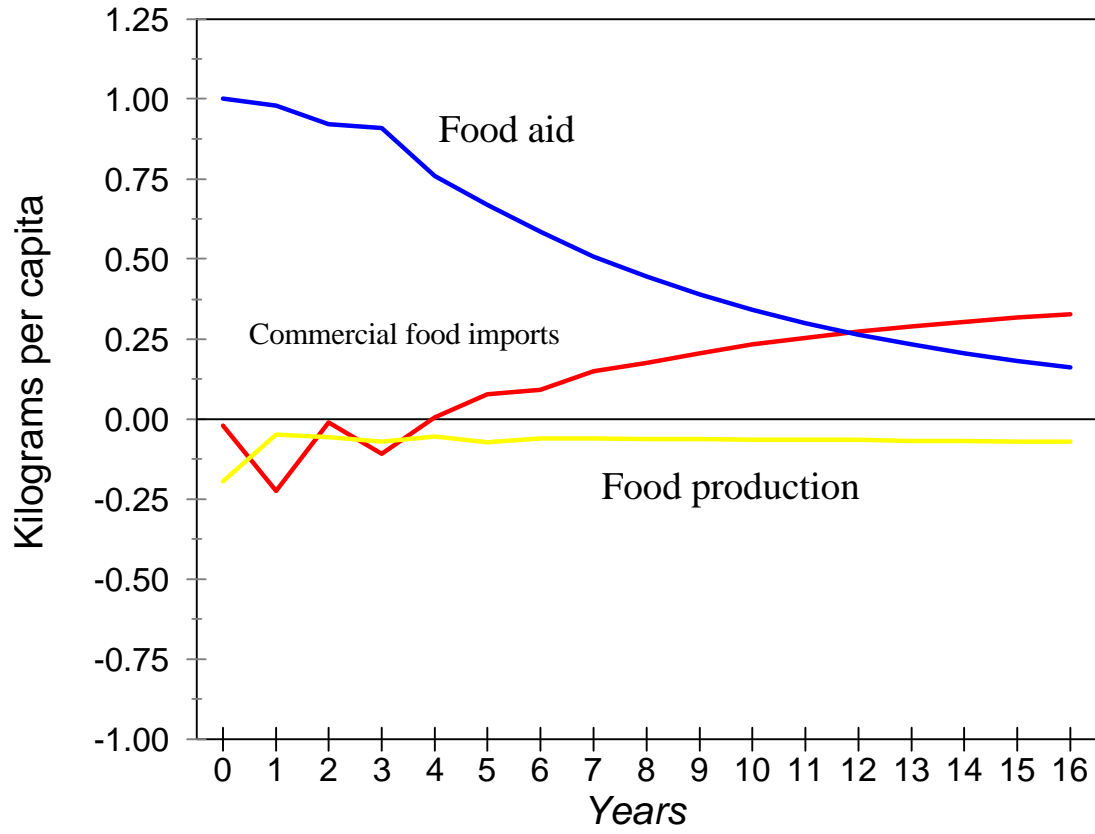
Figure 3

Pecuniary Trade Externalities Following a One Kilogram Per Capita Shock to Food Aid