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Food Aid and Induced Technical Change

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Food Aid and Induced Technical Change

Food aid is an income transfer in kind. As an important U.S. policy instrument its original dates to the 1950's.[1/] During that period the United States had excess production capacity at prevailing price ratios and consequently had accumulated large stocks in Government hands. These stocks were costly and burdensome, and had essentially zero value to the domestic economy. The Federal Government hit upon the idea of disposing of them abroad as food aid. This option seemed especially attractive in light of the prevailing Cold War struggle and the double payoff these resources were perceived to offer in the form of food itself and the counterpart funds which would be generated by the sale of this food. These counterpart funds were used both for development purposes and for market development.

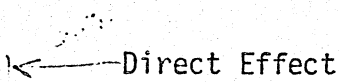
Food aid as it was originally conceived and carried out was little more than a euphemism for dumping, despite the political rhetoric that surrounded it and the admirable development objectives that were assigned to it. By the early 1960's a rather heated debate had developed in the U.S. concerning the effect of this food aid on the agricultural sector of the recipient country. The debate has focused on the effects of food aid from a number of different perspectives, including: (1) the disincentive effects on local food production; (2) the impact on resource allocation; (3) income distribution consequences; (4) the effect on development; (5) stabilization; (6) market development; and (7) dependency. This paper focuses on the first two issues.

After a brief discussion of the disincentive effects of food aid and the supporting literature, we propose a new look at the subject by introducing the possibility of technological change in the recipient countries. By making use of the De Janvry version of the Ahmad induced technical change model, we attempt to show that an unrequited transfer of food which supplements a

nation's food supply may induce increased food production in the recipient country while at the same time facilitating the transfer of resources out of the agricultural sector. Supplementing domestic food production to some extent with food aid may ~~these~~ us not only meet the short term food needs of a country but also induce increased food production to meet long term needs while at the same time fostering economic development by releasing factors with low marginal productivities in the agricultural sector to the non-farm sector where their marginal production ~~are~~ wites higher.

Disincentive Effects of Food Aid

The disincentive effects on production are generally believed to be of two kinds: (1) a direct effect through the impact of the aid on prices farmers receive and (2) an indirect effect on sectoral policies. The essence of the latter argument is that food aid allows governments to neglect public investment in the agricultural sector and to persist in discriminatory price and trade policies in the pursuit of cheap food policies both of which adversely affect the long-run output of agricultural products.



Whether there is a negative effect on price and agricultural production is generally believed to depend on at least five factors: (1) the domestic price elasticities of demand and supply of food; (2) the relative importance of food aid compared to the domestic supply; (3) whether food aid displaces commercial exports or represents additional supply to the local economy; (4) how the food aid is introduced into the local economy; and (5) the institutional arrangements that prevail. In the next section we will add a sixth important factor to that list--the level of installed research capacity and the facility with w new technology can be diffused.

Franklin Fisher constructed a theoretical model for measuring the impact of food aid on domestic food production. Much of the empirical work which has followed has been based on that model. He concluded that the impact depends on (1) the price elasticity of demand for food, (2) the price elasticity of domestic food production, and (3) the ratio of total domestic demand to domestic supply. Fisher began with the following relationship:

(1) $S + I = D$

where S = domestic supply of food;

I = imports of food aid; and

D = domestic demand for food.

Then totally differentiating (1) with respect to I, he derived the following formulas for the impact of food aid on the domestic price and supply of food:

(2) $E = \frac{dP}{dI}\frac{S}{P} = \frac{1}{\eta + \lambda\varepsilon}$ (3) $K = \frac{dS}{dI} = \frac{\eta}{\eta + \lambda\varepsilon}$

where E = the absolute value of the percentage change in price induced by the importation of food aid amounting to one percent of domestic supply;

K = the absolute value of the percentage change in domestic supply induced by an increase in supply equal to 1% of preexisting supplies;

P = the local price of food;

η = the price elasticity of supply;

ε = the price elasticity of demand; and

λ = the ratio of total demand to domestic production. $= \frac{S+I}{S}$ ↑

According to Fisher, there is no decrease food production as a result of food aid only in the unlikely cases that either demand is perfectly price-elastic or supply is perfectly price-inelastic. On the other hand, the lower (higher) the price elasticity of demand (supply), the larger the decrease in domestic production as a result of food aid imports with the maximum decrease possible equal to the quantity of food aid.

The other factor in Fisher's formulas that affects the magnitude of the price and production impact of food aid is the ratio of total demand to domestic supply $\left(\lambda = \frac{D}{S}\right)$. Given equation (1), then $\lambda = 1 + \frac{I}{S}$. Referring to equations (2) and (3), therefore, the smaller the ratio of food aid to domestic supply at the time of importation of the food aid, the greater the impact of food aid on price and domestic supply. In other words, food aid has its greatest negative effect on price and production in the recipient country when domestic production in the recipient contry is large and when food aid has not historically been an important part of domestic supply. Large food imports by such a country would therefore tend to have a large negative effect on both price and production. There have been cases where food aid during a given period has been sufficiently important compared to domestic food supply to lower prices and production, especially for individual commodities. Lancaster, for example, documents the cases of Egypt, Jordan and Bangladesh where P.L. 480 made up 19, 21 and 24 percent, respectively, of total domestic wheat consumption in 1976. When food aid is this important during any period, it can have a sizeable negative effect on price and production. Dudley and Sandilands also document the case of Colombia, in which P.L. 480 wheat virtually eliminated the domestic wheat industry.

To the extent that food aid merely displaces commercial imports, of course, prices and production would be no lower in the recipient country than they would be in the absence of the food aid. In principle, however, food aid is supposed to be above and beyond regular commercial imports. It is for this reason that a "usual marketing requirement" condition is imposed on U.S. food aid. However, most authorities will admit that fulfillment of

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Fisher implicitly assumed that food imports into the recipient country consisted solely of food aid, i.e., no commercial imports. J. S. Mann (1967 and 1968) modified Fisher's theoretical framework to include commercial imports of food and withdrawal from stocks. He used the model in the first quantitive study of the disincentive effects of food aid. Mann's results provide evidence that P.L. 480 imports lead to a decline in prices and food production in the recipient country. He found, however, that the decline in domestic production is always less than the volume of food aid so that there is a net contribution to consumption in a shortage economy.

Another important determinant of the disincentive effect of food aid is the manner in which the food aid is introduced into the economy. If it

is sold or otherwise distributed into commercial markets, as implicitly assumed by both Fisher and Mann, the likelihood of a disincentive effect is rather strong. However, if it is distributed by other means, especially in such a way as to go to those who would not otherwise be purchasing food, the disincentive effect can be minimized or eliminated entirely.

Srivastava attacked Mann's results for India for overlooking "the capacity of fair price shop distribution, through which P.L. 480 supplies are channeled to function as a built-in safeguard against the possibility of disincentive effects (p. 146).

Rogers, Srivastava and Heady developed a theoretical model to test the disincentive hypothesis under a differentiated market assumption. They used Mann's analytical framework but modified it to include an additional equation to provide for cereal purchases on both the open domestic market and the concessional domestic market at lower prices. When distributed through concessional markets, food aid becomes an income transfer to the poor and can produce an income effect that may either partially or completely compensate for the disincentive effect. Rogers, et. al., concluded that the cumulative impact of distribution through a differentiated market on domestic supply is about one-tenth the impact with a non-differentiated market.

Finally, institutional arrangements have a bearing on the disincentive effect. Perhaps the most relevant case is when governments operate particular kinds of procurement policies. For example, a government procures

a certain amount of grain at prices lower than those prevailing in the open market. Once procurement needs have been met the producer can sell his remaining surplus at the higher price. The availability of food aid in this example reduces the amount of grain the government must procure, which in turn increases the amount the producer can sell at the higher world price. Under these circumstances the food aid may actually result in higher average prices to the producer than otherwise would be the case.

Indirect Effects

The indirect or policy effects are now well recognized. Johnson contends that food aid allows governments to neglect public investment in the agricultural sector and therefore to avoid facing up to agricultural development problems.

These are other versions of this argument. Lancaster postulated an especially devious line of logic whereby dependence of the country on counterpart funds for budget support causes them to fail to develop their agricultural sector by design in order to continue receiving this "cheap" form of budget support.

A completely different perspective might be taken on indirect effects, although we have not encountered it in the literature. Many governments inherently discriminate against their agricultural sector through price and trade policy in order to keep food prices low to urban consumers.

In principle, at least, the availability of food aid could reduce or remove the need for such policies. To be effective in this sense the food aid would have to be channeled to the targeted groups and not just sold into the market. In any case, the release of price policy from servicing income goals to better serve resource allocation objectives could result in a substantial improvement in economic policy and reduce the discrimination against agriculture.

Food Aid and the Induced Technical Change Model

An important factor in the price and production effect of food aid, not heretofore considered in the literature is the level of the installed research capacity and the facility with which new technology can be diffused in the recipient country. In this section we present an analytical argument based on De Janvry's version of Ahmad's model of induced technical change in which, given the necessary research and diffusion capability, food aid takes on the role of an inducer of technical change and increased output in the agricultural sector.

We assume that in the recipient country the demand for food is less than perfectly elastic and that supply has some price elasticity. Further, we assume that (1) food aid represents additional supply to the economy; (2) the food is introduced into the economy in such a way as to lower the domestic price of food; and (3) the procurement and other policies of the recipient country's government are such that they do not prevent prices from falling as a result of food aid imports.

The key element of the De Janvry model is the concept of an ex ante Innovation Possibilities Curve (IPC) which can shift over time in response to investments in research, i.e., changes in the stock of scientific knowledge. A given IPC is an envelope of all presently known or potentially discoverable technical blueprints for a given level of scientific knowledge. Technological change can thus result either from improvements in scientific knowledge or from discovery of new production techniques within the same IPC. A separable, two-stage production function is assumed:

(4) $Y = F\ (f_t\ (T, K_t), f_l\ (L, K_l))$

where Y = aggregate output;

T = land ;

L = labor;

K_t= land-augmenting (landesque) capital; and

K_l= labor-augmenting (laboresque) capital.

Within each of the subfunctions (f_t and f_l), the inputs are assumed to be highly substituable while substituatability of inputs between subfunctions is assumed to be relatively low.

Because landesque capital is assumed to be output-increasing while laboresque capital is assumed to be labor-substituting and only mildly output-increasing, the analysis of the effect of food aid on production can be confined to the f_t subfunction. Later, the f_l subfunction will be used to analyze the effect on labor resources.

Consider the ft subfunction as depicted in figure one. The initial unit cost line is AB. It is defined as the locus of points where profit per unit of output is zero and is given by:

(5) $\frac{P_t}{P_o} \bar{T} + \frac{P_{kt}}{P_o} K_t = 1$

where P_t = nominal price of land;

P_{kt}= nominal price of landesque capital; and

P_o = nominal product price.

Initial equilibrium is at 1 where AB is tangent to the unit isoquant I_1 on IPC_t, the unit IPC in period t. Isoquant I_1 represents a given specific technical "blueprint" at a given stage of scientific knowledge. The slope of ray I indicates the proportion in which resources are combined so that equilibrium at 1 represents a land-intensive, traditional production technique. Schumpeterian profits at 1 are zero.

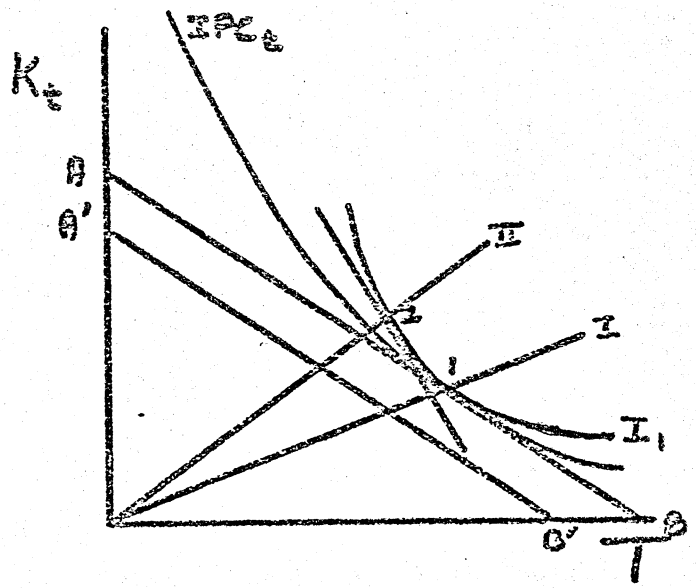

Figure 1. Effects of Food Aid in Recipient Country When No Possibilities for Innovation Exist

In this framework, food aid constitutes a decline in the product price under the assumptions above and is shown as a parallel shift of the unit cost line to A'B'. Profits thus become negative at 1. If the Johnson assumption of government neglect of public research investment holds so that no new IPC exists or insufficient "installed research capability" is available to allow farmers to adopt new available technologies, the negative profits will drive factors out of the agricultural sector.

Factor outmovement lowers food production and raises its price shifting the unit price line back out in a parallel fashion. At the same time the outmovement of factors raises their prices and affects the slope of the unit cost line assuming that their demands are less than perfectly elastic. If for example land shifted out at a faster rate than landesque capital, raising its relative price, the unit cost line would pivot clockwise as a result. Without innovation possibilities, individual farmers would adjust to the new factor price ratios through factor substitution from point 1 to a point like 2 on I_1. The factor ratio also changes from I to II as a result. If, on the other hand, landesque capital shifted out at a faster rate raising its relative price, equilibrum would be established in a similar fashion at a point to the right of 1 on I_1. Thus, where no possibilities for innovation exist and under the assumptions given, food aid lowers domestic food production and displaces agricultural factors of production in the recipient country.

However, suppose now that IPC_{gen} becomes available because of investments in science (figure 2). This new IPC represents latent demand for new production technologies. Again, let food aid result in a decline in the domestic price of food and a shift in the unit cost line from AB to A'B'. Once more profits at the old equilibrium point 1 become negative. If an adequate applied research capacity and research delivery system are available, the negative profits

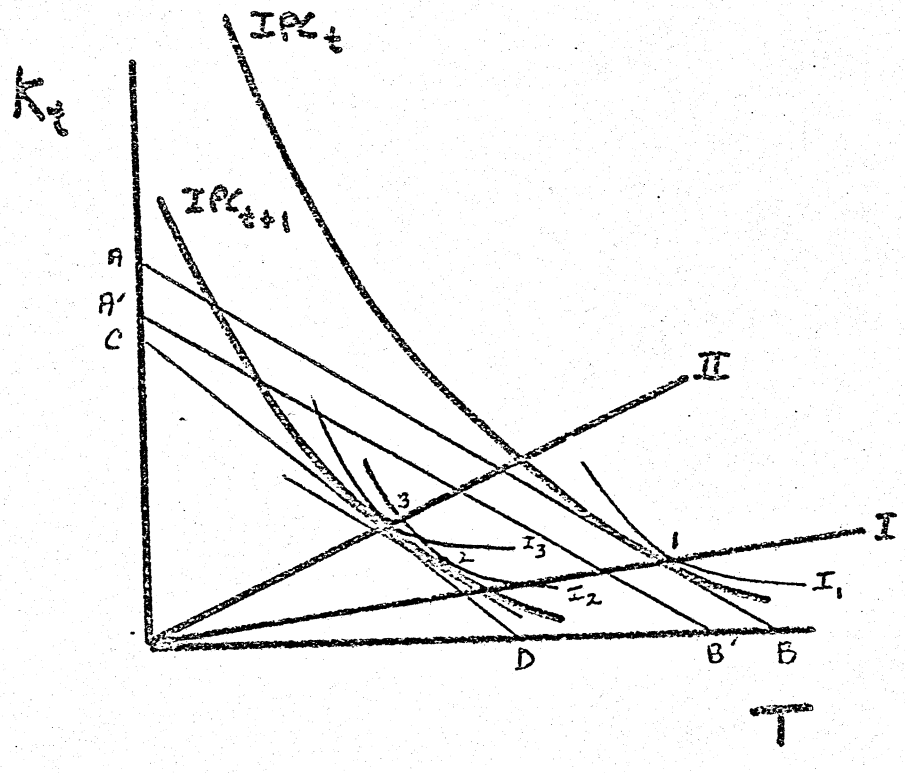

Figure 2. Induced Technological Change Effects of Food Aid in Recipient Country

Act as an inducer of technical change in the agricultural sector. According to De Janvry (p. 24):

> It is possible, furthermore, that threats of deterioration or actual deterioration from some previous state are more powerful attention-focusing devices that are vague possibilities for improvement. There may be psychological reasons why a worsening state of affairs, or its prospects, galvanizes those affected into a more positive and decisive response than do potential movements to improved states ... Such...behavior may possibly be treated more appropriately within a "satisficing" model of entrepreneurial behavior and response, where alternative technologies are explored only when a firm's profit position falls below some minimum acceptable level. In any case, it is clear that threats to [illegible] have served as powerful inducements to technical change.

De Janvry defines stress as negative or falling profits. Farmers thus in a stress situation search for technical output-increasing alternatives and press public and private research institutions to provide them. Therefore, given the new IPC_{t+1} and unit cost line A'B' in figure 2, there exists a latent demand for the innovation of isoquant I_2, at which individual profits will be maximized. Since at point 2 Schumpeterian profits are positive, further price and innovation adjustments are necessary to bring the sector to a new equilibrum.

If factor supplies are elastic, product prices will drop as alert profit seeking farmers adopt the new technologies made available by research institutions and increase aggregate output until a sectoral equilibrum is obtained at 2. If, as is more likely, the supply of land is inelastic and the supply of K_t elastic, the price of land will rise relative to the price of K_t until they internalize all nonzero profits, shifting the cost line to CD and establishing a new sectoral equilibrum at 3 with technology I_3. In the adjustment process factor ratios change from I to II because of technological innovations.

Schuh (p. 4) points out several results of the induced innovation process: (1) there is strong incentive for "conventional" resources to move out of the

agricultural sector causing major adjustment problems; (2) the benefits of the technical change go to the consumer (in the form of lower product prices with greater supply) and to the early adopters (in the form of quasi-profits); (3) non-adopters bear the burden of the adjustment costs ending up with lower incomes and returns on their owned resources or selling out alternative employment.

The process is depicted in figure 3 in terms of the more familiar but analytically limited Marshallian cross diagram. While food aid in the amount AB initially shifts the supply curve from S to S' and lowers domestic production from OC to OA, the food aid also acts as an inducer of technical change resulting in an additional outward shift of the supply curve to S" increasing domestic production to AO + BB' at equilibrium price P_2.

If the food aid reaches consumers in the recipient country through a concessional market such as the fair price shops in India, a Rogers-Srivastave-Heady real income effect may result shifting the demand curve from D to D' in figure 3. To some extent the real income effect counteracts the tendency forward lower prices as a result of food aid. If in this way a recipient country with the adequate installed research capability avoids food-aid-induced price declines thereby eliminating the economic signals that would lead to technical change in agriculture, the country also forgoes a possibility for more efficient allocation of resources, larger domestic food production than otherwise and a step towards agricultural and overall economic development.

The effect of food aid specifically on the sectoral allocation of labor within the recipient country can be analyzed by considering the labor subfunction, f_{K_1}, of the separable production function (4). In figure 4 the falling product price

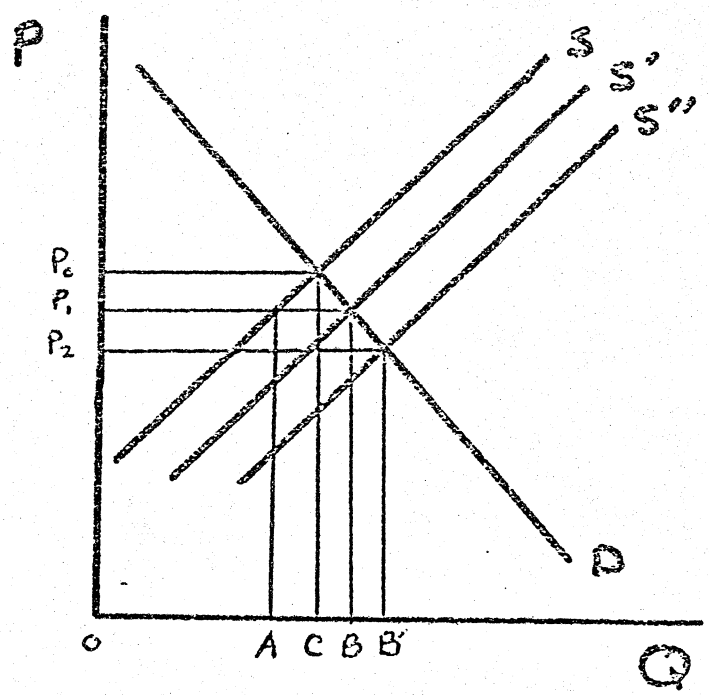

Figure 3. Agricultural Price and Quantity Effects of Food-Aid-Induced Technological Change

as a result of food aid as before forces an inward shift of the unit cost line 2/ to A'B' from AB. Again Schumpeterian profits are negative at the original equilibrium point 1.

The negative profits, as before, drive factors including labor out of the agricultural sector. If no innovation possibilities exist and the demand for labor is inelastic while the demand for laboresque capital in elastic, the relative price of labor will rise shifting the unit cost line to a position like CB' establishing a new sectoral equilibrum at point 2. While agricultural production techniques have not changed, within the constraint of the known techniques factor substitution has taken place changing the factor ratio at equilibrium from I to II. On the other hand if the demand for labor is elastic and for laboreque capital (K_1) is inelastic, equilibrium would result at a point like 3 on I_1 to the right of 1 with the factor ratio becoming more labor-intensive.

Because laboresque capital is assumed to be labor-substituting and only mildly output-increasing, an addition to the stock of scientific knowledge will shift the IPC curve only slightly, perhaps imperceptibly. The major potential for technological change in this case is the discovery of new techniques which allow a greater substitution of capital for labor along a given or slightly changed IPC curve. Assuming that a change in the stock of scientific knowledge has no perceptible effect on IPC_t in figure 4, if public and private research institutions provide new, cost-reducing techniques such as I_2 in response to farmer demands, the necessary price and innovation adjustments will bring the sector into equilibrium at point 4. In the adjustment process technological innovation changes the factor ratio from I to IV. This contrasts with the factor ratio changes from I to II as a result purely of factor substitution. Food-aid-induced technological change

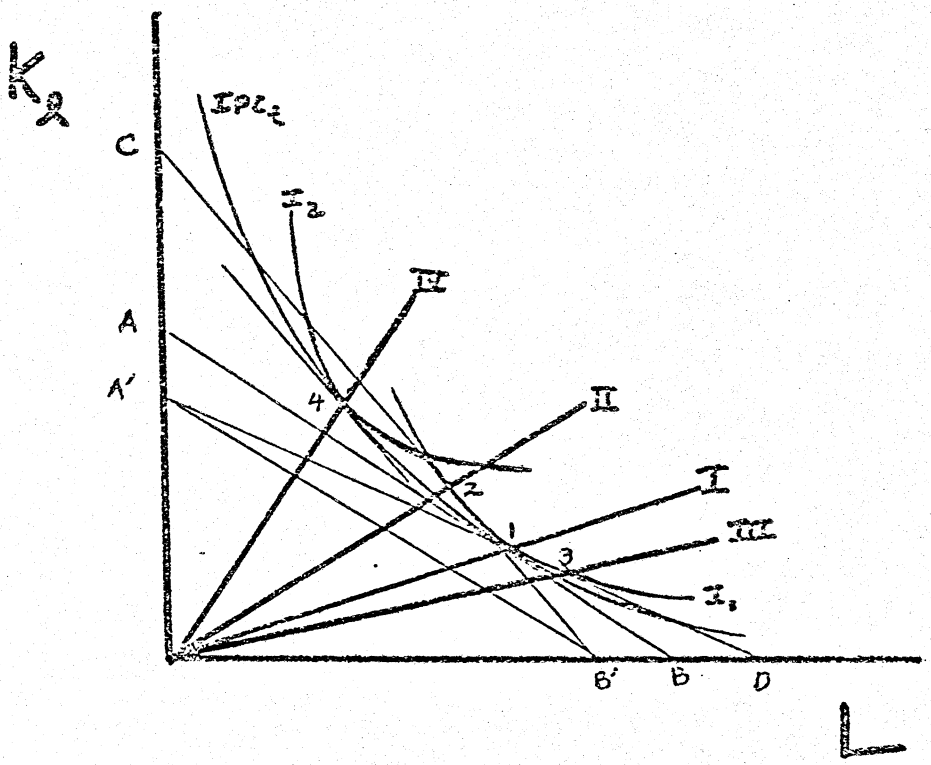

Figure 4. Effects of Food-Aid-Induced Technological Change on the Sectoral Allocation of Labor in the Recipient Country

thus facilitates a substitution of new factors of production for labor and thus an outmigration of labor from agriculture.

The introduction of changes in real wages into the foregoing analysis produces some interesting changes in the above conclusions depending upon the sector to which the food aid is distributed. At one extreme if the food aid is distributed solely to rural consumers, the effect of food aid on the outflow of labor from agriculture is indeterminate. At the other extreme, if the food aid distribution is confined to urban centers, the result is a transfer of labor from rural to urban areas.

Distribution of food aid solely to rural consumers, given the assumptions stated at the beginning of this section, as before results in a lower price of food followed by a decrease in the demand for agricultural factors of production including labor (illustrated as a shift of the demand for agricultural labor from D to D' in figure 5). However, the decline in the price of food also represents an increase in the real wage received by agricultural workers (assuming food a wage good). This means that each agricultural labor unit is now willing to supply more labor than previously at each nominal wage rate (a shift of the labor supply curve from S to S' in figure 5) in the agricultural labor market. Thus, equilibrium is established at OB with no net change in employment or at a higher or lower level depending on (a) the relative shifts of the demand and supply curves, (b) the price elasticities of both demand and supply and (c) the efficiency of both the rural and urban labor markets in adjusting to changing conditions. Thus the effect of food aid on labor employment in the agricultural sector is ambiguous when food aid is distributed only to rural consumers.

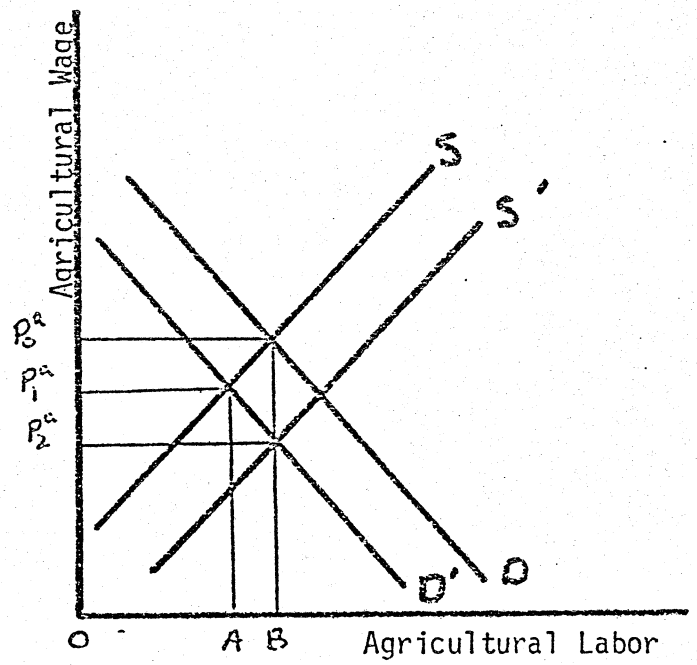

Figure 5. Effect of Rural Distribution of Food Aid on Agricultural Labor Market

Restricting food aid distribution to urban consumers results in a decrease in the demand for domestically produced food, a decline in the product price and a subsequent fall in the demand for labor in the agricultural market (as discussed above and illustrated in figure 5). This time, however, there is no real wage effect on the supply of labor in the agricultural sector. The result is an outflow of labor from agriculture of AB in figure 5 and an equal increase in the supply of labor in urban areas (S to S' in figure 6) at the prevailing urban wage (P_c^u).

The real wage effect instead occurs in the urban sector shifting the urban labor supply curve from S' to S" in figure 6 establishing equilibrium at wage P_1^u and employment level OB.[3] Thus, confining food aid to urban consumers results in an outflow of labor from agriculture and an increase in the level of employment in urban areas.

Note that in figure 6 the employment of the labor transferred from agriculture is totally effected. Whether or not this occurs, however, depends on a) the elasticity of the demand for urban labor, (b) the size of the real wage effect, and (c) the efficiency of both the agricultural and urban labor markets in transferring and employing the agricultural labor.

Summary and Conclusions

By depressing the product price, food aid induces increased domestic food production and an adjustment of conventional resources out of the agricultural sector. With respect to the labor market, food aid displaces labor from agriculture to the urban sector. If real wages are considered, the impact of food aid on the labor market depends on how the food aid is distributed. At one extreme, if the food aid is distributed solely to the agricultural sector, the

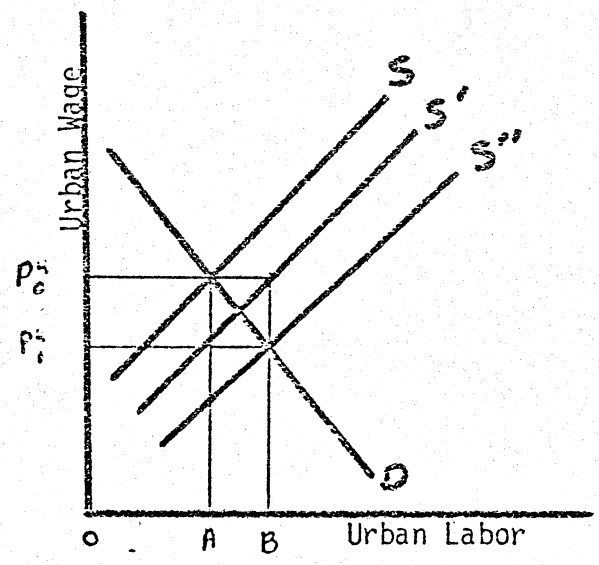

Figure 6. Effect of Urban Distribution of Food Aid on Urban Labor Market

impact of food aid on agricultural labor employment is indeterminate. If, on the other hand, the food is distributed to the urban consumer, food aid facilitates a movement of labor out of agriculture while creating urban employment opportunities.

A crucial assumption made in the analysis of a food-aid-induced increase in output was the existence of a new IPC curve and the "installed research capacity" to allow farmers to innovate and increase output. In many of the underdeveloped countries which receive food aid, neither the scientific knowledge nor the installed research capability exists. In fact, many of these countries have discriminated rather severely against their agricultural sectors. They have not invested in agricultural research to develop new production technologies or extension systems to diffuse new technologies. They have underinvested in the education of their rural people. In these countries food aid most likely constitutes a disincentive to agricultural production.

An important policy implication for these countries is that to the extent that investment funds of these countries are channeled away from the industrial sector towards agriculture with an emphasis on research and extension, improvements in education and training of rural workers and the development of the physical infrastructure for agriculture, food aid can lead to increased food self-sufficiency and an increase in the rate of agricultural and general economic development. Otherwise food aid will simply perpetuate a dependency on foreign sources of food.

For the U.S. the implication is that technical and scientific aid must become an integral part of our food aid program if the long-term, economic development objectives of food aid are to be obtained and the disincentive effects avoided.

However only a large and sustained commitment to a coordinated program of appropriate levels of technical and food aid will significantly contribute to the economic development of recipient countries.

Footnotes

1/ Public Law 480 was passed in 1954, formally establishing a U.S. program of food aid.

2/ The unit cost line is now given as:

$$\frac{P_1}{P_0} \cdot L + \frac{P_{K_1}}{P_0} \cdot K = 1$$

where P_1 = the nominal labor wage; and

P_{K_1} = the nominal price of laboresque capital.

3/ The change in the price of food does not affect the demand for labor in the urban sector since the value marginal product condition is unaffected, i.e., that the nominal wage be equal to the marginal product of industrial labor valued by the price received by industrialists for their output. However, if food aid contributes to an improvement in the nutrition of urban workers and thus leads to a formation of human capital, the result ~~is~~ could be an increase in the marginal productivity of labor, illustrated as a rightward shift of the demand for urban labor curve in figure 6. This further enhances the employment opportunities for agricultural labor in the urban sector.

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