The Gains from Region-wide Facilitation of Transport[1]

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Abstract: This paper formalizes and demonstrates why the development of transport infrastructure *between rural areas* may be one of the most important investments to make in Third World countries to deal with crop failures. In developed economies where transport costs are negligible, a crop failure in one area *enhances* market opportunities for producers in other growing regions. In developing countries where transport costs can be prohibitive, a crop failure in one area can have the reverse effects on other growing regions-- *undermining* market opportunities-- especially where crops must be transported through a central market to which food aid is delivered. We analyze the impacts of crop failures and food aid in a Walrasian general equilibrium model of a small, open, three-region economy, stylized to mimic African countries with prohibitively high costs of transport between rural regions.

Motivation

The lack of transport infrastructure between rural regions *insulates* rural producers from market opportunities while *magnifying* the disincentive effects of food aid. This paper formalizes and demonstrates why the development of transport infrastructure *between rural areas* may be one of the most important investments Third World countries can undertake.

Consider Africa with its exclusively 'hub-spoke' pattern of transport routes from land-abundant/rural/agricultural regions to the capital/port cities (Figure 1). Domestically-grown food must usually be transported first into the center before it can be delivered to another hinterland. A lack of hinterland-hinterland transport routes means that the delivered cost of non-local food and other products can be prohibitively high to rural residents.

Africa's rural people are subsistence or small-scale farmers. It is easy to show that intensive land use (farming for market) is not economically rational where the transportation of agricultural produce to the market makes the delivered price many times higher than the cost of production. If agricultural production displayed constant returns to scale and costs are linear in output and yield per acre, bid rent would be linear in yield per acre and the optimal yield per acre would not depend on transport costs to the market. If there are decreasing returns to scale in terms of agricultural inputs such as seed, fertilizer, etc, then bid rent is strictly concave in yield per acre, and the optimal yield declines with respect to distance from the market or the per unit transport cost rate. This may also explain why attempts to encourage agricultural intensification or the adoption of yield-enhancing technical change have not had as much success as one would hope.

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It is also easy to show that residents of the port/center region benefit from their unique accessibility. It is less easy to show or obvious whether center residents gain or lose from improved transport infrastructure that clearly benefit residents of other regions. In this paper we find that all regions may gain.

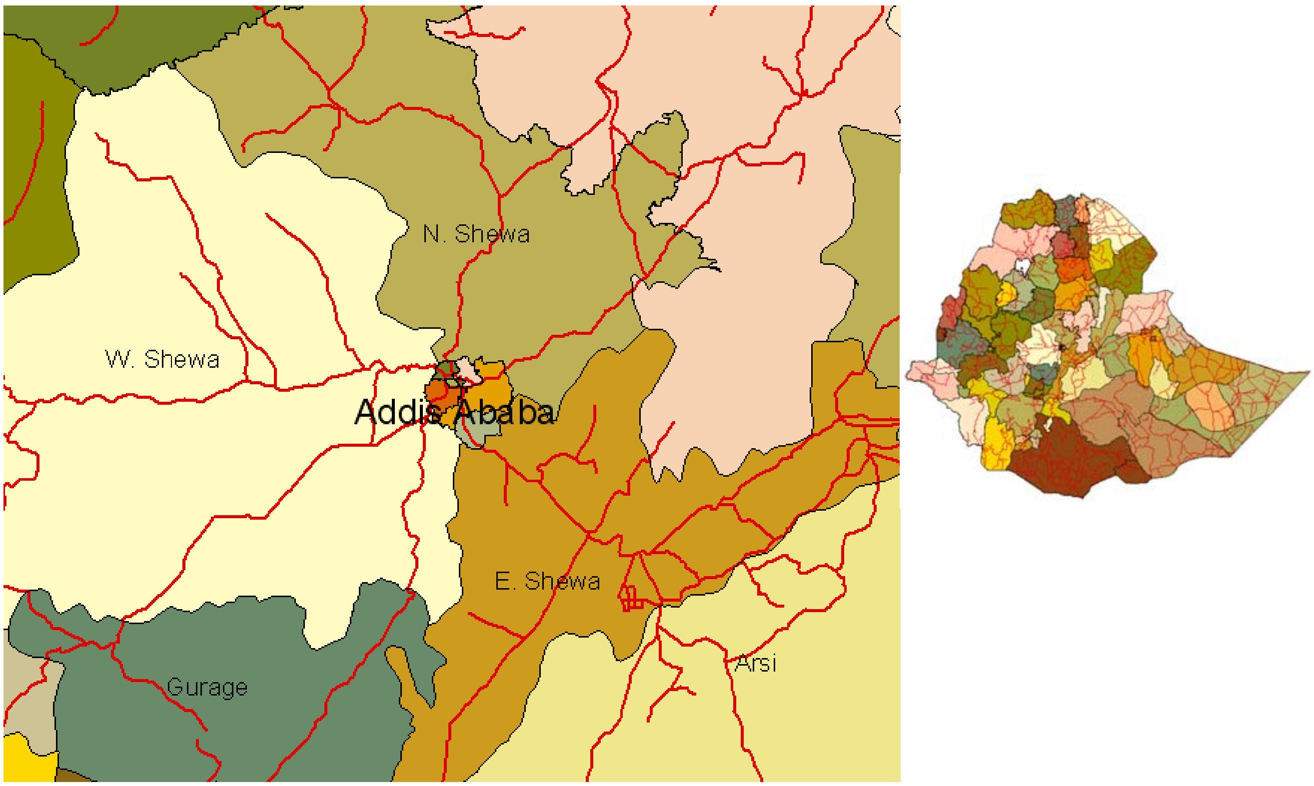

Figure 1. All roads lead to Addis (rather than between rural regions)

In particular, we show that transport infrastructures interact with crop failures and food aid.

When drought or other disaster wipes out the crop in a rural region, the region's residents have nothing to sell nor eat. Markets can do nothing for people who have nothing. Furthermore, where transport costs are high, even savings equivalent to years worth of consumption are not enough to enable rural people to afford food shipped in from outside their region. Non-market intervention that arrives *c.i.f.* – food aid—may be the only way (in the short-run) to avoid starvation in the drought-stricken region.

When food aid is delivered to a capital/port city, the expansion in supply there helps keeps market prices down. One might imagine that the food aid simply replaces the lost crop. The deliveries should simply compensate for the harvest deficits in the drought-stricken hinterlands. But the lack of transport infrastructure between rural areas does not just insulate one agricultural region from the high prices caused by scarcity in another. Paradoxically, it appears to leverage the disincentive effects of food aid. Why would food aid depress market prices below pre-crop failure levels? Why wouldn't the donated commodities simply substitute for the lost harvests? We argue that transport costs matter. We show that it is because crop losses occur in one place, the aid arrives in another, and the cost of moving commodities between the regions is high.

Food aid may be unexpectedly disruptive because the spatial segmentation of market areas due to the high costs of transport mean that when aid deliveries raise the supplies in the center, the market prices in the center can fall below the threshold price that rationalizes the delivery of crops from non-drought affected hinterlands. Thus, in addition to the drought-stricken farmers who have nothing to sell, farmers that were *not* drought-stricken find they have nothing worth selling either. Both drought-stricken and non-stricken hinterlands fall into poverty (see Dercon, 2004).

This is how a crop failure in one rural region can spread devastation to rural regions that did not suffer crop failures. In developed economies where transport costs are negligible, crop failures in one area *enhance* the market opportunities facing other growing areas. In contrast, where rural-rural transport costs are too high, when crop failures strike one area and food aid is delivered to the center, *market opportunities disappear* for *non-stricken* rural areas.

We show that this kind of worst case outcome may be mitigated by reducing the costs of rural-rural transport. We compare the effects of a crop failure in one hinterland in the context of very high and reasonably lower transport costs, when hinterland households have savings sufficient for one year's consumption of local produce during a normal year. When transport costs are high, the country cannot feed itself. When transport costs are low, it can, even with a 50% crop failure. But what if the hinterland households have no savings? We also compare the effects of food aid under very high and reasonably lower transport costs. When transport costs are low, the disincentive effects of food aid are mitigated.

The paper proceeds as follows. Next we briefly cite some related literature about market segmentation, transport costs, food aid and its disincentive effects, and refer to excerpts of a handful of articles published in The Economist since 1984 about African famines that describe the real problem (Appendix 1). We could not find, however, any paper investigating if the disincentive effects of food aid are magnified high transport costs. We also found no economic literature investigating the mechanism by which crop losses in one region have been followed by penury in *other* regions, as has been observed, for example, in Ethiopia in recent decades.

Then we present our model. To analyze the role of transport infrastructure in the market failures following crop failures, we created a Walrasian general equilibrium economic model of a small open economy comprised of two largely agricultural hinterlands plus a central/port region. To trade with a neighboring hinterland, a region must ship through the center.

We apply the model to simulate the effects of crop failure under alternative transport infrastructure scenarios. Our scenario analyses show that when farm output is lost in one rural region, without rural-rural transportation infrastructure there are surplus pressures in other hinterlands and in the market center at the same time as there are the effects of shortages in the hinterland where the crops failed. Our analyses further indicate that origin and destination hinterland regions gain if the transportation network is made complete. The central region also gains (or risks less losses during hinterland region crop failures.) The results highlight the importance of rural-rural transport infrastructure.

Related Literature

Limao and Venables (2001) showed that poor infrastructure accounts for 40-60 percent of predicted transport costs, and that intra-regional transport costs significantly undermine intraregional trade in Africa. Their empirical estimates contrast directly with those of Foroutan and Pritchett (1993) who argued that the poor quality and quantity of transport infrastructures between sub-Saharan African countries did not impede intra-African trade.

Minten and Kyle (1999) documented the significant variation in food prices across products and regions in one African country, Zaire. They demonstrated that transportation costs alone explained most of the food price differentials, and that road quality is an important determinant of transportation costs. Fafchamps and Gavian (1996) also documented spatial market segmentation, finding that livestock prices in Niger are seldom cointegrated and that large price differentials persist between *adjacent* areas over time.

Dercon (2004) showed that weather-related shocks have substantial and persistent impacts on consumption in Ethiopia. He also argued there are substantial externalities from road infrastructure. These findings are very relevant to our analysis.

There exists a large literature on the disincentive effects of food aid since Schultz, 1960. A review of the literature is given by Awokuse, 2006. For example, Mann, 1967, Singer et al, 1987, and Fitzpatrick and Storey, 1989 studied the negative price effect of food aid with respect to domestic production and found evidence of the disincentive effects of food aid. In contrast, more recent studies(Barrett et al, 1999, Abdulai et al, 2005) showed analytically ambiguous price and disincentive effects of food aid on recipient countries. Mohapatra et al, 1999, have attributed this ambiguity to diversity in characteristics of both recipient's economy and food aid programs.

Our analyses will suggest some reasons for the ambiguous findings. We will show that where transport costs are not prohibitive food aid may simply offset crop losses. Where transport costs are prohibitively high between rural regions, food aid may cause as many problems as it attempt to solve.

Oddly, and to our surprise, we found no refereed journal articles in the economics literature formalizing or testing our claims about the importance of *rural-rural* transportation infrastructure. The lack of formal analyses is surprising given how frequently and loudly aid agencies have argued in favor of investments in roads (e.g., Oxfam, 2009); and how many decades have passed since Samir Amin (1976) and many other development economists (e.g., Adelman, 1984) argued that African regional re-integration and intra-regional food trade were key to African economic development.

The General Equilibrium Model

We define a small open economy consisting of three regions producing agricultural and non-agricultural tradable goods. International trade occurs through a central or port city into which all imports arrive and through which all exports are transshipped. Transport is costly, especially from the hinterlands. Furthermore, to trade with a neighboring hinterland, a hinterland's producers must ship through the port city first, then back out to the other hinterland.

The people in the hinterlands are almost exclusively engaged in agricultural production. Because of transport costs, most agricultural production is locally consumed. Some is transported to the center, to enable imports of non-agricultural goods, and to support the relatively dense urban population. Some is exported internationally and this enables imports from the rest of the world.

The high costs of transport lead to low nominal wages and painfully low terms-of-trade for traded goods. Even though agricultural commodities are perceived to be perfect substitutes and markets are perfectly competitive, the delivered cost of non-local food significantly exceeds the prices received by farmers.

Nevertheless, when the hinterlands' harvests are good, they export agricultural products and import other goods from the center and from the rest of the world. In the initial general equilibrium there is no endogenous trade between hinterland regions because the costs of transport through the center render delivered prices from the other rural areas prohibitively high.

We stylize the central port city as having a large non-farm economy as well as farming. It's economy produces food for export and for local consumption. It imports agricultural commodities from the hinterlands, in trade for exports of non-agricultural goods to the hinterlands. Central region citizens enjoy higher nominal wages and higher real utility compared to residents of the hinterlands.

The model endogenously generates the kind of *stagflation* (high prices and low wages) that Jane Jacobs (1985) recognized as a *spatial phenomenon*. To compete, rural producers deduct the costs of distance from the wages or rents they pay to rural factor suppliers. Meanwhile the delivered prices paid by rural consumers of traded goods are higher than the delivered prices paid by port city residents.

The focus of this analysis is on the role of transport infrastructure in poverty and hunger. All sectors are modeled as perfectly competitive (given transport costs) and there are no fixed costs. In this basic version of our model we have not assumed that poor people discriminate among alternative varieties of manufactured goods, and therefore we have not formalized product differentiation or price discrimination. Firm size is indeterminant. The initial spatial equilibrium of the three intra-dependent trading regions open to world trade is summarized by the social accounting matrix (SAM) in Table 1.

Model Details

Consumers preferences are explicitly non-homothetic. The share of income spent on necessities is inversely related to income. In particular, although we assume that consumer preferences are Cobb-Douglas over the two types of goods, food (x_f) and non-food (x_n):

(1) $U(\boldsymbol{x}) = Ax_f^{\alpha}x_n^{1-\alpha}$

the expenditure shares α and $(1\text{-}\alpha)$ are related to income according to the Working-Leser demand system described by Deaton and Muellbauer (1980):

$$(2)\quad \frac{p_f x_f}{\omega} = \alpha = \beta_0 + \beta \log \omega$$

where p_f is the delivered price of food and ω denotes disposable income (region and household type subscripts dropped for simplicity). The 'data' in the initial SAM provides the measures of α for each of the six farm and worker household types in the three regions. Furthermore, the expenditure patterns of the six households shown in Table 1 in the initial equilibrium SAM provides the six 'observations' to estimate β. As the SAM indicates, the higher income city region households spend a smaller share on food. The simple OLS estimate using just six 'observations' gives $\beta = -3$ (approximately). β_0 is then calibrated as $\alpha - \beta log\, \omega$, clearly formalizing food as a necessity.

The food and non-food consumed are comprised of a mix of domestically-produced versions x_{iD} and imported versions x_{iM}. Domestically produced food from the various regions are perfect substitutes in demand. Consumers choose whichever is cheaper (or a mix of all of those that are equally cheap), according to a modified Kuhn-Tucker first-order condition first applied in a general equilibrium model by Kilkenny (1998):

$$3)\quad x_{rr\rightarrow r}(DP_{r\rightarrow r} - DP_{rr\rightarrow r}) \geq 0$$

where *DP* stands for delivered price gross of transport costs, and item subscripts are dropped for simplicity. Equation 3 defines the quantity demanded from region *"rr"* by region *"r"* as non-negative, $x_{rr\rightarrow r} \geq 0$, if the delivered price of the good from $rr \rightarrow r$, denoted $DP_{rr\rightarrow r}$, is not larger than the local product's delivered price $DP_{r\rightarrow r}$.

Equation 3 is particularly well-suited for simulating changes in market access because it does not limit the choice set to the initial choice set. In this regard it is much superior to the typical Armington or New Economic Geography assumption of a Constant Elasticity of Substitution (CES) formalization of the tradeoffs between pre-determined alternative versions of a good, which we assume for the non-agricultural goods.

The sum of deliveries from all domestic regions defines the amounts of domestically-demanded consumer goods of each type supplied in each region. The price of the domestic aggregate, *PD*, determined by within-region market clearing in each region equals the quantity-delivered-weighted average delivered price.

Imports (and foreign aid when simulated) augment to domestic supplies. The price that clears each regional market, *PC,* is the one that equates aggregate demand of the region's households, firms (intermediate demands), and the government to the sum of domestic deliveries, imports, and aid.

The imperfect substitutability between domestic and imported versions of each good (due to alternative seasonal availability, for example) are formalized by Constant Elasticity of Substitution (CES) functions for each type of good, in each region:

4) $x_i = X[\delta_i x_{iD}^{\rho} + (1-\delta_i)x_{iM}^{\rho}]^{1/\rho}$

where X is a shift parameter, δ is the share parameter, and ρ is a function of the elasticity of substitution. The first-order conditions of a consumer's expenditure minimization problem define the demand for the imported and domestic versions:

5) $$\frac{PM}{PD} = \frac{\delta}{1-\delta}\left(\frac{x_M}{x_D}\right)^{\rho-1}$$

where the item subscripts have been dropped for simplicity, *PM* and *PD* are the delivered prices of the imported and domestic aggregates, respectively, and region and item subscripts have been dropped for simplicity. For a strictly concave expenditure function (convex indifference curves) we choose an elasticity of substitution $\sigma > 0$ such that $\rho = 1 - \frac{1}{\sigma}$ is less than 1. As equation 5 indicates, the higher a version's relative price, the less of that version is demanded.

Constant Elasticity of Transformation (CET) functions formalize strictly concave production possibilities sets over supplies to domestic or world markets. In this case the elasticity of substitution we chose is negative (and a separating hyperplane of relative prices will exist). As explained below, the overall price level is determined by fixing the ratio of nominal to real domestic product at unity. Given the overall price level, and the exogenous prices of imports and exports in international markets, within-region market-clearing determines the price of each good in each region.

The initial transport routes are formalized by an adjacency matrix of distances, $D_{r\text{-}rr}$, between each hinterland region and the center:

6)	center	rural_1	rural_2
center	0.05	0.35	0.50
rural_1	0.35	0.10	----
rural_2	0.50	----	0.10

There are no routes directly between rural areas. The only route between hinterlands passes though the center. Thus the initial distances along the two-step paths between rural areas is 0.85 (= 0.50 + 0.35). We will compare the effects of crop failures and foreign aid with this transport infrastructure to the effects when there's a direct route (D = 0.10) ***between*** the rural areas.

Transport services are provided by the labor employed in each sector. To deliver a real quantity *QD* of an item, enough labor and inputs to produce $QS > QD$ must be employed. In particular, $QS = QD(1 + tD)$, with the subscripts for the good and region dropped for simplicity of exposition. Transport costs per unit good per unit distance are denoted t_i. By the same token, the delivered price of a region's output to be paid by consumers, *DP*, exceeds the mill price received by producers, *P,* that is, $DP = P(1+tD)$.

We simulate a time period within which people do not migrate between regions. Labor is intersectorally mobile but inter-regionally immobile. We do not assume nor impose full employment, nor do we impose a minimum wage. "Full employment" in each region is defined to be the initial equilibrium level of employment in the region, $\underline{L}$ (region subscripts dropped for simplicity). Unemployment is calculated as $100*(1- L/\underline{L})$, where $\underline{L}$ is the initial workforce.

Production technology is constant returns to scale (Cobb-Douglas). Agricultural production requires labor, *L,* as well as an intermediate input from the farm sector itself, *F* (seeds or saplings or breeding stock or…) and an intermediate input from the non-farm sector, *N* (tools or fuel for transport or fertilizer or ...):

7) $Q_f = \varphi L^{\partial_L} F^{\partial_f} N^{\partial_M}$ where $\sum \partial_k = 1$.

Non-agricultural production requires only labor: $Q_N = L$. The first-order condition for profit maximization defines each sector's demand for labor:

8) $wL = \partial_L (P \cdot Q - taxes)$

where taxes are collected from businesses by the central government. Similar first-order conditions define the demands for the intermediate inputs.

The government uses tax revenues to finance its purchase of non-food items, for example, to build roads.

The return to labor, w_r, and thus the levels of sectoral employment, L_{ri}, are determined by the competition for local workers between the sectors in each region. The model is a Walrasian general equilibrium system where a price index plays the role of a numéraire. We specify that the ratio of nominal to real product remains fixed at 100%. (Implicitly there is a monetary authority holding the price level steady in the country.) The constant-returns to scale production technologies ensure Engel's Law (that the payments to factors of production exactly exhaust sector revenues). These assumptions explain why wages do not fall to zero even though surplus labor exists in general equilibrium.

Households earn incomes equal to *wL* in each sector and region, and enjoy utility from purchased consumption goods according to the specification in Equation 1.

We measure "hunger" as the ratio of food consumption per capita in a scenario relative to food consumption per capita in the initial general equilibrium (Appendix 2), so the "hunger index" is 100% in the initial equilibrium. We measure food production sufficiency as the ratio of endogenous production relative to production in the initial equilibrium; the "sufficiency index" is also 100% in the initial equilibrium.

Other equations specify the relationships between the world prices paid for exports and the local prices received for exports, given the exchange rate and the distance to the port (in the center) from each region. Assuming the country is small, world prices are exogenous (and equal to 1 in the benchmark). Prices paid for imports are also defined with respect to world prices, given the exchange rate and the costs of transport from the port (at the center) to the region. Prices received for exports are defined with respect to world prices less transport costs to the center/port city.

We also specify aggregate demand, real domestic product, nominal domestic product, the price index, and net inflows of foreign savings if the country's international balance of payments shows a current account deficit, or vice-versa for a current account surplus. The model can be simulated assuming a fixed exchange rate and a floating current/capital account; or a fixed current account and an exchange rate that is endogenously determined (implicitly managed) to achieve that current account balance. We prefer to assume that the exchange rate is stable (along with the price level). The government's budget balance is also endogenously specified.

Finally, one demand equation is excluded from the model. The demand for non-agricultural goods by the center household that works in the non-agricultural sector is implicitly determined, then compared to the result of the explicit demand equation in the report writer. This allows us to verify that our system of equations satisfies Walras' Law. (It does. We wouldn't have a paper if it didn't.)

The model is written using the General Algebraic Modeling System (GAMS) software and solved using the fixed-point algorithm for non-linear simultaneous equation systems. There are three dozen distinct equations representing the objective functions, first order conditions, market clearing, revenue/expenditure, and material balance equations describing employment in three regions in the production of two goods in each region that is consumed by the local labor suppliers (net of transport), used as intermediates in production, purchased by the government as well as traded with the rest of the world. Taking the all the dimensions into account, it consists of over two hundred simultaneous non-linear equations and endogenous variables.

It is extremely difficult to initialize a general equilibrium system of three interdependent, open economies, with transport costs.

We start with a fabricated social accounting matrix (SAM, Appendix 2) that stylizes the two hinterlands plus a central region, and two goods. The nominal values that balance the SAM are then used to initialize the Walrasian system. Eight sets of 'data' are used to parameterize the model. These are, for each good in each region: the initial nominal values consumed by each household by type and region, labor income, quantities delivered (gross of transport costs), foreign trade, intermediate good use by sector and region, government consumption, and taxes. We assume three elasticities of substitution: for consumer demand between domestic and imported alternative and between local and non-local versions of manufactured goods; and for supplies destined for world or domestic markets. With those few assumptions we fully-specify the model.

Benchmark and Simulation Results

The initial Walrasian equilibria in each region is summarized by the base social accounting matrix (Appendix). The center region is has the largest population and thus real gross product (RGDP). It imports agricultural goods from both hinterland regions, and sells non-agricultural goods ("manufactures") to both hinterlands. All regions also trade with the rest of the world. The center has the highest nominal wage and its residents enjoy the highest real welfare.

The initial equilibrium shows how delivered prices define market areas for the perfect substitute goods (farming output). The relatively high transport costs insulate the hinterland markets from each other. In the benchmark scenario the mill price in the center is highest because wages, the largest part of the cost of production, are highest there. Wages and mill prices are lowest where transport costs to the center/rest of the world are highest.

The two rural areas sell some of their farm produce to the center and import non-farm goods from the center. Because the cost of transporting the final product from center farms to center customers is lowest, in the initial benchmark equilibrium, households in the center consume locally produced food and food from the two hinterlands.

The model simulates the disincentive effects of aid in the following manner. Figure 2 shows the evolution of the utility of residents in the center/port region (to which aid is initially delivered) and the utility in the remote hinterland. The delivery of aid reduces local food prices, encourages central region labor to shift to manufacturing, and discourages hinterland farmers. Utility in the central region increases while the utility in the remote rural area falls dramatically. At some point the aid reaches a volume such that the center no longer purchases any food from the remote rural region, and unemployment rises there. This simulation is purely illustrative (there is no rationale for providing aid when there is no crop failure).

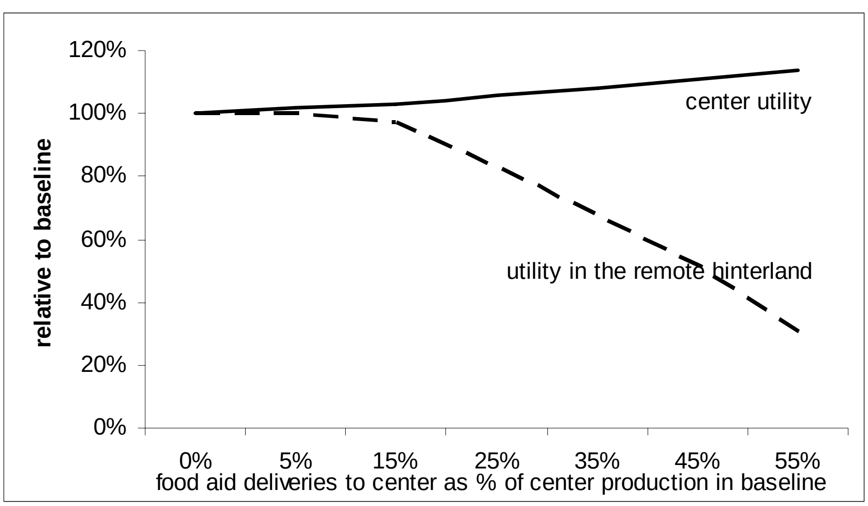

Figure 2. Effects of food aid delivered on center and hinterland utility

Crop Failure in one rural region

Consider a crop failure in the closer hinterland. We impose that farm production falls by more than half. A majority of the workforce there become unable to pay a threshold price above the normal local mill price because of their reduced circumstances. The drought-stricken hinterland cannot afford product delivered from the other hinterland. Furthermore, we expect that aid delivered to the center causes the mill price to fall in the center, and to fall even farther in the more remote, un-stricken hinterland. In the next section we consider the same drought scenario after investments in transport infrastructure in the hinterlands have improved access between the hinterlands. First, consider the simulation of a 50% crop failure in the closer-in hinterland. Table 1 shows the outcomes compared to the initial scenario.

In the stricken region ("a1") procution (Q) falls by 50% (as assumed); food prices rise 16% in nominal terms (PC), locals consume 32% less than what they were consuming before the drought (HI). Welfare according to the utility (U) measure, falls 29%. The stricken regions imports (M) 28% less food and exports (E) 53% less agricultural output, but their exports of manufactures quadruple. The central region suffers too. It experiences 4% unemployment, and a 7% reduction in utility (U). Food prices rise there by 15%. As expected, the price consumers pay (PC) in the unstricken hinterland rises even more, 19%, while the price received by farmers (PS) in the other hinterland falls 23%. The other hinterland's manufacturing sector also suffers a 37% price decline. Otherwise the other hinterland is fairly insulated from the effects (and opportunities) of the crop failure elsewhere.

Table 1. 50% crop failure in Rural 1
(compared to baseline scenario)

	Q	LD	M	E	PC	PS			Q	LD	M	E	PC	PS	
c .f	268.9	180.6	8.526	111.1	1.115	1.071			33%	35%	12%	23%	6%	2%	
c .m	205.5	205.5	99.83	2.639	1.208	1.075			-24%	-24%	22%	-34%	15%	2%	
a1.f	194.3	239.9	41.27	40.04	1.001	0.817			-50%	-29%	-28%	-53%	16%	-16%	
a1.m	147.8	147.8	5.75	23.44	0.956	0.509			193%	193%	-40%	486%	-11%	-54%	
a2.f	139.5	121.6	17.22	28.87	0.913	0.698			-1%	-1%	-1%	0%	19%	-23%	
a2.m	19.44	19.44	3.42	2.096	1.148	0.696			4%	4%	3%	5%	8%	-37%	
	W	U	HI	SSI	unemp				W	U	HI	SSI	unemp		
c	1.073	0.446	0.966	1.334	0.045				7%	-7%	-3%	33%	4%		
a1	0.547	0.326	0.684	0.5					-29%	-29%	-32%	-50%			
a2	0.692	0.429	0.997	0.992					0%	0%	0%	-1%			
DP	c	a1	a2	QD	c	a1	a2		c	a1	a2	QD	c	a1	a2
f.c	1.124	1.445	1.606	f.c	144.2				7%	7%	7%	f.c	42%		
f.a1	1.103	0.899	1.511	f.a1		127.3			5%	5%	5%	f.a1	-100%	-34%	
f.a2	1.047	1.292	0.768	f.a2	12.76		70.04		0%	0%	0%	f.a2	-4%		0%
m.c	1.128	1.451	1.612	m.c	158.5	17.62	8.293		7%	7%	7%	m.c	-19%	-48%	-11%
m.a1	0.687	0.56	0.942	m.a1	37.19	57.03			-35%	-35%	-35%	m.a1		39%	
m.a2	1.044	1.288	0.766	m.a2			14.81		-1%	0%	-1%	m.a2			4%

This scenario demonstrates our claim that domestic produce from non-drought affected rural hinterlands can simply be too expensive for neighboring rural markets struck by crop failures.

It also demonstrates our claim that where rural-rural transport costs are high, when one rural area is stricken, the market opportunities for the non-stricken rural areas decline as well. It demonstrates that a lack of transport infrastructure between rural areas insulates one agricultural region from the market opportunities associated with rising prices caused by increased scarcity in another agricultural region. Market signals to not rationalize the shipment of commodities from an unaffected farming region to a drought-stricken region.

Crop Failure + Aid

With a third of the stricken region's population able to buy food, non-market intervention may be the only way in the short-run to avoid starvation. In this scenario we assume that 60 units of food aid (the maximum the model can solve) is delivered to the port city, the central region. Table 2 shows the outcomes.

The disincentive effects of aid delivered to the center on the agricultural sector of the center are apparent. Farmers in both the center and the drought-stricken hinterland are suffering. The food aid delivered to the center releases labor from farming – resulting in 36% unemployment in the Center, an increase of 700% over the crop failure scenario alone. Utility in the central region falls another 24%. (The deliveries of food aid add real injury to the crop failure insult.)

Furthermore, as hypothesized, the aid displaces food deliveries (QD) from the non-stricken hinterland to the center completely (-100%). The aid never arrives in the region with the crop failure (delivery is costly and no one can afford it.)

Table 2: 50% Crop Failure in Rural 1 + Food Aid delivered to the center
(compared to Crop Failure scenario)

	Q	LD	M	E	PC	PS		Q	LD	M	E	PC	PS	
c .f	276.2	141.7	7.095	120.6	1.071	1.02		3%	-22%	-17%	9%	-4%	-5%	
c .m	116.9	116.9	108.7	0.926	1.491	1.371		-43%	-43%	9%	-65%	23%	28%	
a1.f	194.3	240.6	41	40.2	0.999	0.815		0%	0%	-1%	0%	0%	0%	
a1.m	147.1	147.1	6.234	23.56	1.04	0.505		0%	0%	8%	1%	9%	-1%	
a2.f	113.6	99.87	16.11	24.56	0.894	0.676		-19%	-18%	-6%	-15%	-2%	-3%	
a2.m	41.21	41.21	3.461	4.798	1.246	0.665		112%	112%	1%	129%	9%	-4%	
	W	U	HI	SSI	unemp			W	U	HI	SSI	unemp		
c	1.366	0.341	0.858	1.37	0.36			27%	-24%	-11%	3%	700%		
a1	0.545	0.319	0.682	0.5				0%	-2%	0%	0%			
a2	0.665	0.412	0.981	0.808				-4%	-4%	-2%	-19%			
DP	c	a1	a2	QD	c	a1	a2	c	a1	a2	QD	c	a1	a2
f.c	1.072	1.378	1.531	f.c	142.2			-5%	-5%	-5%	f.c	-1%		
f.a1	1.1	0.896	1.507	f.a1		127.1		0%	0%	0%	f.a1		0%	
f.a2	1.015	1.251	0.744	f.a2			69.817	-3%	-3%	-3%	f.a2	-100%		0%
m.c	1.44	1.851	2.057	m.c	87.81	11.73	5.154	28%	28%	28%	m.c	-45%	-33%	-38%
m.a1	0.682	0.556	0.935	m.a1	31.83	62.71		-1%	-1%	-1%	m.a1	-14%	10%	
m.a2	0.997	1.23	0.731	m.a2	10.63		16.436	-5%	-5%	-5%	m.a2			11%

This simulation demonstrates the transmission of penury from rural regions with crop failures to other rural regions that has been observed in Africa. It also demonstrates that high transport costs leverage the disincentive effects of food aid. Because crop losses occur in one place, the aid arrives in another, and the cost of moving commodities between the regions is high, the provision of aid causes non-stricken regions to suffer also.

Crop Failure in the context of lower rural-rural transport costs

Next, consider the effects of the drought but this time in the context of lower rural-rural transport costs. We re-initialized a baseline in which interregional are the same as intra-regional rural transport costs. The outcomes are presented in Table 3.

The key difference between this scenario and the simple crop failure scenario is that the center benefits from the transport improvements *between the hinterlands*; it does not experience the 4% unemployment as in the first case. It is apparent that the delivered prices of food between rural regions falls (-41-42%), and food is now shipped from one rural region to the area with the crop failure (up to 17.3 units) rather than to the center (-100%). Also, the labor released from the provision of transport services is more productive in non-agricultural activities, allowing the drought-stricken region to ship 47% more non-agricultural goods to the center. Its wages rise (6%) and utility increases (7%). The hunger index in the stricken region also rises 9% relative to the original crop failure scenario.

Table 3. Improve Rural-Rural transport infrastructure, then 50% Crop Failure in Rural 1
(compared to Crop Failure scenario)

	Q	LD	M	E	PC	PS			Q	LD	M	E	PC	PS	
c .f	306.3	207.3	9.204	125.5	1.128	1.078			14%	15%	8%	13%	1%	1%	
c .m	196.8	196.8	112.7	2.477	1.282	1.086			-4%	-4%	13%	-6%	6%	1%	
a1.f	194.3	221.6	42.25	41.86	0.971	0.793			0%	-8%	2%	5%	-3%	-3%	
a1.m	166.1	166.1	6.213	23.56	0.995	0.549			12%	12%	8%	1%	4%	8%	
a2.f	139.3	121.5	17.21	28.85	0.913	0.698			0%	0%	0%	0%	0%	0%	
a2.m	19.54	19.54	3.432	2.11	1.153	0.696			1%	1%	0%	1%	0%	0%	
	W	U	HI	SSI	unemp				W	U	HI	SSI	unemp		
c	1.084	0.453	1.009	1.52					1%	2%	4%	14%	-100%		
a1	0.579	0.35	0.746	0.5					6%	7%	9%	0%			
a2	0.691	0.428	0.997	0.991					0%	0%	0%	0%			
DP	c	a1	a2	QD	c	a1	a2		c	a1	a2	QD	c	a1	a2
f.c	1.132	1.456	1.617	f.c	165.2				1%	1%	1%	f.c	15%		
f.a1	1.07	0.872	0.872	f.a1		125.2			-3%	-3%	-42%	f.a1		-2%	
f.a2	1.047	0.768	0.768	f.a2		17.3	70.03		0%	-41%	0%	f.a2	-100%		0%
m.c	1.14	1.466	1.628	m.c	149.3	18.66	8.154		1%	1%	1%	m.c	-6%	6%	-2%
m.a1	0.741	0.604	0.604	m.a1	54.78	52.93			8%	8%	-36%	m.a1	47%	-7%	
m.a2	1.044	0.765	0.765	m.a2			14.89		0%	-41%	0%	m.a2			1%

The effects of the drought are less painful when the costs of transport between rural areas are lower. As expected, when transport costs are no longer prohibitive, the delivered costs on rural goods to rural customers falls (by 40-41%). Trade occurs between the rural regions (not shown – division by zero). The shipments of food between the stricken and non-stricken hinterlands rise dramatically to a level of twice the trade between the rural regions and the center. And the center is also better off when the transport costs between rural regions are reduced.

Crop Failure and Aid in the context of lower rural-rural transport costs

Finally, consider the effects of aid in the context of lower rural-rural transport costs and the 50% crop failure in one region. Table 4 summarizes the results.

The aid still has devastating disincentive effects in the center region where it is delivered, but the effects are mitigated by the improved transport cost situation. The unemployment rate in the center improves from 36% to 33%; they make and domestically deliver more non-agricultural goods. The stricken region is also better off, given the deliveries of food from the other rural hinterland – despite the aid dropped in the center.

Food production in the second hinterland rises 11%, international exports raise 16% relative to the original "aid + crop failure" scenario, and the employment and output in the relatively tiny non-farm sector falls in the other hinterland by 47%. These are anticipated effects of the improved transport infrastructure between hinterlands.

Table 4. Transport Infrastructure + Crop Failure in Rural 1 + Aid to center
(compared to Crop Failure + Aid)

	Q	LD	M	E	PC	PS		Q	LD	M	E	PC	PS	
c .f	286.6	148.9	7.38	125.1	1.071	1.021		4%	5%	4%	4%	0%	0%	
c .m	121.9	121.9	112.7	0.981	1.493	1.361		4%	4%	4%	6%	0%	-1%	
a1.f	194.3	224.6	41.82	41.74	0.973	0.794		0%	-7%	2%	4%	-3%	-3%	
a1.m	163	163	6.65	23.7	1.074	0.54		11%	11%	7%	1%	3%	7%	
a2.f	135.8	119.3	16.88	28.44	0.908	0.692		20%	19%	5%	16%	2%	2%	
a2.m	21.78	21.78	3.689	2.415	1.259	0.685		-47%	-47%	7%	-50%	1%	3%	
	W	U	HI	SSI	unemp			W	U	HI	SSI	unemp		
c	1.356	0.354	0.89	1.423	0.33			-1%	4%	4%	4%			
a1	0.572	0.34	0.735	0.5				5%	7%	8%	0%			
a2	0.682	0.417	0.989	0.966				3%	1%	1%	20%			
DP	c	a1	a2	QD	c	a1	a2	c	a1	a2	QD	c	a1	a2
f.c	1.072	1.379	1.532	f.c	147.7			0%	0%	0%	f.c	4%		
f.a1	1.072	0.873	0.873	f.a1		125.4		-3%	-3%	-42%	f.a1		-1%	
f.a2	1.039	0.762	0.762	f.a2		14.95	69.787	2%	-39%	2%	f.a2			0%
m.c	1.429	1.837	2.041	m.c	90.67	12.71	5.58	-1%	-1%	-1%	m.c	3%	8%	8%
m.a1	0.729	0.594	0.594	m.a1	47.62	58.54		7%	7%	-36%	m.a1	50%	-7%	
m.a2	1.027	0.753	0.753	m.a2			16.513	3%	-39%	3%	m.a2			0%

Summary

The Walrasian general equilibrium simulations described above have suggested there may be much to gain from facilitating transport between regions, especially between hinterland regions.

The evaluation of the cost and benefits of projects in developing countries raises the challenge that observed local prices are not reliable indicators of value. In the case of transportation projects linking farm regions to markets, agricultural prices may not be good indicators of social values of transport investments because they are much lower in nominal terms, precisely because of the costs of distance. The standard solution (Little & Mirrlees (1974)) to this kind of problems is to choose a consistent set of prices reflecting international (border) prices.

A problem with the LM rules in practice is that labor is not traded in international markets. What wages would be commensurate with the border prices that an analyst might use for traded goods? Bell and Devarajan (1987) provided correspondences between Little & Mirrlees (1974) rules and the implementation of those rules in a computable general equilibrium (CGE) framework. They showed that the solution of a CGE model – like the one here-- will give these hard-to-calculate prices. Thus, a CGE model, which takes border prices for tradable goods as given as we have here, generates a set of solution prices for nontraded goods and labor which represent their appropriate shadow prices. This is the point of departure that our stylized model provides.

Our next task is to elaborate the stylized model more appropriately, then to calibrate it with the data of a real country, say, Ethiopia. We would like to formalize how the intensity of farming varies (inversely) with transport costs. In that case as transport costs to markets fall, seed density and other farm production intensification strategies are rationalized, and greater gains from transport cost reductions would be enjoyed. Furthermore, it is a simple matter to elaborate the non-agricultural sector with respect to both internal and external increasing returns to scale; and less than perfectly competitive market structures. We may also be able to formalize the game between regional public authorities with respect to taxation and public spending on transport infrastructure improvements.

Bibliography

Abdulai, A., C.B. Barrett, and J. Hoddinott(2005) "Does Food Aid Really Have Disincentive Effects? New evidence from Sub-Saharan Africa" World Development, 33 (10): 1689-1704

Adelman, Irma (1984) "Beyond Export-Led Growth," *World Development* 12(9):937-950.

Amin, Samir (1976) <u>Unequal Development: An Essay on the Social Formations of Peripheral Capitalism</u> New York: Monthly Review Press.

Awokuse, Titus O. (2006) "Assessing the Impact of Food Aid on Recipient's Coutries: A Survey" ESA Working Paper, N°06-11, www.fao.org/es/esa.

Barrett, C.B., S. Mohapatra, and D.L. Snyder (1999) "The Dynamic Effect of US Food Aid" Economic Inquiry, 37: 647-656.

Bell, Clive, and Shanta Devarajan (1987) "Intertemporally Consistent Shadow Prices in an Open Economy, Estimates for Cyprus," *Journal of Public Economics*, 32:263-285.

Caucutt, Elizabeth, and Krishna Kumar (2008) "Africa: Is Aid an Answer?" *The B.E. Journal of Macroeconomics: Advances* 8(1):32.

Dercon, Stefan (2004) "Growth and Shocks: evidence from rural Ethiopia" *Journal of Development Economics* 74:309-324.

Dervis, Kemal; Jaime de Melo, and Sherman Robinson (1982) General Equilibrium Models for Development Policy Cambridge: Cambridge University Press.

Fafchamps, Marcel and Sarah Gavain (1996) "The Spatial Integration of Livestock Markets in Niger" *Journal of African Economies* 5(3):366-405

Fitzpatrick, J. and A. Storey (1989) "Food Aid and Agricultural Disincentives", *Food Policy*, 14: 241-247.

Gersovitz, Mark (1989) "Transportation, State Marketing, and the Taxation of the Agricultural Hinterland," *Journal of Political Economy* 97(5):1113-1137.

Jacoby, Hanan and Bart Minten (2009) "On measuring the benefits of lower transport costs" *Journal of Development Economics* 89(1):28-38.

Limao, Nuno, and Anthony Venables (2001) "Infrastructure, Geographical Disadvantage, Transport Costs, and Trade" *The World Bank Economic Review* 15(3):451-479.

Little, I. M. D., and J. A. Mirrlees (1974) Project Appraisal and Development Planning for the Developing Countries. London: Heinemann.

Mann, J.S. (1967) "The Impact of PL 480 Imports on Prices and Domestic Supply of Cereals in India" *Journal of Farm Economics* 49: 131-46.

Minten, Bart and Steven Kyle (1999) "The effect of distance and road quality on food collection, marketing margins, and traders' wages: evidence from the former Zaire" *Journal of Development Economics* 60:467-495.

Mohapatra, S.C.B. Barrett, D.L. Snyder, and B. Biswas (1999) "Does Food Aid Really Discourage Food Production?" *Indian Journal of Agricultural Economics*, 54: 212-219.

Omamo, Steven (1998) "Transport Costs and Smallholder Cropping Choices: An Application to Siaya District, Kenya" *American Journal of Agricultural Economics* 80(1):116-23.

Oxfam International (2006) Causing Hunger: and Overview of the food crisis in Africa

Ravallion, M (1997) "Famines and Economics" *Journal of Economic Literature* 25:1205-1242.

Schultz, T.W. (1960) "Value of US Farm Surpluses to Underdevelopped Countries" *Journal of Farm Economics* 42: 1019-1030.

Singer, H., Wood, J., and T. Jennings (1987) Food Aid: The Challenge and the Opportunity. Oxford: Oxford University Press.

Appendix 1. excerpts of The Economist articles from 1984 through 2009 describing the real problems motivating our research **(emphasis added):**

Nov 3rd 1984 The Economist http://www.economist.com/opinion/displaystory.cfm?story_id=14737952

THERE IS A BETTER WAY

Food aid bad, but food aid essential: an Ethiopian tragedy

Last week the British saw women and children dying on their television screens, and decided belatedly to do something about it. Money and offers of help flowed into the private relief organisations that had orchestrated the publicity. Clergymen and popular newspapers preached practical charity to newly receptive audiences. The government offered a couple of aircraft to fly food to the stricken of Ethiopia. The EEC put a helpful shovel to the maize and milk mountains.

Many British hearts have been warmed, many queasy consciences eased, by such evidence of goodwill. Dire distress provoked swift action, and that is morally excellent. Some lives will be saved in Ethiopia. But the problem is not thereby solved. Once famine has come, giving food is the only way to meet it. **Yet food aid can help make temporary disaster permanent.**

It takes acts of men to turn acts of God into calamity. **In Ethiopia, local drought has been followed, as it always is, by local shortages of food.** Farmers on the fragile soils and in the violent climates of Africa know all about that. Left to themselves, they save in good years for the bad seasons that are bound to come. But the Ethiopian junta has forbidden that. In place of a bad old regime run by grasping and incompetent landlords, Colonel Mengistu Haile Mariam and his colleagues have installed a bad new regime run by doctrinaire and incompetent soldiers. **Saving food from good years is called hoarding. Saving money earned from past harvests is called capitalist accumulation. Earning a living transporting food is called exploitation. All are punished by official extortion, and worse.** That was how Stalin choked off farming in the Soviet Union, where it has still not recovered. In the many-peopled Ethiopian empire now, as in the Soviet one then, economic repression has inspired rebellion. Food supplies have been cut off as a punishment. Hence the famine in the north.

… **Free food relieves hunger near the places from which it is distributed**, where the hungry therefore congregate and, weakened, infect each other with disease. This dreadful cycle has been re-enacted, and re-discovered, from the Irish famine of the late 1840s right up to the latest television films showing its effects in Africa. It is happening now all over Africa: in Chad, in Sudan, in Mozambique, even in fertile Zimbabwe: wherever famine is met by charitable relief.

The charities must therefore be helped to make their aid effective. **Food must be lifted as far as possible into the countryside, in small consignments,** so as not to attract great clusters of refugees; and it must be kept as far as possible out of the hands of government agents, who will eat it themselves, or use it as a political lever, if they can. Above all, the helpers must insist publicly that free food will stop at the first possible harvest. And they must teach the farming techniques that will enable the hungry to feed themselves in future.

…free food is dangerous stuff. Outside famine times, it deters the farmers of needy countries from producing more. **Given normal rains,** relatively free husbandry **and the rudiments of commercial transport, almost every country in sparsely populated Africa could amply feed its own people**. …

… Africa's [food policies] could [work] too, given reasonable prices to farmers, **reasonable programmes of road-building, reasonable co-operation across that continent's absurd European-drawn frontiers.** For that the west can help, not by moral spasms to meet televised famines, but by steady and growing contributions of multilateral financial and technical assistance.

Dec 13th 2001 The Economist http://www.economist.com/world/middleeast-africa/displaystory.cfm?story_id=E1_JDGPRR

WILL THEY EVER HAVE ENOUGH FOOD?

Some day, but ***not until Ethiopia has better roads*** *and secure land tenure*

…The government tries to spot famines before they kill. Food aid usually arrives in time, more or less. Aid agencies maintain offices in Gode, and are poised to respond to any sudden crisis. But the nomads do not want to remain permanently dependent on handouts, so many have settled down and started to grow maize.

When the rains are good, they do well. But when drought strikes, their seeds will not grow in the hot sandy soil. Irrigation, and more fertiliser, might solve the problem. Unfortunately, fertiliser **is twice as expensive in Gode as in the capital, Addis Ababa. So is the fuel** needed to pump water out of the river. The reason is that Gode is **in the middle of nowhere** and has **no tarred roads. Its remoteness also depresses the price its people can get for their surplus crops in good years: they cannot afford to truck their produce to city markets.**

…**About 85% of Ethiopians are farmers.** But if the country is to wean itself off food aid, its people must get better at producing things other than food. **If** Gode had **better roads, residents would be able to earn more cash, which would help them to cope in dry years.** If there were more than one telephone line--controlled by obstructive bureaucrats--among Gode's 60,000 people, small businesses might spring up.

Nov 14th 2002 The Economist http://www.economist.com/world/middleeast-africa/displaystory.cfm?story_id=E1_TQQSRPJ

AFRICA'S HORN OF FAMINE

Facing famine, Ethiopia appeals urgently for food aid

…. Why is this happening? Lack of water is an obvious problem. ... When the rains fail, so does their harvest. **Another problem is a lack of roads, which raises the cost of seeds, tools and fertiliser, and makes it harder for peasants to get their crops to market.** The government is trying to tackle both problems, and so are donors. ActionAid, a British charity, hands out food to the able-bodied only **if they help repair roads** or dig ponds to conserve rainwater.

Politics matters, too. The old military regime used to herd peasants forcibly into collectives, with lethal results. Since its overthrow in 1991, Ethiopians have been able to grow more food, at least in non-drought years.

Between 1994-95 and 2000-01, for example, production of cereals and pulses rose roughly 60%. But subsistence farmers, who, with their families, are perhaps 85% of the population, still find it **hard to amass the necessary surplus in good years** to see them through the bad. …

With American help, the government has set up a "famine early-warning system", to identify areas where food will soon run out. An alert earlier this year attracted some aid, but not enough, perhaps because Ethiopia's troubles were overshadowed by southern Africa's. According to the WFP, Ethiopia will need at least another 2m tonnes of food aid to keep people alive next year. Commendably, America pledged 93,000 tonnes to Ethiopia and Eritrea. But it is a short-term fix. As Clare Short, Britain's aid minister, says: "If you keep giving people **handouts of food, you undermine local agriculture**."

Sept 24th 2009 The Economist http://www.economist.com/world/middleeast-africa/displaystory.cfm?story_id=14506436

A CATASTROPHE IS LOOMING

Governments are at their wits' end to keep their hungry people alive

THIS year's drought is the worst in east Africa since 2000, and possibly since 1991. Famine stalks the land. The failure of rains in parts of Ethiopia may increase the number needing food handouts by 5m, in addition to the 8m already getting them, in a population of 80m. The production of Kenyan maize, the country's staple, is likely to drop by one-third, hitting poor farmers' families hardest. The International Committee of the Red Cross says famine in Somalia is going to be worse than ever. Handouts are urgently needed by roughly 3.6m Somalis, nearly **half the resident population** (several million having already emigrated during years of strife). In fractious northern Uganda **cereal output is likely to fall by half**. Parts of South Sudan, Eritrea, the Central African Republic and Tanzania are suffering too. Rich countries are being less generous than usual. The UN's World Food Programme says it has only $24m of the $300m it needs just to feed hungry Kenyans for the next six months.

Appendix 2: Base Social Accounting Matrix (SAM)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
		farming	mnf	food mkt	goods mkt	hh	public	farming	mnf	food mkt	goods mkt	hh	public	farming	mnf	food mkt	goods mkt	hh	public	R-o-W	sum
1	farming			107.0																90.0	197
2	mnf				206.0						46.0						14.0			4.0	270
3	food mkt	12.0				163.0															175
4	goods mkt	25.0				241.0	26.0														292
5	hh	134.0	270.0																		404
6	public	26.0																			26
7	farming			46.0						166.0										86.0	298
8	mnf										35.0									4.0	39
9	food mkt							9.0				234.0									243
10	goods mkt							19.0				66.0	9.0								94
11	hh							261.0	39.0												300
12	public							9.0													9
13	farming			14.0												54.0				29.0	97
14	mnf																11.0			2.0	13
15	food mkt													3.0				77.0			80
16	goods mkt													6.0				21.0	3.0		30
17	hh													85.0	13.0						98
18	public													3.0							3
19	R-o-W			8	86					77	13					26	5.0				215
	sum	197.0	270.0	175	292	404.00	26.00	298.0	39.0	243	94	300	9	97.0	13.0	80	30.0	98.0	3.0	215.0	