

The Gains from Region-wide Facilitation of Transport

by

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We formalize and demonstrate why the development of transport infrastructure *between rural areas* may be one of the most important investments for these countries to avoid acute hunger despite crop failures.

- simulate the effects of reducing the cost of intra-regional transport using a multi-region Walrasian general equilibrium model with some new economic geography features.
- mimic African economies that depend on agricultural and natural-resource –based production and are open to world trade
- Special features:
 - No direct transport links between hinterlands (only via central region)
 - multiple origins and destinations
 - full employment not assumed

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.

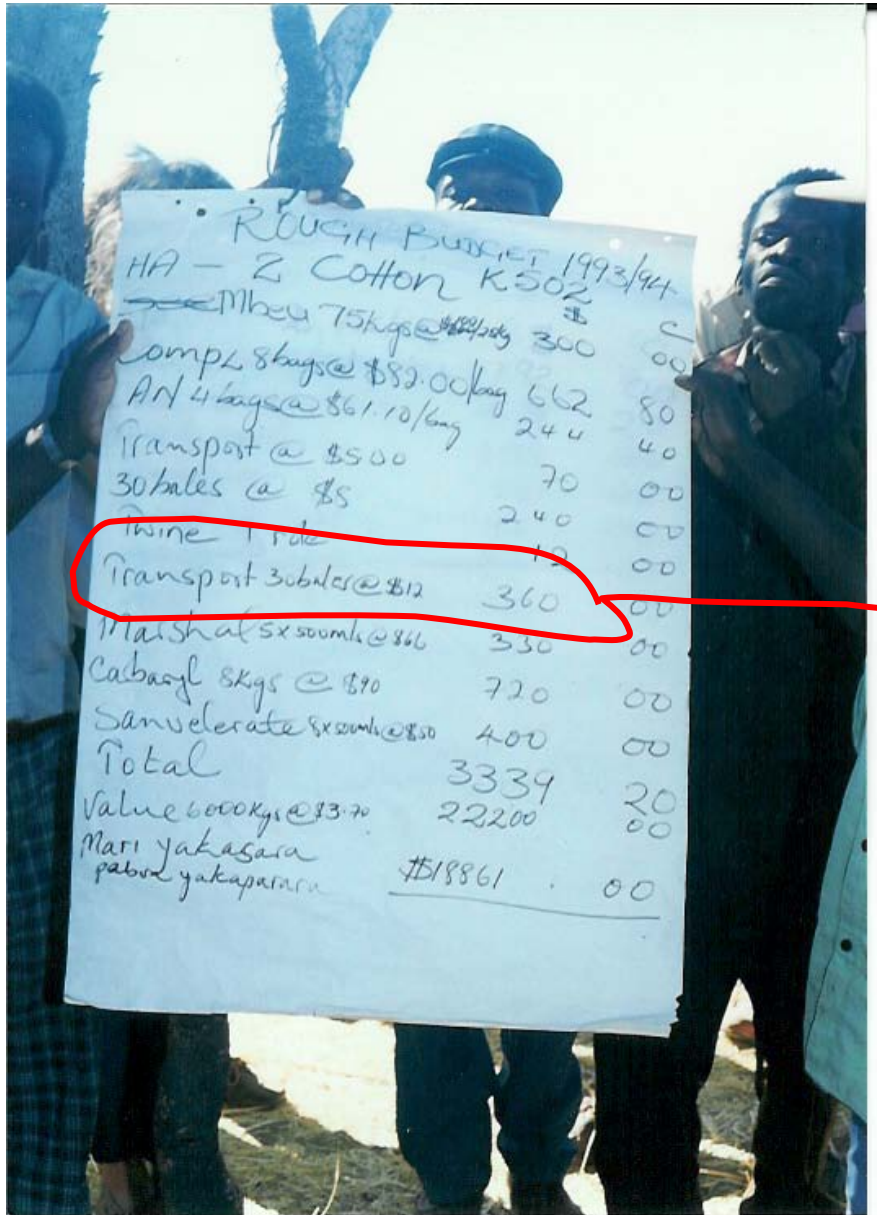
Africa's Infrastructure

A Time for Transformation

Africa Development Forum
(2010) The World Bank

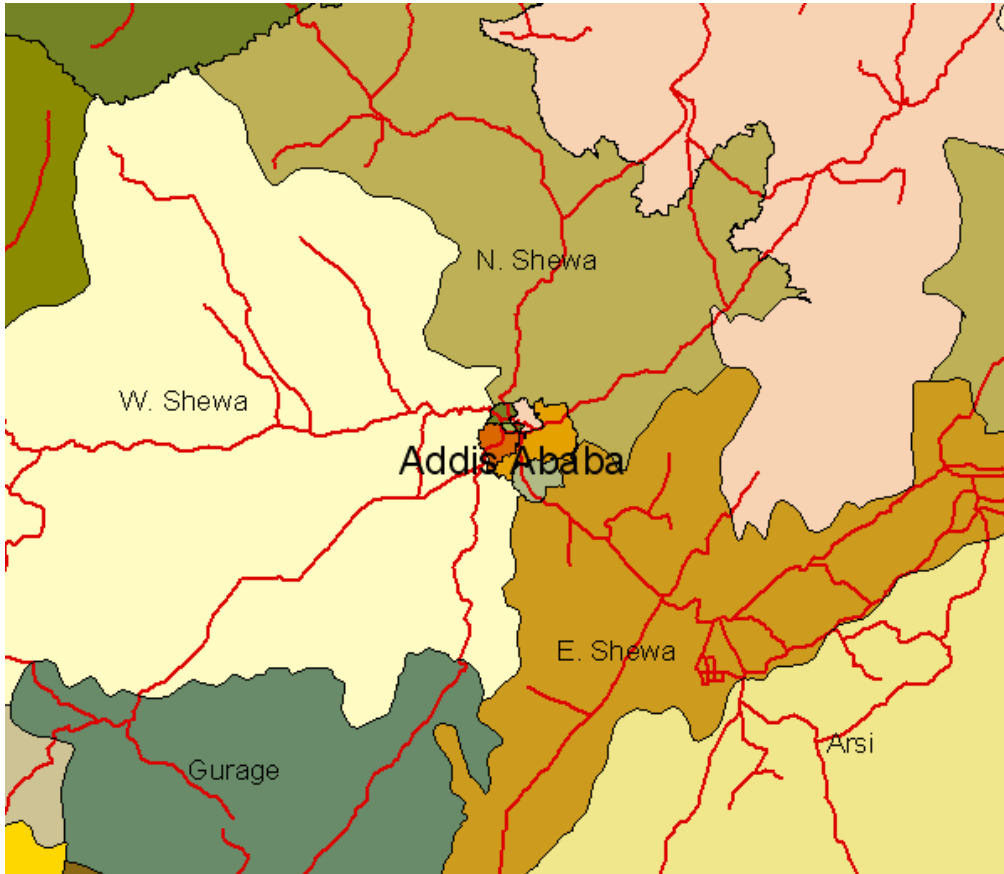
Main findings:

- “Africa’s infrastructure networks...are characterized by missing regional links...”
- “...twice as expensive as elsewhere”
- “the intra-regional road network is characterized by major discontinuities”



Overland transport costs can account for 45% of the final market price (Devlin and Yee, 2005)

Devlin, Julia, and Peter Yee (2005) "Trade Logistics in Developing Countries: The Case of the Middle East and North Africa" *World Economy*



C&K: “all roads lead to the port (or center)”

WB: “the intra-regional road network is characterized by major discontinuities”

We show that:

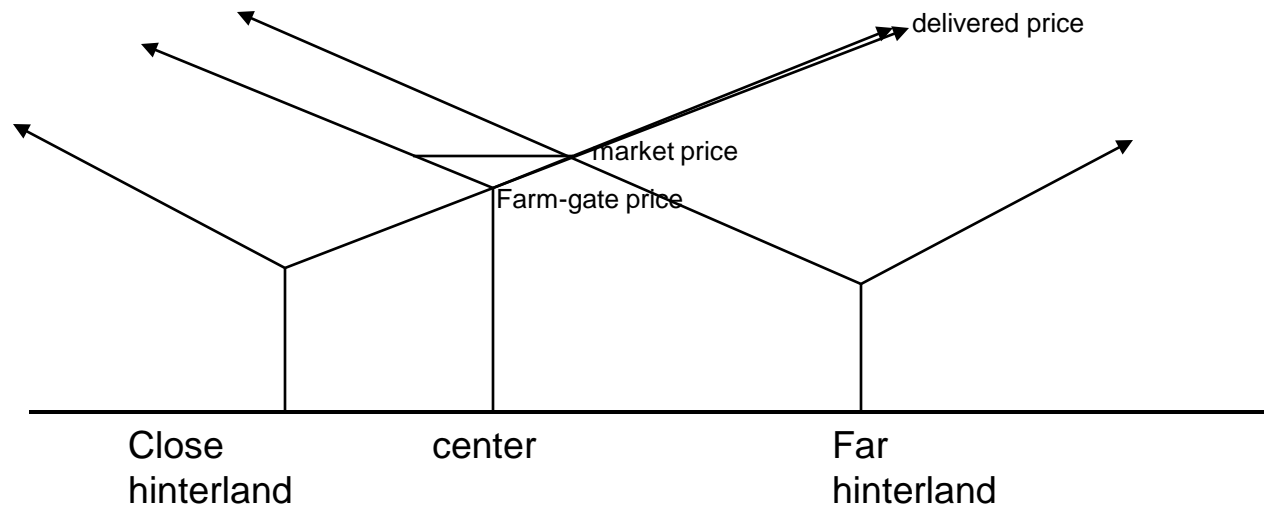
The lack of transport infrastructure between rural regions ***insulates*** rural producers from market opportunities while *magnifying* the disincentive effects of food aid.

- Where transport costs are “negligible”, crop failures in one area *enhance* the market opportunities facing other growing areas.
- Where transport costs are high, when stricken rural areas have nothing to sell, *market opportunities decline* for non-stricken areas as well.

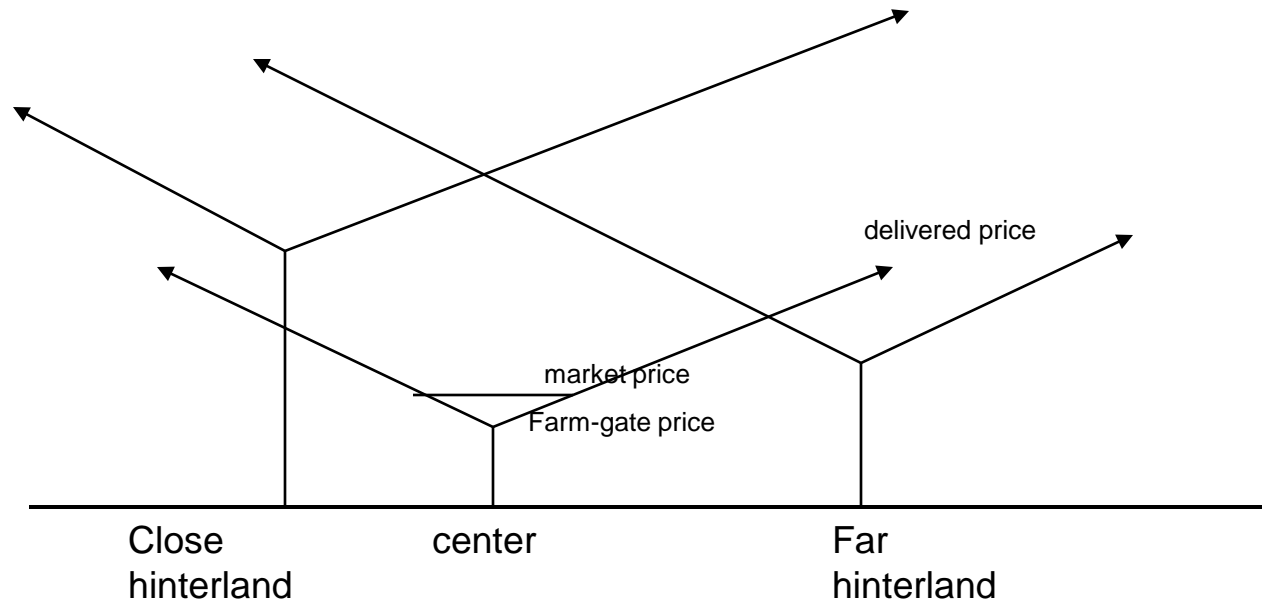
We show that these outcomes can be avoided if *between-rural* transport costs are no higher than *within-rural* transport costs.

The lack of transport infrastructure between rural regions *insulates* rural producers from market opportunities while *magnifying* 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?
 - Why do rural areas that were NOT stricken also suffer low income problems after crop failures in other regions?
- Because crop losses occur in one place, the aid arrives in another, and the cost of moving commodities between the regions is high.



- 1) imports, local produce, and produce from neighboring hinterlands are all consumed in the center (at the same delivered prices)
- 2) rural “farm-gate” prices and rural wages are lower than urban prices and wages, else rural products are not competitive in urban markets
- 3) the nominal “values” of even *highly productive* rural labor and rural land are lower the higher are transport costs (and are higher where t-costs are lower)
- 4) When a direct route is missing, rural hinterlands cannot afford to purchase products from each other



- 1) Crop failure reduces supply in close hinterland (and in the center)
- 2) Aid delivered to center compensates for shortage there; market prices fall in the center; demand for the product from the other hinterland is displaced
- 3) when a direct route between hinterlands is missing, other hinterland's supplies remain too expensive for other rural consumers, even though market prices fall in the other hinterland;
- 4) everyone loses

The spatial equilibrium is a general equilibrium problem because farm-gate and mill prices are endogenous

- A crop failure in one region reduces supply of crops also to the center, and
- reduces income in both regions,
- reduces demand for both food and non-food products,
- releases labor to non-farm activities,
- reduces inter-regional trade/increases autarky,
- reallocates labor across sectors...

- The model is written using the General Algebraic Modeling System (GAMS) software and solved using a fixed-point algorithm for non-linear simultaneous equation systems.
- describes the employment of one primary factor of production in three regions to produce two goods
- Goods are consumed by the local owners of the factor of production (net of transport), used as intermediates in production, and consumed by government as well as traded with the rest of the world.
- 30 distinct equations (x 3 regions x 2 sectors + R-o-W)
 - objective functions,
 - first order conditions,
 - market clearing,
 - revenue/expenditure,
 - material balance
 - One demand equation solved residually (Walras' Law)
- = 191 simultaneous non-linear equations and endogenous variables.

Initial equilibrium (Social Accounting Matrix/SAM)

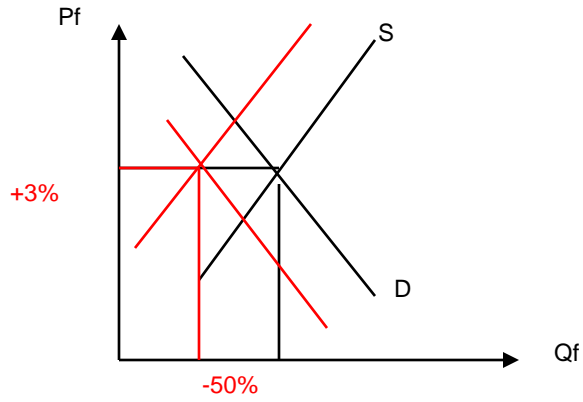
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
	farming	mnf	food mkt	goods mkt	hh	public	farming	mnf	food mkt	goods mkt	hh	public	farming	mnf	food mkt	goods mkt	hh	public	R-o-W	sum	
1 farming			107.0																	90.0	197
2 mnf				206.0						46.0						14.0				4.0	270
3 food mkt	12.0				163.0																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		

~ 'sudoku'

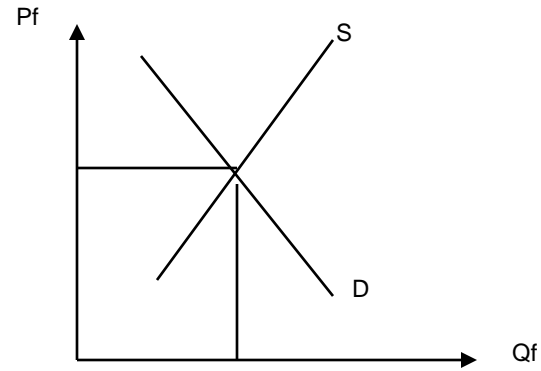
Simulation: drought in the closer hinterland causes 50% reduction in its crop:

	<i>drought</i>								<i>drought</i>						<i>compared to baseline</i>		
	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		c.f	33%	35%	12%	23%	6%	7%			
c.m	205.5	205.5	99.83	2.639	1.208	1.075		c.m	-24%	-24%	22%	-34%	15%	8%			
a1.f	194.3	239.9	41.27	40.04	1.001	0.817		a1.f	-50%	-29%	-28%	-53%	3%	5%			
a1.m	147.8	147.8	5.75	23.44	0.956	0.509		a1.m	193%	193%	-40%	486%	-14%	-35%			
a2.f	139.5	121.6	17.22	28.87	0.913	0.698		a2.f	-1%	-1%	-1%	0%	0%	0%			
a2.m	19.44	19.44	3.42	2.096	1.148	0.696		a2.m	4%	4%	3%	5%	3%	-1%			
	W	U	HI	SSI	unemp				W	U	HI	SSI	unemp				
c	1.073	0.446	0.966	1.334	0.045			c	7%	-7%	-3%	33%	4%				
a1	0.547	0.326	0.684	0.5				a1	-29%	-29%	-32%	-50%					
a2	0.692	0.429	0.997	0.992				a2	0%	0%	0%	-1%					
DP	c	a1	a2	QD	c	a1	a2	DP	c	a1	a2	QD	c	a1	a2		
f.c	1.124	1.445	1.606	f.c	144.2			f.c	7%	7%	7%	f.c	42%				
f.a1	1.103	0.899	1.511	f.a1		127.3		f.a1	5%	5%	5%	f.a1	-100%	-34%			
f.a2	1.047	1.292	0.768	f.a2	12.76		70.04	f.a2	0%	0%	0%	f.a2	-4%		0%		
m.c	1.128	1.451	1.612	m.c	158.5	17.62	8.293	m.c	7%	7%	7%	m.c	-19%	-48%	-11%		
m.a1	0.687	0.56	0.942	m.a1	37.19	57.03		m.a1	-35%	-35%	-35%	m.a1		39%			
m.a2	1.044	1.288	0.766	m.a2			14.81	m.a2	-1%	0%	-1%	m.a2				4%	

Crop Failure

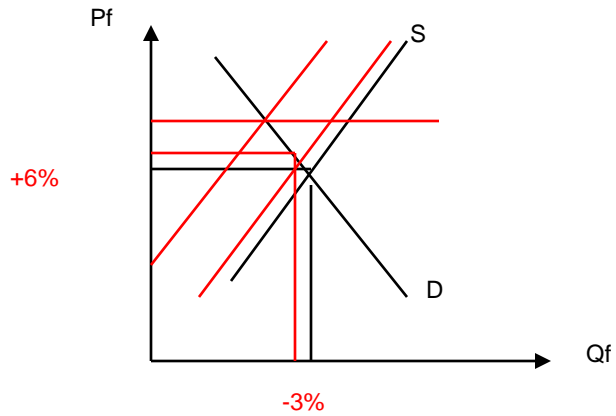


hinterland food market before & **after** crop failure

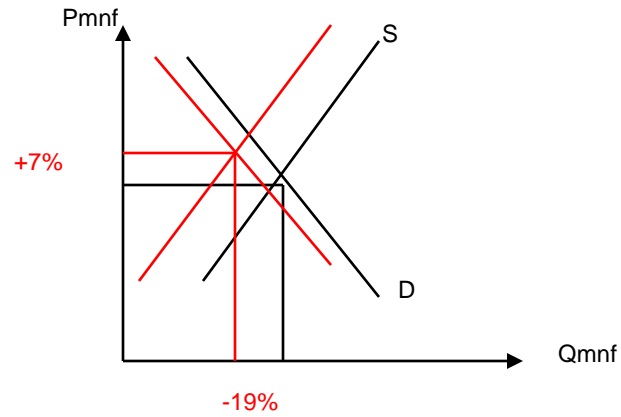


other hinterland food market

High t-costs insulate; segment markets



Central region food market



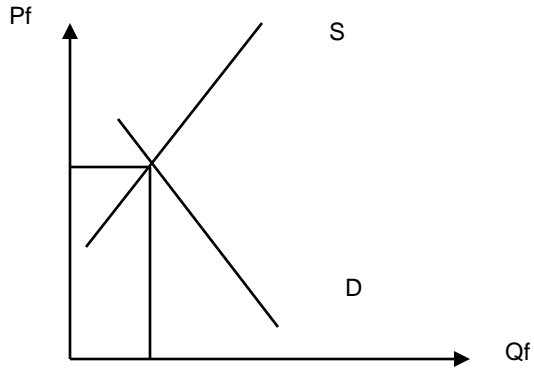
Central region's *non-food* market

+ 4% unemployment,...

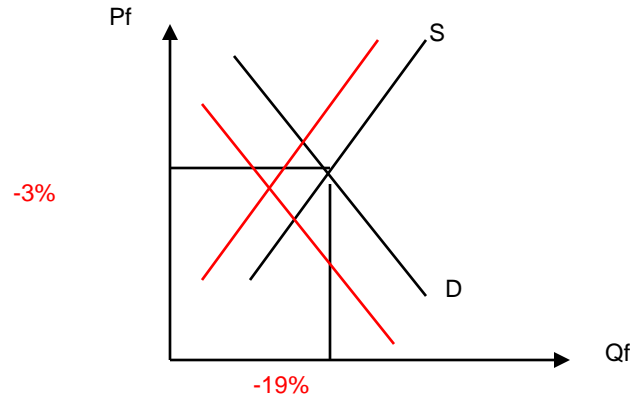
Crop failure + aid delivered to central market (compared to crop failure):

	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%

Crop Failure + Aid to center

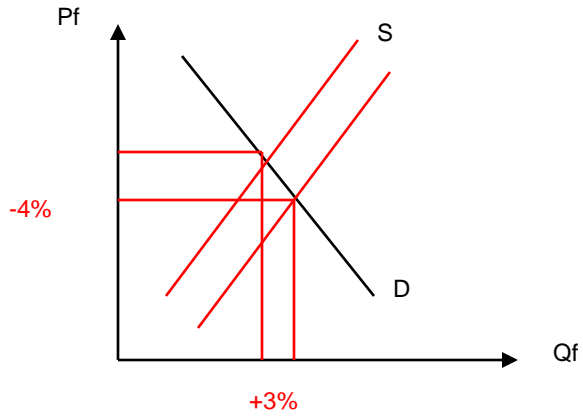


hinterland food market after crop failure and aid

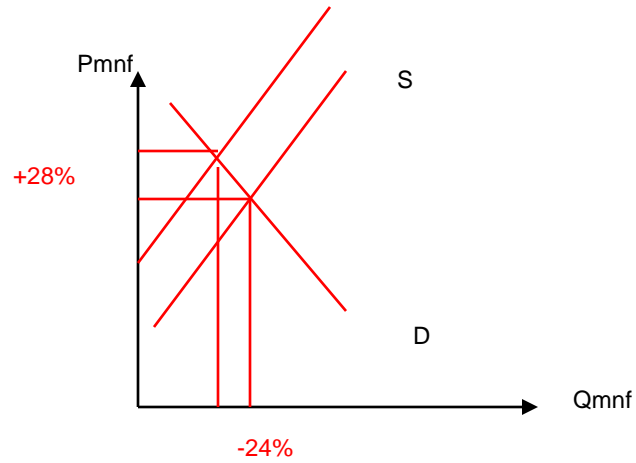


other hinterland food market

High t-costs *magnify* the disincentive effects of food aid



Central region food market



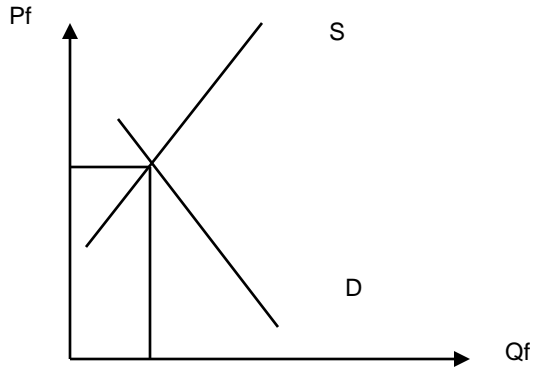
Central region's *non-food* market

+ 36% unemployment!

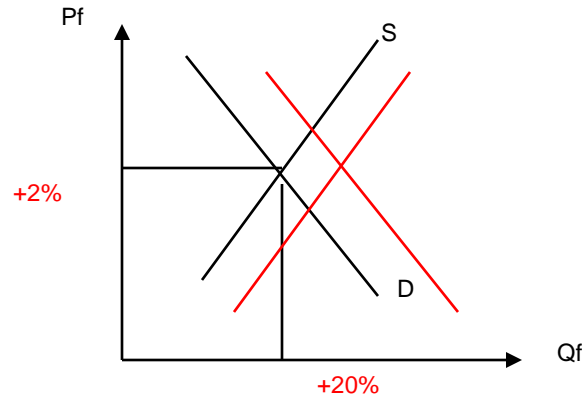
Rural-Rural transport link + crop failure + Aid to center

	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%

Rural-rural transport link + crop failure + aid to center

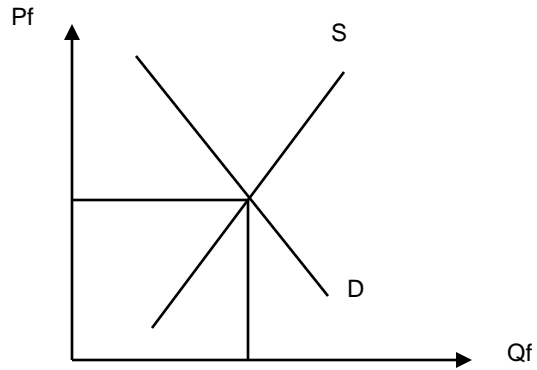


hinterland food market after crop failure and aid

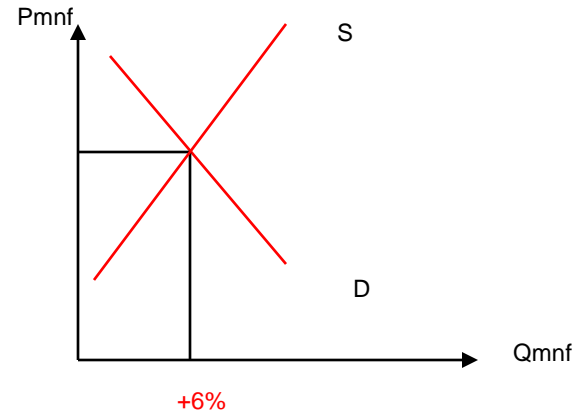


other hinterland food market

With low *t*-costs: one rural failure is other rural's success



Central region food market



Central region's *non-food* market

Less unemployment (-8% less)

With low *t*-costs: all regions better off; less need for aid,...

Summary of results

- A lack of transport infrastructure between rural areas insulates one agricultural region from the high prices caused by episodic scarcity in another
- But also because of high transport costs, the disincentive effects of food aid are magnified.
 - And, market signals to not rationalize the shipment of donated commodities out of the center to the drought-stricken region.
- 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 (especially the center) to also suffer.

- The effects of the drought and the disincentive effects of the aid are less painful when the costs of transport between rural areas are lower
- aid delivered to the center still has disincentive effects, but the unemployment effects are mitigated
- when transport costs are no longer prohibitive, the delivered prices of rural goods to other rural customers becomes affordable
 - trade occurs directly between rural regions
 - shipments of food between the stricken and non-stricken hinterlands rise dramatically
 - shipments of non-food between the non-stricken rural region and both regions also rise.
- All regions gain when transport costs between rural regions are reduced.

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Key recommendations:

- 7) “Development of infrastructure networks needs to be strategically informed by the spatial distribution of economic activities and by economies of agglomeration...”
- “Large agricultural sectors and rural economies remain central to economic growth and poverty reduction in Africa. Yet access of rural populations to infrastructure is extremely low. **Rural roads** and irrigation systems are together perhaps the **most pressing** of rural infrastructure needs. The two go hand in hand, and their development should **follow the value of agricultural land and the spatial proximity to urban markets**” (pages 22; and 125-126)

- 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 problem is to choose a consistent set of prices reflecting international (border) prices.
- Another 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 of 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.

Next tasks:

- elaborate the stylized model more appropriately
- calibrate it with the data of a real country, (e.g., Ethiopia)
- Elaborate:
 - 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.
 - Formalize the non-agricultural sectors with respect to both internal and external increasing returns to scale; and less than perfectly competitive market structures.
 - Introduce land, land rent, and land owners
 - formalize the game between regional public authorities with respect to taxation and public spending on transport infrastructure improvements between or within regions.

Thank you for your attention