Li & Yang on the Great Leap Forward
Econ 43750

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Today's Objectives

Backyard steel mills, misallocation
https://youtu.be/lgzcw6gNYfw?list=PL35E305E3D2CD6415&t=202
(play 3:22 to 6:23)

- Li and Yang's *Journal of Political Economy* Paper on the Great Leap Forward

Introduction

- Failure of GLF, Great Famine was kept a secret for many years.
- Communications fragmented, people believed problem was local
- Unknown in rest of world.
- We learned thorough official data released in the 1970s

Li-Yang Introduction: Potential explanations

1. Bad weather (official explanation)
2. Decreased inputs to grain production (labor and acrage)
3. Excessive taxes on peasants (grain procurement)
4. Poor incentives in communes
5. Inability to exit communes

Li and Yang say, let's test these hypotheses and assess their relative importance in explaining decline in output

Li-Yang Introduction

1. Plot the data and see what you can learn before running regressions
2. Ask if policy decisions can be rationalized, or if Mao was just a nut. In economics, we ask thing through models.
    1. Can it be explained that rationally seeking rapid indstrialization caused resources to be diverted from agriculture to industry? And that combined with excessive taxation (procurement) on the peasants causes output declines and starvation this year. People too weak to work so next year output falle even more.
3. Empirical implementation
    1. Estimate a production function. Then you can pull the levers on the various inputs (counterfactuals) and decompose the output loss into sources
    2. They find
        1. Diversion of resources: 33 %
        2. Excessive procurement (taxation): 28.3%
        3. Weather: 12.9%

Let's review: Development Strategy and Rural Institutions

1. 1949: 90% of the people lived in rural areas, toiled on small plots using centry old labor intensive technology
2. To pay for industrialization,
    1. Tax the peasants, subsidize industry (steel)
    2. Raise agricultural productivity through transformation into *large scale mechanized* farming (collectivization).

Launching the GLF (1958)

1. Collectives turned into communes. There were 26,500 of them, each consisting of thousands of familes
2. Belief in crackpot theories for raising agricultural productivity let local cadres to try to out do each other, issuing baseless claims about grain yield. Created illusion that collectivization was super productive. Go ahead, raise the procurement!
3. 1958: 16.4 million peasants (2 times industrial workforce) were re-located to urban areas to work in industry.
4. Communes also tasked to make steel, land reclamation projects, irrigation projects, drawing down resources devoted to agriculture. 100 million peasants diverted from grain production.

Coarse look at the data

Discussion of Table 1

1. Communes switched some land away from grain to other “cash crops” production
2. Peasants reduced stock of draft animals (probably ate them rather than have them confiscated by communes). These were the most important agricultural capital.
3. Communal kitchens provided free food. Must be a lot of wasted food.
4. State increased it’s procurement (tax)
5. Per capita caloric intake dropped from 2100 (1957) to 1500 (1960). People too weak to work.
6. 1960 reversal. Procurement reduced. 50 million sent back to the countryside to farm.

Table 1 (I converted to plots) This is in levels

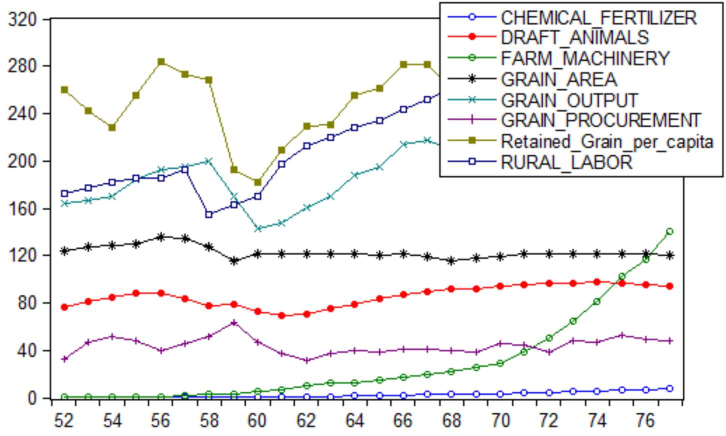
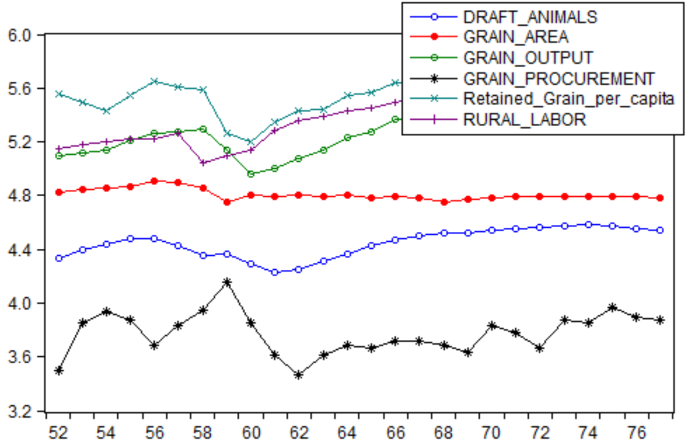


Table 1 (I converted to plots) This is in logs



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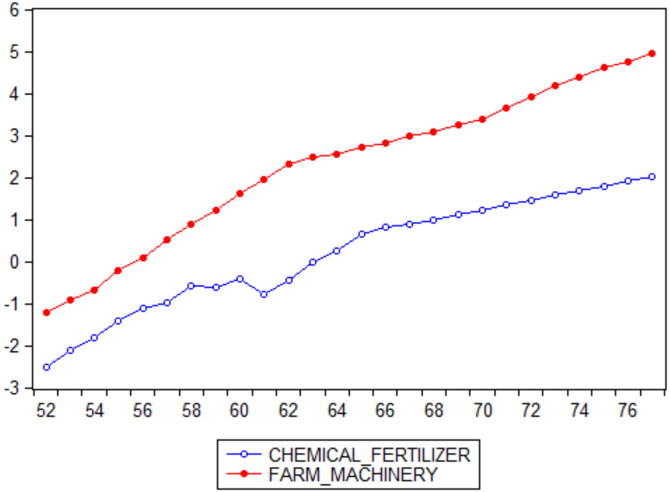


Modelling Mao (a toy model)

Can Mao's decision making be understood in a rational setting, or was he just a nut?

- Two sectors:
  1. Agriculture: only employs labor
  2. Industry: employs labor and grain
- Total labor force normalized to 1.
  L_t works in agriculture, $1 - L_t$ works in industry.
- Effective agricultural labor $L_t^* = L_t h_t$, where $h_t > 0$ is worker's physical capacity (health)
  - $h = f(c)$, Need to eat in order to work.
    $f' > 0, f'' < 0$ (declining marginal productivity) where c is consumption.
  - Hence, $L_t^* = L_t f(c_t)$.

Model: Agriculture

Aggregate agriculture production function

$$Q_t = aL_t^* = aL_t f(c_t) \tag{1}$$

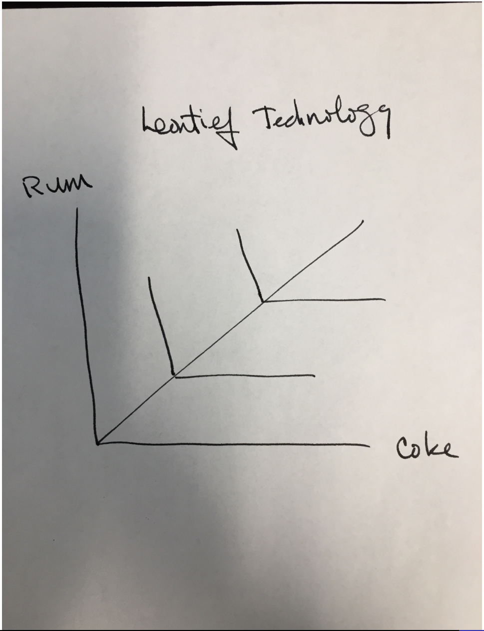
where a is technology level in agriculture. Per capita production function

$$q_t = \frac{Q_t}{L_t} = af(c_t) \tag{2}$$

Per capita state procurement (taxes) p_t. Per capita grain retained is what peasants can eat next year,

$$g_t = af(c_t) - p_t = c_{t+1} \tag{3}$$

Leontief Production (Technology)



Model: Industry (steel)

- Inputs are labor and grain in a Leontief (fixed proportions) technology.
  - One unit of labor needs m units of grain to make one unit steel. Therefore,
  - $(1 - L_t)$ units of labor needs $m(1 - L_t)$ units of grain to make $(1 - L_t)$ of steel
- Government's budget constraint
  - Grain entitlement to city folk: $n(1 - L_t)$
  - Grain input to production: $m(1 - L_t)$
  - Total procurement: $p_t L_t$
  - Budget constraint

$$p_t L_t \geq (m + n)(1 - L_t)$$

  m, n are technology. p_t, L_t are policy variables Government is best off by forcing an equality, in which case,

$$L_t = \frac{m + n}{p_t + m + n} \tag{4}$$

Government's problem

- β is government's discount factor. Patience means β is large (close to 1). Impatient means β is low. $\beta = 0$ means future is irrelevant.
- Problem is to maximize present value of industrial output,

$$\max \sum_{t=0}^{\infty} \beta^t \underbrace{(1 - L_t)}_{\text{labor input}} \tag{5}$$

subject to the budget constraint (4), (reproduced here) $L_t = \frac{m+n}{p_t+m+n}$

- Substitute budget constraint (4) into objective (5).

$$\max \sum_{t=0}^{\infty} \beta^t \left(\frac{p_t}{p_t + m + n} \right) = \sum_{t=0}^{\infty} \beta^t \left(\frac{af\left(c_t\right) - c_{t+1}}{af\left(c_t\right) - c_{t+1} + m + n} \right)$$

- Doing so collapses the two policy variables p_t, L_t into single a decision about choosing $\{c_t\}$.

Government's problem

- Look at first two terms, (at $t = 0$ and $t = 1$)

$$\left(\frac{af\,(c_0) - c_1}{af\,(c_0) - c_1 + m + n} \right) + \beta \left(\frac{af\,(c_1) - c_2}{af\,(c_1) - c_2 + m + n} \right)$$

- Differentiate with respect to c_1 and set result to zero. Rearranging gives

$$a\beta f'(c_1) = \left(\frac{af(c_1) - c_2 + m + n}{af(c_0) - c_1 + m + n} \right)^2 \tag{6}$$

- We could repeat at $t = 1, t = 2$, and differentiate with respect to c_2. You get the same answer but with time subscripts advanced by 1 period. Hence, (6) must hold for all t. The general form sets $t = 0, t + 1 = 1, t + 2 = 2$.
- This is a second-order (nonlinear) difference equation that maps c_t into c_{t+1} and c_{t+2}. Solve by computer.

Li and Yang's experiment

- 5 years into the new government, Mao suddenly becomes impatient (β decreases). Simulations show government directs labor to industry (fig 1a) and increases the procurement (figure 1b).
- The point is, the outcome of GLF might be what one would expect if the central planner is really impatient, and cares only about industrial output.

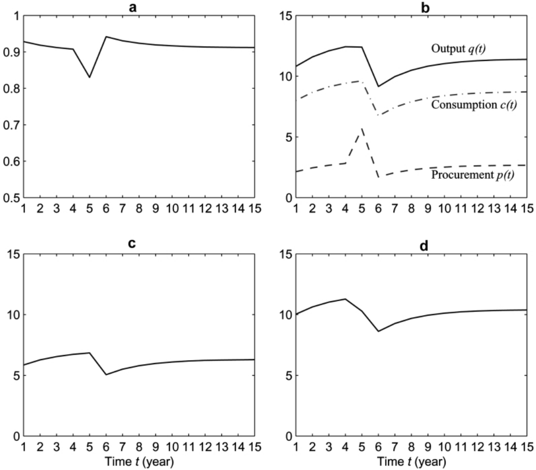


FIG. 1.—Simulated impact of the GLF: the combined effects of overoptimistic expectation and increased impatience: *a*, agricultural labor, $L(t)$; *b*, output, consumption, and procurement per agricultural worker; *c*, work capacity per agricultural worker, $h(t)$; *d*, aggregate agricultural output, $Q(t)$.

Test the Theory, Decompose Determinants of Decline in Agriculture Output

The Data

1. Resource diversion. Use incremental steel and iron production to proxy for diversion of rural labor to non agricultural GLF projects
2. Nutrition. Use data on procurement to proxy. Lagged value of retained grain proxies for food consumption today.
3. Weather.
4. Proportion of communes within province that allowed exit. If you can't exit, incentives to work must be poor.
5. Size of production units. Bigger communes means less incentive to work
6. Communal dining and radicalism. Communal kitchens implies wasted precious food. Use regional participation rates to get cross-sectional variation in participation, hence radicalism, hence waste.

Empirical specification for agriculture

- Textbook 2-factor Cobb-Douglas production function, $0 \leq \alpha \leq 1$,

$$\begin{aligned} Q &= K^{\alpha} L^{(1-\alpha)} \\ \rightarrow \ln Q &= \alpha \ln K + (1-\alpha) \ln L \end{aligned}$$

- Generalized Cobb-Douglas production (Effective inputs)

$$\ln Q_{i,t} = \alpha_L lnL^*_{i,t} + \alpha_A \ln A^*_{i,t} + \alpha_K \ln K^*_{i,t} + \alpha_M \ln M^*_{i,t} + u_i + \nu(t) + \epsilon_{i,t} + W_t \quad (7)$$

Starred variables are effective units

$$\ln Q_{i,t} = \alpha_K \ln K^*_{i,t} + \alpha_M \ln M^*_{i,t} + \underbrace{u_i}_{\text{F.E.}} + \underbrace{\nu(t)}_{\text{CTE}} + \epsilon_{i,t} + \underbrace{W_t}_{\text{weather}}$$
$$+ \underbrace{\alpha_L \ln L^*_{i,t}}_{\ln L^* = \ln L^G + \ln h + \gamma_Z \ln Z + \gamma_E \ln E + \gamma_S \ln S} + \underbrace{\alpha_A \ln A^*_{i,t}}_{\ln A^G + \gamma_I \ln I}$$

- $K^*_{i,t}$ effective capital.
- $M^*_{i,t}$ effective chemical fertilizers
- L^G Labor allocated to grain, h food for peasants
- A^* effective land area. A^G is unadjusted land
- I proportion of crop area irrigated
- Z size of production unit
- E dummy for exit rights,
- S surge in steel (resource displacement),

TABLE 5

ESTIMATION OF GRAIN PRODUCTION FUNCTION IN CHINA, 1952–77

Dependent Variable: ln(Grain Output)

EXPLANATORY VARIABLE	FIXED-EFFECT OLS			FIXED-EFFECT INSTRUMENTAL VARIABLES	
	(1)	(2)	(3)	(4)	(5)
ln(sown area)	.206**	.448***	.479***	.474***	.442***
	(.104)	(.088)	(.088)	(.092)	(.087)
ln(% acreage irrigated)		.131***	.129***	.127***	.110***
		(.029)	(.027)	(.025)	(.025)
ln(% acreage sown with grain)	.019	−.114	−.059	−.055	−.091
	(.059)	(.065)	(.083)	(.097)	(.092)
ln(fertilizer)	.012*	.033***	.022**	.019*	.025**
	(.007)	(.011)	(.010)	(.010)	(.010)
ln(farm capital)	.245***	.224***	.160***	.138***	.158***
	(.030)	(.027)	(.024)	(.030)	(.028)
ln(labor)	.578***	.532***	.311***	.284***	.343***
	(.107)	(.125)	(.087)	(.088)	(.100)
ln(food availability)			.180***	.267***	
			(.050)	(.077)	
Tercile 1 (low)					.271***
					(.108)
Tercile 2 (middle)					.246*
					(.137)
Tercile 3 (high)					.332**
					(.167)
ln(steel production)			−.093***	−.099***	−.090***
			(.027)	(.028)	(.028)
ln(communal dining)		−.083	−.045	−.076**	−.034
		(.073)	(.031)	(.037)	(.039)
ln(production unit size)		.008*	.014**	.013**	.012**
		(.005)	(.007)	(.006)	(.005)
No exit (de jure)		−.006	−.026	−.024	−.038
		(.022)	(.019)	(.018)	(.023)
Good weather		−.016	.006	.011	−.014
		(.021)	(.022)	(.017)	(.026)
Average weather		−.048**	−.036	−.034*	−.044*
		(.020)	(.023)	(.020)	(.025)
Bad weather		−.116***	−.080***	−.076***	−.081***
		(.027)	(.026)	(.023)	(.023)
Very bad weather		−.169***	−.161***	−.156***	−.158***
		(.031)	(.033)	(.036)	(.035)
Time trend		−.107***	−.018	−.002	−.014
		(.042)	(.033)	(.037)	(.034)
R^2	.704	.764	.805	.800	.791
Observations	624	551	428	406	406

TABLE 7
CONTRIBUTION OF EXPLANATORY VARIABLES TO THE GLF GRAIN OUTPUT COLLAPSE AND THE POST-GLF RECOVERY

Contributing Factors	The Collapse (1958–61) Changes in ln(Output) (1)	The Collapse (1958–61) % Contribution to Total Change (2)	The Recovery (1961–66) Changes in ln(Output) (3)	The Recovery (1961–66) % Contribution to Total Change (4)
Observed total change	−.352	−100.0	.445	100.0
Estimated total change	−.232***	−66.1	.315***	70.7
	(.038)		(.024)	
Procurement/nutrition	−.100***	−28.3	.042***	9.4
	(.029)		(.002)	
Resource diversion	−.116***	−33.0	.165***	37.1
	(.024)		(.029)	
Sown area	−.023***	−6.6	.010***	2.2
	(.005)		(.002)	
Farm capital	−.009***	−2.5	.041***	9.2
	(.002)		(.009)	
Labor	−.004***	−1.2	.035***	7.8
	(.001)		(.011)	
Steel production	−.080***	−22.6	.080***	17.9
	(.023)		(.023)	
Weather conditions	−.045***	−12.9	.052***	14.7
	(.008)		(.012)	
Policy factors	.019	5.5	−.013**	−3.0
	(.026)		(.006)	
Communal dining/radicalism	−.049**	13.9	.000	.0
	(.024)			
No exit (de jure)	−.001	−.3	−.001	−.2
	(.001)		(.001)	
Production unit size	−.029**	−8.1	−.012**	−2.8
	(.012)		(.005)	
Modern inputs	.011**	3.0	.055***	12.3
	(.005)		(.017)	
Fertilizer	.009*	2.6	.028*	6.4
	(.005)		(.015)	
% acreage irrigated	.0014***	.4	.026***	5.9
	(.003)		(.005)	
Miscellaneous	−.0014	−.4	.001	.3
	(.0131)		(.016)	
% acreage sown with grain	−.0008	−.2	.002	.5
	(.0014)		(.004)	
Time trend	−.0006	−.2	−.001	−.2
	(.0131)		(.015)	
Residuals	−.119***	−33.9	.130***	29.3
	(.038)		(.024)	