The Impacts of Self-Sufficiency Policies and Fiscal Decentralization on the Efficiency of Grain Production in China

Andrew J. Estrin*

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* Ph.D. Candidate in Agricultural and Resource Economics
University of California, Davis CA 95616
Tel: (530) 752-6456
estrin@primal.ucdavis.edu

1. *Overview*

Domestic grain output has long been a central concern in China since prior to the reform period (Carter, Zhong, and Cai; Huang; Sicular). However, reforms decentralizing fiscal budgets (Wong) and national policy encouraging grain production based on provincial self-sufficiency requirements (Carter, Zhong, and Cai; Sicular) contribute to economic inefficiency in grain production. This paper measures the extent of inefficiency in grain production that can be explained by self-sufficiency policies and by fiscal decentralization.

Commercial reforms in the 1980s permitted the diversification by households out of grain production and into more profitable non grain and rural industrial production (Findlay, Watson and Martin). However, while diversification out of grain production was permitted, households continued to supply grain in order to comply with self-sufficiency policies and, thus, retain their land use rights (Guo). Consequently grain was cultivated, in part, to comply with self-sufficiency policies rather than to maximize profits. This raises the possibility that grain production was inefficient - especially where opportunity costs to grain production were high (Turner, Brandt, and Rozelle). This hypothesis is tested.

Fiscal reforms giving local governments more responsibility for public revenue generation and expenditure may also have resulted in inefficiency in grain production. As the correlation between local revenues and expenditures grew (Wong) low-income provincial governments had fewer resources to invest in agriculture than their wealthier neighbors (Park et al). Consequently, these provinces were more likely constrained by the small sizes of their budgets from investing in agriculture at efficient levels. This hypothesis is also tested.

A multiple output distance function is used to derive expressions for a stochastic production frontier and economic inefficiency to analyze provincial level data for the years 1986-1992 for grain and rural industrial output. These expressions are estimated using maximum likelihood techniques and the findings suggest that agriculture in China could be made more efficient by: 1.) policies that encourage production according to comparative advantage rather than grain self-sufficiency, and 2.) fiscal reforms that increase the responsibility of the central government for agricultural investment.

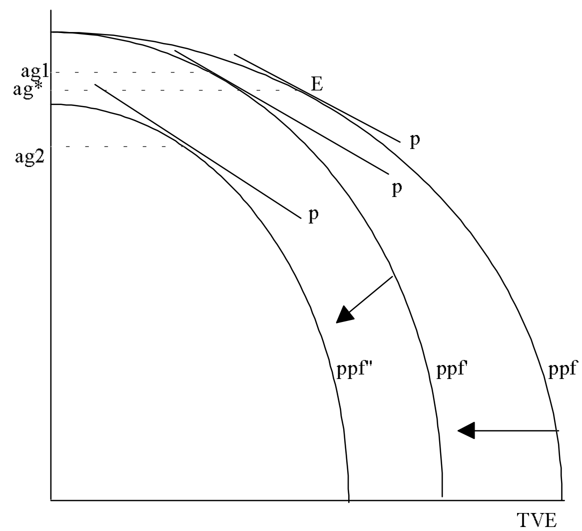
2. *The Conceptual Framework*

Figure 1 depicts the efficiency effects of self-sufficiency policies and fiscal decentralization in a low-income nonagricultural province. PPF represents the production possibility frontier. When agricultural production is inefficient then production will take place inside PPF. Efficient production takes place at point E where the marginal rate of transformation between agricultural and rural industrial production equals the ratio of their prices. The efficient level of grain production is Ag*.

Grain self-sufficiency policies require households to produce grain even if the returns to non-grain production are higher. This raises the possibility of inefficiency in grain production - especially in nonagricultural provinces - and is shown by the leftward shift in PPF to PPF'. The level of grain production rises to Ag1, however, production is less efficient since PPF' lies inside PPF.

Fiscal decentralization results in inefficiency in low-income provinces where small local budgets constrain the provision of inputs to technically inefficient levels. This is expressed as the parallel shift inward of PPF' to PPF" in Figure 1 reflecting additional losses in efficiency. The level of grain production drops to Ag2 from the combined losses in efficiency from fiscal decentralization and grain self-sufficiency policies.

Figure 1: **The Impacts of Self-sufficiency and Fiscal Decentralization on Low-Income, Nonagricultural Provinces**



2. The Methodology

The estimation methodology relies on the concept of a stochastic production frontier. Recent studies of technical efficiency that use stochastic frontier methodology build on the works of Aigner, Lovell, and Schmidt; and Meeusen and Van den Broeck. Stochastic frontier methods to study agricultural efficiency in China are used by Dong; who uses village and household level data, Fan (1991); who uses province level data, and Wang, Wailes, and Cramer; who use household level data. An important distinguishing factor of this study is the use of a multiple output distance function to derive the expressions to be estimated. The use of local government budget expenditures and revenues as well as local and central government agricultural capital as determinants of inefficiency is another distinguishing factor.

The production frontier is defined as the "best practice technology" which represents the maximum amount of output that is possible using a given amount of inputs (Farrel). Economic inefficiency in production can be measured as a deviation from the production frontier. The output distance function provides the conceptual framework for defining a stochastic production frontier and for measuring the extent that actual production deviates from the frontier. It was introduced by Shephard in 1970 and has been used in a number of economic studies such as by Battese and Coelli; Coelli and Perelman; and Morrison, Frengley, and Johnston.

A Cobb-Douglas specification of a distance frontier can be expressed in logarithm form as,

Eq. 1. $\ln D_{oi}(X, Y) = \beta_0 + \Sigma_m \beta_m \ln X_{mi} + \Sigma_j \beta_j \ln Y_{ji} + \beta_t T$

for each province i, inputs X_m, outputs Y_j, and for time T, and the β_i are the relevant parameters.

Homogeneity of degree of 1 in outputs is required for the distance function and can be imposed by choosing a numeraire output (Coelli and Perelman). Thus,

Eq. 2. $\ln D_0(X, \frac{Y}{y_n}) = \ln(D_0(X, Y)/y_n) = \ln D_0(X, Y) - \ln(y_n)$

where y_n is the chosen numeraire output of the output vector Y.

By subtracting $\ln D_0(X,Y)$ from both sides an expression for the numeraire output is obtained.

Eq. 3. $-\ln y_{ni} = \beta_0 + \Sigma_m \beta_m \ln X_{mi} + \Sigma_l \beta_l \ln Y^*_{li} + \beta_t T + v_i - \ln D_i(X, Y)$

where l represents the vector of outputs, j not equal to n, and Y_l^* is the normalized output of y_l

Since $\ln D_i(X,Y)$ represents the deviation from the frontier for production in province i, we make the assumption that some of this deviation is systematic while some of it is random "noise". If we let $-\ln D_{0i}(X,Y) = u_i$, change the sign of $\ln y_{ni}$ on the right hand side we can express the stochastic production frontier and inefficiency equations as,

Eq. 4. $\ln y_{ni} = \beta_0 + \Sigma_m \beta_m \ln X_{mi} + \Sigma_l \beta_l \ln Y_l^* + \beta_t T + v_i + u_i$

and,

Eq. 5. $\mu_i = \Sigma_g \delta_g Z_{gi}$

where,

$\mu_i = E(\exp(u_i | \varepsilon_i)$ and $\varepsilon_i = v_i - u_i$ following Jondrow et al.

The expected level of inefficiency u_i given observed ε_i is restricted to being the positive truncation of the normal distribution with mean 0 and variance σ_u^2 such that the point of truncation is $-\Sigma_g Z_{gi}\delta_g$ (Morrison, Frengely, and Johnston).

$\Sigma_g Z_{gi}$ is the vector of determinants of economic inefficiency in province i, and

δ_g is the marginal effect of determinant Z_g to be estimated.

The unknown parameters of the distribution can be estimated using maximum likelihood techniques with the computer program FRONTIER version 4.1 by Tim Coelli.

3. Data

Provincial level data for the years 1986-1992 from a variety of sources is used in the analysis. Cost of production data on labor and fertilizer come from the updated data set used by Huang and Rozelle. This comes from a national ‘Cost of Production’ survey of farm households conducted annually between the mid 1970s and the early 1990s and contains detailed information on labor and fertilizer use by crop variety.

Data for new central water conservancy construction come from Fan and from China Agricultural Yearbooks (Various Years). Data on government new water conservancy construction is from all levels of government and are compiled from current values of completed construction projects. These figures are aggregated to stock figures with capital prior to 1986 normalized to being zero. Real values of government investment for each province were computed by multiplying the share of nominal total investment for each province and year by the real total investment for each year found in tables in the Fan text. An annual depreciation rate of 3.3% is assumed which is consistent with a life expectancy of irrigation systems of about 30 years (Huang, Rosegrant, and Rozelle). Real values of fixed productive agricultural capital from township governments are then subtracted from the aggregate value of all government stocks to obtain stocks from all levels of government excluding those from local township governments.

Local government stocks of fixed agricultural capital are computed from data on rural collective fixed capital investment obtained from Fan and from China Agricultural Yearbooks (Various Years). Rural collective investment in fixed capital includes that for all productive investment. Data on township-village enterprise (TVE) fixed capital were subtracted from the collective fixed capital to obtain agricultural fixed capital. Since this figure includes capital used in social services, forestry, and animal husbandry, its use in agriculture may be overstated.

TVE fixed capital, profits and rates of return to variable inputs in the TVE sector were compute from data obtained from the China Agricultural Yearbooks. Data for the areas cultivated and quantities produced of rice, wheat, maize, and soybeans were obtained from Jikun Huang and come from SSB (various years). Budgetary revenues and expenditures were obtained from province level budget data from the Ministry of Agriculture and supplied by Funing Zhong.

To account for potential systematic error in the measurement of inputs local and central government investment and cultivated areas were estimated using two stage least squares and their predicted values were used in the maximum likelihood estimation. The measurement error was assumed to result from the dependence of each of these variables on unobserved agricultural characteristics such as technologies, agricultural potential, other policies, etc.

4. The Results

The results from the stochastic production frontier estimation of four models are reported in Table 1. The two models (Models 1 and 2) differ by the specification of inefficiency. Model 1 includes interaction between government capital and dummies for low and high per-capita income provinces as part of the inefficiency specification. Model 2 includes interaction between budgetary revenues and expenditures and low and high per-capita income dummies in the inefficiency specification. In addition, Model 1 includes extra-budgetary revenues and expenditures in the inefficiency specification while Model 2 does not.

Geographic regional dummies designed to capture climatic and other broad geographic agricultural characteristics are important determinants of the frontier in both models. Northeast, and East regional dummies are significant in both models and the Northwest regional dummy is also significant in Model 1 as well. Evidence that rural industry and grain are output substitutes is weak since the coefficients in both models on normalized net rural industrial profits are not significantly different from zero. However, the signs on both of these coefficients are negative suggesting that they are output substitutes. In addition, the coefficient on the multi-cropping index is not a significant determinant of the frontier in either model.

Fertilizer, labor, local agricultural capital and central water conservancy capital are all significant and of the positive signs. Cultivated areas are significant in Model 2 with a smaller than expected coefficient (0.062) and not significantly different from zero in Model 2. The smallness of the coefficient on cultivated are is interpreted as the result of multicolinearity among fertilizer, labor, cultivated areas. Thus, a portion of the coefficients attributed to labor and fertilizer should be attributed to cultivated area. The time trend is negative and significant in both models (-0.03, -0.04 for models 1, 2 respectively) reflecting the trend away from grain production. Evidence that the expressions for inefficiency explain deviations from the frontier is strong as the proportion of the total variance that is explained by inefficiency (Gamma) are significantly different from zero in both models (0.857 and 0.94 in Models 1 and 2 respectively).

Evidence that inefficiency is greater in low-income versus high income provinces is strong. The coefficients on the low-income province dummy is significantly different from zero in Model 1 (4.23) while that for high income province dummy in that model is not. This captures technical inefficiency in agriculture in low-income relative to high income provinces. Furthermore, while neither coefficient on low or high income dummies is significantly different from zero in Model 2, their interaction with budget revenues and expenditures is significant. In model 2 the coefficient on low-income interaction with budget revenues is negative and significant suggesting that budgets may constrain efficient agricultural investment in low-income provinces. The interaction of the low-income dummy with budget expenditures is positive and significant in Model 2 suggesting that low income provinces spend their budgets outside of agriculture. This is consistent with expenditure incentives that result from fiscal decentralization where local governments invest in local industry since most fiscal revenues are derived from local industry while almost no fiscal revenue is derived from agriculture (Rozelle).

The results from both models suggest that producers in nonagricultural provinces are significantly less efficient producers than their neighbors in agricultural provinces. The coefficients on the nonagricultural dummies in models 1 and 2 were positive and significant (0.245 and 0.679 respectively). In addition, neither of the coefficients on the agricultural province dummies in Models 1 and 2 were significantly different from zero. These results support the hypothesis that grain self-sufficiency policies have contributed to inefficiency in nonagricultural provinces.

The coefficients on extra-budgetary revenues and expenditures as well as those on year in both inefficiency specifications are not significantly different from zero. The insignificance of extra-budgetary revenues and expenditures in Model 1 combined with the significance of on-budget revenues and expenditures reported for Model 2 suggests the latter's superiority as a measure of fiscal decentralization. However, colinearity between local investment and extra-budgetary revenues and expenditures in Model 1 may also explain the insignificance of extra-budgetary finance. Consequently, some of the impact on inefficiency that is attributed to local agricultural capital should likely be attributed to extra-budgetary revenues and expenditures.

Table 2 reports the efficiencies of 20 provinces based on 1986 per-capita grain production classification. The efficiencies range from a low of 44% in Liaoning province in 1989 to a high of 99% in Shandong province in 1991. The average efficiency of grain production for the years 1986 - 1992 is the lowest in low-per-capita grain producing provinces at 82% compared with 91% and 92% in mid-range and high per-capita grain producing provinces respectively. The suggests the inefficiency impacts of grain self-sufficiency policies.

The high efficiencies of mid-range per-capita grain producers relative to nonagricultural producers suggests the dominance of self-sufficiency impacts on inefficiency over those from fiscal decentralization. That is, two thirds of the mid-range grain producers (Henan, Sichuan, Guangxi, and Anhui provinces) are also low income provinces and are thus more likely to face budget constraints. This is true for fewer than one third of the nonagricultural provinces (Shaanxi, Guizhou, and Yunnan provinces). Consequently, the relatively high mean efficiency in mid-range producers is implies that the inefficiencies that result from grain self-sufficiency policies is more important than those that result from fiscal decentralization.

5. *Summary and Conclusion*

This paper has considered the impacts that policies of fiscal decentralization and grain self-sufficiency have had on economic inefficiency in agriculture. The incidence of inefficiency from policies of fiscal decentralization is hypothesized to be greater in low-income provinces while that from self-sufficiency policies is hypothesized to be greater in nonagricultural provinces. To measure the effects of these policies on agricultural efficiency a stochastic production frontier and an expression for inefficiency are estimated simultaneously using province level data for the years 1986-1992 for grain and rural industrial output.

Table 1: **Results for Models with Different Inefficiency Specifications**

	(1) ln (Grain Output): Income Interaction with Capital	(2) ln (Grain Output): Income Interaction with Revenues and Expenditures
Intercept	634*	87*
	(2.82)	(3.6)
Northeast Dummy	0.837*	0.833*
	(13.0)	(12.8)
North Dummy	0.080	0.084
	(1.0)	(1.38)
Northwest Dummy	0.237*	0.019
	(2.24)	(0.343)
East Dummy	0306*	0.282*
	(3.42)	(5.41)
Central Dummy	0.058	0.092*
	(1.23)	(2.30)
Southeast Dummy	0.053	0.052
	(1.07)	(1.11)
ln (Multi-Cropping Index)	0.101	0.103
	(1.25)	(1.16)
ln (TVE Net Profits / Grain Output)	-0.0243	-0.0176
	(-0.944)	(-0.699)
ln (Fertilizer)	0.230*	0.254*
	(3.85)	(8.99)
ln (Labor)	0.700*	0.630*
	(6.79)	(11.3)
ln(local Agricultural Capital)	0.0764*	0.089*
	(2.54)	(4.69)
ln(Central Water Conservancy Capital)	0.0813*	0.087*
	(2.04)	(3.41)
ln (Cultivated Area)	0.0455	0.062*
	(0.717)	(1.89)
Year	-0.035*	-0.047*
	(-3.08)	(-3.9)
Sigma-squared	0.0147*	0.037*
	(3.32)	(1.99)
Gamma	0.857*	0.94*
	(8.19)	(23.9)
Intercept	-83.02	45.2
	(-1.12)	(0.609)
Low Income/Capita Dummy	4.23*	-0.377
	(2.13)	(0.735)
High Income/Capital Dummy	4.84	0.852
	(1.69)	(0.1.34)
Low Grain/Capita Dummy	0.245*	0.679*
	(2.35)	(2.2)
High Grain/Capita Dummy	-0.116	-0.047
	(-0.477)	(0.189)
(1) ln (Local Government Capital) x Low Income/Capita	-0.055	-0.00000486*
(2) ln (Budgetary Revenues) x Low Income/Capita	(-0.654)	(-2.0)
(1) ln (Local Government Capital) x High Income/Capita	-0.105	0.00000054
(2) ln (Budgetary Revenue) x High Income/Capita	(-1.46)	(1.1)
(1) ln (Central Water Conservancy Capital) x Low Income/Capita	-0.165*	0.0000005*
(2) ln (Budgetary Expenditures) x Low Income/Capita	(-2.52)	(2.1)
(1) ln (Central Water Conservancy Capital) x high Income/Capita	-0.171	-0.0000006
(2) ln (Budgetary Revenues x High Income/Capita	(-1.58)	(-1.3)
Ln (Extra-Budgetary Expenditures)	0.160	
	(0.745)	
Ln (Extra-Budgetary Revenues)	0.140	
	(0.626)	
Year	0.039	-0.023
	(1.07)	(-0.626)

note: t-statistics are in parentheses.

* indicates statistical significance at the 90% level.

Table 2: **Efficiencies for Provinces by 1986 Per-Capita Grain Production Group** [1]

Low Grain/Capita	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**mean**
Shaanxi	0.818	0.844	0.799	0.818	0.793	0.856	0.832	0.82
Guangdong	0.786	0.823	0.791	0.823	0.86	0.908	0.888	0.84
Fujian	0.876	0.942	0.951	0.982	0.945	0.992	0.918	0.94
Guizhou	0.857	0.988	0.872	0.862	0.928	0.981	0.867	0.91
Yunnan	0.694	0.715	0.715	0.621	0.619	0.683	0.655	0.67
Liaoning	0.633	0.667	0.676	0.443	0.701	0.779	0.793	0.67
Shanxi	0.85	0.88	0.919	0.879	0.876	0.995	0.959	0.91
mean	0.79	0.84	0.82	0.78	0.82	0.88	0.84	0.82
Mid-Range Grain/Capita								
Henan	0.786	0.979	0.924	0.925	0.931	0.983	0.991	0.93
Sichuan	0.973	0.978	0.88	0.796	0.843	0.925	0.865	0.89
Guangxi			0.708	0.814	0.868	0.979	0.975	0.87
Hebei	0.85	0.88	0.919	0.879	0.876	0.995	0.959	0.91
Anhui	0.992	0.99	0.938	0.902	0.864	0.736	0.956	0.91
Zhejiang	0.971	0.963	0.899	0.829	0.831	0.989	0.934	0.92
mean	0.91	0.96	0.88	0.86	0.87	0.93	0.95	0.91
HighGrain/Capita								
Shandong	0.841	0.975	0.867	0.802	0.849	0.99	0.928	0.89
Hubei	0.989	0.975	0.995	0.964	0.984	0.92	0.978	0.97
Hunan	0.949	0.93	0.883	0.919	0.899	0.959	0.927	0.92
Jiangsu	0.92	0.992	0.924	0.866	0.852	0.861	0.893	0.90
Heilongjiang	0.987	0.929	0.961	0.687	0.948	0.958	0.958	0.92
Jilin	0.869	0.99	0.951	0.685	0.982	0.993	0.897	0.91
Jiangxi	0.861	0.916	0.831	0.844	0.909	0.986	0.946	0.90
mean	0.92	0.96	0.92	0.82	0.92	0.95	0.93	0.92

[1] Efficiencies are computed using the results of model 1 from the specification reported in Table 1.

The findings indicate that grain production in nonagricultural provinces is comparatively inefficient. This is attributed to grain self-sufficiency policy. In addition, grain production in low-income provinces is comparatively inefficient since the small sizes of their fiscal budgets constrain agricultural investment to inefficient levels. This is attributed to fiscal decentralization.

The computed provincial efficiencies suggest that the inefficiency effects from grain self-sufficiency policies are greater than those from fiscal decentralization. The findings suggest that grain production in China could be made more efficient by: 1.) fiscal reforms that increase the responsibility of the central government for agricultural investment, and 2.) policies that encourage production according to comparative advantage rather than grain self-sufficiency.

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