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Market Reforms Versus Structural Reforms in Rural China

by

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Abstract

This paper adds to the debate on the impact of market reforms versus structural reforms in explaining agricultural output growth in China. A multiple-output stochastic frontier and a technical inefficiency equation are estimated using provincial data on the rural economy from 1986 to 1995. Grain self-sufficiency policies and incomplete market reforms in the 1980s and 1990s led to allocative inefficiency. Agricultural disinvestment shrunk the production frontier and the fragmentation of land holdings reduced technical efficiency. China's rural economic reform is far from being complete.

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1. Introduction

China's success in rural economic reform has attracted considerable attention in the literature and the sources of productivity gains in China's agriculture have been widely studied (Fan, 2000; Fan, 1991; Fan and Pardey, 1992; Huang and Rozelle, 1996; Lin, 1992; McMillan, Whalley, and Zhu, 1989; Zhang and Carter, 1997; Yao and Liu, 1998; and Wang, Wailes, and Cramer, 1996). However, disagreement about the relative importance of structural reforms versus market reforms in the 1980s and 1990s as sources of rural economic growth remains in the literature. Even though the relative importance of allocative versus technical efficiency gains is central to this debate, with the exception of Wang, Wailes, and Cramer (1996) and Fan (2000), previous studies have failed to distinguish clearly between the two measures of efficiency. In addition, previous studies focus on a subset of agricultural production and omit the importance of rural industrial production from the analysis.

Pre-reform collective farms in China are believed to have been technically inefficient because of the principal-agent problem associated with the high cost of monitoring effort under the old production team system (Nolan, 1988). The introduction of the household reforms in 1979 is commonly credited for addressing this source of inefficiency (Lin, 1992). However, other important sources of inefficiency in the post-reform period have not received much attention. For example, the breakup of collective farms resulted in small and fragmented farm units. This policy is thought to have contributed to technical inefficiency by preventing the realization of gains from scale economies. Furthermore, the dramatic decline in the rate of agricultural investment in the 1980s and the subsequent deterioration of the agricultural infrastructure (Fan, 1995; Stone, 1993) is thought to have contributed to diminished agricultural productivity growth.

In this paper, we link market reforms explicitly to measures of allocative efficiency in China and relate structural reforms to local investment and technical efficiency. Our analysis incorporates the grain, cash-crop, and rural industrial sectors. We find that both market and structural reform policies had important implications for productivity growth during the period from 1986 to 1995.

A farm is technically inefficient if it fails to produce the maximum level of output for a given technology and for specific amounts of inputs. In such a situation, the farm is operating inside the production set. When data on farms are aggregated to the provincial level, technical inefficiency can result not only from the internal mis-management of the farm but also from external factors related to industrial structure and government policies. In contrast, allocative efficiency refers to the correct allocation of inputs and the optimal production of output, based on specified input and output prices. If input and output markets are competitive, profit maximization leads to allocative efficiency under well-known conditions. Incomplete rural market reforms in China, including the persistence of non-price incentives to ensure regional grain self-sufficiency, are believed to have caused allocative inefficiency in rural production.

In China, the growth rate of the total factor productivity index (TFPI) in agriculture rose dramatically from 1978 and peaked around 1984 (Wen, 1993). The estimated TFPI growth rate was 8.1% from 1978 to 1984, and declined to 2.4% from 1984 to 1989. There are two competing explanations for the decline in productivity growth after 1985. The one-off privatization school believes that the 1979 reforms induced one-time productivity gains from privatization of farming (McMillan, Whalley, and Zhu, 1989; Fan, 1991; Lin, 1992) and that the subsequent slowdown in growth was to be expected. This explanation does not take into account the costly impact of farm fragmentation on post-reform agriculture. Nor does it consider the impact of dramatically reduced rates of investment in the agricultural sector in the 1980s resulting from fiscal reforms.

The other school of thought, the market-reform school, asserts that market liberalization was more important to increasing productivity than the decollectivization of farms (Sicular, 1993; Huang, 1998). This group attributes the slowdown in output growth in the mid-1980s to a reassertion of government controls over marketing, and emphasizes the relative importance of marketing reforms and price signals. These signals were positive in the early reform period but became negative after 1984, when the government failed in its efforts to liberalize the grain markets and reinstated mandatory procurement controls (Sicular, 1993). This paper measures the extent of allocative versus technical inefficiency in Chinese agriculture, and identifies the main sources of inefficiency. We examine rural productivity in a comprehensive way, using data on a number of activities and conducting the analysis within a single framework. Structural and market sources of productivity change must be distinguished to determine priorities for further reform and to understand where future productivity gains may lie.

The remainder of this paper is structured as follows. Section 2 discusses the structural reforms that led to agricultural disinvestment and land fragmentation, and market distortions including non-price incentives for grain production. Section 3 discusses our methodology, data, and model specification, and section 4 interprets the findings. The last section draws policy implications.

2. Structural Reforms, Market Reforms, and Efficiency

Beginning in the early 1980s, agricultural disinvestment in China resulted from fiscal reforms that linked local governments' expenditures to their tax revenues (Fan, 1991; Stone, 1992).

Local governments obtained most of their tax revenues from the industrial sector rather than from agriculture (Wong, 1992). The taxation of agriculture was largely implicit in the form of low procurement prices, which bypassed local governments (Huang, 1998). Consequently, the fiscal reforms increased incentives for local government investment in rural industry relative to agriculture (Wong, 1992).

In particular, the fiscal reforms precipitated the growth of local investment in township-village enterprises (TVEs) following the rural industrial reforms instituted in 1985 (Findlay, Watson, and Martin, 1993). The revenues generated by these industries became an important source for local budgets (Dong, 2000). Dong reported that 70 percent of the budget revenues from the villages she surveyed in Shanxi province in the early 1990s were generated from TVEs. At the same time, local investment in agriculture declined and Fan (1995) reported that annual public investment in fixed agricultural assets fell dramatically from 7.27 to 3.38 billion yuan, in real terms with 1980 as the base year, between 1979 and 1981. After 1981, real annual public investment in agriculture rose gradually to reach pre-reform levels by 1994 (Fan, 1995). The financial stake that local governments had in the rural industrial sector is thought to have resulted in the disinvestment and mis-management of the agricultural infrastructure. For instance, a rise in poorly financed and inadequately maintained irrigation facilities and an increasing number of inoperative tube wells in the 1980s is reported by Stone (1993).

The small and highly fragmented farming units that arose from the household responsibility reforms of 1979 is believed to have contributed to technical inefficiency in agriculture. Chen, Davis, and Wang (1997) report that the average area cultivated per household was 0.47 hectares and the average number of plots per household was 3.16 in 1992 (Chen, Davis, and Wang, 1997).

These authors suggest that the small farm sizes and high degree of farm fragmentation prevented households from realizing gains from scale economies.

Non-price incentives for grain production contributed to allocative inefficiency in rural production in China. From the 1950s through the mid-1980s, there was substantial central government price and quantity intervention in the grain market (Huang, 1998; Sicular, 1993). China's development strategy was based on urban industrial development and grain policy was an important component of the strategy (Findlay, Watson, and Martin, 1993). In particular, each province was encouraged to be self-sufficient in grain production and to supply low priced food for its urban workers in order to increase the profitability of state-owned industries (Huang, 1998).

The state's grain procurement and distribution monopoly assured the provision of low-priced grain through rigid controls on production and by paying below world-market prices to grain producers. In addition, central policies prohibited diversification and the transfer of resources out of grain production (Huang, 1998). Local governments enforced household compliance with central grain policy objectives and production quotas.

Grain market reforms began in the early 1980s. The household responsibility system permitted households to diversify out of grain production, once grain procurement quotas had been satisfied. As a result, agricultural production grew rapidly (Lin, 1992). In addition, the fixed grain procurement prices were replaced by contract and above-contract prices that were negotiated directly with household producers (Sicular, 1993). Sicular (1995) reports that procurement agencies competed with non-state grain buyers and that negotiated contract prices were influenced by free market prices. Carter and Zhong (1991) find that farmers began to produce more in line with their comparative advantage.

As resources shifted out of grain production in the mid-1980s, the central government became increasingly concerned with meeting grain self-sufficiency objectives. The preoccupation with grain self-sufficiency resulted in the reinstatement of central controls and non-price incentives for grain production several times in the late 1980s (Sicular, 1993) and into the 1990s (Crook, 1997). With the absence of land markets, land allocation was made by local leaders and frequently linked to grain quota fulfillment (Li, Rozelle, and Brandt, 1998). Such intervention also affected the distribution of fertilizer and other inputs (Sicular, 1993). As an indication of the influence of non-price incentives, Huang (1998) shows that grain production responded more to policy directives than to the agricultural - industrial terms of trade in the late 1980s.

In summary, the previous literature has found that underlying structural and market policy developments have affected China's rural productivity in the 1980s and 1990s. Fiscal reforms adverserly affected levels of agricultural investment, and the breakup of the communes resulted in small and fragmented household farms and this led to technical inefficiency. In addition, incomplete market reforms and the use of non-price incentives for grain production led to allocative inefficiency in rural production. The methodology discussed in the next section provides a framework to measure determinants of rural production growth in China, including the importance of technical versus allocative efficiency. We include the grain, cash-crop, and rural industrial sectors in the empirical analysis.

3. Methodology, Data and Model Specification

We use stochastic frontier methodology to estimate a multiple output distance function to both identify and measure the sources of productivity growth. Stochastic frontier methodology was developed by Aigner, Lovell, and Schmidt (1977); and Meeusen and Van den Broeck (1977).

The distance function was introduced by Shephard (1970) and has been used in a number of studies (Coelli and Perelman, 2000). It is based on the concept of a production frontier, which represents the maximum vector of outputs, **Y** = (Y_1 , , ,Y_j), that is possible to produce using a given vector of inputs **X** = (X_1 , , , X_m) (Farrel, 1957). The output distance function, $D_0(X,Y)$, is defined on the output set, P(x), as:

$$D_0(X,Y) = \min(\theta : (y/\theta) \in P(X)), \tag{1}$$

where θ is defined as a distance parameter which is less than or equal to 1.

D_0 (X,Y) is non-decreasing, homogeneous of degree one, convex in all Y, and decreasing in all X. Furthermore:

$$D_0(X,Y) \leq 1, \tag{2}$$

where $D_0(X,Y) = 1$, if Y is on the production frontier.

A deterministic Cobb-Douglas specification for the distance function can be expressed in logarithmic form for each province i, inputs X_m, outputs Y_j, and time T as:

$$\ln D_{0i}(X,Y) = \beta_0 + \sum_m \beta_m \ln X_{mi} + \sum_j \beta_j Y_{ji} + \beta_t T, \tag{3}$$

where β_0, β_m, β_j, and β_t are the relevant parameters. Homogeneity of degree of 1 in outputs can be imposed by choosing a numeraire output (Coelli and Perelman, 2000). Thus, we have:

$$\ln D_{0i}(X,\frac{Y}{y_n}) = \ln(D_{0i}(X,Y)/y_{ni}) = \ln(D_{0i}(X,Y)) - \ln(y_{ni}), \tag{4}$$

where y_n is the chosen numeraire for the output vector **Y**.

By appending a symmetric error term, ν_i, and subtracting $\ln D_{0i}(X,Y)$ from both sides, the following expression for numeraire output is obtained:

$$-\ln y_{ni} = \beta_0 + \sum_m \beta_m \ln X_{mi} + \sum_l \beta_l \ln Y_{li}^* + \beta_t T + v_i - \ln D_{0i}(X,Y), \qquad (5)$$

where l represents the vector of outputs, $j \neq n$, and Y_{li}^* is the normalized output Y_{li}.

By setting $-\ln D_{0i}(X,Y) = u_i$ and changing the sign of $\ln y_{ni}$ on the right hand side of equation (5), we can express the stochastic production frontier and inefficiency equations, respectively, as:

$$\ln y_{ni} = \beta_0 + \sum_m \beta_m \ln X_{mi} + \sum_l \beta_l \ln Y_{li}^* + \beta_t T + v_i + u_i \qquad (6)$$

and,

$$\mu_i = \sum_g \delta_g Z_{gi}, \qquad (7)$$

where,

$\mu_i = E(\exp(u_i | \varepsilon_i))$ and $\varepsilon_i = v_i + u_i$,

Z_{gi} are the determinants of technical inefficiency in province i, and

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

Equation (7) follows the approach in Jondrow et al. (1982). 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, Johnston, and Frengely, 2000). The unknown parameters of the distribution can be estimated using maximum likelihood techniques, with the computer program FRONTIER version 4.1 (Coelli,1994).

The duality properties of the distance function allows Shephard's lemma to be applied (Grosskopf, Margaritis, and Valdmanis, 1995). Thus, we have:

$$\frac{\partial(D(X,Y))}{\partial y_m} = r_m(X,Y), \tag{8}$$

where $r_m(X,Y)$ is the shadow price of output m. The condition for allocative efficiency can be expressed as:

$$\frac{r_m}{r_n} = \frac{p_m}{p_n}, \tag{9}$$

where p_l with l=m,n are the actual output prices for m and n. Profits and welfare are maximized if the relative shadow output price ratio equals the actual output price ratio for outputs m and n.

Annual provincial data on rural industrial production, cash crop production, fertilizer utilization, rural population, local public capital stock, and area cultivated, are used to specify the empirical counterpart of the production frontier given by equation (6). The impact of disinvestment in agriculture by local governments in the 1980s is measured by the local public capital stock variable. Equation (7) is the technical inefficiency equation, and it is empirically specified by the ratio of cultivated area per-capita and the multiple cropping index. Cultivated area per-capita captures the efficiency effects of land fragmentation. The multiple cropping index is included in the inefficiency equation to control for the effect of fixed factor utilization rates that might otherwise contaminate the measurement of the impact of farm fragmentation.

Dummy variables for seven geographic regions are used in the frontier equation to capture the effects of fixed regional agricultural and industrial conditions. For example, the Northeastern provinces of Hebei, Liaoning, Heilongjiang, and Jilin have short growing seasons and are located relatively close to the industrial and international trade centers of Beijing and Tianjin. Alternatively, provinces in the South; e.g. Fujian and Guangdong, have long growing seasons and, in addition, have unique foreign investment relationships with Taiwan and Hong Kong.

Provincial level data from 1986 to 1995, obtained from yearbooks published by the State Statistical Bureau, are used to construct the data set. Rural population data obtained from the *China Statistical Yearbook* (State Statistical Bureau, various years) are used to reflect the total labor force employed in either agriculture or rural industry. Data on kilowatt hours of rural electricity consumption, obtained from the same source, are used to reflect rural industrial output. Data on tons of nitrogen fertilizer utilization, grain production, and cultivated and sown areas are also obtained from the *China Statistical Yearbook* (State Statistical Bureau, various years). The area sown to non-grain crops is used to reflect cash crop production.

The real value of rural collective fixed capital stock is computed from nominal rural collective fixed capital investment data, obtained from the *China Statistical Yearbook on Investment in Fixed Assets, 1950-1995* (State Statistical Bureau, 1996). Rural collective fixed capital investment data includes all fixed capital investment under the management of rural district, township, and village governments and covers investment in enterprises, schools, clinics, credit cooperatives, as well as in agriculture. Nominal rural collective fixed capital investment is deflated by the aggregate general price index for rural areas with 1985=100, obtained from the *China Statistical Yearbook* (State Statistical Bureau, 1996). Cumulative real investment is then used to reflect local capital stock levels, by assuming a depreciation rate of 3.3%. The initial capital stock in 1986 is estimated by assuming that the mean level of capital investment from 1986 to 1988 was the replacement value for the 1985 capital stock.

The ratio of cultivated area in 1,000 hectares to rural population in 10,000 persons is used in the inefficiency specification to capture the effects of land fragmentation on the realization of gains from scale economies. Provinces with high ratios of cultivated area per-capita, i.e. land abundant provinces[2], are assumed to have experienced less land fragmentation due to the larger plot sizes. The multiple cropping index, i.e., the ratio of sown area to cultivated area is used in the inefficiency specification to control for the intensity of fixed input utilization. The rural manufactured goods price index with 1975=100 and the price indexes for grain and industrial crop production are obtained from the *China Statistical Yearbook* (State Statistical Bureau, various years). These price indexes are used, along with the estimated marginal rate of technical transformation, to construct the test statistics for allocative efficiency.

4. Empirical Results

Table 1 reports the results of the joint estimation of the production frontier and the technical inefficiency equations represented by equations (6) and (7) in the previous section. The results of three alternative model specifications are reported. Model 1 uses rural electricity consumption to reflect rural industrial output and acreage sown to cash crops to reflect cash crop output. Model 2 omits rural industrial output from the specification; and model 3 omits cash-crop output from the specification. The log likelihood function for model 1 is the largest of the 3 models, indicating its superior explanatory power.

[Table 1]

The results indicate that fixed regional characteristics are important determinants of the rural production frontier, including grain, cash crops, and TVE output. The coefficients on 5 of the regional dummies are significantly different from zero in each of the models. The signs and magnitudes of the coefficients on these dummies reflect the fixed production effects relative to those of the omitted Southwest region. From model 1, the fixed effect of the Northwest region shrinks the production frontier compared to the Southwest region. In contrast, the coefficients of the Northeast, Central, and South regions shift the production frontier outward compared to the

Southwest region. These results are expected given that the economy of western China is backward relative to the east. The western provinces are also much colder and drier compared to those in the east.

The coefficients on cash crop production, reflected by the area sown to non-grain crops reported for models 1 and 2 in Table 1, are negative and statistically significant. In addition, the coefficients on rural industrial production, reflected by rural electricity consumption, are negative and statistically significant in models 1 and 3. These results support the use of a multiple-output specification and suggest that both rural industrial production and cash-crop production are substitutes for grain production.

The coefficients on fertilizer utilization reported in Table 1 are statistically significant and positive in all model specifications. In addition, the coefficients on rural population and cultivated land area are statistically significant and positive in all models. Using the coefficients from model 1, an increase in fertilizer utilization by 10% would have resulted in an increase in rural production by an estimated 0.3%. Similarly, a 10% increase in the rural population would have increased rural production by an estimated 6% and a 10% increase in cultivated land area would have increased rural production by an estimated 2.8%.

The coefficients on local capital stock reported in Table 1 are statistically significant and positive in all models. Using the coefficients from model 1, a decline in the local government capital stock by 10%, would have resulted in a decline in rural production by an estimated 0.6%. This finding supports the hypothesis that disinvestment in the agricultural infrastructure in the 1980s and early 1990s resulted in diminished rural production growth. Finally, the time trends in the frontier specifications reported for models 1 and 2 are statistically significant and positive suggesting positive technical change during the time period.

The relatively large t-statistics reported for gamma for all model specifications reported in Table 1 indicate that technical inefficiency is statistically significant. Gamma represents the share of the total output variance that is attributed to negative deviations from the frontier. In addition, the coefficients on the multiple cropping index in the inefficiency equation are statistically significant and of the expected sign in all model specifications. Using the coefficients from model 1, if the multiple cropping index had increased by 10%, efficiency in rural production would have risen by an estimated 22%.

For the inefficiency equation, expressed as equation (7), the coefficients on cultivated area per-capita are negative and statistically significant for all model specifications. This finding supports the hypothesis that land fragmentation limited the realization of gains from scale economies. Using the coefficient from model 1, an increase in the land per-capita ratio by 10% would have increased the efficiency of rural production by an estimated 12%. Finally, the coefficients on the time trend in the inefficiency specifications reported for models 1 and 2 are positive and statistically significant, suggesting a positive trend of inefficiency during the time period studied.

Figure 1 depicts the frequency distribution of the average annual technical efficiency from all sources computed for 20 provinces from 1986 to 1995. The range is wide, with technical efficiency in 2 provinces averaging less than 70% and in 3 provinces averaging greater than 95%. The average annual technical efficiency across all provinces is approximately 86%, with a standard deviation of 9%. This is comparable to the average technical efficiencies reported in Fan (2000). These findings suggest that inadequate management and organization in rural production from all sources resulted in sub-optimal annual production of grain, cash crops, and rural industrial output by a factor of approximately 14%.

[Figure 1]

Test statistics for allocative efficiency are computed for 20 provinces by forming the complex ratio of revenues from cash crop to grain production divided by the computed marginal rate of transformation for the years 1986 to 1995. The coefficient for grain production is inferred by assuming that the coefficients for grain, TVE, and cash-crop output sum to 1.0. The test statistic for province i can be expressed as:

$$T_i = (py_{cash,i}/py_{grain,i})/[\beta_{cash}/(1-\beta_{tve}-\beta_{cash})] \quad (10)$$

where,

$py_{cash,i}$ and $py_{grain.i}$ are the revenues from cash-crop production and grain production for province i, respectively, and,

β_{tve} and β_{cash} are the estimated coefficients on TVE production and cash-crop production, respectively.

A ratio of one indicates allocative efficiency. A ratio of less than one indicates that the share of cash-crop production was less than optimal and a ratio of greater than one indicates that the share of grain production was less than optimal. Both the upper and lower bounds of the confidence intervals for β_{tve} and β_{cash}, obtained from model 1 and reported in Table 1, are used to compute the average annual test statistic by province.

The average annual test statistics for allocative efficiency are reported in Table 2 for 20 provinces. When the upper bound values of β_{cash} and β_{tve} are used, the average test statistics reported for 6 provinces, i.e., Shanxi, Yunnan, Anhui, Guangxi, Guangdong, and Jiangxi, are not statistically different from one, indicating allocative efficiency in those provinces. When lower bound values are used, the test statistics reported for 8 provinces, i.e., Fujian, Hebei, Hubei, Henan, and Hunan in addition to Shanxi, Yunnan, and Anhui, are not statistically different from one.

[Table 2]

When the upper (lower) bound values of β_{cash} and β_{tve} are used, the average test statistics reported for 13 (9) provinces in Table 2 are statistically less than one at the 5% level. This suggests that welfare in those provinces could have been higher had more resources been devoted to cash-crop production rather than grain production. Using the upper (lower) bound values, the average test statistic for one (4) province(s) is statistically greater than one at the 5% level. This indicates that economic welfare could have been increased in that (those) province(s) if more resources had been devoted to grain production, rather than cash crop production. The relatively large number of provinces with test statistic values of less than one supports the hypothesis that non-price incentives for grain production depressed rural incomes during this time period[3].

In summary, our empirical results support the hypotheses related to the impacts of structural and market reforms on rural productivity in China from 1986 to 1995. The coefficient on local investment in the estimated frontier equation is positive and significantly different from zero. This supports the hypothesis that the dramatic decline in the levels of agricultural investment due to fiscal reforms in the 1980s adversely affected subsequent agricultural productivity growth. In addition, the technical inefficiency equation results indicate that the small and fragmented nature of household farms limits the potential gains from scale economies. Finally, test statistics for allocative efficiency suggest that a relatively large number of provinces produce grain in excess of the optimal level. This supports the hypothesis that non-price incentives for grain production diminish rural incomes.

5. Conclusion

This paper contributes to the debate on the importance of structural versus market reform to productivity growth in rural China. Structural reform solved the principal-agent problem associated with the communes but at the same time resulted in fiscal decentralization and small fragmented household farms. The fiscal and farm size impacts were not previously addressed in the debate, but we found they adversely affected rural productivity growth in the 1980s and 1990s. In addition, incomplete market reforms and the use of non-price incentives for grain production were found to have diminished rural economic welfare.

The positive and negative impacts of China's rural reform are analyzed in a comprehensive framework, incorporating both technical and allocative efficiency. Most previous studies have analyzed only a subset of rural production, but we have incorporated the grain, cash-crop, and rural industrial sectors into our analysis. Our analysis did not provide a ranking of the efficiency impacts of each component of reform because of differences in the units of measurement. However, this is a good area to extend this research.

Farm fragmentation is found to have reduced technical efficiency in Chinese agriculture. In addition, relatively low levels of agricultural investment in the 1980s diminished agricultural productivity growth, while higher rates of investment in the 1990s contributed to its revitalization. The average provincial measure of technical efficiency from all sources, is estimated to be approximately 86 percent of the optimal level for 20 provinces from 1986 to 1995.

The findings also suggest that incomplete agricultural market reforms and grain self-sufficiency policy resulted in relatively low rates of allocative efficiency in grain and cash-crop production in a large number of provinces. To the extent that conditions today are comparable to those in the 1986 to 1995 period, our results indicate that continued market reforms and new structural reforms are likely to have large impacts on rural economic growth and welfare. Hence, China's entry into the World Trade Organization would boost the conventional gains from trade liberalization by facilitating domestic market reform and providing additional incentives for structural reform.

By introducing farmland fragmentation into the debate over the effects of China's rural economic reform, we have shown that structural reform is incomplete. The household responsibility system was positive for rural China but it was accompanied by efficiency losses due to land fragmentation. Developments in land policy should be a critical component of domestic liberalization under the World Trade Organization. The current small-scale farms cannot make proper use of mechanization and economic gains from economics of scale through consolidation are foregone. China has a unique system of collective land ownership but it must make room for improved transfer rights.

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Table 1: Estimation Results

Production Frontier	**(1) ln(Grain Output)[a]**	**(2) ln(Grain Output)[a]**	**(3) ln(Grain Output)[a]**
Intercept	-0.61*	-0.62*	-0.91*
	(-2.3)	(-2.4)	(-3.5)
Northeast Dummy	0.15*	0.18*	0.52*
	(2.4)	(2.4)	(6.4)
North Dummy	0.02	0.01	-0.07*
	(0.81)	(0.30)	(2.6)
Northwest Dummy	-0.16*	-0.21*	-0.18*
	(-2.9)	(-5.7)	(2.7)
East Dummy	0.12*	0.13*	0.07*
	(3.5)	(3.7)	(2.1)
Central Dummy	0.31*	0.32*	0.21*
	(8.7)	(10.1)	(6.6)
South Dummy	0.12*	0.12*	-0.03
	(3.1)	(3.1)	(0.86)
ln(Cash Crop Acreage)/Grain Output)[b]	-0.44*	-0.44*	
	(-16.9)	(-16.2)	
ln(Rural Electricity Consumption/Grain Output)	-0.04*		-0.03*
	(-3.7)		(1.9)
ln(Fertilizer Utilization)	0.03*	0.03*	0.01
	(2.1)	(1.94)	(0.76)
ln(Rural Population)	0.60*	0.63*	0.41*
	(12.8)	(12.3)	(6.5)
ln(Local Government Capital Stock)[c]	0.06*	0.04*	0.13*
	(4.2)	(3.3)	(9.1)
ln(Cultivated Area)	0.28*	0.29*	0.50*
	(9.1)	(9.5)	(14.1)
Year	0.02*	0.02*	0.01
	(6.4)	(6.8)	(1.7)
σ^2	0.02*	0.02*	0.05*
	(4.3)	(4.8)	(4.1)
Gamma	0.92*	0.93*	0.98*
	(25.4)	(32.2)	(116)

(continued)

Table 1. (continued) **Estimation Results**

Inefficiency Equation	**(1) ln(Grain Output)[a]**	**(2) ln(Grain Output)[a]**	**(3) ln(Grain Output)[a]**
Intercept	1.0*	1.1*	0.93*
	(8.0)	(8.9)	(7.8)
ln(Multiple Cropping Index)	-2.2*	-2.5*	-1.8*
	(-6.0)	(-6.7)	(-6.2)
ln(Cultivated Area Per-capita)	-1.2*	-1.4*	-0.46*
	(-5.7)	(-6.1)	(-4.6)
Year	0.01*	0.02*	-0.01
	(2.3)	(2.4)	(-0.63)
Log Likelihood Function	208	201	141
LR Test of One-sided Error	144	171	78
Number of observations	198	198	198

[a] Grain output is metric tons of wheat, rice, maize, soybean, and tuber production.
[b] Cash crop acreage is all acreage sown to non-grain crops.
[c] Local capital stock is assumed to have an annual depreciation rate of 3.3%.
Note: t-statistics are in parentheses.
* statistically significant at the 5% level.

Figure 1. Frequency Distribution of the Average Annual Technical Efficiencies from 1986 to 1995, Computed for 20 Provinces

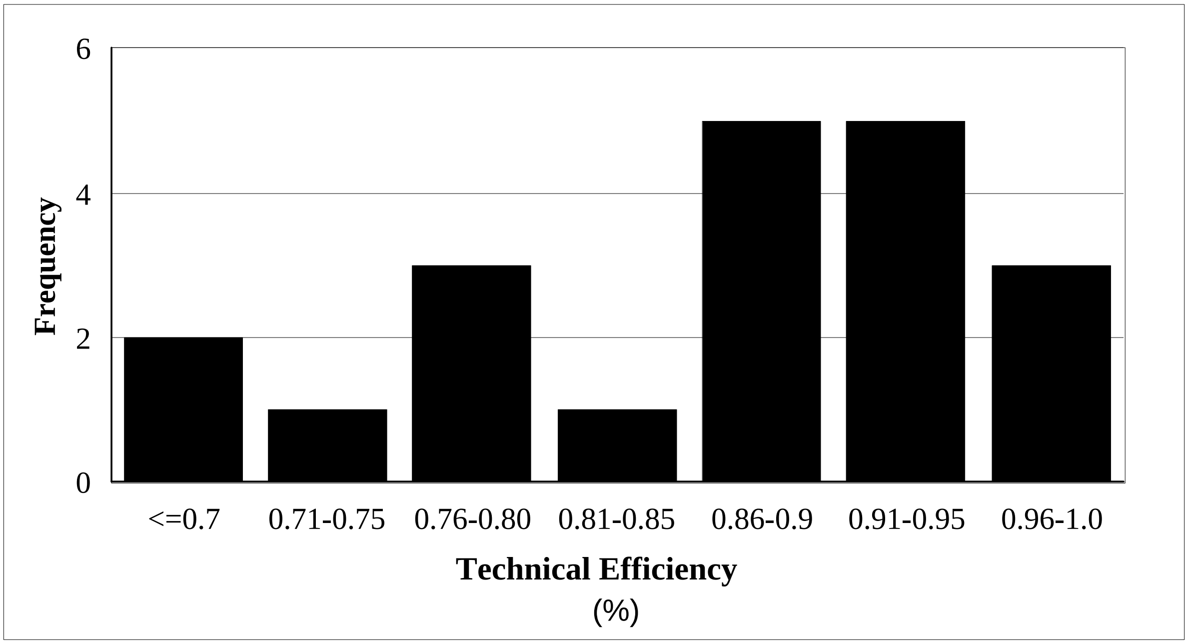
6
4
2
0
Frequency
<=0.7
0.71-0.75
0.76-0.80
0.81-0.85
0.86-0.9
0.91-0.95
0.96-1.0
Technical Efficiency
(%)

Table 2: Provincial Annual Average Test Statistics for Allocative Efficiency of Grain and Cash Crop Production: 1986 to 1995

Province	Test Statistic for Allocative Efficiency (Upper Bounds)	Test Statistic for Allocative Efficiency (Lower Bounds)
Jilin	0.26*	0.34*
Liaoning	0.34*	0.45*
Heilongjiang	0.48*	0.63*
Jiangsu	0.53*	0.70*
Sichuan	0.56*	0.74*
Shaanxi	0.61*	0.80*
Zhejiang	0.61*	0.80*
Shandong	0.66*	0.87*
Fujian	0.68*	0.89
Hebei	0.74*	0.98
Shanxi	0.77	1.02
Yunnan	0.79	1.04
Hubei	0.80*	1.06
Henan	0.80*	1.06
Anhui	0.81	1.07
Hunan	0.83*	1.07
Guangxi	1.07	1.41*
Guangdong	1.07	1.42*
Jiangxi	1.15	1.52*
Guizhou	1.21*	1.60*

Note: *indicates statistically different from 1.0 at the 5% level.

Endnotes

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2. Land abundancy and scarcity are relative terms and do not suggest absolute land endowments per-capita.

3. Values of the test statistic for allocative efficiency are relatively low in provinces with high per-capita incomes, suggesting relatively large positive deviations from optimal grain production in these provinces. This suggests that the benefits from any reform of grain self-sufficiency policies are likely to be greater in provinces with high per-capita incomes.