Productivity Growth and Its Components in Chinese Agriculture After Reforms

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May 15, 1998

The selected paper presented at the American Agricultural Economic Association
Annual Meeting, Salt Lake City, Utah, August 1998

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Abstract

This study uses nonparametric Malmquist procedures to investigate the temporal and spacial nature of productivity growth and its components in Chinese agriculture over the period 1980-1995. The results of this study indicate that total factor productivity grew at 2.37% annually with technical change augmenting the growth by 3.76% while efficiency change reducing productivity growth by 1.44%. Coexistence of amelioration in technical change and retardation in efficiency change indicates the lack of success in diffusing the existing agricultural technology. Continuing innovation and efficiency improvement through capital investment, modern input use, and greater competitive market pressures are important for augmenting productivity growth in Chinese agriculture.

Keywords: Chinese agriculture, economic reform, Malmquist productivity change index, and nonparametric programming approach

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China initiated agricultural reforms in the late 1970s as part of its economic transition programs by decentralizing farm production decisions to family units. These reforms resulted in remarkable progress in the Chinese agricultural sector. Grain production grew at an average rate of about 3% annually during 1978-95. In 1996, grain production reached a record of 490 million tons (USDA). After two decades of progress, China has developed the capability to provide the basic food needs for 22% of the world population with only 7% of the world's arable land. Many have attributed this high growth in agricultural productivity to research, technical innovation, institutional reforms, free-market oriented policies, and industrial growth (McMillan, Whalley, and Zhu; Ma, Calkins, and Johnson; Fan; Fan and Pardey; Fleisher and Liu; Lin, 1987, 1992; Wang, Wailes, Cramer; Kalirajan, Obwona, and Zhao; Koo and Duncan).

The purpose of this paper is to investigate the temporal and spacial nature of TFP growth and its components in Chinese agriculture since reforms using nonparametric Malmquist index procedures with provincial-level data (1980-95). The Malmquist approach measures productivity change from one year to the next using the geometric mean of two Malmquist productivity indexes which are constructed using distance functions (Färe and Grosskopf, 1994). Linear programming techniques are used to derive the values of distance functions. Malmquist index approach facilitates a simultaneous examination of productivity growth and its components: technical change and efficiency change. Also, it provides an index measure of productivity change for each province, which helps to assess interprovince disparity in productivity growth and its components and to identify the agricultural productivity trend for the country as a whole.

Our analysis differs from contemporary studies on Chinese agricultural productivity growth with the following features. First, most of the previous studies focused on TFP growth from the institutional reforms, while decomposition of productivity growth into efficiency change and technical change received scant attention, which is a major focus of this paper. Second, the few previous productivity decompositions implicitly assumed that observed production is efficient, which is refutable given that most farms in developing countries operate below full efficiency. The Malmquist index approach does not require the maintained hypothesis of technical and allocative efficiency. Consequently, this approach, rather than assuming full efficiency, estimates production efficiency based on the observed data. Third, previous studies employed a specific functional form, usually the Cobb-Douglas production function, for incorporating technology. In contrast, the Malmquist index approach does not require a specific functional form. Fourth, the approach requires neither data on prices which are not readily available in developing countries nor cost and revenue shares to aggregate inputs and outputs for measuring TFP growth. Finally, most of the previous studies covered only the limited period during the implementation of economic reforms. Our study employs production data from all provinces covering a longer post-reform era (1980-95), which helps to shed light on the disparity in productivity growth among provinces and over time.

Results and Discussions

The Malmquist productivity change index and its components was computed using linear programs which were formulated using GAMS. Descriptions of nonparametric Malmquist procedure and data can be fund in Wu, Walker and Devadoss in detail. The various Malmquist index measures were computed from optimal solutions for each of the 30 provinces and for every consecutive pair of years. Before turning to disaggregated results for individual provinces, we present a summary description of the average performance for the nation as a whole.

The TFP growth for the country as a whole increased moderately over time. Average change in the Malmquist index over the period 1980 to 1995 was 2.37% annually for the entire nation. This change in productivity was essentially due to shift of the frontier rather than moving closer to the frontier. On average, technical change contributed to productivity growth by 3.76% per year, while efficiency change reduced productivity by 1.34% per year. Progress in the best-practice technology arose essentially from input-biased technical change which averaged about 2.22% annually. Efficiency deterioration resulted from a decline in pure efficiency and improper scale operation, which decreased productivity respectively by 0.78% and 0.56% per year.

Table 1 also illustrates the temporal pattern of changes in productivity and its components in Chinese agriculture. The Malmquist productivity change index varied from a 8.53% increase in 1983/84 to a 2.95% decrease in 1988/89. Variations in productivity growth due to innovation ranged from an increase of 9.85% in 1983/84 to a decrease of 2.80% in 1988/89, while variations in the catching up effect ranged from an increase of 3.24% in 1980/81 to a decrease of 7.79% in 1994/95. The pattern of Malmquist productivity change over time reveals three subperiods: rapid growth during 1980-84, near stagnation during 1984-89, and rapid growth after 1989. This result corroborates previous findings such as Kalirajan, Obwona, and Zhao. The Kruskal-Wallis nonparametric test results showed that for the three subperiods differences in estimated means of the Malmquist index were statistically significant at the 90% confidence level (see Wu, Walker, and Devadoss).

Reforms initiated in 1978 provided strong economic incentives to farmers to use modern technology and inputs and to improve production efficiency. Consequently, during 1980/81-

1983/84, both technological innovation and efficiency improvement resulted in higher productivity growth. The frontier shifts augmented the TFP growth by 3.62%, while the catching up effects contributed to productivity growth by 0.10%, resulting in a TFP increase of 3.73%. During 1984/85-1988/89, however, productivity declined by 0.10% per year. TFP regression was mainly due to efficiency deterioration which decreased 1.15% annually, while technical change showed a slight increase. The success in rural reforms during the late 70s and the early 80s encouraged the government to extend economic reforms to urban sectors in 1985. The rapid development of township and village enterprises led to a flow of labor, particularly young and educated farmers, from the agricultural sector to the industrial sector. The introduction of the contract purchase system in 1985 caused a sharp drop in state procurement prices relative to input prices, which resulted in lower farm profitability. These factors led to a productivity decline in the second half of the 1980s (also see Lin, 1992; Kalirajan, Obwona, and Zhao).

This productivity decline caught the attention of policymakers who were concerned with the pace of agricultural output growth, which led to the introduction of further agricultural reforms. Some of these reforms include: raising grain prices by an average of 18% in 1989 (Sicular), ensuring the availability of chemical fertilizers and fuel to contract farmers, and instituting the free-market economy. These reform measures rejuvenated the growth in agricultural productivity. During 1989/90 to 1994/95, productivity grew at an average rate of 3.56% per year. This higher growth contrasts with that in the first half of the 1980s in that the contribution of technical change to productivity growth was even larger.

The decomposition of productivity growth into technical change and efficiency change reveals that the TFP growth in this economic transition period came mainly from progress in the best-practice technology. Some of the key factors behind technical progress as recognized by Stone include the development of chemical fertilizer use, water control technology, cultivation practices (e.g., green houses, plastic sheeting), and new crop varieties (e.g., hybrid, pest and disease resistant varieties in rice and wheat). The catching up effect augmented productivity growth at the beginning of the 1980s and then stagnated. Some of the forces behind efficiency change are institutional reforms (e.g., phasing out central planning, switching from commune farming system to market-oriented production), change in agricultural policies (e.g., reduced tax on farmers, less government intervention), and improvement of managerial skill. Stagnating efficiency change might indicate that the benefit of previous institutional reforms has played out.

Next, we turn our attention to the spatial nature of TFP change at the provincial level. The results reported in Table 2 illustrate the large variability in productivity growth and its components among provinces during this post-reform period. Guangdong province enjoyed the highest TFP growth at 7.64% per year on average, which was due to both the frontier shift effect (6.14%) and the catching up effect (1.41%). This province had the highest rate of efficiency change in the sample, which indicates that Guangdong is more progressive in moving toward the best-practice frontier. At the other extreme, Xizang experienced productivity decline of 3.95% per year, mainly due to technological regression.

Provinces were grouped according to the estimated Malmquist productivity change index into fast-, moderate- and slow-growing groups (Table 2). The differences in estimated means of the TFP change between the three provincial groups were statistically significant using the Kruskal-Wallis test (see Wu Walker, and Devadoss). The fast productivity growth group includes five provinces, all in the coastal region. Provinces in this group accounted for 13.04% of gross value of agricultural output, 10.78% of grain production, and 8.89% of the arable land in the nation (Table 3). In this group, productivity growth averaged 6.32% per year with the highest growth of 7.64% in Guangdong and the lowest growth of 4.99% in Liaoning. Technical change contributed to productivity growth by 6.36%, while efficiency deterioration reduced productivity growth by 0.03% per year on average.

The moderate productivity growth group consists of 16 provinces, all in the coastal and emerging inland regions. Provinces in this group accounted for 69.63% of gross value of agricultural output, 71.61% of grain production, and 68.37% of the arable land in the nation. On average, productivity grew 2.76% annually with the highest growth of 4.84% in Hainan and the lowest growth of 1.32% in Guangxi. Technical change augmented productivity of this group by 3.96%, while efficiency deterioration eroded productivity by 1.15%.

The slow productivity growth group contains nine provinces, most of them in the underdeveloped deep-interior region. This group produced 17.34% of gross value of agricultural output and 17.61% of grain production with 22.74% of the arable land of the nation. On average, productivity regressed 0.55% annually with a 0.67% increase in Henan and a 3.95% decrease in Xizang. In this group of provinces, technical change contributed to productivity growth by 1.88%, while poor efficiency performance reduced productivity growth by 2.39%.

It is clear that in all three groups, the lack of efficiency improvement eroded gains from technical change. Therefore, in addition to promoting technical change, efficiency improvement should be a major focus for policymakers, particularly for those provinces in the slow-growing group. To improve the efficiency performance, future reforms should encourage production specialization on the basis of provincial/regional comparative advantage, reduce government intervention in agriculture, and eliminate undue restrictions on output and input movements across the provinces. To augment technical progress, given the limited opportunities to expand the cultivable land, the greatest potential lies in increasing/attracting investment in agricultural research and technological development in agriculture.

The wide disparity in productivity growth among provinces persisted over the entire study period. Some provinces in the coastal region enjoyed faster TFP growth. Some provinces in the emerging inland region exhibited moderate productivity growth. Provinces in the deep interior region experienced a slower growth in productivity. This suggests that differences in productivity growth are related to local conditions such as competitive market pressures, investments, and the ability to safeguard against natural disasters.

Economic reforms in China during the past two-decades have moved farmers into a market-oriented economy. Farmers face greater competitive pressures in the coastal region than in the underdeveloped deep-interior region. Farmers in the coastal area have to constantly improve their managerial skills and adopt new technologies to stay in business. In contrast, farmers in the developing region had less exposure to the market-oriented economy, new information, production organizations, and technologies. Since the level of competitive pressures is an important catalyst to improve production efficiency and promote technological progress, future economic reforms should be directed toward strengthening competitive and market-oriented policies.

The five fast-growing provinces had larger capital investment in agriculture, which accounted for 19.46% of national investment in agriculture with less than 9% of the arable land (Table 3). On average, each province in this group invested 94.99 yuan per hectare per year. The sixteen moderate-growing provinces accounted for 58.65% of national investment in agriculture with 68% of the arable land. Each province invested 49.25 yuan per hectare per year, which is 49% lower than in the fast-growing group. The nine slow-growing provinces had 21.89% of national investment in agriculture with nearly 23% of the arable land. Each province invested 57.21 yuan per hectare per year, which is 40% lower than in the fast-growing group. Further, the fast-growing group had the smallest proportion of cultivated area suffering natural disaster damage, averaging 14.8% of planted acreage. The slow-growing group had the largest proportion of cultivated areas suffering natural disaster damage, averaging 19.11% of the planted acreage. Thus, increasing investment in agriculture and minimizing the damage from the natural disaster (e.g., better flood control, irrigating the land during drought, etc.) for those provinces in moderate- and slow-growing groups would be crucial to promote national productivity growth.

Conclusions

Rapid economic growth and productivity increase have occurred since China embarked on economic reforms. Earlier studies attempted to measure and explain productivity growth in Chinese agriculture by either imposing a functional form on technology or using data covering a shorter reform period. In this study, we investigate total factor productivity (TFP) growth in Chinese agriculture over the period 1980 to 1995 using nonparametric Malmquist procedures.

For all provinces over the period 1980 to 1995, we found the rate of Malmquist productivity change averaged 2.37% per year. Technical change contributed to the growth by 3.76%, while the poor efficiency performance reduced productivity growth by 1.44%. These results indicate that technical change was the dominant force augmenting productivity growth during this post-reform period. A high rate of technical progress and deteriorating efficiency performance coexisted in the Chinese agricultural sector. As Kalirajan, Obwona, and Zhao noted, policies designed to encourage technical progress should be accompanied by successful technological diffusions.

Since this study covered provincial-level data over the period 1980-95, it provides valuable insights into the spatial and temporal nature of TFP growth in Chinese agriculture. The results revealed a wide disparity in productivity growth among provinces. The fast-growing group averaged 6.25% per year. Productivity growth in the moderate- and slow-growing groups showed, respectively, an increase of 2.63% and a decrease of 0.55%. Possible reasons for the wide disparity in productivity growth include the differences in the level of competitive pressures, investments, and safeguard against natural disaster. A U-shaped productivity growth plot was found in this post-reform period: fast growth during 1980/81-1983/84, near stagnation during 1984/85-1988/89, and rapid growth after 1989.

The provincial and temporal disparity in productivity growth reveals the need for different policy measures to be undertaken in various provinces. For all provinces, efficiency-enhancing measures such as market-oriented policies, diffusion of practical agricultural technologies, production specialization, liberalization of government intervention, and removal of undue restrictions on input and output movements across provinces should be promoted. To stabilize productivity growth, measures aimed at reducing the damage from natural disasters should be encouraged in all provinces. More capital investments should be directed to the provinces in the moderate-growing groups. The research and development of new technology together with improvement in catching up performance should be stimulated especially for the provinces in the slow-growing group.

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Table 1. Changes in Agricultural Productivity and Its Components for all Provinces: 1980-1995

Year	M(•)	TC	IB	MC	EC	SC	PC
Subperiod (80/81 -83/84)							
80/81	1.0267	0.9945	1.0292	0.9663	1.0324	1.0123	1.0199
81/82	1.0426	1.0831	1.0317	1.0498	0.9626	0.9713	0.9911
82/83	0.9964	0.9745	1.0342	0.9423	1.0224	1.0239	0.9985
83/84	1.0853	1.0985	1.0206	1.0762	0.9880	0.9969	0.9911
Average	1.0373	1.0362	1.0289	1.0071	1.0010	1.0009	1.0001
Subperiod (84/85-88/89)							
84/85	1.0366	1.0515	1.0274	1.0235	0.9859	0.9833	1.0027
85/86	0.9837	1.0165	1.0248	0.9919	0.9678	0.9815	0.9861
86/87	1.0195	1.0161	1.0171	0.9990	1.0034	0.9817	1.0221
86/88	0.9863	0.9990	1.0348	0.9654	0.9873	1.0260	0.9623
88/89	0.9705	0.9720	1.0194	0.9535	0.9985	0.9791	1.0198
Average	0.9990	1.0107	1.0247	0.9863	0.9885	0.9901	0.9983
Subperiod (89/90-94/95)							
89/90	1.0273	1.0497	1.0162	1.0330	0.9787	0.9905	0.9880
90/91	1.0544	1.0321	1.0175	1.0145	1.0216	1.0521	0.9710
91/92	1.0433	1.0805	1.0177	1.0617	0.9655	0.9709	0.9945
92/93	1.0437	1.0423	1.0107	1.0313	1.0013	1.0011	1.0002
93/94	1.0395	1.0747	1.0199	1.0537	0.9672	0.9746	0.9925
94/95	1.0064	1.0914	1.0126	1.0778	0.9221	0.9424	0.9784
Average	1.0356	1.0616	1.0158	1.0451	0.9756	0.9880	0.9874
Minimum	0.9705	0.9720	1.0107	0.9423	0.9221	0.9424	0.9623
Maximum	1.0853	1.0985	1.0348	1.0778	1.0324	1.0521	1.0221
Mean	1.0237	1.0376	1.0222	1.0151	0.9866	0.9922	0.9944
Std. Dev.	0.0307	0.0421	0.0077	0.0447	0.0283	0.0273	0.0172

Note: M(•) = Malmquist productivity change index, TC = technical change, IB = input bias, MC = magnitude component, EC = efficiency change, SC = scale change, and PC = pure efficiency change.

The values in this table minus one multiplied by 100 give percent changes in productivity growth and its components.

In this study, the output bias is equal to one (therefore omitted for reporting) because there was only one output (see Färe and Grosskopf, 1996b).

Table 2. Changes in Agricultural Productivity and Its Components for 30 Provinces

Province	M(•)	Std Dev	TC	IB	MC	EC	SC	PC
Fast-Growing Provincial Group								
Guangdong	1.0764	0.0645	1.0614	1.0063	1.0547	1.0141	1.0024	1.0117
Beijing	1.0714	0.0601	1.0714	1.0357	1.0345	1.0000	1.0000	1.0000
Shanghai	1.0645	0.0869	1.0645	1.0675	0.9972	1.0000	1.0000	1.0000
Fujian	1.0540	0.0531	1.0604	1.0068	1.0533	0.9939	0.9939	1.0000
Liaoning	1.0499	0.0773	1.0601	1.0098	1.0498	0.9904	0.9904	1.0000
Mean	1.0632	0.0684	1.0636	1.0249	1.0377	0.9997	0.9973	1.0023
Moderate-Growing Provincial Group								
Hainan	1.0484	0.1119	1.0484	1.0721	0.9778	1.0000	1.0000	1.0000
Tianjin	1.0466	0.0885	1.0394	1.0304	1.0087	1.0069	1.0069	1.0000
Jiangsu	1.0401	0.0488	1.0515	1.0112	1.0399	0.9891	0.9891	1.0000
Zhejiang	1.0391	0.0562	1.0391	1.0225	1.0163	1.0000	1.0000	1.0000
Jilin	1.0335	0.1110	1.0470	1.0056	1.0413	0.9871	0.9872	0.9999
Shandong	1.0334	0.0944	1.0492	1.0046	1.0445	0.9849	0.9849	1.0000
Jiangxi	1.0313	0.0588	1.0391	1.0049	1.0341	0.9925	0.9925	1.0000
Shaanxi	1.0303	0.0571	1.0396	1.0021	1.0374	0.9910	0.9926	0.9984
Hubei	1.0265	0.0640	1.0429	1.0014	1.0415	0.9843	0.9900	0.9942
Xinjiang	1.0200	0.0710	1.0302	1.0181	1.0119	0.9901	0.9943	0.9958
Heilongjiang	1.0178	0.0957	1.0178	1.0592	0.9609	1.0000	1.0000	1.0000
Hebei	1.0172	0.0431	1.0414	1.0013	1.0398	0.9767	0.9788	0.9979
Sichuan	1.0166	0.0645	1.0206	1.0281	0.9927	0.9961	0.9961	1.0000
Hunan	1.0152	0.0394	1.0398	1.0015	1.0382	0.9764	0.9851	0.9911
Anhui	1.0142	0.0782	1.0445	1.0014	1.0433	0.9710	0.9828	0.9880
Guangxi	1.0132	0.0619	1.0442	1.0030	1.0410	0.9703	0.9858	0.9843
Mean	1.0276	0.0715	1.0396	1.0165	1.0228	0.9885	0.9916	0.9968
Slow-Growing Provincial Group								
Henan	1.0067	0.0824	1.0492	1.0019	1.0472	0.9595	0.9767	0.9825
Qinghai	1.0063	0.0819	1.0257	0.9996	1.0262	0.9811	0.9811	1.0000
Guizhou	1.0061	0.0751	1.0182	1.0208	0.9975	0.9881	0.9977	0.9904
Ningxia	1.0026	0.0750	1.0343	1.0051	1.0291	0.9693	1.0091	0.9606
Gansu	1.0002	0.0629	1.0197	1.0015	1.0182	0.9809	0.9940	0.9867
Shanxi	0.9999	0.0801	1.0399	1.0004	1.0395	0.9616	0.9858	0.9754
Yunnan	0.9953	0.0552	1.0319	1.0065	1.0253	0.9645	0.9815	0.9827
Nei Monggol	0.9738	0.0752	0.9928	1.0270	0.9667	0.9809	0.9870	0.9938
Xizang	0.9605	0.2290	0.9605	1.2422	0.7732	1.0000	1.0000	1.0000
Mean	0.9945	0.0908	1.0188	1.0315	0.9877	0.9761	0.9903	0.9857

Note: see the notes in Table 1 for variable definition.

Table 3. Data on the Selected Variables for the Provincial Groups

Provincial Group	Number of Province	Gross Value of Agricultural Output (%)	Total Grain Production (%)	Area Sown under all Crops (%)	Total Agricultural Capital Investments[a] Percent (%)	Total Agricultural Capital Investments[a] Average (yuan/ha.)	Severe Damage from Natural Disasters[b] Percent (%)	Severe Damage from Natural Disasters[b] Percent[c] (%)
Fast-growing	5	13.04	10.78	8.89	19.46	94.99	8.82	14.80
Moderate-growing	16	69.63	71.61	68.37	58.65	49.25	65.80	15.32
Slow-growing	9	17.34	17.61	22.74	21.89	57.21	25.38	19.00
Total	30	100.00	100.00	100.00	100.00	-	100.00	-
Average	-	-	-	-	-	65.15	-	16.37

[a]Data for agricultural capital construction investment covers the period 1981-92. Average investment per hectare was calculated by dividing agricultural capital investment by area sown under all crops over the period 1981-1992.

[b]Data for cultivated area suffering severe damage from natural disaster covers the period 1983-95. Natural disaster includes flood, drought, frost, freeze, wind, and hail damage.

[c]This percentage was calculated by dividing cultivated area suffering severe damage from natural disaster by area sown under all crops for the period of 1983-95.