

Chinese Regional Agricultural Productivity in the 1990's¹©

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Abstract. A nonstochastic Malmquist Index and a stochastic frontier production function are estimated to examine agricultural productivity growth in Chinese provinces during the 1990's. Results for both methods indicate high productivity growth in the mid 1990's with a declining trend thereafter. While the Malmquist index picks up a reversal of this trend in 2000-2001, this is not evident in the stochastic frontier estimates. Both methods identify the same regions as the most productive. Variables representing public inputs such as education, research and infrastructure are shown to have an important impact on differential provincial performance.

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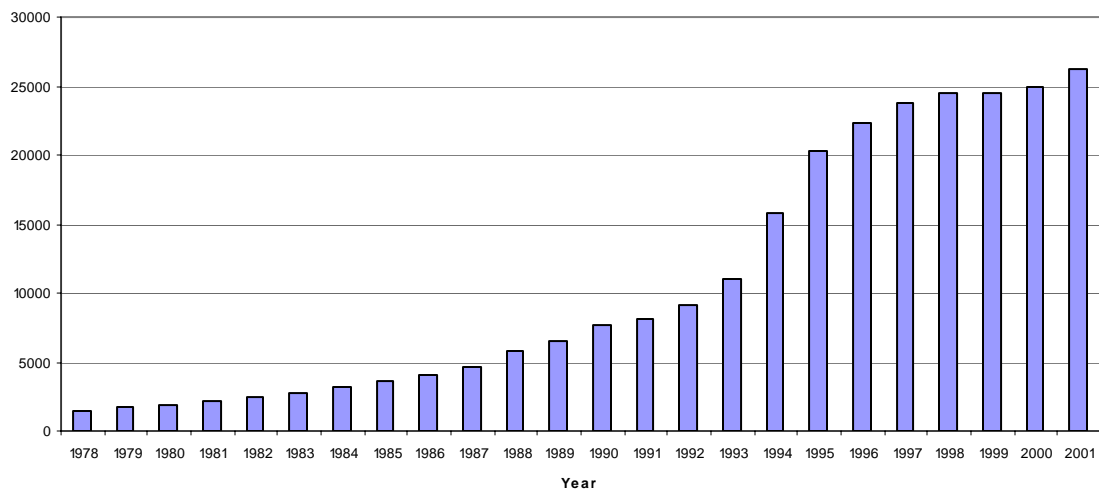
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I. Introduction

Since the economic reforms of 1978, China's agricultural sector has had an impressive performance. According to China's statistical yearbook, the gross output value of farming, forestry, animal industry and fishery in 2001 is more than 2.6 trillion Yuan, while in 1978 the gross output value of agriculture was only 0.13 trillion Yuan. After taking into account inflation, this is still a significant increase.

The following graph shows the trend of gross output value in agriculture since 1978 without taking inflation into consideration.

Gross output value of agriculture (1978-2001)



The following facts³ may give some idea of the importance of agriculture in China.

- China's total population was 1,259 billion people at the end of 1999
- 69 percent of China's people live in rural areas
- China is fourth in the world in land area

³ From ERS in USDA website.

- China has 9 percent of the world's total arable land, and 22 percent of the world's population.

The study of China's agricultural sector growth is attractive given the importance of agriculture in China and the rapid expansion of production. Many studies have examined agricultural growth of China. The studies can be divided by the time period of analysis into two sets. The first set covers the 1980's. The second set refers to the 1990's. During the 1980's, China's agricultural output and productivity experienced very rapid growth. On the contrary, it seems that growth slowed down in the 1990's and there are no regional studies that analyze this period with any depth, except this one. In addition, most other studies have focused on aggregate productivity at the national level while the main purpose of this paper is to explore differential agricultural productivity growth at the regional level.

This paper's objective is to examine regional agricultural productivity growth in China during the 1990's. This involves three steps: a) measurement using a Malmquist index method, b) measurement using a stochastic frontier production function, and c) identification of particular factors that might have contributed to productivity change.

The reason for examining productivity growth at the provincial level is that some factors may be disguised in national data. China is a country with diverse ecosystems and with a large population working on agriculture. It would be of interest to identify which regions have grown faster and how this growth compares across provinces..

There is also a wealth of information at the provincial level that lends itself to this analysis and provides detailed information about regional production systems. When using cross regional data, the analysis is affected by different institutions prevailing in

different regions. However in China, the political environment across regions has been similar. This allows extraction of sources of growth beyond “institutional factors.” This is important because past studies have reported this as the main contributor of economic growth in China.

The Malmquist index and a stochastic frontier production function are particularly suitable to examine China’s agricultural productivity because they rely on quantity data only. There is no need to use prices, which is an advantage given that they were distorted due to government intervention. Compared with a production function, the Malmquist index does not suffer from specification error. But the disadvantage of this index is that it is nonstochastic and therefore very sensitive to errors. A stochastic frontier translog production function is also used to estimate the production structure of Chinese agriculture and its productivity growth rate. These estimates are then compared across methodologies.

Both the Malmquist Index and the stochastic frontier production function show that productivity growth in Chinese agriculture has been higher in the mid 1990’s than in the late 90’s.

A literature review is found in section II. Section III has some background on China’s agricultural sector policies and the reforms during the 1980’s and 1990’s. Section IV reports the Malmquist index results. Section V reports the outcome from the stochastic frontier production function. Section VI presents a model that includes potential explanations for differential growth across regions. Finally, section VII concludes and suggests future work.

II. Literature Review

As mentioned above, lots of research has been done on agricultural growth in China. We summarize their findings in this section.

McMillan, Whalley and Zhu (1989) examined the effects of price increases and the introduction of HRS (household responsibility system) on agricultural performance from 1978 to 1984. They set up an “institutional” production function to capture the contribution of institutional change and price change to productivity growth. They found about 78 percent of agricultural productivity growth is due to institutional change and about 22 percent is due to price increase. Their reported productivity growth ranged from around 2 percent to 10 percent for different years.

Fan (1991) used a frontier production function to separate agricultural growth into input growth, technical change and institutional reform. Total factor productivity change includes technical change and institutional change. He divided the nation into 7 regions to examine the cross regional difference. He found that different regions benefited differently from HRS. He also found that institutional change contributed more than technical change to TFP growth. In his later work in 1997, he compared a constant price index with a Tornqvist index and concluded that the constant price index is not appropriate for this analysis. He also pointed out that investment in the agricultural sector was needed for long run production growth when institutional changes are almost exhausted. In his recent work with Zhang (2001), they used a generalized maximum entropy approach to estimate a multi output production technology for twenty-five provinces during the period of 1979-1996. They found that technological growth was input bias toward fertilizer and labor in the grain sector and output biased toward cash

crops (against grain crops).

Lin (1992) employed a fixed effects model (using provincial level data) to evaluate the effects of decollectivization (HRS), price adjustments and other factors on productivity growth. He found that institutional reform contributed most to productivity growth during this period. Inputs were found to respond heavily to procurement prices. He also pointed out that stagnation after 1984 may be due to “exodus of labor force” and “decline in the growth rate of fertilizer usage”⁴ which accompanied the procurement price decline. His work on efficiency of different systems (1993) showed that household farms outperformed cooperative farms, which gave support for institutional reform in China. In his work of 1995, he examined rice production and tested the induced institutional innovation theory. He concluded that there was improved resource allocation and productivity after lifting the legal restrictions. In his work of 1997, he examined agricultural growth from 1952 to 1995. He divided the whole period into three sub-periods: 1952-1978 (pre-reform period), 1979-1984 and 1984-1995. Growth in the first and the third sub periods was slow and while it was fast in the second period. He attributed the slow growth in the first period to the collective farming system, which was “detrimental to farmers’ incentives”⁵. The second period’s high growth was attributed to the institutional changes (HRS), while he attributed the third period’s low growth to the procurement price system. He concluded that freeing prices and further market liberalization were needed to improve China’s grain production.

Huang and Rozelle (1995) studied environmental stress and grain production using a fixed effect model and data from 1952 to 1990. They found that the 1.8% production

⁴ Lin, 1992, pp. 48.

⁵ Lin, 1997, pp. 201.

growth in the period 1984 to 1990 was much lower than the 4.7% of 1978-1984. They concluded that “erosion, salinization, soil exhaustion and degradation of the local environment may be partially responsible for the slowdown” during 1984-1990.

Rozelle, Park, Huang and Jin (1997) examined market integration after the implementation of liberalized economic policies in food markets. They found there was evidence of market integration and improvement in market and producer efficiency.

Rozelle, Taylor and DeBrauw (1999) used a labor migration framework to model the effect of migration and remittances on agricultural productivity growth in China. They found that “net effect of migration and remittances on maize production is negative.”⁶

De Brauw, Huang and Rozelle (2000) examined how market liberalization influenced the behavior of producers. They found that producers were more responsive after liberalization.

Zhang and Carter (1997) constructed a Cobb-Douglas production function to separate the contribution of input, weather and efficiency to growth of grain production from 1980 to 1990. They examined cross regional data and found that institutional contribution had less impact than in previous studies if good weather was taken into account. Their results showed that input growth is a big factor contributing to grain output growth. Their results also showed that the contribution of efficiency change was higher at the end of 80’s than that at the beginning of 80’s.

Colby, Diao and Somwaru (2000) used a Tornqvist Index to analyze the sources of outputs growth in total grain and four major crops in China (rice, wheat, corn and soybean). Their data ranged from 1978 to 1997 and the data was broken down to three periods: 1978-1985, 1986-1994 and 1995-1997. They found that the growth rate of output

⁶ Rozelle, etc, pp. 291.

and TFP are quite different for each period. TFP growth rate is highest during the period of 1978 to 1985 and lowest during the period of 1986 to 1994, which seems quite consistent with the work of Lin (1997). Their outcomes showed that TFP contribution to output growth is decreasing. Then they used a restricted profit translog function to study the output supply and input demand responses. They found “own price elasticities of soybean, corn and rice are greater than unity while wheat’s elasticity is less than unity.”⁷ They also found that input demands are price elastic.

The above studies are the most important work done on agricultural productivity growth (and grain growth) in China. Based on the above studies, we can draw the following conclusions: agricultural productivity growth in China was higher immediately after the introduction of the HRS (from 1978 to mid 80’s) than recent years; the main contribution of TFP growth in the period 1978 to mid 80’s is institutional reform (which can be viewed partly as efficiency change); there is evidence that TFP growth is down during recent years, which may be due to the exhaustion of the institutional effect, the procurement price system and lack of agriculture investment and innovations that hinder further grain productivity growth in China.

III. China’s Agricultural Policies

Before 1978, agriculture in China was under a collective system. After 1978, China adopted the “household production responsibility system (HRS)”. Under HRS system, although farmland is not privately owned, peasants can have long term use rights to land. They are also free to allocate resources as they see fit but need to deliver a quota to the government at procurement prices. The leftover output is traded freely in the market. Of

⁷ Colby, etc. 2000, pp.15.

course peasants also need to pay taxes and local fees. Local government is responsible for some extension services and the introduction of new technologies and seed varieties.

China's agricultural policies have experienced quite a bit of change over the last 20 years. China has undergone a reform from a planning economy to a market economy. There has been elimination of government intervention to facilitate the role of market forces. The first biggest step in China's agricultural reform was the introduction of HRS in 1978. HRS motivated farmers to pursue profit. This system gave farmers the incentives to reduce costs and adopt new technologies. Another very important reform happened at the beginning of 1990's (1993), when China abandoned the food rationing system. Under the grain-rationing system, urban consumers used coupons to buy a fixed amount of grain at a low price. To buy more they have to pay the market price that is usually higher. Due to the budget pressure, the government began to reduce the gap between the ration and market price in 1991 and 1992. Seeing no resistance from urban consumers, the government finally eliminated the rationing price in early 1994.

Among different agricultural products, the government also has different policies for different agricultural products. The government has relative less intervention in the production of fruits, vegetables and livestock and much more intervention on grain production.

A recent reform involves the Grain-Bag responsibility system (introduced in 1995), which requires leaders in each province to maintain overall balance of grain supply and demand within each province and to regulate local markets. This policy advocates self-efficiency of grain production. The result of the Grain-Bag policy is that grain output

has due to reallocation of resources away from other products.⁸. This policy may introduce some inefficiency in resource allocation due to regional protectionism.

IV. The Malmquist Index

We used the provincial data from year 1993-2001 to construct a Malmquist productivity index. The Malmquist index is a non-parametric, nonstochastic index used to examine productivity change. Productivity growth is different from output growth. Productivity refers to output per unit of input and can be measured by dividing an output index by an input index. We care about productivity because it indicates an increase in output for given resources.

Because the Malmquist index is quantity based, it is more suitable to China's situation due to the existence of procurement price and quotas. As specified by Fare et al (1994) this index is:

$$M_{0}(x_{t+1}, y_{t+1}, x_t, y_t) = \left[\frac{D_o^t(x_{t+1}, y_{t+1})}{D_o^t(x_t, y_t)} * \frac{D_o^{t+1}(x_{t+1}, y_{t+1})}{D_o^{t+1}(x_t, y_t)} \right]^{1/2}$$

The subscript 0 shows that this is an output oriented Malmquist index. Here D_o refers to an output distance function. D_o is calculated as follows.⁹

$$[d_o^t(x_t, y_t)]^{-1} = \max_{\phi, \lambda} \phi,$$

$$\text{st. } -\phi y_{it} + Y_t \lambda \geq 0,$$

$$x_{it} - X_t \lambda \geq 0,$$

⁸ China's Grain Policy at a Crossroads, Economic Research Service/USDA.

⁹ Coelli 1996, pp. 27.

$$\lambda \geq 0$$

where x and y are input and output vectors respectively. $X (K*N)$ and $Y (M*N)$ are the input and output matrixes respectively. λ is a $N*I$ vector of constants. Here $I = \phi < \infty$ and $\phi - I$ is the proportional increase in inputs that could be achieved by the i -th region, with input quantities held constant. Fare et al also show that the index can be factored into efficiency change and technical change, which is a geometric mean of technologies in two periods:

$$M_{0}(x_{t+1}, y_{t+1}, x_t, y_t) = \frac{D_o^{t+1}(x_{t+1}, y_{t+1})}{D_o^t(x_t, y_t)} \left[\frac{D_o^t(x_{t+1}, y_{t+1})}{D_o^{t+1}(x_{t+1}, y_{t+1})} * \frac{D_o^t(x_t, y_t)}{D_o^{t+1}(x_t, y_t)} \right]^{1/2}$$

Technical efficiency change tells us whether a particular region is moving closer to the frontier or further away from the frontier. Technical change refers to a shift of the frontier. Indexes smaller than one represent inefficiency and regressive technical change. In this paper the Data Envelopment Analysis (Computer) Program (DEAP) developed by Tim Coelli is used to calculate the Malmquist Index. All the data used in the construction of this index are from China Statistical Yearbook. We use agricultural output¹⁰ in real Yuans for 30 provinces during 1993-2001.

There are four inputs. Total sown areas of agricultural products¹¹ (in thousands hectares), agricultural machinery (in 10 thousand KW), labor (in 10 thousand persons) and fertilizer (in 10 thousands tons.) Fertilizer includes Nitrogenous fertilizer, Phosphate

¹⁰ It is the gross output value of whole agriculture sector, which includes farming, forestry, animal industry and fishery.

¹¹ In our model, input of land is calculated by subtracting areas affected by flood and drought from the total sown area.

fertilizer, Potash fertilizer and compound fertilizer. A summary of the data is attached in the appendix.

As mentioned before, the Malmquist index is very sensitive to outliers. The data for Tibet seems to be abnormal and this region is deleted from the data set for this analysis until more information on this province is obtained. Table 1 reports the mean productivity change of all the regions, except for Tibet, by year. Table 2 reports the mean productivity index during the period of 1993 to 2001 for each region. Complete results by year and province are provided in Appendix 6.

All the means reported are geometric means. The last column is the Malmquist index, which measures total factor productivity change (tfp change). This can be separated into two parts, efficiency change and technical change. Efficiency change refers to movements towards the frontier, also referred to as "catch up." Technical change represents shifts of the frontier of production or innovations.

year	effch	techch	tfpch
1994	1.057	1.199	1.266
1995	1.067	1.054	1.125
1996	0.966	1.023	0.988
1997	0.906	1.086	0.984
1998	0.919	0.945	0.869
1999	1.029	0.929	0.955
2000	0.967	1.044	1.01
2001	0.939	1.018	0.956
MEAN	0.979	1.034	1.013

In table 1 we see that in 1994 and 1995, China experienced very high productivity growth [$(\text{tfpch}-1)*100$ is the productivity growth]. From 1996 to 2001, the agricultural

sector shows technological regression except for year 2000. Positive productivity growth has been mainly due to technological innovations.

There are few other papers we can use for comparison with ours given that we cover a very short and recent time period. The most recent work done is that of Colby, et al. They used a Tornqvist index to measure China's grain productivity and conclude that there is higher productivity growth in the mid 1990s which is somewhat consistent with ours. They do not show yearly productivity growth estimates in their paper. Also, they measure the productivity of grains and we measure productivity for the whole agricultural sector.

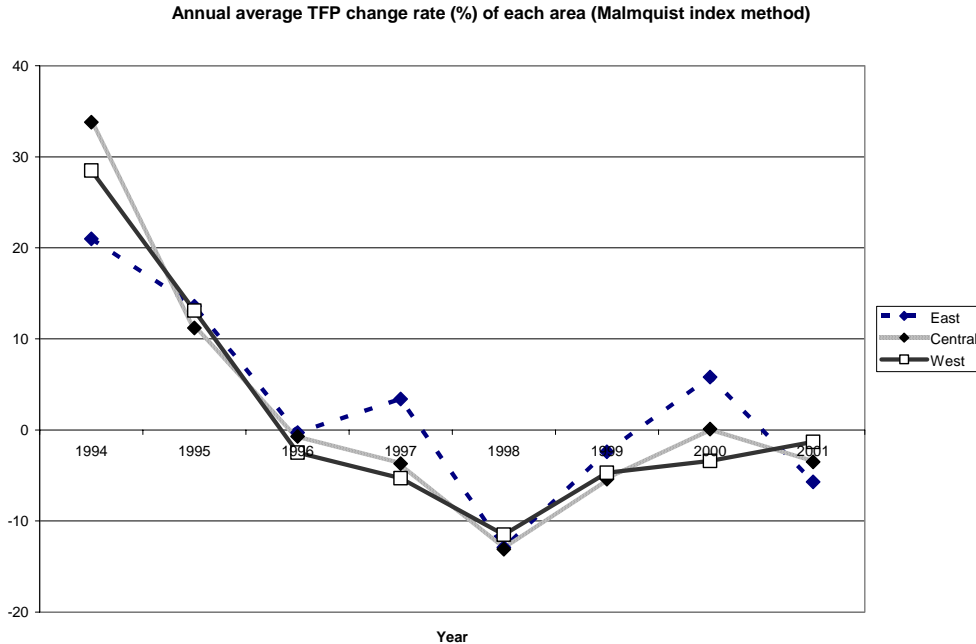
From table 1, we see high productivity growth in 1994, declining in later years. Five years show negative rates of productivity change. On average, total factor productivity growth in Chinese agriculture during 1994-2001, as estimated by this index, is 1.3% annually. This is not a low rate if one compares it with 1.5% to 2% estimated for U.S. agriculture in the 1950-1996 period or with the negative rates of agricultural productivity growth for developing countries estimated by a number of authors.

From Table 2 we can see that most of the regions experienced positive TFP growth. Beijing and Shanghai define the frontier throughout the period and are the regions whose technical change drive the shift of the overall frontier. Here Beijing and Shanghai refer the rural area around these two cities. Other regions with good productivity performance are: Shanxi, Jilin, Jiangsu, Zhejiang, Fujian, Jiangxi, Hubei and Hunan. The worst performer is Guangxi.

Table2 MALMQUIST INDEX SUMMARY OF REGIONAL MEANS			
REGION	effch	techch	tfpch
Beijing	1	1.074	1.074
Tianjing	0.939	1.045	0.981
Hebei	0.986	1.045	1.03
Shanxi	1.01	1.035	1.046
Inner mon	0.987	1.009	0.996
Liaoning	0.983	1.057	1.04
Jilin	0.978	1.049	1.026
Heilongjiang	0.964	1.03	0.993
Shanghai	1	1.06	1.06
Jiangsu	0.956	1.074	1.026
Zhejiang	1.011	1.031	1.042
Anhui	0.97	1.031	1.001
Fujian	0.966	1.06	1.024
Jiangxi	0.984	1.029	1.012
Shandong	0.949	1.06	1.006
Henan	0.975	1.035	1.009
Hubei	0.969	1.042	1.01
Hunan	1.004	1.006	1.01
Guangdong	0.967	1.029	0.995
Guangxi	0.957	1.013	0.97
Hainan	0.961	1.012	0.972
Sichuan	0.972	1.028	0.999
Guizhou	0.981	1.023	1.003
Yunnan	1.005	0.994	0.999
Shaanxi	0.973	1.039	1.011
Gansu	1	1.005	1.005
Qingghai	1.03	1.015	1.046
Ningxia	0.969	1.04	1.008
Xinjiang	0.963	1.029	0.991
MEAN	0.979	1.034	1.013

The following graph summarized the agricultural performance of China, measured by the Malmquist index, in three regions¹²:

¹² East includes: Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Guangxi and Hainan. Central includes: Shanxi, Inner Mongolia, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, and Hunan. West includes: Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xingjiang.



We can see that the trend has been downwards in the three regions but that the East has outperformed the other two regions, except in 1994 (notice that Tibet is not included).

Some of the factors that might have affected economic performance during this period are: 1) the elimination of the rationing system in years 1994 and 1995; 2) the steady decline in procurement prices during this period; 3) the introduction of the Gain-Bag Responsibility System in 1995; and 4) bad weather condition in the 90's.

We remind the reader that the Malmquist is affected by extreme data points, that it is calculated with information of two consecutive years only, and that we purged the information for Tibet out of the data set.

V. Stochastic Frontier Translog Production Function

In this section we propose to estimate TFP using Battese and Coelli 's (1992) stochastic frontier production function which is specially suited for panel data and is stochastic. The model is expressed as follows.

$$Y_{it} = x_{it}\beta + (V_{it} - U_{it})$$

In our case, $i=1, 2, \dots, 30, t=1, 2, \dots, 9$.

Here Y_{it} is the logarithm of the output level of the i -th province in the t -th time period. x_{it} is a 4×1 vector of the logarithm of the input quantities of the i -th province in the t -th time period. β is the coefficient vector. The V_{it} are random errors which are assumed to be iid $N(0, \sigma_v^2)$ and are independent of U_{it} . $U_{it} = (U_i \exp(-\eta(t-T)))$. U_i are iid one sided errors that are assumed to account for technical inefficiency and to be truncated at zero of the $N(\mu, \sigma_v^2)$ distributions. And η is a parameter to be estimated.

The following translog production function is used in estimation:

$$\ln Y_{it} = \alpha_0 + \sum_m \alpha_m \ln x_{mit} + \alpha_t t + \frac{1}{2} \sum_m \sum_n \beta_{mn} \ln x_{mit} \ln x_{nit} + \frac{1}{2} \beta_{tt} t^2 + \sum_m \beta_{tm} \ln x_{mit} * t + v_{it} - u_{it}$$

$m, n = D(\text{land})^{13}, L(\text{labor}), F(\text{fertilizer})$ and $P(\text{power})$.

Labor, fertilizer and power are the same inputs used in the construction of Malmquist index while land is corrected for floods and droughts.

The above equation is estimated using Coelli's Frontier 4.1 econometric package with symmetry imposed. The maximum likelihood estimates of the parameters are reported in appendix 2.

Technical change is obtained through differentiation of the above equation with respect to t :

¹³ This variable is obtained by subtracting flood and draught areas from total sown areas.

$$\frac{\partial \ln Y_{it}}{\partial t} = \alpha_i + \beta_u t + \sum_m \beta_m \ln x_{mit}$$

Technical efficiency level of firm i at time t is defined as follows.

$$TE_{it} = \exp(-u_{it})$$

It is the ratio of the actual output to the potential output.

The elasticity of output with respect to the m th input, the production elasticity of input m , is defined by

$$\varepsilon_m = \frac{\partial \ln f(x, t)}{\partial \ln x_m} = \alpha_m + \sum_{n \neq m} \beta_{mn} \ln x_n + \beta_{mm} \ln x_m + \beta_m * t,$$

$m, n = D, L, F$ and P .

Using these production elasticities we can obtain an estimate of aggregate returns to

scale, $\varepsilon = \sum_m \varepsilon_m$. When $RTS > 1$, $= 1$ and < 1 , there are increasing, constant and decreasing

return to scale respectively.

The rate of TFP (total factor productivity) is defined as the rate of change in output that is not explained by the input change:

$$TFP = \dot{y} - \sum_m \varepsilon_m \dot{x}_m = \text{Technical change} + \text{Efficiency change}.$$

The national and state average rates of technical change and technical efficiency change along with the rates of change of TPF from 1993 to 2001 are reported in table 3 and table 4 respectively. Comparing the national average from this approach with the results from the Malmquist index we can see that the growth rate of technical change is consistent in the two approaches except in 2000 and 2001. In these two years, the

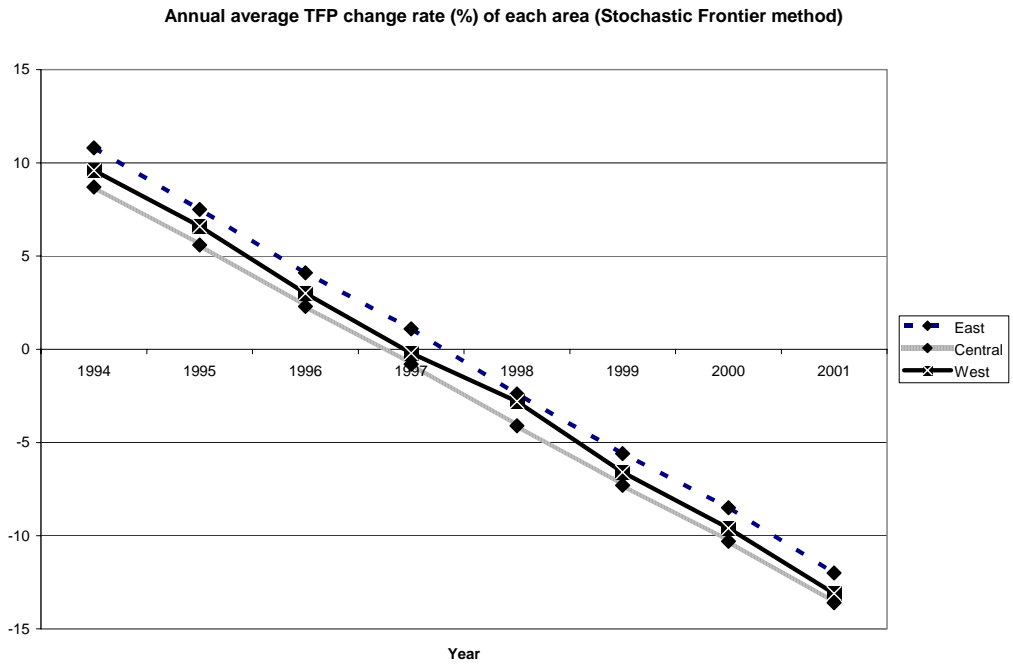
Malmquist shows positive technical change while the stochastic frontier shows negative technical change. Both approaches also show, on average, deteriorating technical efficiency.

Year	Rate of Technical Change	Rate of Technical Efficiency Change	Rate of TFP change
1993	0.14		
1994	0.11	-0.0099	0.1001
1995	0.08	-0.0083	0.0717
1996	0.04	-0.0101	0.0299
1997	0.01	-0.0102	-0.0002
1998	-0.02	-0.0103	-0.0303
1999	-0.05	-0.0104	-0.0604
2000	-0.08	-0.0105	-0.0905
2001	-0.11	-0.0106	-0.1206
Mean	0.014	-0.01	0.004

Comparing Tables 2 and 4 we see that Beijing, Tianjin, Zhejiang, Shanghai, Hainan, and Qinghai share high TFP growth across methodologies. Guangxi is also identified by both methods as a poor performer.

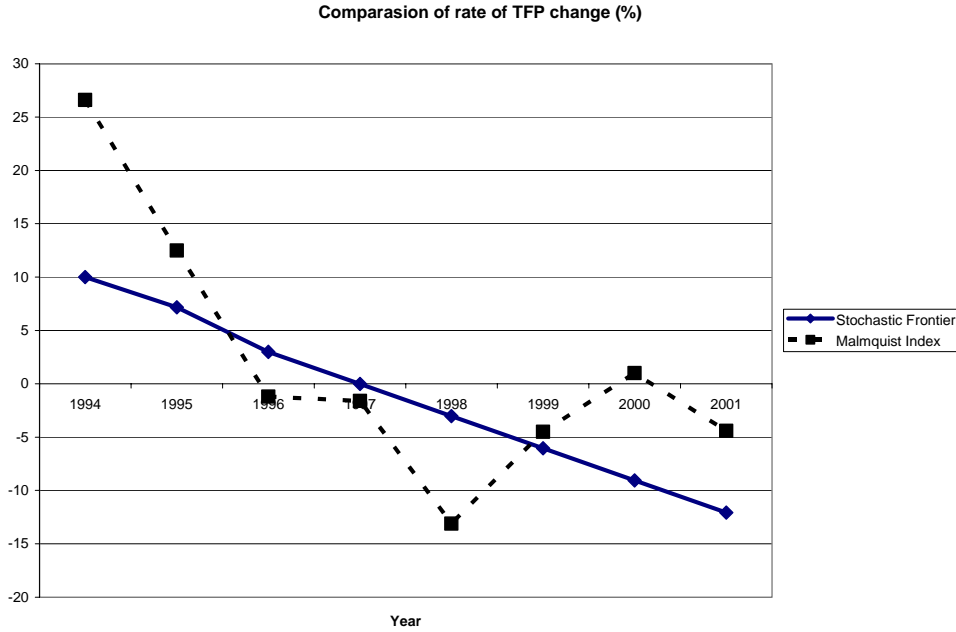
Region	Technology change rate	Technical Efficiency Change Rate	TFP change rate
Beijing	0.042	-0.0051	0.0369
Tianjin	0.05	-0.0153	0.0347
Hebei	0.017	-0.0146	0.0024
Shanxi	0.022	-0.0229	-0.0009
Inner Mongolia	0.011	-0.0131	-0.0021
Liaoning	0.014	-0.0057	0.0083
Jilin	0.005	-0.0124	-0.0074
Heilongjiang	-0.003	-0.0138	-0.0168
Shanghai	0.022	-0.0041	0.0179
Jiangsu	0.002	-0.0065	-0.0045
Zhejiang	0.021	-0.0044	0.0166
Anhui	0.004	-0.0133	-0.0093
Fujian	0.009	-0.0067	0.0023
Jiangxi	-0.002	-0.0076	-0.0096
Shandong	0.008	-0.0105	-0.0025
Henan	0.004	-0.0151	-0.0111
Hubei	-0.005	-0.0111	-0.0161
Hunan	0.005	-0.0073	-0.0023
Guangdong	0.008	-0.0006	0.0074
Guangxi	0.003	-0.0126	-0.0096
Hainan	0.021	-0.0089	0.0121
Sichuan	-0.007	-0.001	-0.008
Geizhou	0.001	-0.0095	-0.0085
Yunnan	0.008	-0.0126	-0.0046
Tibet	0.058	-0.0252	0.0328
Shaanxi	0.006	-0.0179	-0.0119
Gansu	0.015	-0.0194	-0.0044
Qingghai	0.044	-0.0279	0.0161
Ningxia	0.026	-0.0337	-0.0077
Xinjiang	0.006	-0.0131	-0.0071

Detailed information for all provinces and all years is provided in Appendix 7. A summary of the information in these tables is presented in the following graph where the evolution of the rate of total factor productivity growth is shown for three regions:



This graph makes the downward trend clear (the linearity has been imposed by the approximation we chose) and shows that the East has consistently outperformed the Central and West regions. This is consistent with the information provided by the Malmquist index. In addition this graph shows the West outperforming the Central region. This is not consistent with the Malmquist index growth rates. We need to keep in mind though that the stochastic frontier estimates included the data for Tibet while we had eliminated this information from the Malmquist index calculations. We note, in table 4, that Tibet shows a high and positive rate of agricultural productivity growth.

Another comparison of interest is the one presented in the following graph where the average rates of agricultural productivity growth estimated by both methods are superimposed:



We can see that both estimates are consistent. More detailed information of the estimates by province and by region is provided in the appendices along with production elasticities and returns to scale.

VI. A Model for Differential Performance of the Regions.

In an attempt to identify variables that are potential contributors to technical inefficiency, we follow the specification of Battese and Coelli (1995). They suggest that technical inefficiency, which reflects regional heterogeneity, may be influenced by particular variables. In our case we hypothesize that differential performance of the regions will be affected by availability of public goods like public agricultural expenditures, education, and infrastructure.

The model is specified as follows:

$$\ln Y_{it} = \alpha_0 + \sum_m \alpha_m \ln x_{mit} + \alpha_t t + \frac{1}{2} \sum_m \sum_n \beta_{mn} \ln x_{mit} \ln x_{nit} + \frac{1}{2} \beta_{tt} t^2 + \sum_m \beta_{tm} \ln x_{mit} * t + v_{it} - u_{it}$$

Y_{it} , x_{it} and β are the same as defined earlier.

V_{it} are still assumed to be random errors which are iid $N(0, \sigma_v^2)$ and are independent of U_{it} . U_{it} are non negative random variables that account for technical inefficiency. U_{it} are independently distributed as truncations at zero of the $N(m_{it}, \sigma_U^2)$. And $m_{it} = z_{it}\delta$. Here z_{it} is a 3×1 vector of variables that may contribute to the technical efficiency of a region. And δ is the parameter vector to be estimated.

The three variables in the z vector are: public agricultural expenditures, the rate of illiteracy, and the irrigation ratio. We expect that the first and the third will increase technical efficiency, and the second will lower technical efficiency.

Public agricultural expenditures include expenditures on agricultural water conservancy, meteorology, resource investigation, subsidies to well drilling, sprinkling irrigation projects and popularization of improved varieties. The amount of expenditure is related to the production level. To get a unit level expenditure, total agricultural expenditure of each province is divided by total sown area in each province. This can be viewed as a provision of a public goods to farmers and we should expect it to contribute positively to productivity.

The rate of illiteracy includes illiterate and semi-literate population ratio for individuals of age 15 and over. This variable can be viewed as a proxy for education, which reflects the quality of the labor input. We expect a negative sign here.

Irrigation denotes the irrigation ratio, which states the ratio of irrigated area to total sown area. This can be viewed as a proxy for land quality and a positive sign is expected.

Because the Yearbook only provides data on agricultural expenditure after 1996, the

estimated regression is based on the data from 1996 to 1999 and 2001¹⁴.

The impact of these variables in explaining differential behavior across regions is reported in table 5. It should be noted that this is not a special case of the model of the last section. In fact these models are non-nested and we use fewer observations in the latest estimation. So we will not compare the estimated coefficients from the two specifications. Table 6 only reports the estimates of the parameter of the z vector of variables to give us some idea of the impact of these variables. This analysis indicates that availability of public goods like R&D, education and infrastructure are important in explaining the differential performance of the agricultural sector across Chinese provinces. These figures indicate that the more human capital, infrastructure, and research expenditures the better the performance of the region.

Table 5 Estimates of the Parameters of the z Vector				
		Coefficients	Standard-error	t-ratio
Irrigation	delta 1	-0.0110	0.0047	-2.35
Illiterate	delta 2	0.0208	0.0046	4.53
Ag expenditure	delta 3	-0.0054	0.0008	-6.83

VII. Conclusion

In this paper, a nonstochastic Malmquist Index and a stochastic frontier production function are estimated to examine agricultural productivity growth in Chinese provinces during the 1990's. Results for both methods indicate high productivity growth in the mid 1990's with a declining trend thereafter. While the Malmquist index picks up a reversal of this trend in 2000-2001, this is not evident in the stochastic frontier estimates. This is

¹⁴ Year 2000 is excluded because the yearbook for that year's data does not provide the illiterate ratio we used for our model.

not a surprising result given that the econometric approach summarizes in its estimates the information for the whole period while the Malmquist index uses only two consecutive years' data. Both methods identify the same regions as the most productive. Variables representing public inputs such as education, research and infrastructure are shown to have an important impact on differential provincial performance.

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Appendix 1

Data Summary Across Regions						
<i>Year</i>		<i>Gross Output Value*</i> <i>(100 million yuan)</i>	<i>Land Area**</i> <i>(1000 hectares)</i>	<i>Labor</i> <i>(10000 Persons)</i>	<i>Fertilizer</i> <i>(10000 tons)</i>	<i>Power</i> <i>(10000 kw)</i>
1993	Mean	367	4349	1109	105	1061
	Standard Deviation	279	3060	975	89	860
1994	Mean	484	4849	1090	111	1127
	Standard Deviation	359	3437	952	90	953
1995	Mean	564	4396	1078	120	1204
	Standard Deviation	412	3298	939	98	1055
1996	Mean	594	4514	1075	128	1285
	Standard Deviation	436	3186	928	105	1193
1997	Mean	593	4263	1081	133	1403
	Standard Deviation	437	3107	924	108	1368
1998	Mean	558	4562	1088	136	1507
	Standard Deviation	411	3306	917	113	1493
1999	Mean	534	4490	1097	137	1633
	Standard Deviation	393	3319	936	115	1657
2000	Mean	523	4173	1093	138	1752
	Standard Deviation	385	3176	945	117	1818
2001	Mean	527	4280	1082	142	1839
	Standard Deviation	390	3156	927	121	1930

Note: * Gross output value is deflated by indices of gross output.

**Land area is obtained by using total sown area minus areas affected by flood and draught area.

Appendix 2. Estimated parameters for stochastic frontier translog production function

Parameters	Estimates	T-ratio
α_0	-0.972	-0.434
α_D	0.622	1.911
α_L	1.048	2.190
α_F	-0.622	-1.139
α_P	0.125	0.229
α_t	0.229	5.158
β_{DD}	-0.008	-0.333
β_{LL}	-0.027	-0.450
β_{FF}	-0.006	-0.115
β_{PP}	-0.537	-0.885
β_{DL}	-0.190	-2.175
β_{DF}	0.098	1.166
β_{DP}	0.062	0.665
β_{LF}	0.103	1.2217
β_{LP}	0.069	0.745
β_{FP}	-0.048	-0.483
β_{Dt}	-0.019	-2.101
β_{Lt}	0.004	0.451
β_{Ft}	-0.012	-1.182
β_{Pt}	0.018	2.07
β_{tt}	-0.017	-14.669

Appendix 3

Output elasticity of input evaluated at national mean					
Year	Power	Land	Fertilizer	Labor	Scale elasticity
1993	0.04	0.03	0.53	0.15	0.765
1994	0.05	0.02	0.54	0.15	0.767
1995	0.07	0.06	0.52	0.13	0.782
1996	0.08	0.06	0.52	0.12	0.788
1997	0.09	0.08	0.51	0.11	0.794
1998	0.09	0.08	0.52	0.11	0.792
1999	0.1	0.09	0.51	0.1	0.791
2000	0.11	0.11	0.5	0.08	0.794
2001	0.11	0.11	0.5	0.08	0.796
Mean	0.08	0.07	0.52	0.11	0.785

Appendix 4. Regional technical efficiency change, technical change, and total factor productivity growth rates, Malmquist Index.

Annual Average of Technical Efficiency Change for Each Area (Malmquist Index Method)								
Year	1994	1995	1996	1997	1998	1999	2000	2001
East	0.997	1.041	0.968	0.970	0.926	1.027	0.974	0.915
Central	1.124	1.070	0.969	0.887	0.916	1.015	0.975	0.947
West	1.084	1.112	0.967	0.861	0.938	1.061	0.956	0.974

Note: East area includes the following regions: Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Guangxi and Hainan. The central area includes Shanxi, Inner Mongolia, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, and Hunan. The west area includes Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang.

Annual Average Technical change for Each Area (Malmquist Index Method)								
Year	1994	1995	1996	1997	1998	1999	2000	2001
East	1.215	1.093	1.031	1.070	0.942	0.954	1.086	1.026
Central	1.192	1.039	1.027	1.099	0.952	0.937	1.026	1.019
West	1.188	1.018	1.011	1.120	0.947	0.909	1.011	1.017

Annual Average TFP change rate (%) for Each Area (Malmquist Index Method)								
Year	1994	1995	1996	1997	1998	1999	2000	2001
East	21	13.6	-0.3	3.4	-12.9	-2.4	5.8	-5.7
Central	33.8	11.2	-0.7	-3.7	-13.1	-5.4	0.1	-3.5
West	28.5	13.1	-2.5	-5.3	-11.5	-4.7	-3.4	-1.3

Appendix 5. Regional technical efficiency, technical change, and total factor productivity growth rates, stochastic frontier production function,

Annual Average of Technical Efficiency for Each Region (Stochastic Frontier Method)									
Year	1993	1994	1995	1996	1997	1998	1999	2000	2001
East	0.72	0.71	0.71	0.70	0.70	0.69	0.69	0.68	0.68
Central	0.57	0.57	0.56	0.56	0.55	0.54	0.53	0.53	0.52
West	0.50	0.49	0.48	0.48	0.47	0.46	0.46	0.45	0.44

Annual Average Technology Change Rate for Each Area (Stochastic Frontier Method)									
Year	1993	1994	1995	1996	1997	1998	1999	2000	2001
East	0.149	0.115	0.082	0.049	0.018	-0.016	-0.048	-0.076	-0.111
Central	0.134	0.099	0.068	0.035	0.004	-0.028	-0.060	-0.089	-0.122
West	0.147	0.112	0.083	0.047	0.016	-0.010	-0.047	-0.078	-0.112

Annual Average TFP Change Rate (%) for Each Area (Stochastic Frontier Method)								
Year	1994	1995	1996	1997	1998	1999	2000	2001
East	10.8	7.5	4.1	1.1	-2.4	-5.6	-8.5	-12
Central	8.7	5.6	2.3	-0.8	-4.1	-7.3	-10.3	-13.6
West	9.6	6.6	3	-0.2	-2.8	-6.6	-9.6	-13.1

Appendix 6

Summary of provincial technical change rate (%) (Malmquist index method)								
REGION	1994	1995	1996	1997	1998	1999	2000	2001
Beijing	23.1	19.4	6.9	4.8	-7.3	0.6	4.8	9.7
Tianjing	14.1	0.8	-4.6	23.5	-7.2	-8.1	7.2	15
Hebei	15.4	11.5	1.6	7.5	-7	-4.2	-1.2	14.8
Shanxi	16.7	6.5	-1.9	18.2	-10.7	-6.1	0.7	8.7
Inner mon	15.3	0.3	-4.9	31.3	-13.9	-17	-2.4	6.4
Liaoning	27.2	7.4	3.3	8.6	-8.8	-2.6	20.6	-4.9
Jilin	21.9	4.2	9.2	-2.4	-2.2	-0.7	12.1	-0.7
Heilongjiang	33.8	2.5	3.1	20.6	-6.4	-21.1	-0.3	1.2
Shanghai	38.5	10.6	5.9	11.3	-6.6	-10.8	4.6	1.5
Jiangsu	25.6	15.8	6.3	-0.6	-5.7	4.6	11.1	5
Zhejiang	14.1	10.1	0	24.6	-11.2	-16	-1.4	11
Anhui	16.3	6.2	2.1	6.7	-5.3	-2	3.1	-0.6
Fujian	19.4	13.8	9.9	-3.6	-4.1	4.4	9	1.8
Jiangxi	17.5	1.2	8.6	-4.5	1.2	0.5	4.3	-4.1
Shandong	23.4	7.2	3.6	6.2	-8.8	3.6	8.5	7
Henan	16.6	7.4	0.4	14.5	-6.8	-5.6	2.3	1.7
Hubei	17.5	1.2	8.6	-4.5	1.2	0.5	6.3	4.5
Hunan	16.9	5.6	-1.3	8.9	-0.6	-18.2	-2.7	0.2
Guangdong	22.6	10.4	4.3	0.6	-5.5	-7.3	3.1	-2.4
Guangxi	17.5	1.5	3.1	-0.4	1.2	-6.8	-0.2	-3.5
Hainan	16.8	2.8	-3	2	1.2	-12.5	37.3	-23.8
Sichuan	17.5	1.2	8.6	-4.5	1.2	-0.2	4.8	-4.9
Guizhou	17.5	1.2	8.6	-4.5	1.2	-2.7	2.3	-3.8
Yunnan	17.2	0.5	-5.9	12.1	-2.6	-17.8	-3.4	-0.7
Shaanxi	17.5	5.7	9	-2.6	-1.1	2.3	4.7	-2.9
Gansu	15.8	1.1	-6	30.4	-13.9	-17.3	-2.7	4.9
Qingghai	14.2	-2.1	-6	30.3	-13.9	-15.7	-1.2	14.8
Ningxia	18.7	4.6	-3.3	31.3	-9.7	-8.5	1	4.3
Xinjiang	31.6	2	3.8	3.3	-3.9	-13.3	3.1	1.9

Summary of provincial efficiency change rate (%) (Malmquist index method)

REGION	1994	1995	1996	1997	1998	1999	2000	2001
Beijing	0	0	0	0	0	0	0	0
Tianjing	0	0	-8.1	-19.7	-3.8	2.4	-4.2	-13.4
Hebei	3.6	16.2	-6.1	-3.4	-9.9	5.8	-3.6	-10.7
Shanxi	8.1	23.2	-0.6	-3.2	-16.6	17.3	-7.8	-6.2
Inner mon	20.5	-2.1	-6.4	-32.4	15.8	13.7	2.6	-10.3
Liaoning	-1.8	18.2	-12	24.9	-36.6	17.2	3.5	-10.7
Jilin	25	1.2	-13.8	5	-17.3	-6.4	11.1	-14.8
Heilongjiang	0.2	10.6	-1.1	-26.9	-17.2	10.1	-2.1	4.4
Shanghai	0	0	0	0	0	0	0	0
Jiangsu	0.8	-6	-8.1	1.6	-0.5	-5.6	-6.7	-10.2
Zhejiang	9.1	1.4	-0.6	-18.7	14.1	11.3	5.3	-9.1
Anhui	15.7	-0.9	-10	-11.4	4.3	-5.5	-5	-8.4
Fujian	2.5	-2.6	-9	-0.2	4.1	-10.4	-7.7	-3.1
Jiangxi	10.8	9.2	-5.3	-3.5	-11	-9.9	-2.3	1.6
Shandong	-10.8	7.1	4.6	0.3	-20	-6.7	-4.4	-7.8
Henan	1.5	6.8	5.3	-14.8	-6.5	4.2	-7.9	-6.1
Hubei	18.9	5.2	-4.3	-0.2	-13.2	-8.9	-11.9	-6.7
Hunan	10.7	9.5	8.2	-14.3	-13.9	6.7	1	-1.1
Guangdong	-8.1	5.3	-1	-5.7	-5.8	6	-8.8	-7
Guangxi	0.7	9.7	1.3	-5.4	-22.3	-8.2	-5	-2.1
Hainan	0	0	0	-9.7	-8.5	21.1	0	-27.5
Sichuan	7.2	6.5	-5	0.2	-13.8	-12.1	-8.5	6.2
Guizhou	10.5	13.2	-9.2	0.5	-12.9	-9	-9.8	5.1
Yunnan	-1.8	13.7	7.4	-17.7	-4.1	38.7	-15.7	-6.2
Shaanxi	2.6	14.1	-5.5	-5.1	-11.8	-10.2	-5.7	2.5
Gansu	21	20.4	-4.1	-30.1	0.3	13.2	-1.7	-8.1
Qingghai	20.8	8	4.4	-23.3	13.9	16.3	-0.8	-7.6
Ningxia	8	6.6	-3	-27.8	-16.2	9.8	12.3	-6.5
Xinjiang	-1.2	6.7	-11.6	-7.9	-4.7	1.8	-5.2	-6.5

Summary of provincial TFP change rate (%) (Malmquist index method)

REGION	1994	1995	1996	1997	1998	1999	2000	2001
Beijing	23.1	19.4	6.9	4.8	-7.3	0.6	4.8	9.7
Tianjing	14.1	0.8	-12.3	-0.9	-10.7	-5.9	2.7	-0.4
Hebei	19.5	29.5	-4.6	3.8	-16.2	1.3	-4.7	2.6
Shanxi	26.2	31.3	-2.5	14.5	-25.5	10.1	-7.2	1.9
Inner mon	39	-1.8	-11	-11.3	-0.3	-5.7	0.1	-4.6
Liaoning	24.9	26.9	-9.1	35.5	-42.2	14.2	24.8	-15.1
Jilin	52.4	5.5	-5.8	2.5	-19.1	-7.1	24.5	-15.3
Heilongjiang	34.1	13.3	1.9	-11.8	-22.5	-13	-2.4	5.6
Shanghai	38.5	10.6	5.9	11.3	-6.6	-10.8	4.6	1.5
Jiangsu	26.7	8.9	-2.4	0.9	-6.2	-1.3	3.6	-5.7
Zhejiang	24.5	11.6	-0.6	1.3	1.4	-6.5	3.8	0.9
Anhui	34.5	5.3	-8.1	-5.5	-1.2	-7.5	-2	-8.9
Fujian	22.3	10.8	0	-3.8	-0.2	-6.4	0.6	-1.3
Jiangxi	30.2	10.5	2.8	-7.9	-9.9	-9.4	1.9	-2.6
Shandong	10	14.8	8.4	6.6	-27.1	-3.3	3.7	-1.3
Henan	18.3	14.6	5.6	-2.5	-12.8	-1.6	-5.8	-4.5
Hubei	39.7	6.5	3.9	-4.7	-12.2	-8.4	-6.3	-2.5
Hunan	29.5	15.5	6.8	-6.7	-14.4	-12.7	-1.7	-0.8
Guangdong	12.7	16.2	3.3	-5.1	-10.9	-1.7	-6	-9.2
Guangxi	18.4	11.3	4.4	-5.8	-21.4	-14.4	-5.2	-5.5
Hainan	16.8	2.8	-3	-7.9	-7.4	5.9	37.3	-44.7
Sichuan	25.9	7.8	3.1	-4.3	-12.7	-12.2	-4.1	1
Guizhou	29.9	14.6	-1.4	-4	-11.9	-11.5	-7.8	1.1
Yunnan	15	14.3	1.1	-7.8	-6.5	14	-18.6	-6.9
Shaanxi	20.6	20.5	3.1	-7.6	-12.7	-8.1	-1.3	-0.5
Gansu	40.2	21.8	-9.9	-8.9	-13.7	-6.5	-4.4	-3.6
Qingghai	38	5.8	-1.9	0	-1.9	-2	-2	6.1
Ningxia	28.3	11.5	-6.2	-5.2	-24.3	0.4	13.4	-2.5
Xinjiang	30.1	8.8	-8.2	-4.9	-8.4	-11.7	-2.2	-4.8

Summary of provincial technical change rate (%) (Stochastic Frontier)								
Region	1994	1995	1996	1997	1998	1999	2000	2001
Beijing	13.8	10.7	7.5	4.2	0.6	-2.5	-5.4	-8.4
Tianjing	15	11.3	8	5	1.6	-1.9	-4.5	-8.2
Hebei	11	8	5	2.1	-1.6	-4.5	-7.7	-10.9
Shanxi	11.4	8.6	5.3	2.5	-1.6	-3.6	-7.3	-10.1
Inner mon	10.8	7.6	4	1	-2.5	-5.5	-8.3	-11.5
Liaoning	10.7	7.9	4.3	1.9	-2.4	-5	-7.3	-11.4
Jilin	9.7	6.8	3.4	1	-2.9	-6.2	-8.2	-12
Heilongjiang	9.2	6.1	2.8	-0.4	-3.3	-6.9	-9.7	-13.1
Shanghai	12.2	8.6	5.2	2.6	-1	-4.5	-7.9	-11.1
Jiangsu	9.9	6.6	3.2	0.1	-3.3	-6.3	-9.4	-12.8
Zhejiang	11.7	8.6	5.2	2	-1.2	-4.3	-7.5	-10.6
Anhui	9.8	6.7	3.3	0.3	-2.7	-5.9	-8.9	-12.3
Fujian	10.7	7.5	4	0.8	-2.4	-5.8	-8.9	-12.2
Jiangxi	9.2	6.1	2.7	-0.5	-2.9	-6.8	-9.7	-13
Shandong	10.2	7	3.9	1	-2.6	-5.6	-8.4	-11.7
Henan	9.7	6.5	3.5	0.6	-2.9	-5.8	-8.9	-12.4
Hubei	9.2	6	2.8	-0.7	-3.8	-7.2	-10.2	-13.3
Hunan	9.9	7	3.8	0.2	-2.7	-6.1	-9.3	-12.3
Guangdong	10.7	7.3	3.6	0.7	-2.5	-5.7	-9	-12.4
Guangxi	10.2	6.9	3.7	0.1	-3	-6.2	-9.6	-12.7
Hainan	11.8	8.6	5.1	1.6	-1.6	-4.7	-5.9	-11.4
Sichuan	8.9	5.7	2.4	-0.7	-4	-7.2	-10.4	-13.4
Guizhou	9.5	6.5	3.3	-0.1	-3	-6.4	-9.6	-12.8
Yunnan	10.5	7.3	4	0.9	-2.5	-5.5	-9.2	-12.4
Tibet	14.9	11.8	7.6	4.3	8.4	-1.3	-4.3	-7.6
Shaanxi	9.9	7.3	3.5	0.9	-2.9	-5.8	-9	-12.2
Gansu	10.9	8.3	4.5	1.5	-2.1	-4.9	-7.8	-11.2
Qinghai	13.7	10.9	7.4	4.1	0.8	-1.7	-3.9	-8.3
Ningxia	12.2	9.3	5.6	2.5	-1.2	-3.9	-6.6	-10.3
Xinjiang	10.5	7.2	3.8	0.5	-2.9	-5.9	-9.1	-12.4

Summary of provincial technical efficiency change rate (%) (Stochastic Frontier)								
Region	1994	1995	1996	1997	1998	1999	2000	2001
Beijing	-0.5	-0.5	-0.5	-0.5	-0.51822	-0.5	-0.5	-0.6
Tianjing	-1.4	-1.5	-1.5	-1.5	-1.54723	-1.6	-1.6	-1.6
Hebei	-1.4	-1.4	-1.4	-1.4	-1.5	-1.5	-1.5	-1.6
Shanxi	-2.1	-2.2	-2.2	-2.3	-2.3	-2.4	-2.4	-2.5
Inner mon	-1.2	-1.2	-1.3	-1.3	-1.3	-1.3	-1.4	-1.4
Liaoning	-0.5	-0.5	-0.5	-0.6	-0.6	-0.6	-0.6	-0.6
Jilin	-1.2	-1.2	-1.2	-1.2	-1.3	-1.3	-1.3	-1.3
Heilongjiang	-1.3	-1.3	-1.3	-1.4	-1.4	-1.4	-1.4	-1.5
Shanghai	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4
Jiangsu	-0.6	-0.6	-0.6	-0.6	-0.7	-0.7	-0.7	-0.7
Zhejiang	-0.4	-0.4	-0.4	-0.4	-0.4	-0.5	-0.5	-0.5
Anhui	-1.2	-1.3	-1.3	-1.3	-1.3	-1.4	-1.4	-1.4
Fujian	-0.6	-0.6	-0.6	-0.7	-0.7	-0.7	-0.7	-0.7
Jiangxi	-0.7	-0.7	-0.7	-0.8	-0.8	-0.8	-0.8	-0.8
Shandong	-1	-1	-1	-1	-1.1	-1.1	-1.1	-1.1
Henan	-1.4	-1.4	-1.5	-1.5	-1.5	-1.6	-1.6	-1.6
Hubei	-1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.2	-1.2
Hunan	-0.7	-0.7	-0.7	-0.7	-0.7	-0.8	-0.8	-0.8
Guangdong	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
Guangxi	-1.2	-1.2	-1.2	-1.2	-1.3	-1.3	-1.3	-1.3
Hainan	-0.8	-0.8	-0.9	-0.9	-0.9	-0.9	-0.9	-1
Sichuan	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
Guizhou	-0.9	-0.9	-0.9	-0.9	-1	-1	-1	-1
Yunnan	-1.2	-1.2	-1.2	-1.3	-1.3	-1.3	-1.3	-1.4
Tibet	-2.3	-2.4	-2.4	-2.5	-2.5	-2.6	-2.6	-2.7
Shaanxi	-1.7	-1.7	-1.7	-1.8	-1.8	-1.8	-1.9	-1.9
Gansu	-1.8	-1.8	-1.9	-1.9	-2	-2	-2	-2.1
Qinghai	-2.6	-2.6	-2.7	-2.8	-2.8	-2.9	-2.9	-3
Ningxia	-3.1	-3.2	-3.3	-3.3	-3.4	-3.5	-3.5	-3.6
Xinjiang	-1.2	-1.2	-1.3	-1.3	-1.3	-1.4	-1.4	-1.4

Summary of provincial TFP change rate (%) (Stochastic Frontier)								
Region	1994	1995	1996	1997	1998	1999	2000	2001
Beijing	13.3	10.2	7	3.7	0.1	-3.1	-6	-8.9
Tianjing	13.6	9.9	6.5	3.5	0	-3.5	-6.1	-9.8
Hebei	9.6	6.6	3.6	0.6	-3.1	-6	-9.2	-12.5
Shanxi	9.3	6.4	3	0.2	-3.9	-6	-9.7	-12.6
Inner mon	9.6	6.4	2.8	-0.2	-3.8	-6.8	-9.7	-13
Liaoning	10.2	7.4	3.8	1.3	-3	-5.6	-7.9	-12
Jilin	8.5	5.7	2.2	-0.3	-4.2	-7.4	-9.5	-13.3
Heilongjiang	7.9	4.8	1.4	-1.7	-4.7	-8.3	-11.1	-14.6
Shanghai	11.8	8.2	4.8	2.1	-1.4	-4.9	-8.3	-11.5
Jiangsu	9.3	5.9	2.6	-0.6	-3.9	-7	-10	-13.5
Zhejiang	11.3	8.2	4.8	1.5	-1.6	-4.8	-7.9	-11
Anhui	8.6	5.5	2	-1	-4	-7.3	-10.3	-13.8
Fujian	10.1	6.8	3.4	0.2	-3.1	-6.5	-9.6	-12.9
Jiangxi	8.5	5.4	2	-1.3	-3.7	-7.6	-10.5	-13.8
Shandong	9.2	6	2.9	-0.1	-3.7	-6.7	-9.5	-12.8
Henan	8.3	5.1	2	-0.9	-4.4	-7.4	-10.5	-14
Hubei	8.1	5	1.7	-1.8	-4.9	-8.3	-11.3	-14.5
Hunan	9.2	6.4	3.1	-0.5	-3.4	-6.8	-10	-13.1
Guangdong	10.6	7.3	3.6	0.6	-2.6	-5.8	-9.1	-12.5
Guangxi	9	5.7	2.4	-1.1	-4.3	-7.5	-10.9	-14.1
Hainan	11	7.7	4.3	0.8	-2.5	-5.6	-6.8	-12.4
Sichuan	8.8	5.6	2.3	-0.8	-4.1	-7.3	-10.5	-13.5
Guizhou	8.6	5.6	2.4	-1	-4	-7.4	-10.6	-13.8
Yunnan	9.3	6.1	2.8	-0.4	-3.8	-6.8	-10.5	-13.7
Tibet	12.6	9.4	5.2	1.8	5.9	-3.9	-6.9	-10.3
Shaanxi	8.2	5.6	1.8	-0.8	-4.7	-7.6	-10.9	-14.2
Gansu	9.1	6.5	2.6	-0.4	-4	-6.9	-9.8	-13.3
Qingghai	11.1	8.3	4.7	1.4	-2.1	-4.5	-6.9	-11.3
Ningxia	9.1	6.1	2.3	-0.8	-4.6	-7.3	-10.1	-13.9
Xinjiang	9.3	5.9	2.6	-0.8	-4.2	-7.3	-10.5	-13.8