Decomposition of Agricultural Labor Productivity Growth and its Regional Disparity in China

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Abstract: This paper studies the regional disparity of China's agricultural productivity growth by decomposing it into technical changes, efficiency changes and input accumulation per worker. The convergence test is also used to analyze the determinants of regional disparity. The paper finds that during 1987 and 2005, although the growth of China's agricultural labor productivity mainly depended on the accumulation of inputs, technical changes contributed more to regional disparities in agricultural productivity growth. Improving efficiency to promote TFP growth is important for agricultural labor productivity growth for the three regions—Eastern, Central and Western of China. The increase in inputs for Western China, and the improvement in technical change for Central and Western China are significant aspects to promote the growth of agricultural productivity and narrow the gap with the Eastern China.

Key Words: Agricultural labor productivity growth, Decomposition, Regional disparity

1. Introduction

With the implementation of rural reform started in 1978, China agricultural production grew rapidly. In 1984, agricultural growth rate reached 12.9%, which was the highest rate since 1978. From 1985, this growth rate lowered[3], while the regional

[3] There have been two controversial opinions in academic community about the remarkable deceleration of agricultural growth in China since 1985. The first is that the institutional reform of HRS only brought one-off effect, thus the agricultural growth would definitely slow down with the fading effect of institutional evolvement (McMillan et al., 1989; Fan, 1991; Lin, 1992). The second believes that the market liberalization is more important to agricultural growth than the liberalization of household operation, and the deceleration during mid-1980s was

disparities among Eastern, Central, and Western China enlarged[4]. Large body of literature (McMillan et al., 1989; Fan, 1991; Fan and Pardey, 1992; Lin 1992; Zhang and Carter, 1997; Yao and Liu, 1998; Fan and Zhang, 2002; Fan et al., 2004; Liu and Wang, 2005; etc.) have studied the rapid agricultural growth and analyzed the sources of growth in China agriculture, but few of them pay attention to the regional disparities of agricultural growth in China. However, it is necessary to study the determinants of regional disparities in agricultural labor productivity growth to better-understand China's agricultural growth and reduce the regional inequality.

Typically, there are two major sources of agricultural growth—growth of factor input and productivity. Whether input or productivity contributed more to regional disparity of agricultural labor productivity growth is an interesting question when studying agricultural labor productivity growth in China. This paper aims to investigate determinants of regional disparities in agricultural labor productivity growth by decomposing growth rate into technical changes, efficiency changes and the accumulation of inputs per worker. The structure of the paper is as follows: Section II introduces the decomposition approach and data, and reports the results. Section III analyzes the sources of agricultural productivity, while section IV concludes.

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because of the change of governmental policy to grain market at the end of 1985, when the grain trade was brought back again under government control (Sicular, 1993; Huang, 1998). Certainly, at that time many researchers attributed the stagnation of agricultural growth in 1985 to the marketization of the grain transaction contract at the beginning of that year, thus by the end of 1985 government endowed again the nature of "national mission" to the contract policy.

[4] The agricultural labor productivity is the Eastern, Central and Western China in 1986 separately is 3335.99, 2167.52 and 1654.94 yuan per worker (at 1990 constant price), and in 2005 separately is 9704.28, 5775.10 and 4400.22 yuna per worker (at 1990 constant price).

2. Methodology, Data and Empirical Results

2.1 Methodology

This paper employs Data Envelopment Analysis (DEA), a non-parametric technique which does not require specification of a particular form of the production function. Following Maudos (2000)[5], agricultural productivity growth is decomposed into components attributable to technical changes, efficiency changes and the accumulation of inputs per worker. These components help to analyze the sources of the growth rate of agricultural productivity.

2.2 Data and Variables

Agricultural labor productivity is defined as output of agricultural products per agricultural worker. Agricultural output (Y) measures the gross value of agricultural output which includes farming, forestry, animal husbandry, and fishery. Gross value of agricultural output is measured at 1990 constant price to eliminate the influence of price inflation.

Farmland (N) is the cultivated area of major crops. Capital (K) is the intermediate input. Considering the simultaneous increase in the value of gross agricultural production and the price of intermediate input, the cost of intermediate input is deflated by the price index of gross value of agricultural output to eliminate the influence of price inflation or deflation, i.e. intermediate input cost at current price ÷ (gross value of agricultural output at current price ÷ gross value of agricultural at 1990 constant price). Following the approach of Denison (1985), the labor input (Lab)

[5] For details, see Maudos, J., J.M. Pastor and L.Serrano (2000), Convergence in OECD Countries: Technical Change, Efficiency and Productivity, Applied Economics, Vol.32 (6), pp.757-765.

includes the quantity and quality of labor. The quality of labor input is represented by education, which is reflected by average years of education, and the quantity of labor input is represented by the number of agricultural workers. The quality index of labor input is used as the weight of the quantity, i.e., the growth rate of workers' average education years (E) is used as the weight of the number of workers (L), thus $L \times E$ could reflect the labor input (Lab). When calculating the average years of education, the weights are as follows: illiterate (0 year); primary school (6 years); junior secondary school (9 years); senior secondary school (12 years); technical secondary school (14years), and college and higher level (16 years).

The sample includes data on agricultural production of 30 provinces, autonomous regions and municipalities[6] in mainland China from 1987 to 2005. All the data are from the *China's Rural Statistical Yearbook*.

Eastern China includes Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, and Hainan. The Central region of China includes Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, and Hunan, while the Western region includes Inner Mongolia, Sichuan, Chongqing, Guizhou, Yunnan, Guangxi, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang.

2.3 Empirical results

Using DEAP software (Coelli, 1996), we decompose agricultural labor productivity growth for the period 1987-2005 into three components. Results for all provinces are showed in Table 1.

[6] Since Chongqing was once a part of Sichuan province and its data are not available before 1997, we merge it into Sichuan province here.

Table 1 Decomposition of the growth of agricultural labor productivity (I)

Region	LP2005/LP1987	TFP	Change in Efficiency	Technical Change	Inputs
Beijing	4.056	2.061	1.000	2.061	1.968
Tianjin	3.828	1.480	1.262	1.175	2.587
Hebei	4.065	1.134	1.000	1.134	3.586
Liaoning	2.981	1.354	1.094	1.240	2.201
Shanghai	2.545	2.097	0.865	2.407	1.214
Jiangsu	3.339	1.644	1.037	1.587	2.031
Zhejiang	3.277	1.587	0.965	1.644	2.065
Fujian	3.669	2.134	0.930	2.286	1.719
Shandong	3.364	1.331	0.819	1.615	2.528
Guangdong	2.641	1.957	0.865	2.286	1.350
Hainan	3.605	1.794	1.114	1.587	2.009
Eastern Mean	*3.360*	*1.655*	*0.988*	*1.672*	*2.030*
Shanxi	2.114	1.094	1.018	1.075	1.933
Jilin	2.906	1.354	1.037	1.307	2.146
Heilongjiang	1.989	1.037	0.914	1.134	1.918
Anhui	2.203	0.965	0.930	1.037	2.283
Jiangxi	2.609	1.037	0.930	1.114	2.517
Henan	2.785	1.075	1.018	1.055	2.592
Hubei	2.838	0.947	0.835	1.134	2.996
Hunan	2.444	0.930	0.897	1.037	2.627
Central Mean	*2.463*	*1.048*	*0.945*	*1.109*	*2.351*
Neimenggu	3.033	1.114	1.000	1.114	2.724
Guangxi	3.347	1.075	1.000	1.075	3.115
Sichuan	2.787	1.075	1.055	1.018	2.594
Guizhou	1.689	0.965	1.000	0.982	1.751
Yunnan	2.211	1.000	0.930	1.055	2.211
Tibet	1.865	1.055	1.000	1.055	1.767
Shaanxi	2.447	1.154	1.114	1.037	2.120
Gansu	2.269	1.154	1.114	1.037	1.966
Qinghai	1.393	1.018	1.075	0.947	1.368
Ningxia	2.565	0.805	0.776	1.037	3.188
Xinjiang	2.525	1.262	0.982	1.262	2.001
Western Mean	*2.307*	*1.055*	*1.000*	*1.054*	*2.187*
National Mean	2.695	1.242	0.981	1.265	2.169

Table 1 shows that agricultural labor productivity growth of Eastern China is significantly greater than the Central and Western regions. But because of the low initial level of western region, the gap is not significant between the Western and Central regions. For both the national and three regional averages, between 1987 and 2005, the contribution indexes of agricultural TFP growth and input accumulation per worker are more than 1, which indicates both agricultural TFP growth and input accumulation played important roles in agricultural growth. The contribution index of agricultural TFP growth is smaller, which denotes that agricultural labor productivity growth is mainly from the accumulation of inputs. And TFP growth is mainly from technical changes, while efficiency change does not play a positive role.

Based on the three regional decomposition results, the disparity of TFP contribution indexes among regions is larger than that of the accumulation of inputs. The contribution of inputs to output growth in Central and Western China is larger than that in Eastern China. The contribution of TFP in Eastern China is larger than that in Central and Western China. The contribution of efficiency change to output growth in the three regions does not significantly differ. The contribution of technical changes in Eastern China is larger than that in Western China.

The above elementary comparison of the three regions is based on the results obtained from national sample. In order to observe the trend of agricultural labor productivity growth with its components for each region, we compute the results for the regional samples separately which are showed in table 2.

Table 2 Decomposition of agricultural labor productivity growth of three regions

	Year	Agricultural Labor Productivity Growth	TFP	Change in Efficiency	Technical Change	Inputs
Eastern Region	1988/1987	1.079	0.988	0.944	1.046	1.092
	1989/1988	1.013	0.998	1.064	0.937	1.016
	1990/1989	1.055	1.011	1.018	0.993	1.044
	1991/1990	1.054	1.013	0.989	1.025	1.040
	1992/1991	1.090	1.034	1.005	1.029	1.054
	1993/1992	1.110	1.027	0.973	1.055	1.081
	1994/1993	1.134	1.004	0.991	1.013	1.129
	1995/1994	1.127	1.034	0.995	1.039	1.090
	1996/1995	1.075	1.041	0.992	1.049	1.032
	1997/1996	1.001	0.995	1.000	0.994	1.006
	1998/1997	1.060	1.022	1.001	1.021	1.037
	1999/1998	1.031	1.021	1.000	1.021	1.010
	2000/1999	1.063	1.029	0.965	1.067	1.033
	2001/2000	1.070	1.043	1.011	1.032	1.026
	2002/2001	1.073	1.044	1.002	1.042	1.027
	2003/2002	1.091	1.083	1.001	1.082	1.008
	2004/2003	1.076	1.034	0.997	1.036	1.041
	2005/2004	1.061	1.014	0.983	1.032	1.046
	1987-2005 Mean	1.070	1.024	0.996	1.028	1.045
Central Region	1988/1987	0.998	0.973	0.992	0.981	1.026
	1989/1988	0.980	0.992	1.030	0.964	0.988
	1990/1989	1.071	1.064	1.006	1.058	1.006
	1991/1990	0.957	0.952	0.997	0.954	1.005
	1992/1991	1.089	1.067	1.002	1.065	1.020
	1993/1992	1.105	1.033	1.013	1.019	1.069
	1994/1993	1.091	0.991	0.992	0.998	1.101
	1995/1994	1.111	1.013	1.000	1.013	1.096
	1996/1995	1.119	1.034	1.012	1.021	1.082
	1997/1996	1.000	1.000	1.010	0.990	1.000
	1998/1997	1.017	1.029	0.968	1.062	0.988
	1999/1998	1.021	1.001	1.009	0.992	1.020
	2000/1999	1.029	0.997	1.020	0.978	1.032
	2001/2000	1.039	1.014	0.998	1.016	1.025
	2002/2001	1.079	1.026	0.981	1.046	1.051
	2003/2002	1.061	1.052	1.020	1.032	1.009
	2004/2003	1.113	1.014	1.003	1.011	1.097
	2005/2004	1.066	1.010	0.991	1.018	1.055
	1987-2005 Mean	1.051	1.014	1.002	1.012	1.037

（Continued Table2）

	Year	Agricultural Labor Productivity Growth	TFP	Change in Efficiency	Change in Technical	Inputs
Western Region	1988/1987	1.030	1.004	0.978	1.026	1.026
	1989/1988	1.016	0.992	1.020	0.973	1.024
	1990/1989	1.048	1.031	0.999	1.032	1.016
	1991/1990	1.025	0.978	0.983	0.995	1.048
	1992/1991	1.039	1.042	1.021	1.021	0.998
	1993/1992	1.050	0.994	1.007	0.987	1.056
	1994/1993	1.041	1.013	1.018	0.995	1.027
	1995/1994	1.056	0.978	1.035	0.945	1.080
	1996/1995	1.080	1.008	1.075	0.937	1.071
	1997/1996	1.014	1.009	0.915	1.103	1.005
	1998/1997	1.064	1.016	1.034	0.982	1.047
	1999/1998	1.023	1.012	0.997	1.015	1.011
	2000/1999	1.041	1.001	0.962	1.041	1.040
	2001/2000	1.049	1.005	1.075	0.935	1.043
	2002/2001	1.050	1.022	0.940	1.087	1.028
	2003/2002	1.081	1.073	1.055	1.017	1.007
	2004/2003	1.079	1.009	0.992	1.018	1.070
	2005/2004	1.074	1.008	0.963	1.047	1.066
	1987-2005 Mean	1.048	1.011	1.003	1.008	1.036

Over the whole period, annual average growth of Eastern China is higher than the other two regions. The contribution of input accumulation to each region’s agricultural labor productivity growth is outstanding, which is significantly higher than that of TFP, and the growth rate of input accumulation in the eastern, central and western regions are 4.5%, 3.7% and 3.6% respectively. Among the three regions, the contribution of TFP to labor productivity in the eastern region is most substantial.

Concentrating on the contributions of the components of TFP, we can observe differences existing in the three regions. For Eastern China, technical progress is the important sources of TFP growth. Meanwhile, inefficiency is observed. For the central and western regions, technical progress and efficiency improvement are both the important sources of TFP growth, and the contributions of technical progress, 85.71% and 72.73% respectively, are more significant than that of efficiency improvement, 14.29% and 27.27% respectively.

3. Sources of Convergence

The analysis of the impacts of each of the sources of growth on convergence of labor productivity is the subject of this section, and is intended to help us deeply understand the regional growth disparity in labor productivity. Following Maudos, Pastor and Serrano's（2000）approach, we estimate the relative contribution of each factor to convergence between years 0 and T by taking logarithmic differences between the two using the following regressions:

$$g_{LP_i} = \alpha + \beta_{LP} L\,\mathrm{n}\, LP_{i0} + \varepsilon_i \qquad (1)$$

$$g_{TP_i} = \alpha + \beta_{TP} L\,\mathrm{n}\, LP_{i0} + \varepsilon_i \qquad (2)$$

$$g_{EC_i} = \alpha + \beta_{CE} L\,\mathrm{n}\, LP_{i0} + \varepsilon_i \qquad (3)$$

$$g_{TFP_i} = \alpha + \beta_{TFP} L\,\mathrm{n}\, LP_{i0} + \varepsilon_i \qquad (4)$$

$$g_{INC_i} = \alpha + \beta_{IN} L\,\mathrm{n}\, LP_{i0} + \varepsilon_i \qquad (5)$$

Where g_{LP_i} , g_{TP_i} , g_{EC_i} , g_{TFP_i} , g_{IN_i} ,are respectively annual growth of agricultural labor productivity, technical progress, efficiency, TFP growth, and input accumulation per worker of province i. $L\,\mathrm{n}\, LP_{i0}$ is the logarithm of the initial agricultural labor productivity. Furthermore, we have:

$$\beta_{LP} = \beta_{CE} + \beta_{TP} + \beta_{IN} = \beta_{TFP} + \beta_{IN} \qquad (6)$$

Table 3 Convergence in Agricultural Labor Productivity and its Sources

		R1				
		g_{LP}	g_{CE}	g_{TP}	g_{TFP}	g_{IN}
National	$LnLP_0$	0.0121	-0.0004	0.0219	0.0216	-0.0102
		(2.10) **	(-0.15)	(4.47) ***	(4.59) ***	(-1.81) *
	_cons	-0.0381	0.0017	-0.1584	-0.1578	0.1244
		(-0.84)	(0.09)	(-4.11) ***	(-4.25) ***	(2.79) ***
Eastern	$LnLP_0$	-0.0065	0.0022	0.0154	0.0177*	-0.0243*
		(-0.81)	(0.35)	(1.20)	(1.97)	(-1.87)
	_cons	0.1233	-0.0183	-0.0967	-0.1161	0.2397
		(1.87) *	(-0.36)	(-0.92)	(-1.58)	(2.25) **
Central	$LnLP_0$	-0.0019	-0.0016	0.0074	0.0058	-0.0079
		(-0.22)	(-0.39)	(2.48) *	0.94	(-0.93)
	_cons	0.0661	0.0092	-0.0523	-0.0430	0.1109
		(1.00)	(0.29)	(-2.23) *	(-0.88)	(1.65)
Western	$LnLP_0$	0.0056	-0.0013	0.0082	0.0077	-0.0024
		(0.42)	(-0.26)	(3.40) **	(1.48)	(-0.18)
	_cons	0.0052	0.0097	-0.0593	-0.0551	0.0624
		(0.05)	(0.26)	(-3.24) **	(-1.40)	(0.61)
		R2				
		g_{LP}	g_{CE}	g_{TP}	g_{TFP}	g_{IN}
National	$LnLP_0$	0.0145	-0.0034	0.0256	0.0221	-0.0083
		(2.79) ***	(-1.17)	(7.99) ***	(6.15) ***	(-2.03) **
	_cons	-0.0659	0.0262	-0.1993	-0.1723	0.1113
		(-1.54)	(1.10)	(-7.53) ***	(-5.80) ***	(3.30) ***
Eastern	$LnLP_0$	0.0013	-0.0042	0.0257	0.0213	-0.0201
		(0.15)	(-0.87)	(3.65) ***	(3.07) ***	(-2.77) ***
	_cons	0.0543	0.0353	-0.1930	-0.1563	0.2117
		(0.68)	(0.84)	(-3.17) ***	(-2.60) ***	(3.35) ***
Central	$LnLP_0$	0.0081	-0.0099	0.0188	0.0089	-0.0015
		(0.45)	(-1.20)	(2.43) **	(0.84)	(-0.14)
	_cons	-0.0211	0.0754	-0.1500	-0.0747	0.0601
		(-0.14)	(1.12)	(-2.39) **	(-0.87)	(0.65)
Western	$LnLP_0$	0.0179	-0.0026	0.0134	0.0105	0.0071
		(2.22) **	(-0.39)	(2.52) **	(1.83) *	(0.85)
	_cons	-0.0947	0.0202	-0.1050	-0.0821	-0.0105
		(-1.49)	(0.39)	(-2.52) **	(-1.83) **	(0.16)

*Notes: Asymptotic t-ratios are reported in parenthesis. ***, **, * separately denotes significance at 1 percent level, 5 percent level and 10 percent level.*

Table 3 provides the estimation results for the national, and the eastern, central, and western regions for the period 1987-2005. For the upper part of Table 3 (R1), the sample data is from 1987-2005. For R2 in Table 3, the period 1987-2005 is divided into five intervals: 1987-1989, 1990-1993, 1994-1997, 1998-2001, and 2002-2005. LP_{i0} are agricultural labor productivity in 1987, 1990, 1994, 1998, and 2002 respectively.

Comparing the results between R1 and R2, we find that there are not obvious differences among estimation results. Because the estimation results of R2 are more significant than R1, R2 is chosen in the following analysis.

We find there is significant divergence in the levels of agricultural labor productivity over the whole period, which means disparities in agricultural labor productivity among regions in China became larger. The technical change is a significant source of divergence. Although the effect of efficiency change is positive to convergence, it is not statistically significant. The two effects of technical change and efficiency change together induce agricultural TFP to show divergent trend. The accumulation of inputs per worker has convergent effect on agricultural labor productivity but the convergent effect is not statistically significant for the whole nation.

The convergence test results indicate that the mechanisms of different regions are also different. For the eastern region, input accumulation has positive effect, but TFP has negative effect on labor productivity convergence. Furthermore, technical change has divergent effect; however the efficiency change has convergent effect which is not statistically significant. Finally, agricultural labor productivity in the eastern region is found to be negligibly diverging.

Similarly for western region, technical change has divergent effect, while efficiency change has convergent effect which is not statistically significant, and the total effect of the two on TFP is divergent which is also not statistically significant. The accumulation of inputs per worker has an insignificant divergent effect. Finally agricultural productivity in the western region is found to be significantly diverging.

For the central region, only the parameter of technical change is statistically significant, which is a positive sign indicating convergence. The total effect of all sources of convergence is found to be negligible divergence and not statistically significant.

4. Conclusions

Following the approach of Maudos (2000), this study decomposes the growth of agricultural labor productivity into three components: technological progress, changes in efficiency, and the accumulation of inputs per worker to help analyze the sources of China's agricultural growth and examine the regional disparities in its agricultural growth.

For both national and each regional samples, both agricultural TFP growth and the accumulation of inputs played important roles in agricultural growth over the period 1987-2005. By comparison, the contribution index of agricultural TFP growth is smaller and thus agricultural labor productivity growth mainly attribute to the accumulation of inputs per worker, and TFP growth mainly comes from technical changes, while efficiency change does not play a positive role. The above results indicate that improving technical efficiency to promote TFP growth is important for agricultural growth. For China’s agricultural growth, the co-existing phenomena of progress in production frontier and loss in efficiency provides striking evidence that diffusion of existing agricultural technology in China is not efficient. To promote the development of agricultural growth in China, government should not only improve agricultural production technology, but also strengthen the application of technology to increase agricultural production efficiency in the future development of China's agriculture.

According to regional empirical results, the contribution of input accumulation to labor productivity growth in Central and Western China is larger than that in Eastern China. The contribution of TFP in Eastern China is larger than that in Central and Western China. The contribution of efficiency change to labor productivity growth in the three regions does not significantly differ. The contribution of technical changes in Eastern China is larger than that in the Western Region. Increase in inputs for Western China and the efficiency change for Central and Western China are important aspects to promote the growth of agricultural labor productivity and narrow the gap with the Eastern Region.

The convergence test results indicate that the mechanisms of different regions are also different. For the national sample, it is divergent in the levels of agricultural labor productivity over the whole period, and the divergent contribution of technical change to TFP is a significant source of divergence. The accumulation of inputs per worker has convergent effect on agricultural labor productivity but the convergent effect is not significant for the whole sample. The convergence test gives similar result with decomposition of agricultural labor productivity growth, which points out that agricultural labor productivity growth is mainly from the accumulation of inputs, but TFP is the important source of regional disparity of agricultural growth, especially technical progress in TFP.

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