Did Agricultural Technological Changes Affect China's Regional Disparity?

***Xiaoyun Liu*[a]*, Xiuqing Wang*[b, c]*, Xuefeng Mao*[d]*, Wanchun Luo*[e]*, and Xian Xin*[b, c]**

[a] *College of Humanities and Development, China Agricultural University, Beijing, P.R. China*
[b] *College of Economics and Management, China Agricultural University, Beijing, P.R. China*
[c] *Center for Rural Development Policy, Beijing, P.R. China*
[d] *Renmin University of China, Beijing, P.R. China*
[e] *Chinese Academy of Social Science, Beijing, P.R. China*

Corresponding: xinxian@cau.edu.cn

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Abstract: China's agricultural sector has developed very rapidly in the past 30 years and agricultural technological progress is deemed one of the most substantial factors leading to its rapid agricultural GDP growth. In this paper, we assess the impacts of agricultural technological changes on regional disparity using a general equilibrium model of multiple regions and multiple sectors. Our results suggest that agricultural technological changes significantly reduced China's agricultural regional disparity and accounted for 40% reduction in agricultural regional disparity in terms of agricultural GDP per capita. Agricultural technological changes, however, led to an increase in China's overall regional disparity and accounted for 6% increase in its overall regional disparity in terms of per capita GDP.

Key words: Agricultural technological change, Regional disparity, General equilibrium model

Jel Classification: Q16, R13, O18, O33, C67

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1. Intoduction

China's agricultural sector has developed very rapidly in the past 30 years. Agricultural GDP measured at 1978 constant prices in 2007 is 3.7 times that in 1978 (NBSC, 2008). Agricultural technological progress is deemed one of the most substantial factors leading to China's rapid agricultural GDP growth with contribution ratio ranging from 30% to 60% (Fan, 1997; Jin et al, 2002; Carter, Chen and Chu, 2003; Mao and Koo, 1996; Hu and McAleer, 2003). China's agricultural technological changes not only lead to an increasing amount of agricultural products for final consumption but also provide more agricultural products for non-agricultural production use. The inter-sector linkage of agricultural and non-agricultural sector has become very close. If we divide the Chinese economy into three sectors, agriculture, food processing, and non-food processing and services, China's input-output table (NBSC, 2008) suggests that agricultural materials account for 60% of intermediate inputs to the food processing sector, and 15% to the non-food processing and services sector. Moreover, China's agricultural technological changes also result in releasing labor resources for use in the non-agricultural economy. Agricultural technological changes thus have significant impacts on China's non-agricultural development.

China is also characterized by pronounced regional disparities in natural resourses, human capital, physical capital stocks, and agricultural technological changes which in turn results in pronounced regional disparity in GDP per capita. Quite a number of studies have investigated the causes and impacts of China's regional disparity using different methods and data sources, such as Zhang et al (2008), Jian, Sachs and Warner (1996), Jones, Li, and Owen (2003), Yao and Zhang (2001), Zhang and Zhang (2001), Chen and Zheng (2008), Cai, Wang, and Du (2002), and Lu (2008).

Of particular interest to this paper is that agricultural technological changes differ among China's different regions. Our rudimentary analysis suggests that China's regional agricultural technological changes ranged from 0.44% to 54.74% between 1987 and 2000. Did the observed agricultural technological changes affect China's regional disparity? To the best of our knowledge, there have been no studies to assess the impacts of agricultural technological changes on regional disparity as we do here. Part of the reasons lies in the fact that China's inter-regional input-output tables are absent.

In this paper, we set up a general equilibrium (GE) model of multiple regions and multiple sectors. We use the most recently published and unique set of data on China's inter-regional input-output tables to calibrate the parameters of the general equilibrium model. The earliest and latest available Chinese interregional and international trade flows and input-output data are for 1987 and 2000. Our results suggest that agricultural technological changes significantly reduced China's agricultural regional disparity between 1987 and 2000 and accounted for 40% reduction in regional disparity in agricultural GDP per capita. Agricultural technological changes, however, led to an increase in China's overall regional disparity and accounted for 6% increase in its overall regional disparity in per capita GDP.

The rest of the paper is organized as follows: Section 2 presents the model that we use to assess the impacts of agricultural technological changes on regional disparity. Data sources and the parameters calibrated to 1987 and 2000 data are reported in section 3. In section 4, counterfactual experiment results assessing the impact of agricultural technological changes on regional disparity are set out. Section 5 concludes.

2. Model Structure

The general equilibrium model we use comprises eight regions (seven Chinese regions and the rest of the world) and six sectors, with the rest of the world (ROW) output of the six sectors exogenously given. We use r to represent the seven Chinese regions, w the rest of the world, and s the eight regions. The seven Chinese regions are North-east (including Heilonjiang, Jilin, and Liaoning), North (including Beijing, Tianjin, Hebei, Shandong, Inner Mongolia), East (Including Jiangsu, Shanghai, and Zhejiang), South (Including Fujian, Guangdong, and Hainan), Central (Including Shanxi, Henan, Anhui, Hubei, Hunan, and Jiangxi), North-west (Including Shannxi, Ningxia, Gansu, Qinghai, and

Xinjiang), and South-west (Including Sichuan, Chongqing, Guangxi, Yunnan, Guizhou, and Tibet). The six sectors are Agriculture, Mining, Light Industry, Heavy Industry, Construction, and Service.

Production functions of the seven Chinese regions and utility functions in each of the eight regions are assumed to be nested constant elasticity of substitution (CES), but parametrically different across regions and sectorial commodities. We also assume firms used different combinations of inputs to produce commodities.

On the production side, a three-stage production structure is used to also capture interregional and international trade in intermediate products. At the first stage, firms are assumed to maximize profits using two aggregate inputs, value added (an aggregate of labor and capital) and aggregate intermediate inputs (an aggregate of the six commodities) according to:

$$Q_{rc} = a_{rc}(\alpha_{rcv} V_{rc}^{\rho_{rc}} + \alpha_{rci} I_{rc}^{\rho_{rc}})^{1/\rho_{rc}} . \quad (1)$$

where Q_{rc} is the output of commodity *c* produced in region *r*; V_{rc} and I_{rc} are aggregate inputs of value added and aggregate intermediate inputs used in the production of *c* in regions. a_{rc} is a units term; α_{rcv} and α_{rci} are corresponding share parameters: ρ_{rc} =(σ_{rc}-1)/ σ_{rc}, where σ_{rc} is the elasticity of substitution between aggregate value added and aggregate intermediate inputs. Share and elasticity parameters in (1) need not be the same across regions and commodities. Both output and input markets are assumed competitive.

Value added, in turn, at the second stage is assumed to be a CES function of labor and capital (Equation 2), and aggregate intermediate input a CES function of the six sectorial commodities (Equation 3).

$$V_{rc} = (\alpha_{rcl} L_{rc}^{\rho_{rcv}} + \alpha_{rck} K_{rc}^{\rho_{rcv}})^{1/\rho_{rcv}} . \quad (2)$$

$$I_{rc} = (\sum_{c'} \alpha_{rcc'} FI_{rcc'}^{\rho_{rci}})^{1/\rho_{rci}} . \quad (3)$$

where L_{rc} and K_{rc} are labor and capital inputs used in the production of V_{rc}; $FI_{rcc'}$ is the input of aggregate commodity c' (c' is the alias of *c*) in the production of I_{rc}; α_{rcl} and α_{rck} are corresponding share parameters; α_{rcl} is the share parameter of $FI_{rcc'}$; ρ_{rcv} = (σ_{rcv}-1)/ σ_{rcv}, σ_{rcv} is the elasticity of substitution between L_{rc} and K_{rc} ; and ρ_{rci} = (σ_{rci} -1)/ σ_{rci}, σ_{rci} is the elasticity of substitution between the elements $FI_{rcc'}$.

Each Chinese region chooses between seven Chinese regions and the ROW goods in intermediate use. The bottom level CES function is

$$FI_{rcc'} = \sum_{r'} (\alpha_{rcc's} F_{rcc's}{}^{\rho_{rcc'}})^{1/\rho_{rcc'}} . \tag{4}$$

where $F_{rcc's}$ is the intermediate input demand for region *s* in the production of $FI_{rcc'}$ and $\alpha_{rcc's}$ is the corresponding share parameter $\rho_{rcc'}$ = ($\sigma_{rcc'}$ -1)/ $\sigma_{rcc'}$, and $\sigma_{rcc'}$ is the corresponding elasticity parameter.

Final demands are generated in each of the eight regions by maximizing utility, choosing a bundle of agriculture, resource, manufacturing, construction and service goods each aggregated over the corresponding regional products (Equation 5). We follow the same nesting procedure as with intermediate inputs in the preference structure to yield each region's final demand for different regions' goods (Equation 6). The seven Chinese regions' expenditure on final demand equals incomes from endowments of labor and capital plus international transfers, which we treat in the model as exogenous and equal to trade imbalances in the data. The expenditure on total demand for the rest of the world is equal to total endowment income $\sum_{c} P_{wc} Q_{wc}$. The seven Chinese regions' final demand and the rest of the world's total demand are represented as:

$$H_{sc} = (\alpha_{sch} / PH_{sc})^{\sigma_{sch}} E_s / \sum_{c} (\alpha_{sch}{}^{\sigma_{sch}} PH_{sc}{}^{1-\sigma_{sch}}) . \tag{5}$$

$$Q_{scs'} = (\alpha_{scs'} / P_{sc})^{\sigma_{sce}} E_{sc} / \sum_{s} (\alpha_{scs'}{}^{\sigma_{sce}} P_{sc}{}^{1-\sigma_{sce}}) . \tag{6}$$

$$PH_{sc} = \sum_{r'} (\alpha^{s}{}_{sc}{}^{\sigma_{sce}} P_{sc}{}^{1-\sigma_{sce}})^{1/(1-\sigma_{sce})} . \tag{7}$$

$$E_{sc} = H_{sc} \times PH_{sc} \tag{8}$$

where E_s is the expenditure in region *s*. E_{sc} is the expenditure on *c* in region *s*; H_{sc} is the aggregate demand for commodity *c* in region *s*; PH_{sc} is the corresponding price index, α_{sch} is the corresponding share parameter; $Q_{scs'}$ is the final demand in region *s* for *c* produced by region s' (s' is the alias of *s*), and $\alpha_{scs'}$ the corresponding share parameter. σ_{sch} is the elasticity of substitution at the first stage of final demand and σ_{sce} is the elasticity of substitution of across commodities *c* produced in different regions; P_{sc} is the price of *c* produced in region *s*.

Equilibrium in this model is given by goods and factor prices such that market clearing conditions hold for goods (Equation 9) and factors by region (Equations 10 and 11). [i]

$$Q_{sc} = \sum_{s'} Q_{scs'} + \begin{cases} \sum_{(c',s')} F_{rcc's'}, & s = r = ne, nc, ec, sc, ce, nw, sw\,; \\ 0, & s = w\,; \end{cases} \tag{9}$$

$$L^* = \sum_r \sum_c L_{rc}\,. \tag{10}$$

$$K^* = \sum_r \sum_c K_{kc}\,. \tag{11}$$

where L^* and K^* are the labor and capital endowments.

3. Data and Calibration

To assess the impacts of agricultural technological changes on China’s regional disparity, we first use observed data to calibrate model parameters as in Whalley (1985). Calibration of the GE model involved setting the specified parameters so that they replicate the benchmark data set as a model solution (Table 1).[ii] Once calibrated, the GE model can be used to assess the impacts of agricultural technological changes on China’s regional disparity.

The earliest and latest available Chinese interregional and international trade flows and input-output data are for 1987 and 2000. We use 1987 data to generate the base case model scenario. We then calibrate the model parameters for 2000. The differences between the two years’ model parameters associated with top level agricultural production functions reflect the conventional agricultural technological change. We can replace the 2000 agricultural technology with that of 1987 to conduct counterfactual experiments. The difference between the observed 2000 regional disparity and counterfactual experiment result is thus the contribution of agricultural technological changes.

The Chinese interregional and international trade data and input-output data are taken from Ichimura (2007) and IDE (2003). Data for the rest of the world of the same period are adjusted from the *World Bank* database and NBSC (2005). The seven Chinese regions' labor endowments are represented by the wage bill, thus appealing to the unit convention that the base case price of labor in each region is unity.[iii] The endowment of capital was obtained from the value of output by subtracting the value of intermediate goods and labor inputs also using the unitary price base case convention.

Since elasticities of substitution can play an important role in model results, we utilize the existing literature.[iv] Here we used an elasticity of substitution of 1.25 for the top-level sub-utility function in each region and 2 for bottom level sub-utility functions. The elasticity of substitution between aggregate value added and intermediate inputs was set at 0.5 with a similar value used for the elasticity of substitution between commodity inputs. The elasticity of substitution between labor and capital was set to 1.25. Other model parameters associated with agricultural production functions for the seven Chinese regions were then calibrated and share parameters generated. These two years of calibrated parameters are reported in Table 1 with clear and large differences between them. Agricultural tecnoligical changes also differ among the seven Chinese regions.

Table 1: Calibrated Top Level Agricultural Production Function Parameters

	North -east	North	East	South	Central	North-west	South-west
1987	4.16	3.24	3.73	3.51	2.88	3.33	3.11
2000	4.86	5.01	5.09	4.09	3.21	4.86	3.12
Technoligical Progess (%)	16.75	54.74	36.67	16.55	11.53	45.92	0.44

Source: Calibrated by authors with GAMS software.

4. The impacts of agricultural technological changes on regional disparity

Using the calibrated model parameters, the impacts of agricultural changes on China's regional disparity can be evaluated by removing agricultural technological changes in the seven Chinese regions. We do this by using top level agricultural production function unit parameters generated by calibration to 1987 data rather than those from calibration to 2000 data to conduct counterfactual experiments. When all agricultural technological changes are removed from all Chinese regions in 2000, the counterfactual experiment results should reflect the scenario of 2000 without technological changes compared to 1987. The difference between the observed 2000 regional disparity and counterfactual experiment result is thus the contribution of agricultural technological changes.

Results are reported in Table 2. The removal of agricultural technological changes leads China's agricultutal regional disparity in 2000 to an order of 0.140 rather than the actual 0.119. Agricultural technological changes thus account for 40% changes in China's agricultural regional disparity from 1987 to 2000. Agricultural technological changes merely account for 6% changes in China's regional disparity during the same period.

Table 2: The impacts of agricultural technological changes on regional disparity

	Regional Disparity Index			Countribution rate of agricultural technological changes in regional disparity change
	1987	2000		
		Actual	Without technoligical changes	
Agricultural GDP per capita	0.172	0.119	0.140	40%
GDP per capita	0.240	0.374	0.366	6%

Source: Counterfactual experiment results conducted by authors with GAMS software.

These results suggest that China's agricultural technological changes were successful in reducing its agricultural regional disparity. Agricultural GDP per capita came to be more equalized across regions as the results of agricultural technological changes. The observed agricultural technological changes aggravated China's overall regional disparity in terms of GDP per capita although by an order of 6%. The reasons behind these changes may be that the non-agricultural sectors in different regions differ in the efficiency of the use of labor, capital and agricultural products resulting from agricultural technological changes. Agricultural GDP has been playing a decreasing role in China's overall GDP and thus the differences in regional non-agricultural GDP per capita overweighted the equalization of agricultural GDP per capita. These results imply that the Chinese government should resort more to non-agricultural development to fight against the enlarging regional disparity.

5. Conclusions

China has observed rapid agricultural technological changes in the last decades which in turn promoted the transfer of significant amount of rural labor and capital to the non-agricultural industry. Agricultural technological changes also increased China's agricultural products which also contributed to China's non-agricultural industry growth. On the other hand, China's regional disparity in GDP per capita has been increasing thus raising great concerns for the Chinese government.

We, in this paper, assess the impacts of agricultural technological changes on regional disparity using a general equilibrium model of multiple regions and multiple sectors. We use a unique set of data to calibrate the parameters of the general equilibrium model for 1987 and 2000. We then replace the 2000 agricultural technology with that of 1987 to conduct counterfactual experiments. Our results suggest that agricultural technological changes significantly reduced China's agricultural regional disparity and accounted for 40% reduction in agricultural regional disparity in terms of agricultural GDP per capita. Agricultural technological changes, however, led to an increase in China's overall regional disparity and accounted for 6% increase in its overall regional disparity in terms per capita GDP.

China's GDP has been growing very rapidly since 1978 and agricultural GDP has been playing a decreasing role in China's overall GDP. Regional disparity in non-agricultural GDP per capita overweighted the equalization of agricultural GDP per capita. Our results imply that the Chinese government should resort more to non-agricultural development to fight against the enlarging regional disparity.

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Notes:

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[i] This model form does not explicitly incorporate trade costs. The discussions in Anderson and van Wincoop (2004) and Obstfeld and Rogoff (2000) indicate that the share parameters embody trade costs if trade costs are not explicitly imposed. In this sense, the calibrated share parameters in our model also reflect trade costs.

[ii] Prior to parameter calibration, adjustments have to be made in the basic data, typically from several sources, to satisfy the equilibrium conditions of the GE model. The adjusted data set is usually called the “benchmark” data set. For details on calibration methods, see Dawkins, Srinivasan, and Whalley (2001).

[iii] The Harberger convention (1962) allows for the simplification by representing heterogeneous quantities in a homogenous manner in data as well as in the model.

[iv] Anderson and van Wincoop (2004), Saito (2004), Yi (2003), Whalley and Xin (2006) provide detailed reviews of the magnitudes of elasticity parameters used in different studies. The weakness of the elasticity estimates and the use of elasticity parameters are discussed in Wigle (1991), Dawkins, Srinivasan, and Whalley (2001).