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E2011/2

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ISSN 1749-6101
January 2011

The Impact of Price Regulations on Regional Welfare and Agricultural Productivity in China

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Abstract:

The nineties' agricultural reform in China that was aimed at deregulating the agricultural market eventually resulted in a huge drop in agricultural production and a high rate of inflation in agricultural prices; this apparently motivated the government to take over the control of agricultural prices in 1998. We examine how and to what extent this reform affected the productivity and welfare of grain farmers in China at the regional level. We find that the price regulation that destroyed the incentive to exert more effort adversely affected the growth in agricultural productivity but contributed to the growth in farmers' welfare. Although the price regulations resulted in short term improvement in welfare across all the regions, for the long run such regulations can result in larger drop in agricultural production because of its negative impact on incentives to produce more.

JEL Codes: N55, O13, O53, Q12.

Keywords: China, Welfare, TFP, Agriculture, Grain Production.

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1 Introduction

During 1978-1997 the government of China introduced a series of agricultural policy reforms which were mainly aimed at achieving a higher level of aggregate production of major foodgrains. However, during the nineties China suffered significant declines in grain production. In addition, the liberalization of markets in the nineties allowed for higher degrees of inflation in agricultural prices which eventually resulted in a less than expected level of real income for farmers. This apparently motivated the government to take back the control of agricultural prices in 1998 (through the introduction of the grain self-sufficiency program). In this paper we examine how the price regulations introduced in 1998 affected the productivity and welfare of grain farmers in 30 main agricultural regions of China.

We follow the analytical approach as in Hayami and Ruttan (1985), which McMillan et al. (1989), Lin (1992) and Zhang and Carter (1997) explore to study foodgrain productivity growth in China for 1978-84, 1970-87 and 1979-86, respectively. None of these studies consider the most recent important agricultural reform in China that was introduced in 1998. We examine how the 1998 reform affected the Total Factor Productivity (TFP) of grain production and the welfare level of farmers at a regional level. In this way our study extends all these important previous studies. This paper also adds a new dimension to the empirical relevance of the analytical approach of these works (and others, such as Halbrendt and Gempesaw, 1990 and Che et al., 2001, 2006) by simulating the effect of regulations on the welfare of farmers and the TFP at the regional level[2].

In economies in transition factor price and product price increase at different rates with market reforms. If the net price effect favours farmers, they earn higher income which adds to their utility. However, earning higher income requires more effort that gives them disutility. In this paper we examine the net utility effect of the most recent agricultural reform in China. We use panel data of 30 major grain-producing regions of China for the period 1997-2006 in order to estimate a transformed production function that captures the farmer's optimal response to changes in institutions and policy. We use the results of the econometric estimation in order to simulate the time path of TFP and the time path of optimal utility levels for each of the 30 regions that we consider.

We find that while the price regulations of 1998 resulted in an average negative growth in TFP for almost all regions (except Jiangxi, Jilin, Henan, Liaoning and Tibet), it contributed to the growth in welfare of farmers for all 30 regions. The average regional growth in welfare during 1997-2006 is as high as 9.91% (e.g. Beijing), and the average regional growth in TFP during the same period is as low as -4.07% (e.g. Shanghai). Based on the largest grain producer per hectare scale, most of the large regions experienced decline in TFP but around 7% growth in welfare. Relatively smaller grain producing regions such as Xinjiang, Tianjin, Shanghai, Qinghai and Beijing all experienced over 8% growth in welfare. These results suggest that although the stabilization of agricultural prices

[2] Carter (2003) conducts an investigation of agricultural productivity in China at both the aggregate and farm levels, but his study does not involve any analysis of welfare effects at the regional level.

contributed to farmers' income, it destroyed the incentives to increase effort, resulting in a decline in TFP but also resulting in a positive net impact on farmers' welfare.

2 The Analytical Model

There are j regions which produce grain, and $j = 1, 2, ..., N$. Farmers' utility function is:

$$u(\tau_j, \varepsilon_j) = \tau_j - \theta \varepsilon_j^{\frac{1}{\theta}} \tag{1}$$

where $\theta \in (0,1)$, τ_j denotes the net income from grain production and ε_j is the level of effort by the representative farmer in region j[3]. Grain production requires four inputs: effective contribution of labour ($\varepsilon_j N_j$), land (L_j), machinery power (M_j) and chemical fertilizers (F_j). With $\delta_0 \in (0, \infty)$ and $\delta_i \in [0,1], i = 1,2,3,4$, such that $\sum_{i=1}^{4} \delta_i = 1$, the *technical* constant returns to scale (CRTS) grain production function for region j is:

$$Q_j = \delta_0 (\varepsilon_j N_j)^{\delta_1} (L_j)^{\delta_2} (M_j)^{\delta_3} (F_j)^{\delta_4} \tag{2}$$

Output per farmer is simply $q_j = \delta_0 \varepsilon_j^{\delta_1} l_j^{\delta_2} m_j^{\delta_3} f_j^{\delta_4}$. Let $w_{ij}, i = 1,2,3,4$, denote the price of input i. Farmers choose the least cost combination of inputs, and the total cost function for region j is:

$$C_j = \xi \Phi_j(w) Q_j \tag{3}$$

where $\xi > 0$ is a constant, and the average real input price is $\Phi_j(w) \equiv \prod_i w_{ij}^{\delta_i}$. Let $\varphi_j \equiv \frac{\Phi_j(w)}{p_j}$, which is the ratio of the observed average input to product prices for region j. The net income per farmer in j is simply $\tau_j = p_j q_j \left(1 - \xi \varphi_j\right)$. Farmers choose effort level in order to maximize utility. The representative farmer's utility maximization problem, after substituting $q_j = \delta_0 \varepsilon_j^{\delta_1} l_j^{\delta_2} m_j^{\delta_3} f_j^{\delta_4}$ and $\tau_j = p_j q_j \left(1 - \xi \varphi_j\right)$ in (1), is:

$$\max_{\varepsilon_j} u(\varepsilon_j) = \left[p_j \delta_0 \varepsilon_j^{\delta_1} l_j^{\delta_2} m_j^{\delta_3} f_j^{\delta_4} \left(1 - \xi \varphi_j\right) - \theta \varepsilon_j^{\frac{1}{\theta}} \right] \tag{4}$$

The optimal value of effort level satisfies

$$\left(\varepsilon_j^*\right)^{\left(\frac{1}{\theta} - \delta_1\right)} = \left[p_j \left(1 - \xi \varphi_j\right) \delta_0 \delta_1 l_j^{\delta_2} m_j^{\delta_3} f_j^{\delta_4} \right] \tag{5}$$

Notice here that since price regulation changes the way the output price and the input prices are determined, observing these prices the farmers choose their optimal effort level according to (5). Substituting for the optimal effort level in (2) we derive the production function that captures

[3] The marginal utility of income is strictly positive and constant, while the marginal disutility of effort is increasing in the level of effort. In this model the variable *effort* includes everything that determines the quality of the farmers' labour as well as the willingness to exert more effort as a result of enhanced incentives to earn more by producing more.

farmers' optimal response to changes in market and institutions:

$$Q_j = \left[(\delta_0)^{\frac{1}{1-\delta_1\theta}} \left\{ \delta_1 p_j \left(1-\xi\varphi_j\right) \right\}^{\frac{\delta_1\theta}{1-\delta_1\theta}} \right] (N_j)^{\frac{\delta_1(1-\theta)}{1-\delta_1\theta}} (L_j)^{\frac{\delta_2}{1-\delta_1\theta}} (M_j)^{\frac{\delta_3}{1-\delta_1\theta}} (F_j)^{\frac{\delta_4}{1-\delta_1\theta}} \tag{6}$$

We define $A_j \equiv (\delta_0)^{\frac{1}{1-\delta_1\theta}} \left\{ \delta_1 p_j \left(1-\xi\varphi_j\right) \right\}^{\frac{\delta_1\theta}{1-\delta_1\theta}}$ as the total factor productivity (TFP) coefficient of grain production for region j. Given the anaytical model, any policy reform that alters the prices of inputs and output has two channels of affecting the welfare level: the enhanced incentives to earn higher income (which adds to welfare), and the incentive to exert more effort in order to earn higher income (which reduces welfare). Net improvement in welfare due to a particular policy reform thus will depend on which of these two effects dominates. Intuitively, if a particular reform brings in a relatively higher rate of increase in the price of output it will affect both the net income and the optimal effort level. Unless the net effect is numerically characterized, it is not possible to determine the net welfare effect of reforms. Price regulation is expected to stabilize agricultural prices, which in turns will stabilize the income levels of farmers. However, price regulations will in general destroy farmers' incentive to exert more effort, which is why it is likely to result in a decline in productivity and an increase in the level of farmers' welfare.

We estimate (7) using regional level grain production data. Once we obtain the estimates of the share coefficients of the inputs, together with $\sum_{i=1}^{4} \delta_i = 1$ we have 5 equations in 5 unknowns, δ_1, δ_2, δ_3, δ_4 and θ. By solving this system we pin down these parameters.

For the simulation of optimal utility we need to simulate first the optimal effort level, and for both simulations we need the data for net income per farmer. Simulation of the optimal effort level also requires a pinned down value for the parameter δ_0. For this, notice that the TFP in (7) has two components, $(A_0)_j = \left[(\delta_1)^{\frac{\delta_1\theta}{1-\delta_1\theta}} (\delta_0)^{\frac{1}{1-\delta_1\theta}} \right]$, and $(A_1)_j = \left[p_j \left(1-\xi\varphi_j\right) \right]^{\frac{\delta_1\theta}{1-\delta_1\theta}}$,and $A_j = (A_0)_j (A_1)_j$. With regional level data on net income per farmer, we simulate a series for $(A_1)_j$ for each j. We use the standard Solow residual approach in order to simulate a series for A_j. This in turns enables us to simulate a series for $(A_0)_j$, and deriving a series for the parameter δ_0 is then straightforward. We use the simple arithmetic average of this series in order to pin down one value of δ_0 for all regions. This, together with the regional level data for net income of farmers enable us to simulate the optimal utility undex for all regions for the full sample period.

3 Data, Estimation, Simulations and Results

Our main data source is the Statistical Yearbook published by the National Bureau of Statistics, China (SYB, CBNS)[4]. Summary statistics for the panel data (including variable descriptions) are

[4] This is the primary source for Chinese agricultural data published by the Economic Research Service at the United States Department of Agriculture (ERS, USDA), *http://www.ers.usda.gov/Data/China/*, and *All China Data* at the China Data Center of the University of Michigan, Ann Arbor, *http://chinadataonline.org/*. The SYB, CBNS data that we use are freely available online in *http://www.stats.gov.cn/english/statisticaldata/yearlydata/* . The SYB, CBNS reports regional data for 31 regions, but we leave out Hainan because for this region there are many missing values.

presented in table 1 (in appendix). For the econometric estimation of (7) we convert the output, machinery power and fertilizer data in per hectare form. The labour data is taken in the form of person days per hectare (i.e. calculated by dividing the workers per hectare by three hundred as an approximate number of working days in one year).

We estimate (7) using different combinations of fixed and random effects, and in table 2 (in appendix) we report the results from a model that was estimated using period fixed effects. For this model the period fixed effects are significant (based on fixed effects redundancy test), and from a pool of estimated models this particular one is chosen on the basis of standard likelihood ratio test, the highest $\overline{R}^2$, no misspecification and the lowest AIC (where applicable). In table 3, we summarize the diagnostic test results. We find CRTS in grain production (based on a standard wald test). Only the output elasticity estimate for labour is statistically insignificant. Based on these estimates and the CRTS assumption in (2), we pin down δ_1, δ_2, δ_3, δ_4 and θ, which are $0.0203, 0.8041, 0.0182, 0.1571$ and 0.5106, respectively.

Simulation of $(A_1)_j$ requires more information at the regional level, because of the term $p_j\left(1-\xi\phi_j\right)$. The SYB, CBNS does not report prices for individual inputs for the regional level, which is why we use available information and $\tau_j = p_j q_j\left(1-\xi\varphi_j\right)$ in order to derive a series for the term $p_j\left(1-\xi\phi_j\right)$ for each region[5]. We collect the information on per capita *net income* of rural population (in yuan, which is our proxy for τ_j) from the *people's livelihood* series in the SYB, CBNS. We derive the per farmer grain output by dividing the aggregate grain output by the number of agricultural workers for each region j. Together with $\tau_j = p_j q_j\left(1-\xi\varphi_j\right)$ this gives us a series for the term $p_j\left(1-\xi\phi_j\right)$ for each j, and simulating $(A_1)_j$ is now straightforward. Together with $A_j = (A_0)_j\,(A_1)_j$ we derive a series of δ_0, and pin down one value of $\delta_0 = 0.512$ for all regions. Using these pinned down parameter values, we simulate the optimal effort for each region j and then simulate the optimal utility for each region j for the full sample period. We convert both the TFP and the optimal utility into indices with previous year as the base year. This enables us to examine the changes in TFP and welfare due to the price regulations introduced in 1998.

In figure 1 (in appendix) we present the simulated paths of the TFP index and the welfare index for all 30 regions for the full sample period. For all 30 regions the TFP is volatile but the rate is mostly in the negative margins. There is a clear trend of an increase in welfare for all regions. Almost all large grain producers, except for Liaoning, Jilin, Henan and Jiangxi, suffered negative average growth in TFP in the range of -0.19% (Yunnan) to -1.94% (Guangdon) for the full sample period. The smaller regions such as Beijing, Shanghai, Tianjin and Xinjiang suffered larger average decline in TFP, equal to -3.07%, -4.07%, -3.44% and regions -2.21%, respectively. These smaller regions also experienced the largest average growth in welfare (over 8%), implying that there exists a clear tradeoff between productivity growth and welfare growth which came as a result of the price regulations. Except for Guangdon, Guangxi, Heilongjiang and Jilin, all large grain producing regions experienced over 7% average growth in welfare.

[5] The term $p_j\left(1-\xi\phi_j\right)$ is simply the ratio of net income (per farmer) and output (per farmer).

4 Concluding Remarks

Many important studies which were undertaken before 1998 (e.g. Halbrendt and Gempesaw, 1990, Harrold, 1992 and Lin, 1992) argue that the pre-nineties agricultural reforms in China performed their aim of generating rapid economic growth on the basis of efficiency gains. But during the liberalized regime of the nineties the country-wide average growth rate of grain production was -1.4%, accompanied by a 10.07% growth in grain price index and a 3.02% growth in the real net income of rural households (SYB, CBNS data). Allegedly, these observations motivated the government to take back the control of agricultural prices in 1998. In this study, we show that following the price regulations of 1998 farmers' of all grain producing regions of China have experienced a growth in their welfare. Data suggests that during 1998-2005 the average growth rate of grain price index was 1.42%. In this paper we show how this stabilization of agricultural prices has contributed to farmers' income *vis a vis* welfare. We also show that the price regulations has adversely affected the productivity growth in almost all regions of China that produce grain. If China aims to increase agricultural production and productivity, future policy reforms should address the issue of relaxing the price regulations and at the same time creating a sound agricultural market environment such that any degree of liberalization does not lead to worsening of the growth in farmers' welfare.

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Appendix: Tables & Figures

Table 1: Summary statistics for regional level data (30 regions, 1997-2006)//

Variable	Description	Mean	St. Dev	Min	Max
Output	Total yield of grain (1000 tons)	1589.1	1145.13	58	4582
Labour	Agricultural employment (10000 persons)	1061.62	815.67	57.9	3903.7
Machinery	Total power of agricultural machinery (10000 kw)	1772.14	1836.16	63.6	9199.33
Land	Total area of land sown for grain (10000 Hectares)	3577.66	2436.76	141.3	10027.6
Fertilizer	Total quantity of chemical fertilizer (10000 tons)	140.87	113.64	2.5	493.16
Net income	per capita net income of rural population (1000 yuan)	2.766	1.371	1.1	9.138
Output per farmer	per farmer yield of grain (tons)	1.715	0.932	0.581	6.156

//All data are from SYB, CBNS. Output of grain is the total production of cereal (rice, wheat and corn), beans and tubers, measured on an annual basis in 10000 tons. The areas (total cultivated land and sown area for grain) are in 1000 hectares, and agricultural employment is in 10000 persons. This agricultural labour force refers to the total labourers who are directly engaged in farming and receive remuneration payment or earn business income in the farming sector. The machinery power data is the total power of agricultural machinery (in 10000 kw) used in farming, forestry, animal husbandry, and fishery, including ploughing, irrigation and drainage, harvesting, transport, plant protection and stock breeding. Fertilizer data is the quantity of chemical fertilizer (in 10000 tons) applied in agriculture during the year, including nitrogenous fertilizer, phosphate fertilizer, potash fertilizer, and compound fertilizer.

Table 2: Summary of panel estimation results

Cross section	Period	Cov. method	Constant [p-value]	$\widehat{\frac{\delta_1(1-\theta)}{1-\delta_1\theta}}$ [p-value]	$\widehat{\frac{\delta_2}{1-\delta_1\theta}}$ [p-value]	$\widehat{\frac{\delta_3}{1-\delta_1\theta}}$ [p-value]	$\widehat{\frac{\delta_4}{1-\delta_1\theta}}$ [p-value]	$\overline{R}^2$
None	Fixed	White	0.7269	0.0119	0.8160	0.0185	0.2008	0.9671
		CS	[0.0024]	[0.6402]	[0.0000]	[0.0760]	[0.0000]	

Table 3: Summary of diagnostic tests

Null hypothesis	Test statistic	p value	Decision
Redundant fixed effects	30.4384	0.0006	Reject Null
Constant Returns to Scale	1.4066	0.1107	Accept Null
All coefficients in (7) are together insignificant	692.56	0.0000	Reject Null
Model correctly specified	0.4399	0.2324	Accept Null

Figure 1: Simulated Welfare index and Simulated TFP index in 30 grain producing regions of China, 1997-2006.