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Grain Price Stability and Farmer Decision Making in China

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Domestic grain price stabilization has been one of the major objectives of China's government since the founding of the People's Republic 50 years ago (Ke, 1995). In part, leaders abandoned markets and adopted planning in the 1950s to avoid the inevitable cyclical price swings in agriculture. As recently as last year, the top leadership reaffirmed that price and income stabilization were top policy objectives (Fuell, 1998), and the quest for domestic price stability has also affected China's other sectoral policies, such as those for trade (Carter, Chen, and Rozelle, 1998).

Policy officials in China and many developing countries are most concerned with several negative aspects of price volatility. High price variability may negatively affect urban dwellers and rural consumers who are net purchasers. Price variations also could have a negative impact on the grain output. This situation is especially true in the past decade, as risk averse farmers, who are increasingly on their own, might try to avoid destabilizing income flow by switching land to other crops with less volatile price streams. Concern over the impact of grain prices has surfaced after the two large price swings in the late 1980s and the middle 1990s have raised concern that China's markets are becoming more volatile.

Given such importance, it may be surprising that so little detailed work has been conducted on grain price determination, in general, and the variation of prices, in particular. The main goal of this paper is to understand and systematically investigate the causes, and impacts of China's grain price variability during the reform period. Specifically, we have two main objectives. We document grain price movements and inter-year grain price variations since the 1970s. We also analyze the effect that price variability has had on grain sown area.

To accomplish these objectives, our paper describes and analyzes price movements and inter-year price variations using annual farmgate prices from 1975-1995. The impact of grain price variability on the microeconomic decisions of households has been studied by several authors in recent years (e.g., Park, 1996; Stone and Rozelle, 1993; Carter, Chen, and Rozelle, 1997). We are particularly interested in examining whether or not price variation has been rising during the reform era and using an empirical approach developed by Chavas and Holt (1990) to measure the impact of price variation on acreage allocation decisions.

The price data set for our study are from China's national "Cost of Production Survey" and contains provincial cross section, time series data for 26 provinces from 1975 to 1995. The information is generated as part of a large household data-collection program that has been run by the State Price Bureau since the mid-1970s. Based on annual household surveys conducted by county Price Bureau personnel, detailed information on the costs and revenues of crop production and unit value farmgate prices are available by crop. The data for total acreage for rice, wheat, and corn are from annual yearbook published by State Statistical Bureau (SSN, various issues).

Inter-Year Grain Price Variations

To examine changes in price variability over time, our farmgate price data are used to calculate measures of inter-year price variation. A national price is computed as a weighted average of provincial prices, with the share of provincial production in the national total as the weights. The price series were deflated into 1978 prices with the Rural Consumer Price Index (SSB). In real terms, rice, wheat, and corn prices have been declining in real terms since the 1970s (Rozelle, et al., forthcoming). Directions of price changes since the mid-1980s, however, have changed almost from year to year.

To facilitate analyzing changes in price variation over time, we divide our study period into two subperiods, 1975-84, and 1985-95, years that roughly correlate with periods before and after China’s major post-reform grain marketing policy change. In order to distinguish price variability from systematic shifts in prices, prices are detrended with a linear time trend variable and provincial dummies. The latter are assumed to take account of price differences that have resulting from differences in transportation costs among provinces. After detrending, the residuals are used to calculate the coefficient of variation (CVs) of inter-year prices for rice, wheat, and corn. The movement of CVs for each province and country as a whole were computed for each subperiod.

Rice price variation at the national level, measured by the CV, increased sharply over time from 2 percent in 1977 to about 18 percent in 1993 (Table 1). Wheat price variation reached its first peak of nearly

10 percent in 1988, decreased in 1990 and 1991, and then increased again in 1993. In the mid-1980s, wheat experienced more price variation than rice. In the 1990s, rice exhibited more price variation than wheat. The movement of CVs for corn were similar to that of those for wheat. Differences between CVs in the first and second period for major crops are significant in a statistical sense (Table 1).

Equally striking trends emerge when we compare the average CVs in two subperiods for each province. The average CVs in the second period display much higher variation for most provinces in the case of rice, wheat, and corn (Table 2). Statistical tests show that in the case of 15, 11, and 15 of the provinces (out of 26 provinces) these differences are statistically significant. On average, the CVs for rice and wheat double from about 6 percent in the first sub-period to more than 10 percent in the second. In addition, there were also large differences in price variations among the provinces.

In comparison with world price variations, we find the CVs of rice, wheat, and corn prices in China were only half of those observed in the world market in the period of 1975-1984.[1] However, in the second period from 1985-1996, except for wheat, rice and corn prices experienced similar magnitude of fluctuation as world prices. Given one of major objectives of Chinese grain policies is to stabilize the domestic market, China's price stabilization policy can not be counted as a success. Problems in the trade and storage sector may account for this failure (Carter, Chen, and Rozelle).

Impact of Price Variation on Acreage Allocation

In this section we examine the impact that price variability has had on farm sown area decisions. Since the late 1970s, farmers mostly have had control rights over farming operations on their cultivated land. On average, only 20 to 30 percent of the sown area is used by farmers in China to fulfill the state procurement quota. China's farmers still have considerable flexibility in allocating their land among major crops. To study the impacts of price movement and their variation on acreage allocation decisions, we adopt an empirical approach outlined in Chavas and Holt (1990).

[1] World grain prices were deflated using Consumer Price Index of the United States from 1975 to 1995.

Theoretical and Empirical Model

A representative farm household has a Von Neumann-Morgenstern utility function *U(G),* and it wants to

$Max \quad EU(G)$ subject to two constraints

(1) $I + R - C = qG$ or

Where *I* represents the exogenous income obtained from nonfarm activities, *R* is expected farm income, and *C* is farm costs. *G* is the index of consumption of goods purchased with price index *q*. *qG* denotes the total expenditure of the farm household.

Equation (1) can be rewritten as

$$(1') \quad I + \sum_{i=1}^{n} P_i * Y_i A_i - \sum_{i=1}^{n} c_i * A_i = qG$$

When the household's farming revenue can be represented by:

$$R = \sum_{i=1}^{n} P_i Y_i A_i$$

where A_i is the number of hectares devoted to the *i*th crop and Y_i is the corresponding yield per hectare, i=1,…,n. P_i is the average price farmers receive.

If the cost of production per hectare of *i*th crop is denoted by c_i, then the total cost of agricultural production is

$$C = \sum_{i=1}^{n} ciAi$$

The output prices $p=(p_1,p_2,\ldots,p_n)$ and $y=(y_1,y_2,\ldots,y_n)$ are not observed by the farmers when they make planting decisions, so they are treated as random variables in the model. Alternatively, input prices and per hectare cost are known, so they are predetermined.

The second constraint is the acreage constraint, represented by

(2) $f(A) = 0$ where A=$(A_1, A_2,\ldots,A_n)$.

After substituting the budget constraint, the maximization problem can be written

(3) $Max\left\{ EU\left[\frac{I}{q}+\sum_{i=1}^{n}(\frac{pi}{q}Yi-\frac{ci}{q})Ai\right]\right\} s.t.(2)$ or

(4) $Max\left\{EU\left(w+\sum_{i=1}^{n}\pi iAi\right)\right\}$ s.t. (2)

Where w=(I/q) is normalized initial wealth and $\pi i=(pi/q)Yi-(ci/q)$ denotes normalized profit per hectare of the *i*th crop. This formulation incorporates both price and production uncertainty.

Based on the theoretical model, and following the same approach used by Chavas and Holt, we set up the empirical model to simulate the impacts of price variation on the acreage allocation decision. The model is given as

(5) $Ait=a_i+(\partial A_i/\partial w)W_{t-1})W_{t-1}+\sum_{j=1}^{3}(\partial A_i/\partial \Pi_j)\Pi_{jt}+\sum_{k\geq j}^{3}\sum_{j=1}^{3}(\partial A_i/\partial \sigma_{jk})\sigma_{jkt}+\theta_i t+\mu_t$

$i=1,2,3$ represents rice, wheat, and corn respectively, A_{ij} is number of acres planted to the ith crop at time t, and π_{jt} is expected profit for one unit of sown area for planting crop *i*, which can be denoted as:

(6) $\Pi_{jt}=E_{t-1}\{(P_{jt}/q_t)Y_{jt}-(c_{jt}/q_t)\}$

letting $\beta_{ij=}\partial A_i^c/\partial\Pi_j$ be the compensated slopes with respect to and π, $\alpha_{i=}\partial A_i/\partial w$, and $\gamma_{ijk}=\partial A_i/\partial\sigma_{jk}$. The symmetry condition requires that $\beta_{ij=}\beta_{ji}, i\neq j$. The equation (5) is can be rewritten as

(7) $A_{it}=a_i+\alpha_i(W_{t-1}+\sum_j A_j\Pi_{jt})+\sum_j\beta_{ij}\Pi jt+\sum_{k\geq j}\sum_j\gamma_{ijk}+\sigma_{jkt}+\theta_i t+\sum_{k=1}^{5}region_k+\mu_{it}$

Where i=1,2, and 3, denote the rice, wheat, and corn respectively. Dummy variables for six regions are added to capture the different allocation patterns in the different areas of China. However, if equation (7) is used directly, it would incur an endogeneity problem, as A_{it} appears both as the dependent variable as well as one component of the independent variable. To solve this problem, the (7) is transformed as

(7')

$$A_{it} = (a_i + b_i(W_{t-1} + \sum_{j \neq i} A_j \Pi_{jt}) + \sum_j \eta_{ij} \Pi jt + \sum_{k \geq j} \sum_j c_{ijk} \sigma_{jkt} + f_i year + \sum_{k=1}^{5} e_{it} region_k + \mu_{it}) / (1 - \pi_{it} bi)$$

The A_{it}s are treated as endogenous variables in the three-equation system. To identify the system, we only include one out of three covariance variables in each equation. The one covariance variable included in one equation is different from one used in the other equation, thus, the system is identified.

Let $J = a_i + b_i(W_{t-1} + \sum_{j \neq i} A_j \Pi_{jt}) + \sum_j \eta_{ij} \Pi jt + \sum_{k \geq j} \sum_j c_{ijk} \sigma_{jkt} + f_i year + \sum_{k=1}^{5} e_{it} region_k$

The net profit elasticity ε are computed as

$$\varepsilon_{ii} = \frac{\eta_{ii} * (1 - b_i * \overline{\pi}_i) + J * b_i}{(1 - b_i * \overline{\pi}_i)^2} \frac{\overline{\pi}_i}{\overline{A}_i};$$

$$\varepsilon_{ij} = \frac{b_i A_j + \eta_{ij}}{(1 - b_i * \overline{\pi}_i)} \frac{\overline{\pi}_j}{\overline{A}_i}$$

$$\varpi_{ij} = \frac{C_{ij}}{(1 - b_i * \overline{\pi}_i)} \frac{\overline{\sigma}_{ij}}{\overline{A}_i}$$

And the price variation elasticities are computed as

Impacts of Price Variability for Surplus and Deficit Farmers

Finkelshtain and Chalfant (1997) stress the importance of simultaneous consideration of farm households as both producers and consumers, who consume a large portion of the farm products they produce. They pointed out that if the good in question is a normal good and the household has a marketed surplus, the necessary condition for the household to prefer stabilization is satisfied. In addition, the larger proportion farmers sell their farm products in market, the more they prefer price stabilization, and more likely to decrease the sown area so as to decrease the risk.

We construct a surplus variable, $Surp_i$, which measures the degree of surplus for every specific crop in each province. The surplus variable is constructed as the difference between total crop production and total rural consumption, the latter is computed by multiplying the total rural population for the specific province, and per capita rural consumption of rice, wheat, and corn. By including a regressor which is the product of the surplus variable with price variability variable, we hope to detect how the farmers in different regions (in terms of the level farmers depends on market) reacted to price variation. We would expect the coefficient for the interaction term of $Surp_i$ and σ_i would be negative. However, in setting up the empirical model, we should be aware that there is an endogeneity problem associated with the $Surp_i$, which is also dependent upon sown area. In other words, the larger the sown area is, the more surplus the province is likely to be. In order to deal with this problem, we include another interaction term between the price variance variable and one period lagged sown area in an attempt to reduce endogenous effects. We also include the interraction term of $Surp_i$ and π_{it} to detect the difference in impacts of unit profit on sown area in the surplus or deficit provinces.

Thus, we also estimate the following empirical model:

$$(8)\ A_{it} = (a_i + b_i(W_{t-1} + \sum_{j\neq i} A_j \Pi_{jt}) + \sum_j \eta_{ij} \Pi jt + \sum_{k\geq j}\sum_j c_{ijk}\sigma_{jkt} + f_i year + \sum_{k=1}^{5} e_{it} region_k$$

$$+ \sum_{i=1}^{3} h_{it}\sigma_{it} * surp_{it} + \sum_{i=1}^{3} m_{it}\sigma_{it} * A_{i,t-1} + \sum_{i=1}^{3} q_{it} surp_{it} * \pi_{it} + \mu_{it})/(1-bi*\pi_{it})$$

Estimation and Result

When calculating the expected unit return from cultivating rice, wheat, and corn, we use the expected revenue, as a result of insufficient information on unit cost. By doing so, we are assuming that the cost of production maintains the same proportional relationship to unit revenue over time and across provinces. In addition, we use the primary industry GDP as a proxy for the wealth level of the farm household. Finally, as we are using aggregate provincial data, we are assuming that there is a representative farm household, attempting to maximize its utility, which is consistent with micro theory.

With the symmetry condition imposed, equation (7') is estimated with a nonlinear three-stage estimation procedure using SAS package. The estimated parameters estimated for equation (7') are shown in table 3. Almost all the coefficents are statistically significant and have the expected signs. The compensated own revenue elasticities are 0.32, 1.24, and 1.44 respectively, all of them are statistically significant, indicating that farmers did adjust their acreage based on expected profitability. Farmers increase sown area when they expect more profit from specific cropping activity, as reflected by the estimated positive coefficients for N11, N22, and N33, and the later two are statistically significant.

Our findings also suggest that farmers in China are indeed risk averse. Producers decrease their planted area of rice and wheat when prices became volatile (Table 3). For corn, however, this relationship is not found. One possible reason might be that corn is more of an intermediate crop, in the sense that most of corn is consumed as livestock feed. The corn planting decision with respect to corn may be closely linked to events in livestock industry. For example, if the livestock industry, especially the hog industry, experienced even more volatile price variation, the farmers, as the major producers of a commodity (hogs) that use a volitile good, may increase corn sown area despite the large price variation of corn.

To further illustrate the implications of price variation on sown area decisions, we take rice as an example. From our earlier analysis, we have shown that CVs for rice doubled in the second period, and increased by about 6 percentage points compared with the first period. If there had not been such a large increase in price variation, given our results hold in large range, we would have seen that sown area for rice had increased rather than decreased over the period. This would also be true for wheat with slightly different magnitude.

Also, we observe significant positive wealth effects, which may imply decreasing absolute risk aversion. The other implication might be that if farmers are more wealthy, e.g., they obtain more income from other activities other than agricultural practices, and as a result they are less sensitive to price volatility.

To further investigate the different response to price variability on sown area in surplus regions and deficit regions, we estimate equation (8). We find that that surplus regions responded more negatively towards price variation, as reflected by the significant negative coefficients associated with interaction term between *Surp* and variance variables. As expected, the farmers in the surplus region exhibited greater response to the expected revenue (results not reported because of space constraints).

Conclusions and Further Research

In this paper we find that real grain prices in China have displayed increased volatility in the past decade. This is true for rice, wheat, corn, and for most of provinces. Farmers in China are found to be risk averse because when they make acreage allocation decisions. Given the widespread access to land in China, farmers mostly respond negatively in their sown area decisions towards price risk. The large price variations from 1984-1995 may have contributed to the slowdown in agricultural output growth.

While interesting, our research to date raises a number of key questions. Further research should focus on the fundamental causes of the large price variations in the past decade. Why were there such large price swings despite government efforts devoted to stabilizing prices? The effectiveness of the current price stabilization schemes is very much questionable. It is our belief that the actual practices of the current grain storage and trade systems are not helping to stabilize domestic prices.

Table 1: Grain Price Variation In China, 1975-1995

Year	Rice	Wheat	Corn
1977	0.018[a]	0.008[a]	0.020[a]
1978	0.023	0.010	0.015
1979	0.033	0.020	0.029
1980	0.033	0.021	0.027
1981	0.032	0.027	0.028
1982	0.056	0.060	0.048
1983	0.059	0.060	0.051
1984	0.069	0.082	0.082
1985	0.062	0.081	0.078
1986	0.055	0.083	0.084
1987	0.069	0.092	0.094
1988	0.096	0.110	0.115
1989	0.092	0.070	0.056
1990	0.065	0.041	0.032
1991	0.076	0.040	0.043
1992	0.128	0.055	0.069
1993	0.176[a]	0.109[a]	0.122[a]

Source: all numbers are cofficient of variations according to author's own calculation
[a]CV in 1993 is significantly different from CV in 1977 at 1% level; standard error are approximated by $D=cv1*\{[(1+2cv1^2)/2](1/5+1/5)\}^{0.5}$ (Hazell, 1989); test statistics are computed as $Z=(cv2-cv1)/D$.

Table 2: The Average CVs of Grain Farmgate Prices in Two Sub-Periods in China, 1975-1995

		Rice		Wheat		Corn	
Province	code	75-84	85-95	75-84	85-95	75-84	85-95
Beijing	1	0.042	0.137***	0.036	0.082***	0.043	0.056
Tianjin	2	0.071	0.049	0.063	0.085	0.057	0.145***
Hebei	3	0.044	0.085**	0.064	0.097	0.060	0.122**
Shanxi	4	0.043	0.133***	0.045	0.064	0.058	0.073
Liaoning	5	0.085	0.122	0.049	0.088*	0.047	0.103**
Jilin	6	0.092	0.114	0.049	0.089*	0.061	0.096
Heilongjiang	7	0.082	0.109	0.068	0.091	0.048	0.128***
Shanghai	8	0.069	0.152***	0.064	0.065	0.054	0.085
Jiangsu	9	0.038	0.171***	0.040	0.083**	0.056	0.096
Zhejiang	10	0.042	0.155***	0.050	0.095**	0.050	0.138***
Anhui	11	0.032	0.143***	0.055	0.113**	0.059	0.155***
Fujian	12	0.046	0.106***	0.048	0.076	0.063	0.159***
Jiangxi	13	0.059	0.073	0.068	0.086	0.093	0.116
Shandong	14	0.081	0.235***	0.036	0.073**	0.046	0.122***
Henan	15	0.085	0.301***	0.044	0.096**	0.049	0.129***
Hubei	16	0.042	0.096***	0.032	0.066**	0.055	0.134***
Hunan	17	0.044	0.103***	0.051	0.065	0.093	0.108
Guangdong	18	0.045	0.135***	0.049	0.068	0.064	0.147***
Guangxi	19	0.040	0.122***	0.049	0.068	0.063	0.160***
Sichuan	20	0.060	0.103	0.039	0.088***	0.061	0.084
Guizhou	21	0.074	0.092	0.051	0.085	0.055	0.090
Yunnan	22	0.061	0.082	0.152	0.121	0.088	0.055
Shanxi	23	0.103	0.114	0.081	0.089	0.069	0.109
Gansu	24	0.060	0.115***	0.048	0.074	0.041	0.119***
Ninxia	25	0.039	0.067	0.045	0.095**	0.040	0.102***
Xinjiang	26	0.118	0.184	0.080	0.106	0.071	0.131*
China		0.041	0.091***	0.036	0.076**	0.038	0.077**
Average		0.061	0.127**	0.056	0.085	0.059	0.114**
World[a]		0.164	0.120	0.107	0.150	0.125	0.133

Source: see text.

Note: *, **, and *** denote the CVs in the second period are significantly different from those in the first period in 90, 95, and 99 percent confidence level, respectively.

[a] World prices are Bangkok price for rice, U.S. No. 2 gulf prices for wheat, and US yellow corn prices.

Table 3. Parameter estimates of Sown Area Allocation Model using Three-stage, nonlinear least squares estimators

	Rice equation			Wheat Equation			Corn Equation		
	Para	Estimate	T-ratio	Para	Estimate	T-ratio	Para	Estimate	T-ratio
intercept	A1	-28714.2	-1.13	A2	58223.34	1.91	A3	43816.9	2.73
wealth	B1	0.007643	9.19	B2	0.01102	10.23	B3	0.005835	10.42
⑨$_{1}$ rice price variance	C11	-926.213	1.64	C21	4022.14	5.34	C31	1090.44	2.8
⑨$_{2}$ wheat price variance	C12	-3792.96	-3.92	C22	-3531.98	-2.78	C32	-1408.01	-2.14
⑨$_{3}$ maize price variance	C13	670.4671	0.8	C23	807.857	0.7	C33	598.3868	1.03
⑥$_{1}$	N11	10.88276	0.07						
⑥$_{2}$	N12	-1368.42	-9.78	N22	1770.14	8.06			
⑥$_{3}$	N13	-500.239	-6.12	N23	-493.562	-3.84	N33	904.967	6.68
⑥$_{1*}$ South dummy	N14	-627.935	-3.57						
⑨$_{12}$ Covariance: rice-wheat	D11	69.96783	1.16						
⑨$_{13}$ Covariance: rice-corn				D21	38.33856	0.63			
⑨$_{23}$ Covariance: wheat-corn							D31	32.93143	1.2
region 1	E11	226.811	1.81	E21	-514.496	-3.08	E31	1226.64	14.14
region 2	E12	195.9161	1.76	E22	326.7554	2.19	E32	788.0187	10.24
region 3	E13	2842.91	11.48	E23	-1171.66	-7.25	E33	-415.714	-4.96
region 4	E14	2382.32	9.48	E24	-1994.29	-10.03	E34	-380.292	-3.7
region 5	E15	1821.14	7.07	E25	-711.615	-3.81	E35	473.6388	4.84
year	F1	15.16835	1.18	F2	-28.2324	-1.83	F3	-21.757313	-2.68
Elasticity									
Net profit elasticity	ε_{11}	0.022		ε_{21}	-1.715		ε_{31}	-0.899	
	ε_{12}	-0.689		ε_{22}	1.038		ε_{32}	-0.409	
	ε_{13}	-0.269		ε_{23}	-0.308		ε_{33}	0.820	
Price vriation elasticity	ω_{11}	-0.072		ω_{21}	-0.083		ω_{31}	0.141	
	ω_{12}	-0.220		ω_{22}	-0.253		ω_{32}	-0.136	
	ω_{13}	0.048		ω_{23}	0.055		ω_{33}	0.071	

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