Grain Policy in China's Provinces: Simulating the Response of Yields to Pricing, Procurement and Loan Policies

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By

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Paper Abstract

This paper assesses the effects of pricing, procurement and loan policies on China's grain economy. A dynamic control model of the village leader is specified. Parameters of structural and control equations are estimated using time series cross-section data. Simulation results show that pricing and procurement policies are not effective in raising yields due to conflicting objectives of officials. Loan policies can increase yields.

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Introduction

Over the past 10 years leaders in China have pursued economic reform. In their most heralded move during this drive for development, governmnet officials decollectivized agriculture, making rural households the basic unit of agricultural production. The central government also reduced the scope of government planning and decentralized decision making (Sicular, 1988). Local governments gained control over more of their own revenues (Shue, 1988) and new regulations encouraged individuals to create non-state economic units (He, 1990; Nee, 1990). Responsibilities were spelled out for local actors and, within a new set of expanded guidelines, local officials could more freely pursue economic gain once their obligations to the state had been fulfilled. The productivity response and efficiency gains in certain sectors were unparalleled (Chen et al. 1988; Lin, Yao and Wen, 1989; Longworth, 1990).

Despite these early gains, central and regional leaders have grown increasingly concerned about their inability to effectively implement policy (Oi, 1989). Even more common are reports of policies with unintended and harmful consequences (Wiens, 1987), because after being filtered down through China's administrative bureaucracy, policies are often implemented only after severe distortions by local leaders promoting their own objectives (e.g., Zhu, 1990; Wang, 1990). Policy breakdown in key sectors of the economy, in part, explains the central leadership's growing suspicion of economic reform, and has led to recent efforts to regain control by reverting to more traditional planning apparatus.

This paper assesses the effects of changes in government pricing, procurement and loan policies on the performance of the grain sector in order to understand how changes in the fundamental decision making framework of local officials have dampened the effectiveness of grain programs. To do this, the paper focuses on the village grain economy, and traces the behavioral responses of village leaders to changes in exogenous policy parameters. Time-series data from 40 villages in central China are used to econometrically estimate a set of structural and behavioral equations of a dynamic optimal control model of the behavior of village leaders. The effects of these policy adjustments on a series

of local decision variables--industrial output, investment, technology adoption, fertilizer allocation and the intensity of cash cropping activities--are simulated into the future. The effects of pricing and procurement measures are shown to have little or even negative effect on raising grain yields; only rural industrial credit policies succeed at increasing agricultural productivity.

Modelling the Economy in Chinese Villages

The Model. Village leaders are assumed to maximize a multiple attribute utility function and make choices subject to a series of state equations. In matrix notation the model is:

$$(1) \qquad \max V = E \left\{ \sum_{t=1}^{\infty} \beta^t (\omega_t' X_t + X_t' \Omega X_t) \right\}$$

subject to:

$$(2) \qquad X_t = AX_{t-1} + CU_t + b + \varepsilon_t$$

where Ω and ω_t = matrices of weights; X_t = a vector of eight state variables; U_t = a vector of six control variables; ε_t = a vector of error terms; and A, C and b = matrices of structural parameters.

By assuming the quadratic-linear functional form, the optimal levels of the control variables are linear functions of the lagged state variables (both endogenous and exogenous):

$$(3) \qquad U_t^* = GX_{t-1} + g$$

where G and g, the behavioral coefficients, are functions of the parameters of (1) and (2).

Estimation and Data. For estimating the parameters of (1) through (3), this study adopts a two step approach developed by Chow (1983) and refined by Fulton and Karp (1989). The first step is to estimate the parameters of (2) and (3) directly by using fixed effect methods (i.e., by using OLS with dummy variable for each village). Because Ω and ω from (1) are implicit functions of A, C, b, G and g, it is possible in a second step to recover the set of objective function coefficients that are consistent with those revealed through the observed behavior of village leaders. See Rozelle (1991) for details.

Data for 1983 through 1988 from a village survey conducted by the author during 15 months of field work in Central China were used in estimation. The data included information on production, investment, non-farm activities, credit, prices and technology adoption and come primarily from records

kept by the accountant in each village and from account books and records kept by the treasurer in each village-run factory. Data were collected from 40 villages chosen randomly from more than 100 villages in three townships of Jiangsu province. This province, located on the lower reaches of the Yangtze River Valley, is in a densely populated region, which has a well developed agricultural infrastructure and a rapidly developing rural industrial base.

Industrial prices used in the analysis are village specific. Agricultural prices were collected at the township level and assumed to be identical for villages within each township, but do vary over time and across township. Commodity prices for grain and cash crops were aggregated into a single index. All prices were deflated by an index constructed from county-level producer data. The procurement obligation includes all "required" sales of grain by farmers to the state grain bureau. Sales are classified as either "basic" or "bonus" quotas. Amounts sold under either of these categories are viewed as obligatory, not voluntary. Loan activity measures formal lending transactions between the village industrial enterprises and official financial intermediaries, including state run banks and departments within Township and Village Industry Bureau.

Simulating the Impact of Changes in Pricing, Procurement and Loan Policy.

Estimated Model. Looking at tables 1 and 2, the structural and control equations perform consistently well. The adjusted R-square statistics for the structural equations range between 0.46 and 0.80; those for the control equations are all above 0.60, except for that of the wage equation (0.25). The signs on the coefficients of the independent variables in both sets of equations are also consistent with prior expectations and many of their estimated standard errors are relatively small compared to their magnitude. Estimates of the weights on the five variables in the village leader's objective function, ω and Ω, from equation (1) provide additional evidence of the model's performance. The elasticities of utility derived from the estimated coefficients for the two variables associated with rural industrialization, capital assets and factory profits, are 0.84 and 0.39, respectively. These are much higher than the ones on the variables associated with either agricultural (grain yields--0.0038--and hybrid rice adoption--0.00000019) or the welfare of farm households in the village (non-farm

employment--0.022). These results are consistent with the expectation that leaders are preoccupied with rural industrialization to further personal gain and independence from higher authorities. At the same time, however, they remain concerned about maintaining agricultural productivity and overall village welfare. See Rozelle (1991) for a full discussion of these results.

Since this analysis focuses on the simulation results from the grain yield state equation, the estimated results of this equation are of primary importance. From the equation, village leaders try to control grain yield by requiring farmers to plant a larger proportion of hybrid rice. Increases in fertilizer supply are also important in explaining grain yields. This coefficient has interesting implications for village policy. At the means, to increase the value of grain production by 1000 yuan at the margin requires 2000 yuan of fertilizer. While this result appears economically irrational, it is important to remember that farmers are diverting some of the fertilizer to crops other than grain. In this sense the value of the fertilizer is underestimated. The empirical result is also consistent with the status afforded village leaders whose villages have high grain yields, and it also reflects the leaders' concern for meeting grain quotas.

The coefficient of the price variable is also positive, although its standard error is somewhat large relative to the magnitude of the coefficient. The positive sign indicates that even when facing declining relative agricultural prices, village grain yields continue to rise. Apparently, village leaders have effectively used administrative means to encourage farmers to sustain agricultural yields.

The effect on grain yields of increasing cash crop area is negative. As cash crop area rises, farmers are likely to allocate more time and current inputs to these crops, since they are relatively more profitable. However, this drop is minimal (a loss of less than 1 jin--0.5 kg--of grain yield for each 10 mu converted to cash cropland), perhaps because farmers are tacitly allowed to cultivate additional cash crop area only on the condition that their grain yields remain relatively constant.

Model Validation. Before moving to the simulation, it is important to get an idea of the predictive power of the model over the sample period. This validation process begins by predicting the dependent variables by inserting the observed values of the independent variables into the state and control equations for all years of the sample period and comparing them with the actual values. In

general, the Theil measures of the model's predictive accuracy show that most of the equations have substantial predictive power. For the structural equations the Theil coefficients are between 0 and 1 except for industrial profits. Likewise, these measures for the control equations are also between 0 and 1, except the one for the wage rate.

Simulation. The actual policy simulation is performed in a way similar to the model validation except that values of the dependent variables are forecast into the future, rather than predicted over the sample period. Simulation results are derived for each of the 40 villages. For purposes of discussion, these results are averaged over all villages. The three policy experiments are: increasing agricultural prices by 20 per cent; increasing procurement by 20 per cent; and reducing lending by 20 per cent. The policy experiments for procurement and lending are accomplished through ceteris paribus changes in these variables; changes in agricultural prices, however, are inversely related to the industrial-agricultural price ratio. When changes are made to one target policy variable, the other two exogenous state variables are assumed to be unchanged from their 1988 levels.

This particular combination of experiments is selected for illustrative purposes, but they are consistent with the government's desire to increase grain productivity and arrest rural industrial growth. They are extensions of trends that began in 1988. The emphasis on increased grain yields stems primarily from the central government's concern about stagnant food supplies resulting from the three successive mediocre harvests of 1985, 1986 and 1987. There was also concern that an overheated economy, led by the rural industrial sector, was inflationary, and was creating serious problems for government firms in the formal state sector of the economy.

The qualitative effects of simulated policy changes on all of the state and control variables are presented in Table 3. Figure 1 graphically traces the impacts on grain yields.

Price Policy Change. The effects of an increase in agricultural prices on grain yields are surprising. Yields do increase in the initial two years, but by 1991 yields drop and continue to do so. This is also true for the base scenario. The most unexpected result, however, is that throughout the simulation period grain yields are lower relative to the base scenario after the policy change. These results in part are explained by recognizing the fact that the agricultural price index includes prices for

both grains and cash crops[1]. The agricultural price rise creates an initial increase in the derived demand for fertilizer and stimulates a positive change in cash crop area. With inoperable land markets, expansion of cash crop area can come only at the expense of grain crop area. The reduction in grain yields on a smaller area with more fertilizer available can be partially explained by the fact that the additional fertilizer is being reallocated to cash crops and not grain. Yields also decline due to a decrease in the intensity of hybrid rice cultivation (a higher-yielding, rice variety).

Procurement Policy Change. Procurement policy changes force villages to deliver 20 per cent more grain under obligation, initially leading to a reduction in the supply of fertilizer and cash cropped area relative to the base scenario. The other three control variables--industrial output, investment and hybrid adoption--are higher for all years than in the base scenario. These effects are responsible for the observed decreases in grain yields relative to the base scenario.

The mechanism underlying the effects of the procurement policy changes is in marked contrast to those for price policy. One of the most fundamental differences between the two policies lies in the fact that the procurement policy changes force village leaders to increase the area sown to grain. To minimize this additional land requirement, they allocate more of the grain area to higher yielding hybrid rice. Despite adopting new technology, leaders decrease area sown to cash crops. It is this reduction that leads to the decrease in the village's fertilizer supply. The new crop mix in the village requires less total fertilizer (which is at least partially technologically related, since major cash crops such as cotton, mint and mulberry use very high levels of chemical fertilizer). The additional procurement quotas are satisfied by increasing sown area, not yields.

Loan Policy Change. Reducing loans to the village economy clearly leads to an immediate and absolute reduction in village leader welfare when compared to the base scenario. Levels of all of the

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[1] Multicollinearity between the cash crop price index and the grain price index precluded using an econometric specification with both of these variables. The price of cash crops closely tracks those of grain prices in part due to the institutional structure of the procurement system in rural China. When grain officials intervene and change prices, officials with responsibility for procuring cash crops apparently respond by increasing the prices of their commodities. Viewed in this way, grain price policy is tied to the price policy of other cash crops. Consequently, this paper's focus on the agricultural price index could also be viewed as looking at grain price policy.

state variables fall in 1989, and all except grain yields remain at levels below those of the base policy throughout the simulation period. According to government policy makers who recognize the susceptibility of local industries to lending policies (Wang, 1990), reductions in loans are designed to restrain the growth of the rural industrial sector and refocus the attention of leaders on grain products.

Curiously, even though grain productivity is only a secondary objective of loan policy, it is the only measure that does eventually have a positive effect on grain yields. Yields under the loan reduction policy rise in the second year to equal the base policy grain yields. After 1990, the new policy gradually results in relatively higher grain productivity.

The negative impact on the industrial state variables seems to succeed in refocusing the attention of village leaders on the agricultural sector. When the utility of village leaders is reduced by declines in profits and capital assets, they can offset part of this loss by increasing grain yields. Decisions to increase fertilizer supplies and raise the area sown to cash crops draw labor back into the agricultural sector. After two periods, enough resources are drawn back into in grain production that yields surpass those experienced when lending remained at the base-scenario levels.

Summary and Conclusions

At present research tools to assist policy makers in their decisions in today's unique reform environment are uncommon. Most existing ones in China are based on the assumptions of central planning, and contained few behavioral parameters. Transplanted neo-classical models which rely on classical assumptions and simplified economic structures also have not performed well (An, 1989). Therefore the purpose of this paper is to develop more effective analytical tools for use by policy makers in countries making a transition from a state controlled economy to one where market forces are used to guide economic decision making.

If the results from this paper's simulations do capture some of the general behavioral and structural elements of the Chinese reform economy, the implications for policy setting are somewhat unexpected. The results suggest that if officials are interested in setting an agricultural policy to encourage higher grain yields, they can reduce overall agricultural prices, decrease marketing

obligations and/or cut back the loans available for rural industrialization. Counter-intuitive as some of these policies may seem, there is a common mechanism that is responsible for leading to these results.

Each of these policies tries to increase the "competitive" position of the food grain sector by either decreasing the relative returns or restricting the flow of resources to rural industries. The case of loan policy is relatively straightforward. The effects of agricultural pricing and procurement policies are more complicated and multi-dimensional. Perhaps part of the explanation of the ineffective results lies in the fact that agricultural policy is created as a series of single dimension measures arising from several agencies. Officials in each agency evidently base their decisions on narrow objectives and are unable to coordinate their efforts. In the case where grain price increases are matched or even exceeded by price increases of "competing" cash crop procurement agencies, it is likely that the resulting combination of policies may contain fundamental contradictions. One subset of the policies may be counteracting the effectiveness of some other, leading to a situation in which it appears there is no control. In reality, the real explanation is that both policies are effective but taken together they are canceling out one another. Thus, a good understanding of the interaction between policy parameters and the elements that determine the behavior of local actors is critical in the process of developing integrated rural policy.

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Table 1. Structural Equations Describing the Village Environment, Fixed Effects

Equations	Independent Variables												
	Industry Output (r_t)	Capital Invst. (I_t)	Hybrid Area (h_t)	Fert. Supply (f_t)	Indust. Wage (w_t)	Cash Crop Area (c_t)	Lagged Endogenous Variables				Lagged Exogenous Variables		
							(π_{t-1})	(C_{t-1})	(K_{t-1})	(L_{t-1})	(P_{t-1})	(O_{t-1})	(B_t)
Industrial Profit Equation (π_t)	0.011	0.39			-0.15				0.29		17.40		
	(2.84)	(2.44)			(0.54)				(2.09)		(1.43)		
Grain Yield Equation (C_t)			76.00	15.48		-0.11					0.03		
			(2.00)	(3.04)		(1.44)					(1.00)		
Industrial Capital Equation (K_t)					-0.032		-0.071		1.00*	10.97	-5.26		1.38
					(0.22)		(1.48)			(0.40)	(0.84)		(9.48)
Non-Farm Labor Equation (L_t)	0.000019	-0.00015	-64.89		-0.00028						0.0018	0.00025	
	(4.23)	(0.90)	(3.68)		(0.75)						(0.12)	(0.09)	
Hybrid Rice Equation (h_t)						-0.00028		0.00024		-0.0012	0.00012	0.000025	
						(1.95)		(1.55)		(4.52)	(1.96)	(1.58)	
Industrial-Ag. Price Equation (P_t)											-2.64		
											(2.61)		
Marketed Surplus Obligation Equation (O_t)												0.045	
												(0.60)	
Loan Equation (B_t)													-2.28
													(2.97)

Note: Estimated as a village fixed-effects model, but the coefficients of the dummies are not reported. The t-ratios are in parentheses.

* Restriction placed on model.

Table 2. Control Equations Describing Village Leader Behavior

Equations	Dependent Variables: Lagged Profits (π_{t-1})	Lagged Gr. Ylds. (G_{t-1})	Lagged Capital (K_{t-1})	Lagged NonAg Lab. (L_{t-1})	Lagged Price Rat. (P_{t-1})	Lagged Obligation (O_{t-1})	Lagged Loans (B_{t-1})
Industrial Output (r_t)	1.74	184.02	4.04	2543.82	35.22	7.53	11.66
	(0.79)	(0.28)	(1.38)	(1.97)	(0.13)	(0.12)	(2.13)
Industrial Investment (I_t)	0.011	-7.34	-0.45	85.21	1.39	0.22	0.80
	(0.24)	(0.56)	(7.77)	(3.34)	(0.25)	(0.18)	(7.48)
Hybrid Rice Area (h_t)	0.0000012	0.00013	-0.00000015	-0.0013	0.00013	0.000022	-0.063
	(2.24)	(0.79)	(0.80)	(3.96)	(1.87)	(1.39)	(0.46)
Fertilizer Supply (f_t)	0.00000022	-0.00023	-0.000012	0.0086	-0.00029	-0.00017	-0.0000040
	(0.04)	(1.15)	(1.73)	(2.77)	(0.44)	(1.12)	(0.31)
Village Wage Rate (w_t)	-0.0051	-7.78	0.010	-13.91	8.76	0.077	-0.010
	(0.17)	(0.84)	(0.26)	(0.77)	(2.27)	(0.09)	(0.14)
Cash Crop Area (c_t)	0.000021	0.0089	-0.00020	0.33	-0.012	-0.0035	-0.0024
	(0.07)	(0.10)	(0.51)	(1.91)	(0.32)	(0.43)	(3.39)

Note: Estimated as a village fixed-effects model, but the coefficients of the dummies are not reported. The t-ratios are in parentheses.

Table 3. Direction of Response of Endogenous State Control Equation to 20 Percent Change in Exogenous Policy Instrument.

	Endogenous State Variables				
Policy	Industry Profits	Grain Yields	Industry Assets	Non-farm Employment	Hybrid Adoption
Ag-Price Increase	-	-	+	+	-
Procurement Increase	+	-	0	+	+
Loan Reduction	-	-[1]	-	-	0

	Control Variables[2]				
Policy	Industry Output	Industry Investment	Hybrid Adoption	Fertilizer Supply	Cash-Crop Sown Area
Ag-Price Increase	-[1]	-	-	+	+
Procurement Increase	+	+	+	-	-
Loan Reduction	-	-	0	+	+

Notes: Direction of response are measured relative the "base" scenario where no changes are made to any of the policy variables. All increases and reductions of policy variables are 20 percent of 1988 level.

[1] Direction of initial response, but at some point in the time path, the base and revised variables cross.

[2] Village wage rate held constant at 1988 rate.

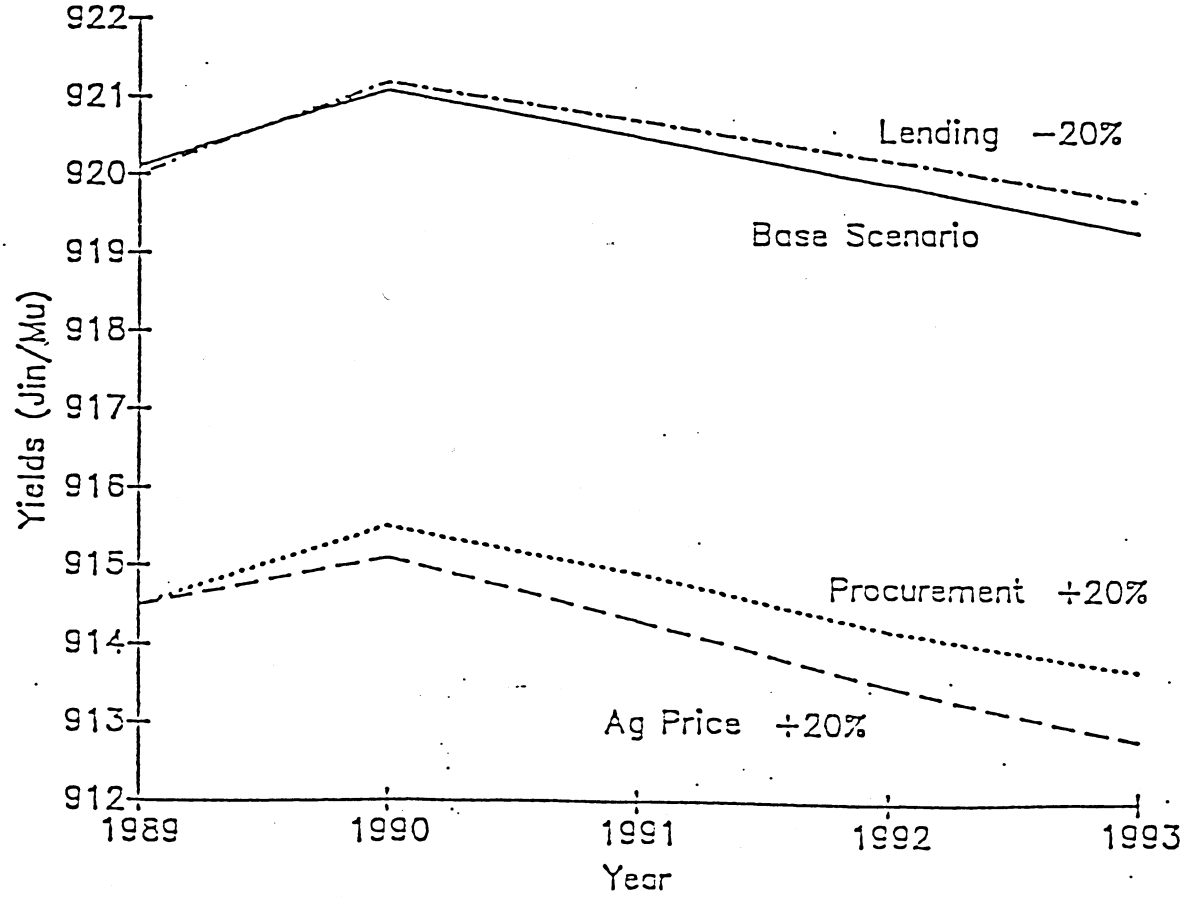

Figure 1: Comparison of Grain Yields Under Different Policies, 1989 to 1993.