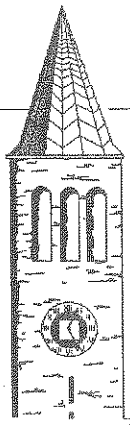

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Control in a Dynamic Economy: Modeling the Behavior of the Chinese Village Leader

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ABSTRACT

Village leaders in the Chinese reform economy are assumed to maximize a multiple-attribute utility function; their behavior is modeled in a dynamic control framework. Using village data, structural and control equations for industrial output, grain yields, capital, non-farm employment and hybrid rice are estimated. Results confirm hypotheses that village leaders are preoccupied with rural industrialization but are also concerned about maintaining high agricultural productivity to meet grain obligations.

Control in a Dynamic Economy:

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Introduction

Economic reform in China has changed the face of the rural economy, stimulating both rapid growth in agriculture and a broadening of the scope of economic activity. Grain production rose at almost 5% per year from 1979 through 1984; the value of gross agricultural product (GAP) increased at an even greater annual rate, 8% (ZGNYNJ, 1980 - 1988). Growth in the rural industrial sector since the reforms has been even more dramatic. In the late 1970's, rural industrial output was less than 10% of gross rural product. It now constitutes over half the economic activity of rural areas (ZGNCNJ, 1988).

The expansion of agricultural output during this period was due in part to the adoption of agricultural technology, changes in pricing policies and input supply, and, most importantly, due to major institutional adjustments (Wiens, 1987; Lin, 1987). In conjunction with the decollectivization of agriculture, the incentive system was redesigned to encourage rural people to diversify agricultural production and expand rural industrial activities.

In the past several years, however, growth in parts of the rural sector has slowed. Grain production has never recovered to the record levels of 1984. Between 1985 and 1988 the growth in GAP continued, but at only half the annual rate of the first half of the decade. High-level administrators blame the faltering in the rural economy on the inability to effectively implement policies at the local level (Oi, 1988). Leaders do not have experience in dealing with the contradictions implicit in a dualistic system (i.e., administrative and market). Moreover, there is no model with which policy

makers can analyze the new relationships that have been established between the village leaders and farmers, the fundamental economic actors in rural areas (Nee and Young, 1989; Shue, 1989).

Chinese and Western economists have addressed this emerging problem of control. Johnson (1989), Sicular (1988), Stone (1988), Su (1989), Taylor (1988) and Lin, Yao and Wen (1989) point to many unintended consequences of new pricing policies and experiments in markets for fertilizer, labor and land. Lin (1989) also attributes recent problems in China's agricultural science and technology system to the reforms. These studies, however, generally concentrate on only one, or at most several, aspects of the problem. Data limitations and restricted access to rural areas have precluded any previous efforts to provide a multi-dimensional model which could be used to analyze microeconomic activity in China's reform economy.

The purpose of this paper is to provide a comprehensive, integrated framework to analyze the behavior of village leaders and farmers in China's reform economy. A dynamic optimal control model will be used to describe and quantify the relationships among the economic actors. Village leaders are assumed to maximize a multi-attribute utility function subject to certain structural and endowment constraints and only limited control over the behavior of farmers. The theoretical model is estimated empirically using a unique set of pooled time-series, cross-section village data collected during 15 months of field work in Central China.

The Village Decision Framework

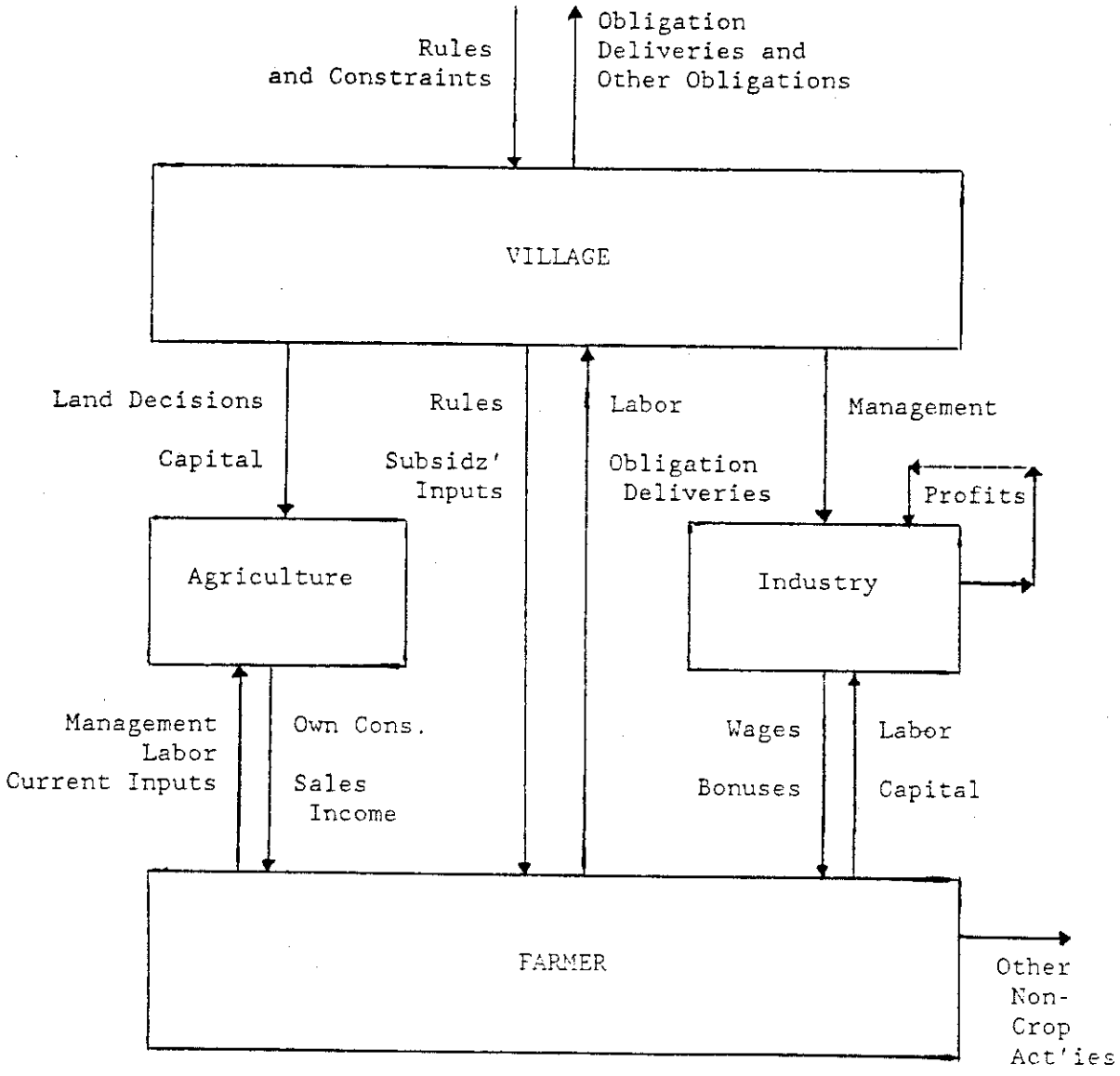
Although village leaders face administrative restrictions from higher levels of government, extensive personal interviews clearly revealed that

village leaders and farmers are important economic actors in rural China. By far the most important role of village leaders in the 1980's is as economic managers. As seen in figure 1, they are responsible for operations to varying degrees in both agriculture and village industries. Village leaders make decisions to achieve their goals subject to factor endowment limitations and rigidities caused by the structure of the economy. They have substantial, but not complete, control over farmers' production decisions and labor allocation. Thus, to accomplish village objectives, village leaders must work to affect the behavior of farmers directly or indirectly, and attempt to anticipate farmer response to policy changes and economic conditions in emerging markets.

Agriculture: In agriculture, village leaders have direct control over many production decisions. In the allocation of land they make both long-term allocations of land among village households and yearly crop and varietal selection decisions. Farmers, on the other hand, are primarily responsible for allocating labor between agricultural enterprises and non-farm economic activities. Furthermore, most current inputs (e.g., fertilizer, farm chemicals, seed, plastic sheeting, fuels, etc.) must be purchased and applied by the farmer using the farmer's own operating capital.

Village leaders, however, can influence both labor and current-input usage directly and indirectly. They can require farmers to perform up to 15 days of free "obligation" labor per year -- to be used not only to maintain agricultural infrastructure, but also for other activities such as building structures to be used for village industries. They can also establish rules involving minimum levels of application of certain inputs or affect application levels by providing inputs at subsidized prices. Some leaders

Figure 1. The Relationship between Village and Farmer in Jiangsu, China: A Flow Chart Representation



spend a great deal of time finding and procuring inputs that are in critically short supply and transporting back to the village.

One of the most effective tools that village leaders use to control their local economies is agricultural technology. In particular, each year leaders must decide what proportions of their fields are to be sown with hybrid rice, conventional rice varieties and other cash crops. Hybrid rice varieties, while higher yielding, require more labor, fertilizer and insecticides, as well as better water control and overall management. There is a class of farmers who would rather not cultivate a rice crop that requires more intensive use of labor and capital; leaders recognize the tradeoffs between hybrids and conventional modern varieties.

Despite their substantial power, village leaders must operate within administrative restrictions, the most important of which is a marketed surplus contract through which they commit the village to supply certain amounts of grain, oilseed and fiber product to the state marketing system. The prices for these products are low, especially relative to the free market prices that exist for some crops. In return, villages receive an allocation of nitrogen fertilizer, diesel fuel and credit at subsidized prices. When coupled with restrictions that discourage or prohibit grain sales back to villages, these "obligation" levels of production can be very high and are often a real burden to the village.

The emphasis on rural industry intensifies the competing demands for scarce village resources. Village fields are often diverted from "obligation" crops to higher value cash crops to be used by rural industry directly as inputs or as a source of investment capital. This places a premium on

increasing yields on the remaining grain land and highlights the important linkages between the two major sectors of the rural economy.

Industry: Although the agricultural sector is an indispensable part of the village community, it is easy to understand why village leaders have focused on rural industry for village development. Rural industries generally operate under fewer administrative restrictions from higher levels of government. However, there can still be substantial impediments to industrial growth. For many industries, locating and maintaining raw material supplies are the most frequently encountered and serious operational problems. In the early years of operation, a new industry often depends on its own village's agricultural resources for some portion of the required raw materials or as a source of capital. Thus, agricultural restrictions and quota burdens indirectly impinge on industrial behavior.

Furthermore, factor markets for labor and capital for industry are also seriously limited. The lack of a labor market has made village leaders monopsonists since they can set wage rates within certain limits. Loans are rationed by higher-level administrators. These loans are formally granted either as seed capital for new factories, or for covering short-term operational needs. Village leaders understand the fungibility of these cash infusions and admit that scarce capital is often used to meet both fixed and operating capital requirements.

In the absence of grants from official channels, capital is often limited by sources of village funds. Major sources of funds are: (1) investment by farm families of the same village; (2) funds coaxed from private entrepreneurs within the village and (3) the retained earnings of the existing enterprises. Village leaders claim that the accumulation of capital funds for

both factory expansion and for the day-to-day operations is the biggest difficulty in running a village enterprise. Another source of non-cash investment is the labor provided by farmers to construct a new building or to perform other tasks that will foster industrial development.

Village Objectives: Partially in response to the institutional changes, village leaders clearly have a number of potentially competing objectives. They are motivated by both political and economic forces which further their interests. These motivations mean that village leaders are doing more than trying to maximize profits. In some circumstances village leaders do make decisions that are consistent with the principles of a competitive economy. There are many situations, however, where village leaders are making decisions which would seem irrational under the assumptions of profit maximization, but which are logical and consistent when viewed as actions taken by individuals who are maximizing a more complicated, multiple-attribute utility function.

These goals are pursued through measures that are taken to shape the agricultural and non-agricultural sectors of the village. For example, achieving high agricultural productivity in grain production will boost the status of a village leader and can provide opportunities for leaders to be promoted into the state agricultural hierarchy. Raising grain yields, however, requires resources and could conflict with efforts to accumulate capital and mobilize labor for investment in village industries. Leaders perceive industrialization as a way to increase their power in the village and as a means to supplement their own incomes.

The levels of grain yields themselves are objectives to be pursued by village leaders; the same is true for hybrid rice adoption. Most village leaders know the level of adoption of hybrid rice for most every other village

in the township. The village leaders within the township who are identified as the "best" agricultural leaders invariably have both the highest yields and the highest level of hybrid adoption. Furthermore, they admit that there is frequently pressure applied by township and county leaders for increasing the level of hybrid rice adoption. Township leaders view high rates of hybrid rice adoption as a "signal" that local leaders are "trying" to improve agriculture.

A more complete discussion of goals and objectives of village cadres is reported elsewhere (Rozelle, 1989). On the basis of extensive interviews with village leaders, the most important goals are related to promotion, personal profit, status, power, job security, independence and the altruistic commitment to their constituents. There also seems to be general agreement that these goals are pursued through the following economic measures: industrial profits, grain yields, investment in village enterprises, non-farm employment opportunities and technological progress in agriculture, not all of which are afforded the same level of importance.

The Model and Empirical Specification

The Theoretical Model: The above characterization of the goals and objectives of village leaders is consistent with the conceptual approach popularized by Kirshen and Morrisens (1973), in which goals of leaders are achieved through a set of economic measures. To quantify the importance of the set of economic measures or objectives, and to further understand the behavior of rural economic agents, this section outlines a model consistent with this approach. Stated differently, village leaders are assumed to be maximizing a multi-dimensional objective function over time by controlling the

processes in the rural economy affecting the variables which contribute to utility. It is proposed that the behavior of the village leaders can be described by a dynamic optimal control model (Bertsekas, 1976). In matrix notation, the village leader maximizes a utility function,

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

subject to:

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

where:

β^t = a discount rate;
Ω and ω_t = matrices of weights;
X_t = a vector of state variables;
U_t = a vector of control variables;
ε_t = a vector of error terms; and
A, C and b = matrices of structural parameters.

By assuming that the functional form of the objective function is quadratic, and that the structural constraints are linear, when equation (1) is maximized subject to equation (2), the optimal levels of the control variables are linear functions of the lagged state variables:

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

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

The Empirical Specification: The specifications of equations (1) and (2) used in the application of the model to village leaders in Central China are given in table 1, along with the definitions of the variables. The village environment is described by the set of nine structural equations for industrial profits, grain yields, capital, investment, non-agricultural labor,

Table 1. Empirical Specification of the Village Leader Model

(4) $\max_{r_t,\ i_t,\ h_t,\ f_t,\ w_t,\ c_t} E(V) = E\Big\{ \sum_{t=1}^{\infty} \beta^t (\omega_1\pi_t + \omega_2\pi_t^2 + \omega_3 G_t + \omega_4 G_t^2 + \omega_5 K_t + \omega_6 K_t^2 + \omega_7 L_t + \omega_8 L_t^2 + \omega_9 h_t + \omega_{10} h_t^2 + \text{interactive terms}) \Big\}$

subject to:

(5) $\pi_t = \alpha_0 + \alpha_1 r_t + \alpha_2 i_t + \alpha_3 w_t + \alpha_4 K_{t-1} + \alpha_5 P_{t-1} + \varepsilon_{1t}$

(6) $G_t = \beta_0 + \beta_1 h_t + \beta_2 f_t + \beta_3 c_t + \beta_4 P_{t-1} + \varepsilon_{2t}$

(7) $K_t = K_{t-1} + i_t$

(8) $i_t = \partial_0 + \partial_1 w_t + \partial_2 \pi_{t-1} + \partial_3 L_{t-1} + \partial_4 P_{t-1} + \partial_5 B_{t-1} + \varepsilon_{3t}$

(9) $L_t = \tau_0 + \tau_1 r_t + \tau_2 i_t + \tau_3 h_t + \tau_4 w_t + \tau_5 P_{t-1} + \tau_6 O_{t-1} + \varepsilon_{4t}$

(10) $h_t = \rho_0 + \rho_1 L_{t-1} + \rho_2 G_{t-1} + \rho_3 c_t + \rho_4 P_{t-1} + \rho_5 O_{t-1} + \varepsilon_{5t}$

(11) $P_t = \lambda_0 + \lambda_1 P_{t-1} + \varepsilon_{6t}$

(12) $O_t = \mu_0 + \mu_1 O_{t-1} + \varepsilon_{7t}$

(13) $B_t = \phi_0 + \phi_1 B_{t-1} + \varepsilon_{8t}$

STATE VARIABLES:

π_t = profits, village industries

G_t = grain yields

K_t = capital in rural industries

L_t = off-farm employment

h_t = proportion hybrid rice area

P_t = industrial-ag price ratio

O_t = marketed surplus obligation

B_t = loans to village industries

CONTROL VARIABLES:

r_t = output (revenue), village industries

i_t = investment in capital plant

h_t = proportion hybrid rice area

f_t = fertilizer supplied

w_t = village industry wage

c_t = cash crop area

hybrid rice area, prices, the grain obligation and loans in the Chinese village. Since equation (7) is an identity, equation (8) can be substituted into (7) for estimation. Of the remaining eight equations, the first five can be considered "endogenous" both because the state variables of these equations appear in the objective function, and because actions taken in the local economy affect their levels. The following discussion briefly reviews the specification of each equation, and highlights some of the important and less obvious expectations.

Equation (5) describes the process which the village uses to create industrial profits. The level of industrial output (r_t) and capital (K_{t-1}) would be expected to positively affect profits. Although there are costs associated with investment (i_t), the addition to the current capital base should be expected to add to current profitability. The wage rate of the village industrial sector (w_t) is included in the equation because village leaders have monopsonistic power in setting wages; its sign in the equation should be negative because as wage rates increase, less of the earnings are retained by the village as profits. Since flexibility in decision making is greater in the industrial sector than it is in agriculture, it is reasonable to expect that some measure of industrial prices relative to agricultural prices (P_{t-1}) would be positively related to industrial profits.

In equation (6), village leaders are hypothesized to influence grain yields by varietal selection and by the allocation of subsidized inputs. By choosing a higher proportion of the grain area to be sown to hybrid rice (h_t), the new higher-yielding, agricultural technology, grain yields would be expected to increase. Similarly, when leaders increase the amount of nitrogen fertilizer (f_t) available to village farmers, at least part of the additional

increment would be expected to be applied to grain crops. However, if the area sown to cash crops (c_t) is increased, resources can be expected to be diverted to these crops away from grain, with an adverse effect on grain yields. Finally, both village leaders and farmers can be expected to adjust grain yields in response to changes in the price of agricultural goods relative to that of industrial products (P_{t-1}). But the direction of the change in the local Chinese economy is ambiguous. Left on their own, farmers would increase yields in response to a rise in agricultural prices (i.e., a decrease in P_{t-1}). With rising industrial prices, however, village leaders might be inclined to push for higher grain yields to be able to devote even more land resources to cash crops that may be a supply of additional raw materials for their factories.

After substituting equation (8) into equation (7), capital becomes a function of wages, lagged profits lagged non-agricultural labor, lagged prices, and loans obtained from financial institutions, the principal contributors to the current stock of capital. Loans (B_t) should be expected to be an important positive factor in the increases to capital stock. The sign on the coefficient of the wage variable (w_t), however, is ambiguous. On the one hand, the wage variable is included since higher wages may increase the potential for village leaders to encourage employee investment in local industry. On the other hand, higher wages also reduce retained earnings available for future investment from village resources. The signs on the lagged profit and price variables are similarly indeterminate. Higher profits and prices in the previous year (π_{t-1} and P_{t-1}) would increase retained earnings and facilitate investment in the current year. When strong markets for industrial goods lead to increased profits and prices, however, the demand

for operating capital rises also, possibly forcing firms in China's capital short economy to postpone fixed investment. Finally, labor in the previous year (L_{t-1}) is included because some proportion of non-agricultural labor is often committed to constructing physical plant, which becomes part of the capital stock in the subsequent year. Total non-agricultural employment is used because the proportion of labor devoted to capital construction is not available in the data.

Equation (9), the non-agricultural labor equation, reflects the allocation of the village labor supply between the non-agricultural and agricultural sectors. Industrial activity (r_t) would be expected to increase the flow of labor into the non-agricultural sector. Likewise, the coefficients of the wage variable (w_t) and the price index (P_{t-1}) should both be positive, since higher off-farm wages should pull farmers out of agriculture and lower agricultural prices, ceteris paribus, should push them into the non-farm sector. The adoption of new rice technology (h_t), which increases the returns to cropping activities, however, would stem the flow of labor into the non-agricultural sector. For a given level of industrial activity, the investment variable (i_t) would be expected to have a negative sign if labor and capital are substitutes. Only the coefficient on the village's marketed surplus obligation (O_{t-1}) variable is ambiguous. On the one hand, the higher minimum grain constraint means that the household must devote more resources to agriculture. On the other hand, as the quota increases, and farmers are required to sell more grain at a below market price, agricultural households have an incentive to supply more labor to the non-farm sector.

Equation (10) explains the adoption rate of new agricultural technology. Village leaders set the proportion of grain area sown to hybrid rice at the beginning of a cropping cycle by observing the grain yields (G_{t-1}) and labor availability (L_{t-1}) during the previous year. Leaders might be expected to respond to low agricultural yields in the previous period by increasing hybrid rice area in the current period. Conversely, high levels of employment in the non-agricultural sector are likely to work against the adoption of hybrid rice. When faced with higher delivery obligations for grain (O_{t-1}), village leaders might be expected to fulfill at least part of this additional requirement by increasing the proportion of area sown to higher yielding hybrid rice varieties. Finally, labor intensive cash crops (c_t) would also be expected to exert pressure on village leaders to move into less labor intensive rice varieties.

Equations (11) through (13) are the equations of motions in the economy for the price, total obligation and loan variables; they are included for completeness. It is assumed that these variables are generated through processes determined by factors exogenous to the village. At this point the interest is centered mainly on how these variables affect the five other state variables.

Estimation: The dynamic control model for equations (1) through (3) contains three sets of parameters to be estimated--the parameters of the structural equations (A and C), the parameters of the control equations (G), and the objective function coefficients (Ω). These parameters, however, are not independent (Fulton and Karp, 1989). Intuitively, if any two sets are known, the third set should be recoverable. In the most typical application of the quadratic-linear control problem, the weights of the objective function

are assumed, structural coefficients are estimated or borrowed, and parameters of the control equations are derived through algebraic manipulation.

In this application, it is difficult even to guess at the relative magnitudes of the weights of the different variables in the objective function of the utility function of the village leader. Following Chow (1983) and Fulton and Karp (1989), the overall strategy of this research is to estimate the parameters of the structural and control equations directly, and then use these two sets of estimates to recover the objective function coefficients. This paper focuses only on estimating the first two sets of parameters. Estimation of the third set, the weights, is a part of the senior author's Ph.D. research which is yet to be completed.

In the structural equations all but one of the right-hand-side variables are exogenous or lagged endogenous variables. To account for statistical problems arising from having the hybrid rice variable on the right-hand side, predicted values of hybrid rice sown area from an Ordinary Least Squares (OLS) estimate of equation (10) were used as instruments in equations (6) and (9). To pick up differences in the dependent variables between villages that might arise from unobservable factors, the system of equations was estimated with dummy variables for each of the villages.

From equation (3) there are six control equations to be estimated in this application. Each control variable is a function of all but one of the state variables, lagged one period. Hybrid rice is not included as an independent variable in the control equations since it did not appear in a lagged form in the structural equations. The parameters of the control equations, G, are also estimated by OLS with village dummies in each equation to account for inter-village differences in the management decision making

process that might arise due to differences in village-specific factors and different management abilities.

The Data

Six years of data (1983 through 1988) from a village survey conducted by the author during 15 months of field work in Central China were used in estimating the model. The data included information on agricultural production, investment, non-farm activities, credit, prices and technology adoption. The data 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. Supplementary data were recorded from secondary sources at the township level.

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. The villages are located in northern Yangzhou prefecture and were selected to be in the same agro-climatic environment.

The villages are in a region which is still predominantly agricultural, has a high proportion of land sown to grain, and has a mixture of new and conventional modern rice varieties. The average income of rural residents in the villages is slightly below the average of the province, but significantly higher than the average for all of rural China. The villages, however, have higher per capita agricultural output and marketing rates than the provincial average. These facts reflect the historic importance of agriculture in the

region, even though the growth rates of rural industry in the late 1980's are among the highest in the province (JSTJJJNJ, 1988). Summary statistics for the first and last years of the time series are reported in table 2.

Industrial prices were typically those which were actually faced by the leaders in each of the villages themselves. In the event prices were not reported by the village, then they were recovered by a variety of methods, including (1) creating prices by dividing factory output into gross revenue; (2) using prices from the nearest village with a factory in the same industrial category; or (3) using prices from the township factory in the same industrial category. Village agricultural prices were assumed to be identical within townships, but varied over time and between the three townships. Commodity prices for the six major grain and cash crops were aggregated into a single agricultural price index. All prices were deflated by an index constructed from county-level producer data.

The Results

The estimated coefficients (except for the village dummy variables) for the structural and control equations are in tables 3 and 4, respectively (table 4 appears later in this section). These results are somewhat preliminary and will be refined as the senior author's thesis research progresses. However, for the most part, these parameter estimates are reasonable and are of the expected sign.

The Structural Equations: From the village leader's standpoint the structural equations are perhaps the most important. They relate the variables over which leaders have some control to the important economic outcomes. Turning first to the industrial profit equation, these results

Table 2. Means and Standard Deviations of 40 Sample Villages, 1984 and 1988

Variable	1984 Mean	1984 Standard Deviation	1988 Mean	1988 Standard Deviation	Percent Change 1984 to 1988
π_t **Profits** (yuan)	12000	29000	36000	55000	+300
G_t Grain Yields (jin/mu)	818	153	801	161	- 2
K_t Capital (yuan)	19000	36000	47000	53000	+247
L_t Non-Ag Labor	88	59	139	80	+150
r_t Industrial Revenues (yuan)	39000	66000	157000	180000	+400
h_t Hybrid Rice Area (mu)	665	401	510	400	- 23
f_t Fertilizer (tons, N)	22	10	24	12	+ 9
w_t Industrial (Y/month)	77	42	97	61	+ 26
c_t Cash Crop Area (mu)	190	134	260	160	+ 37
P_t Industrial-Ag Price Ratio	863	1213	761	1083	- 12
O_t Obligations (10,000 jin)	14053	88535	13600	85722	- 3
B_t Loans (Yuan)	2500	7000	2000	10800	- 20

Constant 1980 Yuan: 1 Yuan = \$3.71 US; 1 mu = 1/6 acre = 1/15 hectare;
1 jin = 1.1 lbs. = 1/2 kilogram

Table 3. 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})	(G_{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 (G_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.

generally support the original hypotheses, each of the coefficients has the expected sign and, except for the wage variable, the standard deviation of each coefficient is small relative to the magnitude of the coefficient. Increases in industrial output and the village industry's fixed capital both lead to higher profits, as expected. If there is a cost to investment, the increase in profits due to the expansion of the capital base of village enterprise more than offsets it. Also, as industrial prices rise relative to agricultural prices, village industries do become more profitable. Conversely, an increase in the industrial wage rate leads to a reduction in profit levels because of its adverse effect on retained earnings.

From the grain yield equation, it appears that village leaders do try to control grain yield by requiring farmers to plant a larger proportion of grain area to hybrid rice. Increases in fertilizer supply are also important in explaining grain yields. The magnitude of this coefficient has interesting implications for village policy. Using the mean values of the variables, the coefficient implies that to increase the value of grain production by 1000 yuan at the margin requires 2000 yuan of additional fertilizer at current prices. 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, however, 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 sign on 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.

As expected, the loan variable has the most explanatory power of any of the variables in the industrial capital equation. The magnitude of the coefficient suggests that most loans do go for new fixed investment, and that they often act as seed capital. For each dollar granted to the village enterprise, leaders invest 1.38 dollars in new capital plant. The coefficient of the lagged non-agricultural labor variable is also positive as expected, although its magnitude is small relative to the size of its standard error.

Hypotheses regarding the effects of the remaining variables on the level of capital were ambiguous. The estimates of their coefficients help explain the determinants of increase to capital plant. The negative signs on the lagged profit and price variables could arise in part due to the capital shortages within the village economies. These coefficients mean that when profits and prices are high, the capital base is lowered in the subsequent years. In an expanding economy, retained earnings that are produced from profitable years are not invested into capital stock, but are used as short-term operating capital. Conversely, the signs of the coefficients mean that

when profits and prices are down, firms will begin to build up their capital bases. These actions by village leaders, while counter-intuitive in a competitive economy, are consistent with the goals represented by the multi-attribute objective function. Industrial profits and capital levels both contribute to power, personal profit and increased independence from township leaders. When prices are low, there is a negative effect on these goals through the profit variable. During these times, village leaders can compensate by substituting investment in fixed plant for lower profits. The reduced levels of industrial operations in sluggish markets also decrease the need for operating capital, allowing scarce capital resources to be used on longer-term capital projects.

In the non-agricultural labor equation, all but one of the coefficients have the expected signs, although in some cases the standard errors are small relative to their magnitudes. The results confirm the hypothesis that labor and capital are substitutes in village industries. Furthermore, the negative sign on the hybrid rice variable illustrates the competition for labor between labor-intensive agricultural technology (i.e., hybrid rice) and the non-farm sector. The coefficient implies that as village leaders force farmers to increase hybrid rice area the flow of labor out of the agricultural sector is reduced.

The results were mixed on the wage, price and obligation variables. As expected, rising prices in the industrial sector and lower agricultural prices do appear to encourage labor to move out of the farming sector. The positive coefficient on the obligation variable also means that the amount of labor flowing to off-farm jobs will increase as officials force villages to sell more grain to the grain stations at below-market prices.

The negative coefficient on the wage variable in the non-agricultural labor equation, however, is unexpected. This variable is not significant in any of the structural equations. Part of the problem may be in the way that the wage variable was constructed, the wage bill divided by the total number of labor-days. Since some factories offer bonuses and have profit sharing incentive plans that are considered part of the wage bill, the daily wage for some villages may be overstated. Likewise, the effort required by factories in different villages varies greatly; these differences are not accounted for.

In the final equation, the coefficient of the lagged labor variable suggests that the flow of labor out of farming in previous periods prompts village leaders to reduce the relative area to hybrid rice. Conversely, when the obligation variable and the industrial-agricultural price index increase, the proportion of area planted to hybrid rice rises. While the coefficient on the price variable might seem wrong for the profit maximizing agent, village leaders may raise the area sown to hybrid rice even when agricultural prices are falling relative to the price of industrial goods. From discussions with village leaders, it was hypothesized that low lagged grain yields would lead to a higher level of current hybrid rice area. The positive sign on this coefficient does not support this hypothesis.

The Control Equations: In this dynamic framework, the control equations identify the feedback relationships between the levels of the lagged state variables and the current control variables. As seen in equation (3), the current control variables are functions of all of the lagged state variables from the structural equations. The estimated results for these equations are found in table 4.

Table 4. Control Equations Describing Village Leader Behavior

Equations	Lagged Profits (π_{t-1})	Lagged Grain Yields (G_{t-1})	Lagged Capital (K_{t-1})	Lagged Non Ag. Labor (L_{t-1})	Lagged Price Ratio (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.

The industrial output equation suggests that the levels of capital and labor resources in the village are important determinants of planning industrial production in the village. There is also strong feedback between loans in the previous year and current production, a relationship that might be expected in a capital-short economy. Likewise, large profits in the previous year appear to lead to expanded current output, although it is difficult to place much confidence in this result because the standard error of this coefficient is large relative to its magnitude. The coefficient on the lagged price variable is also positive, but because of its large standard error it seems likely that resource availabilities are more important than relative prices in formulating current production decisions.

The results of the investment equation support the observations made earlier regarding the capital equation: Loans and non-farm labor allow village leaders to expand their local industries through new investment. The feedback between lagged capital and investment, however, is negative. The sign of this coefficient is consistent with the observation that, without loans, major capital investments could be made only after small amounts of funds had been accumulated over a period of several years.

The results from the hybrid rice equation support the hypothesis that village leaders strive to maintain agricultural productivity through the adoption of agricultural technology, even under conditions that would otherwise lead to reduced production levels. In particular, village leaders appear to increase the proportion of land planted to hybrid rice even when agricultural prices fall relative to those in the industrial sector. Hybrid rice area also rises along with profits in village industries and the size of the marketing obligation. All three responses are consistent with the

observation that the yield increases from new technology release land for reallocation to the production of cash crops or crops used as raw materials in village factories. These results are reconfirmed by the signs on the coefficients for the same variables in the cash crop equation, although the level of confidence that can be placed on the magnitude of the coefficients is lower.

Most of the coefficients in the fertilizer supply equation are as expected. The sign on the coefficient of lagged non-agricultural labor indicates that village leaders view fertilizer as a substitute for labor that has left agricultural production. In years following high levels of investment in the industrial sector, less fertilizer is supplied for current production. One possible explanation is that operating capital to purchase fertilizer is in short supply. There also appears to be a negative feedback relationship between grain yields and fertilizer. Low yields in the previous year prompt village leaders to increase the availability of fertilizer for current production.

The problems in measuring the wage rate appear to have also affected the results of the control equation for village wage rates. The coefficients of most lagged state variables have large standard errors, making it difficult to place confidence in their signs or in their absolute magnitudes. Current wages do appear to be higher in years following high industrial prices.

Summary and Conclusions

In this paper, a dynamic control framework is used to create an integrated model of the village in China's reform economy. Village leaders are assumed to maximize a multi-attribute utility function subject to certain

structural and endowment constraints and only limited control over the behavior of farmers. The theoretical model is designed to assist policy-makers in analyzing the new relationships that exist between village leaders and farmers in rural areas. It is estimated empirically using village data.

In the empirical specification, village leaders are assumed to achieve their goals by selecting the levels of important agricultural and industrial decision variables over which they have control. Nine structural equations are specified to describe the relationship between the agricultural and non-agricultural sectors of the village. The control equations derived from within this framework capture the feedback relationships between lagged state variables and current variables under village control.

In formulating the model, information collected during intensive interviews with village leaders provided the basis for generating testable hypotheses concerning important village objectives. In the empirical analysis, estimates were obtained for the parameters of the structural and control equations.

The empirical results generally support the hypotheses implicit in the specification of the model. It does appear that village leaders are concerned with a number of competing objectives. The results are consistent with the current preoccupation with industrialization in rural China. They are also consistent with the observation that maintaining high agricultural productivity enhances the status and promotional opportunities of village leaders, while simultaneously reflecting concerns for meeting agricultural grain obligations. Further evidence on the relative importance of these objectives will be forthcoming from on-going research designed to recover the weights associated with the various objectives.

The empirical results are quite encouraging particularly given the fact that econometric analysis generally has had a poor track record when applied to Chinese data. Analysts often blame models based on inappropriate economic behavioral and institutional assumptions for these difficulties. The type of model used in this paper accounts for some of the institutional and structural factors that affect decision making in China's mixed economy. This and similar models should be of increasingly greater interest to economists as the reforms deepen and as pressure mounts to perform more sophisticated ex-ante policy analysis.

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spend a great deal of time finding and procuring inputs that are in critically short supply and transporting back to the village.

One of the most effective tools that village leaders use to control their local economies is agricultural technology. In particular, each year leaders must decide what proportions of their fields are to be sown with hybrid rice, conventional rice varieties and other cash crops. Hybrid rice varieties, while higher yielding, require more labor, fertilizer and insecticides, as well as better water control and overall management. There is a class of farmers who would rather not cultivate a rice crop that requires more intensive use of labor and capital; leaders recognize the tradeoffs between hybrids and conventional modern varieties.

Despite their substantial power, village leaders must operate within administrative restrictions, the most important of which is a marketed surplus contract through which they commit the village to supply certain amounts of grain, oilseed and fiber product to the state marketing system. The prices for these products are low, especially relative to the free market prices that exist for some crops. In return, villages receive an allocation of nitrogen fertilizer, diesel fuel and credit at subsidized prices. When coupled with restrictions that discourage or prohibit grain sales back to villages, these "obligation" levels of production can be very high and are often a real burden to the village.

The emphasis on rural industry intensifies the competing demands for scarce village resources. Village fields are often diverted from "obligation" crops to higher value cash crops to be used by rural industry directly as inputs or as a source of investment capital. This places a premium on