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Monitoring Costs in Chinese Agricultural Teams

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Large productivity gains have been observed in Chinese agriculture following the transition from collective farming to household contracting. Using a model of mutual monitoring in an egalitarian production team, we estimate that labor supervision absorbed about 10–20 percent of total labor time for a sample of Chinese agricultural teams during 1970–76. These agency costs are lower than comparable estimates derived from aggregate data.

I. Introduction

Chinese agricultural institutions underwent dramatic reform beginning in the late 1970s. A centerpiece of these reforms was the replacement of collective farms by the household contracting system. Agricultural productivity rose substantially in the wake of this policy shift (Lin 1990).

The reasons for this productivity gain remain controversial. Some authors argue that collectivization led to severe incentive and monitoring problems that could be cured only by a return to family farming (Lin 1987, 1988; Nolan 1988). Others emphasize dysfunctional state policies during collectivization: poor terms of trade for agricul-

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ture, discouragement of crop specialization and interregional trade, political meddling in team management, and repeated campaigns against material incentives (Lardy 1983, 1984; Blecher 1985; Putterman 1985, 1987*a*). These constraints were all relaxed during the transition to household contracting.

Here we use micro-level data on Chinese production teams in the period 1970–76 to estimate the labor supervision costs that were incurred under collective farming. We find that the teams in our sample devoted roughly 10–20 percent of their total labor time to the task of monitoring worker effort. Assuming that monitoring costs are zero under household farming, one can take this as an estimate of the effective increase in labor supply resulting from China's institutional reforms. While clearly substantial, this figure is much smaller than estimates by McMillan, Whalley, and Zhu (1989), who conclude that effective labor supply per worker nearly doubled as a result of the shift to household contracting.

Section II develops a mutual monitoring model in which a shirker risks detection by nonshirking colleagues. Section III describes our data set, derives an estimating equation, and summarizes our empirical results. Section IV comments briefly on implications for the debate over Chinese collective agriculture.

II. Mutual Monitoring in a Production Team

Consider a production team with n identical workers. Each worker spends a fraction $\alpha \in [0, 1]$ of the total working day in productive labor. The remaining time $1 - \alpha$ is used for monitoring activities. Effort choices are binary, with $e_i \in \{0, 1\}$ denoting worker i's effort level. For simplicity, each worker's effort is monitored by only one other team member.

A worker who supplies positive effort is not punished. If worker i shirks ($e_i = 0$), the probability of detection depends on the effort of the worker j who is assigned to evaluate i. If j also shirks ($e_j = 0$), then j cannot provide any evidence against worker i, who thus escapes punishment. But if j works ($e_j = 1$), the probability $\phi(\alpha)$ that worker i is punished depends on the time used for monitoring. We assume $\phi'(\alpha) < 0$ (more monitoring time leads to a higher probability of detection) and $\phi(1) = 0$ (no one is punished when monitoring time is zero).

Each worker i has the same expected utility function

$$u_i = y_i - ve_i, \tag{1}$$

where y_i is income and $v > 0$ is the disutility of effort. All agents are risk neutral. Team revenue is

$$Y = g(\mathbf{x})\left(\alpha \sum_{j=1}^{n} e_j\right)^{\lambda}, \tag{2}$$

where $\mathbf{x}$ is a vector of nonlabor inputs. Net team income is $Y - D$, where $D \geq 0$ is expenditure on nonlabor inputs and fixed costs. The corresponding per capita variables are $y \equiv Y/n$ and $d \equiv D/n$.

Worker i's income is

$$y_i = \gamma s_i(Y - D) + (1 - \gamma)(y - d), \tag{3}$$

where $\gamma \in (0, 1]$ is the share of net income distributed according to work performance, with $1 - \gamma$ distributed by "need" (i.e., on a per capita basis). If worker i is caught shirking, then $s_i = 0$ and i's income is based solely on need. Otherwise, $s_i = 1/\tilde{n}$, with $\tilde{n} \leq n$ being the number of team members not caught shirking. This scheme inflicts the largest possible penalty on shirkers (subject to the constraint that some income must be paid out independently of work) and is a stylized version of the payment rules actually used by Chinese collective farms (Putterman 1987*a*).

We next derive conditions under which mutual effort supply is a Nash equilibrium. Assume $e_j = 1$ for all $j \neq i$. If $e_i = 1$ also, then $s_i = 1/n$ because no one is punished. This yields

$$E(u_i | e_i = 1) = y^n - d - v, \tag{4a}$$

where

$$y^n \equiv \frac{g(\mathbf{x})(\alpha n)^{\lambda}}{n}. \tag{4b}$$

The expression y^n is per capita revenue when all n team members work. If $e_i = 0$, then the fact that $e_j = 1$ for $j \neq i$ implies that i is monitored by a nonshirker. This yields

$$E(u_i | e_i = 0) = (y^{n-1} - d)(1 - \phi\gamma), \tag{5a}$$

where

$$y^{n-1} \equiv \frac{g(\mathbf{x})[\alpha(n - 1)]^{\lambda}}{n} \equiv y^n\left(\frac{n-1}{n}\right)^{\lambda}. \tag{5b}$$

The expression y^{n-1} is per capita revenue when $n - 1$ team members work. From the inequality $E(u_i | e_i = 1) \geq E(u_i | e_i = 0)$, mutual effort supply is a Nash equilibrium if and only if

$$B(\alpha) \equiv y^n(\alpha) - y^{n-1}(\alpha) + \gamma\phi(\alpha)[y^{n-1}(\alpha) - d] \geq v. \tag{6}$$

The term $y^n - y^{n-1}$ is the increase in per capita income resulting from worker i's effort. This residual claim effect will be small in a large team. But worker i has a further incentive to supply effort due to the second term, which is the expected penalty for shirking. The term $B(\alpha)$ is the overall gain to i from positive effort.

The team chooses its time allocation subject to a constraint on effort supply. In a nonshirking equilibrium, each worker has the payoff $y^n - d - v$. Universal shirking gives $-d$. The former dominates if $y^n \geq v$, which holds for any α obeying (6). If such values of α exist, the team maximizes y^n by maximizing the time used in productive labor, subject to the constraint that no one wants to shirk. The team therefore chooses

$$\alpha^* \equiv \max \alpha \in [0, 1] \quad \text{such that } B(\alpha) \geq v. \tag{7}$$

The following proposition states conditions under which α^* exists and the incentive-compatibility constraint $B(\alpha) \geq v$ binds in (7).

PROPOSITION. Assume $\lambda \leq 1$ (nonincreasing returns to labor) and $\phi''(\alpha) \leq 0$ for all α (nonincreasing returns to monitoring time). We define

$$\bar{v} \equiv B(1) = y^n(1) - y^{n-1}(1), \tag{8a}$$

$$\hat{v} \equiv \max_{\alpha \in [0,1]} B(\alpha), \tag{8b}$$

$$\pi \equiv -\frac{\lambda \bar{v}}{\gamma \phi'(1)} > 0. \tag{8c}$$

Clearly $\bar{v} \leq \hat{v}$. The following conditions can be shown:

i) If $v \leq \bar{v}$, then $\alpha^* = 1$.
ii) Whenever $y^{n-1}(1) - d > \pi$, we have $\bar{v} < \hat{v}$. If it is also true that $\bar{v} < v \leq \hat{v}$, then $B(\alpha^*) = v$ holds with $\alpha^* < 1$. But if $\hat{v} < v$, then $B(\alpha) \geq v$ does not hold for any α.
iii) Whenever $y^{n-1}(1) - d \leq \pi$, we have $\bar{v} = \hat{v}$. If $\hat{v} < v$, then $B(\alpha) \geq v$ does not hold for any α.

Proof. See Dong and Dow (1991).

For low effort disutilities ($v \leq \bar{v}$), the team dispenses with formal monitoring and sets $\alpha^* = 1$ because there is no free-rider problem: effort can be maintained simply by assigning each worker a per capita share of total income. At higher disutility levels, positive effort requires that shirkers be penalized. The largest loss that could be imposed on a shirker is $y^{n-1}(1) - d$. If this penalty exceeds π and v is no greater than $\hat{v}$, then effort can be enforced by allocating some time to monitoring tasks. Otherwise, no solution for α^* exists and shirking is inevitable.

Assuming that a solution exists and that there is a free-rider problem ($\alpha^* < 1$), we can conduct a comparative static analysis using the identity $B(\alpha^*) \equiv v$. Let θ be some shift parameter in the revenue function (price, productivity, or a nonlabor input), with $\partial g/\partial\theta > 0$, and let ω be a parameter (monitoring effectiveness), with $\partial\phi/\partial\omega > 0$. Denoting partial derivatives by subscripts, we obtain

$$\frac{\partial\alpha^*}{\partial\theta} = -\frac{B_\theta}{B_\alpha} > 0 \quad \text{(revenue effect)}, \tag{9a}$$

$$\frac{\partial\alpha^*}{\partial d} = -\frac{B_d}{B_\alpha} < 0 \quad \text{(fixed cost effect)}, \tag{9b}$$

$$\frac{\partial\alpha^*}{\partial\gamma} = -\frac{B_\gamma}{B_\alpha} > 0 \quad \text{(penalty effect)}, \tag{9c}$$

$$\frac{\partial\alpha^*}{\partial n} = -\frac{B_n}{B_\alpha} \gtreqless 0 \quad \text{(team size effect)}, \tag{9d}$$

$$\frac{\partial\alpha^*}{\partial v} = \frac{1}{B_\alpha} < 0 \quad \text{(disutility effect)}, \tag{9e}$$

$$\frac{\partial\alpha^*}{\partial\omega} = -\frac{B_\omega}{B_\alpha} > 0 \quad \text{(detection effect)}. \tag{9f}$$

These results accord with intuition. The team devotes more time to production when revenue (θ) increases or fixed costs (d) fall. In either case, shirkers lose more income when detected, allowing the team to relax labor supervision. The team also opts for less monitoring when more income is distributed according to work (γ), when effort is less onerous (v), or when the monitoring process is more effective (ω). For brevity, we omit a discussion of the ambiguous team size effect (but see Dong and Dow [1991]).

III. Estimation

Our empirical research relies on micro-level data from Dahe People's Commune in northern China. The data set was assembled by Steven Butler in 1979–80 and Louis Putterman in 1986, and is described by Putterman (1989). Butler (1985) refers to Dahe as "broadly representative of moderately prosperous grain-producing regions of North China" (p. 97). During the 1970s, Dahe had 16 production brigades and about 100 production teams. These teams, averaging around 50 households and 80 able-bodied adult workers each, serve as the units of observation for our analysis.

To derive an estimating equation, we assume $B(\alpha^*) = v$ as in Section II. The production function is taken to be Cobb-Douglas:

$$Y = \theta L^\lambda K^{\kappa_1} T^{\kappa_2} F^{\kappa_3}, \tag{10}$$

where $L = \alpha n$ is productive labor time. The parameter θ captures output price and technical productivity. The nonlabor inputs are capital stock (K), sown area measured in mu (T), and current farm expenditures measured in yuan (F). Inverting (10) gives

$$\alpha = \left(\frac{y}{\theta k^{\kappa_1} t^{\kappa_2} f^{\kappa_3}}\right)^{1/\lambda} n^{(1-\lambda-\kappa_1-\kappa_2-\kappa_3)/\lambda}, \tag{11}$$

where the variables y, k, t, and f are obtained by placing Y, K, T, and F on a per worker basis.

The monitoring technology is assumed to be exponential:

$$\phi(\alpha, \omega) = 1 - e^{-\omega(1-\alpha)}. \tag{12}$$

For large n, we get

$$y^n - y^{n-1} \equiv \frac{y^n[n^\lambda - (n-1)^\lambda]}{n^\lambda} \cong \frac{\lambda y^n}{n}. \tag{13}$$

On substituting (13) into the definition of $B(\alpha)$ in (6), using (12), and setting $B(\alpha) = v$, we derive the estimating equation

$$\gamma\left[y\left(1 - \frac{1}{n}\right)^\lambda - d\right] - \left(v - \frac{\lambda y}{n}\right)[1 - e^{-\omega(1-\alpha)}]^{-1} = u, \tag{14}$$

where u is a team-specific error term with zero mean, and α is given by (11). The parameters to be estimated are θ, λ, κ_1, κ_2, κ_3, v, and ω. The endogenous variable is y (revenue per worker in yuan), and the exogenous variables are k, t, f, n, d, and γ. Detailed definitions of variables and a defense of our exogeneity assumptions can be found in Dong and Dow (1991). Sample means and standard deviations for each variable are listed in table 1.

Equation (14) was estimated separately for each of the seven years in the period 1970–76. A cross-sectional approach was used because only a small set of teams had the required variables for all seven years, and a suitable price deflator was unavailable in any case. Estimation was carried out by the nonlinear two-stage least-squares method, using the Gauss-Newton algorithm in TSP version 4.1 (more information on the estimation procedure is provided in Dong and Dow [1991]). Table 2 reports the results from estimating (14) under constant returns to scale ($\lambda + \kappa_1 + \kappa_2 + \kappa_3 = 1$). This restriction was imposed because we were unable to reject the hypothesis of constant returns at the 5 percent level in any year.

The labor coefficients in table 2 are a bit large. However, in each year in which this coefficient is above 0.8 (1971, 1972, and 1974), the capital coefficient is negative, suggesting that these high values should

TABLE 1

SAMPLE MEANS AND STANDARD DEVIATIONS

	1970	1971	1972	1973	1974	1975	1976
y	370.2	383.9	453.0	441.5	505.2	512.2	491.8
	(74.1)	(81.0)	(80.9)	(103.9)	(106.1)	(148.3)	(92.7)
k	149.3	165.6	228.4	196.6	220.6	257.7	278.0
	(72.6)	(69.0)	(62.5)	(64.6)	(88.7)	(88.5)	(96.8)
t	6.4	6.1	6.5	5.7	5.5	5.1	5.0
	(3.4)	(1.7)	(1.6)	(1.6)	(1.5)	(1.5)	(1.3)
f	113.8	120.1	166.2	175.5	198.9	235.1	243.0
	(33.9)	(42.3)	(34.7)	(64.8)	(53.7)	(77.6)	(56.8)
n	84.3	84.6	72.4	80.6	80.3	82.9	89.9
	(51.3)	(50.5)	(30.0)	(27.1)	(28.6)	(25.9)	(31.7)
d	173.7	190.6	229.9	241.5	292.0	309.1	302.0
	(35.7)	(47.2)	(42.7)	(70.4)	(74.7)	(102.6)	(67.5)
γ	.48	.47	.44	.44	.40	.39	.39
	(.06)	(.08)	(.08)	(.07)	(.09)	(.09)	(.09)

be viewed with skepticism. In the years in which all coefficients are positive and significant (1970 and 1975), we obtain more reasonable estimates of 0.64 and 0.62. The estimates for effort disutility (v) and the monitoring parameter (ω) appear satisfactory. They have the right signs and attain the 1 percent level of significance in every year.

Marginal value products (in yuan) are listed in table 2 for cases in which statistically significant estimates were obtained. The marginal value product for expenditure on current farm inputs (chemical fertilizers, seeds, etc.) ranges from 0.17 to 0.79 and generally covers less than half of their marginal cost (equal to unity). This is consistent with the excessive use of such inputs observed at Dahe prior to 1979–80 (Butler 1985, p. 102).

The marginal product of capital is the derivative of revenue with respect to the value of the team's capital stock (tractors, draft animals, buildings, etc.) and ranges from 0.04 to 0.28. We place little confidence in these estimated rates of return because of the likelihood of substantial measurement errors in the capital stock variable. The marginal product of land is the derivative of revenue with respect to sown acreage (in mu) and ranges from 11.4 to 16.1 yuan. These are plausible values since the marginal product of sown land for China as a whole, computed from data at the provincial level during 1980–83, has been estimated at 15.5 yuan (Putterman 1987*b*).

The marginal product of labor is computed with respect to the number of workers (n). The values for 1970 and 1975 (236.9 and 317.6 yuan, respectively) are probably the most reliable. Table 2 shows that labor's marginal value product is consistently larger than the net average product $y - d$, which hovers around 200 yuan.

TABLE 2

NONLINEAR TWO-STAGE LEAST-SQUARES ESTIMATION RESULTS (Constant Returns Imposed)

	1970	1971	1972	1973	1974	1975	1976
θ	149.6	344.7	201.6	159.6	247.9	122.4	177.2
	(6.49)*	(3.87)*	(1.41)***	(2.33)*	(5.45)*	(5.96)*	(2.82)*
Labor	.64	.82	.84	.74	.83	.62	.80
	(22.8)*	(18.6)*	(14.0)*	(6.17)*	(17.6)*	(15.9)*	(12.1)*
Capital	.04	−.14	−.01	.02	−.01	.14	.02
	(1.96)**	(−1.66)***	(−.14)	(.35)	(−.30)	(4.97)*	(1.79)**
Land	.24	.18	−.04	.06	.04	.16	.01
	(7.14)*	(3.35)*	(−.64)	(.75)	(.91)	(6.33)*	(.68)
Other	.08	.14	.21	.18	.14	.08	.17
	(1.71)**	(2.39)*	(2.53)*	(4.57)*	(2.85)*	(2.59)*	(2.43)*
v	3.87	7.86	7.60	6.12	5.77	3.77	5.64
	(6.37)*	(6.20)*	(4.84)*	(4.96)*	(11.0)*	(10.5)*	(9.51)*
ω	.13	.21	.25	.28	.22	.11	.19
	(2.33)*	(3.27)*	(3.98)*	(3.60)*	(2.92)*	(4.30)*	(4.46)*
Sample size	38	37	38	47	58	78	75
	Marginal Value Products						
Labor	236.9	314.8	380.6	326.7	419.3	317.6	393.4
Capital	.10	...	...	...	...	.28	.04
Land	13.8	11.4	...	...	...	16.1	...
Other	.26	.45	.79	.45	.36	.17	.34
	Net Average Product of Labor						
$y - d$	196.5	193.3	223.1	200.0	213.2	203.1	189.8

NOTE.—"Other" is expenditure on current nonlabor farm inputs (mainly chemical fertilizers). Numbers in parentheses are the standard normal variables. The labor coefficient λ is one minus the sum of the nonlabor coefficients. The marginal product of labor is λy. All marginal and average products are computed at the sample means.

* Differs from zero at the 1 percent level.
** Differs from zero at the 5 percent level.
*** Differs from zero at the 10 percent level.

We next turn our attention to monitoring costs. Equation (6) indicated that effort incentives can be decomposed into two effects: a *residual claim effect,* $y^n(\alpha) - y^{n-1}(\alpha) \simeq \lambda y^n(\alpha)/n$, and a *monitoring effect,* $\gamma\phi(\alpha)[y^{n-1}(\alpha) - d]$. A free-rider problem will exist if and only if

$$v > y^n(1) - y^{n-1}(1) \simeq \frac{\lambda y^n(1)}{n}$$

since otherwise effort could be induced through residual claims alone. If we substitute from the definition of $y^n(1)$ given by (4b) and impose constant returns to scale, this hypothesis becomes

$$\text{free-rider} \equiv v - \lambda\theta k^{\kappa_1} t^{\kappa_2} f^{\kappa_3} n^{-1} > 0. \tag{15}$$

We test this relation against the null of no free-rider problem. Results are given in the top row of table 3. The null hypothesis is rejected at the 10 percent level in every year except 1975 and at the 1 percent level in four years out of seven.

The second row of table 3 tests whether the fraction of time used for productive labor (α) is less than unity. The third row tests whether the detection probability for shirkers is greater than zero. The nulls are rejected at conventional levels for all years except 1975 (at the 1 percent level in five of the seven years). The fraction of labor time used for supervision ($1 - \alpha$) exceeds 10 percent in four of the seven years and in 1971 reaches 20 percent. We conclude that about 10–20 percent of team labor time was absorbed by monitoring. Our estimated punishment probabilities are low (in the 1–4 percent range per year), but since a large share of each worker's income is at stake, the resulting incentives are not negligible.

This is borne out by the last three rows of table 3, which examine the incentive structure of the production teams in more detail. We compute the following effects:

$$\text{residual claim} \equiv \frac{\lambda y}{n} \tag{16a}$$

and

$$\text{monitoring} \equiv \gamma\phi(\alpha)\left[y\left(\frac{n-1}{n}\right)^{\lambda} - d\right]. \tag{16b}$$

We also list the estimated effort disutility v from table 2 for purposes of comparison. Table 3 shows that the residual claim effect is always highly significant. The monitoring effect is significant in every year except 1975 (where the value of α at the sample means is roughly 1.0 and no free-rider problem was detected in the top row). In five of seven years the monitoring effect achieves the 1 percent level of significance.

TABLE 3

EFFORT INCENTIVES (Constant Returns Imposed)

	1970	1971	1972	1973	1974	1975	1976
Free-rider	.73	3.39	1.73	1.56	.64	−.09	1.02
	(3.73)*	(3.17)*	(2.66)*	(2.09)**	(1.61)***	(−.30)	(3.52)*
α	.85	.80	.89	.86	.98	1.00	.93
	(9.76)*	(7.01)*	(11.2)*	(11.3)*	(1.84)**	(−.03)	(10.1)*
Prob	.02	.04	.03	.04	.01	−.0001	.01
	(5.85)*	(3.49)*	(4.68)*	(3.23)*	(1.45)***	(−.03)	(4.29)*
Residual claim	2.83	3.71	5.29	4.08	5.14	3.86	4.35
	(24.1)*	(18.4)*	(14.2)*	(6.1)*	(10.1)*	(22.0)*	(12.1)*
Monitoring	1.88	3.64	2.71	3.27	.56	−.004	1.01
	(5.85)*	(3.49)*	(4.71)*	(3.22)*	(2.07)**	(−.03)	(4.31)*
v	3.87	7.86	7.60	6.12	5.77	3.77	5.64
	(6.37)*	(6.20)*	(4.84)*	(4.96)*	(11.0)*	(10.5)*	(9.51)*

NOTE.—Numbers in parentheses are the standard normal variables. Free-rider is computed as in eq. (15), using sample means of the exogenous variables and the parameter estimates in table 2. The second row tests $\alpha < 1$ against the null $\alpha = 1$, using sample means to compute α from eq. (11). Prob is defined to be $\phi(\alpha)$ evaluated using the α value from the preceding row and the estimated value of ω from table 2. Under the null hypothesis of no formal monitoring, Prob = 0. Residual claim and monitoring are computed as in eqq. (16a) and (16b), using sample means and the parameter estimates from table 2. v is the effort disutility from table 2. See notes to table 2 for significance levels.

Comparative static results are reported in table 4. Except for the estimates of $\partial\alpha/\partial d$ and $\partial\alpha/\partial\gamma$ in 1975, which are insignificant, all derivatives have the signs expected from (9a)–(9f) in Section II. Four of the seven results for output price (θ) and team size (n) achieve the 10 percent significance level; five of the seven results for fixed cost (d), penalties (γ), and effort disutility (v) do so; and all seven estimates for the detection effect (ω) achieve this significance level.

Elasticities of production time α^* with respect to exogenous parameters are displayed in table 5 (only those with significant partial derivatives are reported). We focus here on parameters associated with external policy constraints. Other things equal, a 1 percent increase in output price (θ) would have led to an increase in productive labor time ranging from 0.57 percent to 3.52 percent. An increase of 1 percent in fixed cost per worker (d) due to an increase in taxes or nonlabor input prices would have reduced production time by 0.13–2.04 percent. Finally, a 1 percent increase in the fraction of team income distributed on the basis of work performance would have increased productive labor time by 0.10–1.18 percent.

We can carry this exercise one step further by calculating rough estimates of the supply elasticities corresponding to these policy variables. With a labor coefficient of $\lambda = .6$ (a low value in view of table 2), the estimates in table 5 for θ imply that team output had a price elasticity above unity in the period 1970–72. The corresponding elasticities with respect to fixed costs were lower (well below unity except in 1970). The supply elasticity with respect to penalties (γ) was about 0.2–0.8 during 1970–73 but later became negligible. These numerical values should not be taken literally, but do suggest the general size of the output losses induced by low prices for agricultural output, high rates of taxation on collective farms, the compulsory use of expensive modern inputs, and hostility to material incentives.

IV. Discussion

McMillan et al. (1989) estimate that changes in work incentives accounted for 78 percent of the productivity gain from household contracting (they impute the other 22 percent to simultaneous adjustments in pricing policies). Similar estimates are given by Lin (1992). McMillan et al. find that during collective farming, labor input per worker was only 56 percent of the level attained under the household contracting system, implying a near doubling of effective labor supply through this institutional reform. Our own estimates of the agency costs from collective farming are much smaller. We find that only about 10–20 percent of overall labor time was used for monitoring, suggesting that (all else equal) the improvement of incentives under

TABLE 4

PARTIAL DERIVATIVES OF α^* WITH RESPECT TO PARAMETERS

	1970	1971	1972	1973	1974	1975	1976
θ	.02	.004	.01	.02	.001	.0002	.003
	(1.43)***	(6.11)*	(1.60)***	(1.00)	(.81)	(.03)	(2.16)**
d	−.01	−.002	−.002	−.004	−.0001	.00	−.0004
	(−1.40)***	(−3.68)*	(−3.78)*	(−1.32)***	(−.64)	(.02)	(−5.04)*
γ	2.09	.87	.64	1.60	.64	−.0001	.23
	(1.40)***	(3.68)*	(3.77)*	(1.31)***	(.64)	(−.02)	(5.05)*
n	−.03	−.01	−.01	−.02	−.004	−.0003	−.006
	(−1.52)***	(−7.60)*	(−2.63)*	(−1.28)	(−.93)	(−.03)	(−5.48)*
v	−.53	−.11	−.10	−.22	−.05	−.005	−.09
	(−1.55)***	(−6.30)*	(−2.63)*	(−1.32)***	(−.93)	(−.03)	(−5.23)*
ω	23.0	8.86	7.27	9.80	5.67	9.08	7.46
	(2.23)**	(5.35)*	(3.77)*	(1.91)**	(2.62)*	(2.10)**	(7.28)*

NOTE.—Numbers in parentheses are the standard normal variables. All computations are based on sample means and parameter estimates from table 2. See notes to table 2 for significance levels.

TABLE 5

ELASTICITIES OF α^* WITH RESPECT TO PARAMETERS

	1970	1971	1972	1973	1974	1975	1976
θ	3.52	1.72	2.27	...	...	...	.57
d	−2.04	−.48	−.52	−1.12	...	...	−.13
γ	1.18	.51	.32	.82	...	...	.10
n	−2.98	−1.06	−.81	...	...	...	−.58
v	−2.41	−1.08	−.85	−1.57	...	...	−.55
ω	3.52	2.33	2.04	3.19	1.27	1.00	1.52

NOTE.—All computations are based on sample means and the parameter estimates from table 2.

household contracting would have increased the effective supply of labor by a similar order of magnitude.

Several factors could account for the discrepancy between our results and those of McMillan et al. First, McMillan et al. (and Lin) make use of aggregate time-series data, whereas our approach uses micro-level cross sections. More important, they treat work incentives as a residual explanation for productivity increases that cannot be explained by changes in state pricing policies. It seems likely that this overestimates the importance of incentive effects. At the same time, we could be underestimating the true increase in labor supply from household contracting. Our model in Section II assumes that monitoring is intensive enough to guarantee maximum effort and that total labor time is fixed. This enables us to estimate the proportion of time allocated to monitoring but not the potential expansion of labor supply resulting from increased effort per hour or additional hours worked.

McMillan et al. infer that Chinese collective farmers behaved as though they received about 30 percent of their marginal value product. Because the average number of able-bodied adult team members was about 60 at the time, this implies that work incentives were substantially larger than the level achievable by means of residual claims alone. The results given in table 3 (positive monitoring time, positive detection probabilities, and substantial expected punishments for shirking) support this view. A similar conclusion is reached by Putterman (1990, 1991), who also worked with the Dahe data set.

At the other pole of the monitoring debate, Lin (1990) has argued that formal supervision was technologically impossible in Chinese collective farms and that the only way to extract effort was to threaten shirkers with informal retaliation (i.e., exit from the team by honest workers). Lin goes on to assert that the stagnation of Chinese agricultural productivity during 1959–78 can be attributed to the state's elimination of such exit rights.

A critical assessment of this hypothesis appears elsewhere (Dong and Dow 1993). Without going into details, we note that our results contradict Lin's view, which implies that monitoring effects should be zero in table 3. However, we agree with Lin that incentives may have been problematic for many agricultural teams. Even if monitoring was technically feasible, relatively poor teams were probably unable to impose serious punishments on shirkers because of the constraint that most team income be distributed according to need. These incentive problems would only have been aggravated by low agricultural prices and high rates of rural taxation.

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