Managerial Strategies of the Cotton South

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Abstract

Relative efficiencies of antebellum slave farms are suggested by many empirical studies. This paper considers a theoretical aspect of those results using a repeated principal-agent problem. Within its theoretical analysis, with relevance to profitability of slave farms, it will be shown that when inter-temporal punishments are necessary and when they can perform efficiently in production. Applying those theoretical results, some empirical studies on relative profitability and relative efficiencies are discussed. In the empirical study, relative efficiencies of each farm scale—free farms, task farms, and gang farms—are estimated region by region by a stochastic profit frontier model.

Keywords: *Relative efficiency of antebellum slave farms; repeated principal-agent problem; profit maximizing contracts; stick and carrot on plantations*
JEL Classifications: *C72; C73; J41; N51*

1. Introduction

Many cliometricians study efficiency of antebellum slave farms empirically. Except for a series of study of Grabowski and Pasurka (1988 and 1989),[1] relative efficiencies of antebellum slave farms over antebellum free farms are suggested after Fogel and Engerman (1974a, Ch. 6).[2] However, it is also true that those studies on efficiency of slave farms have confronted lots of criticism; as such, it is just a numbers game or on their estimating method. The aim of this study is to provide a theoretical foundation to the efficiency of antebellum slave plantations from the viewpoint of incentives and re-evaluate their efficiency with theoretical results.

Antebellum planters considered rewarding their slaves were as important as punishments for plantation management—avoiding revolts or resistances that usually invited gigantic losses. If sufficient provisions avoided those losses and planters committed to afford those costs, plantations would be a reward-driven institution. However, it is also intuitively plausible that slave masters could use threat in order to enforce their slaves to work at lower provisions if there were not much loss from

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[1] They control data in somewhat doubtful way; cane sugar is excluded from farm products and the unit price of peas and beans should be in pound but in bushel. I correct those issues in this paper to estimate technical efficiencies. See also Field-Hendrey (1995) and Hofler and Folland (1991) for criticisms against their studies.

[2] See, for example, Field (1988) and Field-Hendrey and Craig (2004).

punishments. In such a case, plantations would be a fear-driven institution and slaves would be severely exploited (Fenoaltea 1985). Very similar arguments are also given by Chwe (1991) for coerced labor farms to be fear-driven and to be inefficient. However, the crux for planters was not to maximize hours of work of their slaves but to maximize their productivity (Fogel 1989, pp. 21-29)

On rewards and punishments, some historical observations say a managerial problem of antebellum slave masters were to reward their slaves and to obtain their exact needs than whipping them (for example, Fogel and Engerman 1975, Ch. 4; and Phillips 1918, Ch. 14). Fogel and Engerman, in their study, also suggest antebellum southern slaves were not exploited comparing to antebellum free workers—slaves were assuredly exploited but its ratio was not so high comparing to tax rate on free workers. Those situations are understandable by considering how antebellum planters were living in the South. If they were living on their plantation with their slaves, revolts would directly suffer their lives. Even if they were living in remote towns, they would be suffered from losing their welfare by turmoil on their plantation. Then we can consider the possibility that antebellum slave farms to be fear-driven should be rare.

What would be necessary for antebellum plantations to be reward-driven and what would be its result? Intuitively, if plantations were sufficiently profitable to afford to supply their slaves with sufficient provisions and losses from resistances were sufficiently large, those plantations would be reward-driven and slaves would not be severely physically exploited. If those provisions gave incentives to work hard, those plantations would also perform efficiently in production. Then profitability is the key factor for slave plantations to perform efficiently in production and for slaves to be sufficiently provided.

This paper shows those predictions are theoretically true using a repeated principal-agent problem and evaluate the result by some empirical studies. Within the analysis, it is shown that when inter-temporal punishment schemes is necessary to be introduced.

2. Theoretical Analysis

The relationship among masters and their slaves can be regarded as a relationship between principals and their agents. In this paper, I consider repeated interactions between a master and a slave. Within the context of repeated principal-agent problem without budget constraints, a strong result by Levin (2003) exists which shows long-term relationships between the principal and the agent can be represented by period-by-period contracts—say, the one-shot payment scheme. Then dynamic interactions within those contexts have less meaning to implement efficient outcomes. However, it is violated in some cases. Then incentives should be considered within inter-temporal actions as traditional studies do—say, the inter-temporal punishment scheme—such as Radner (1985). Under inter-temporal punishment scheme, some inefficient periods for enforcement of efficient actions are necessarily to turn up.

Suppose the slave produces a product and the master sells it at the market and provides the slave with provisions (payments). Both of them are risk neutral and there is no borrowing and lending. At the beginning of each period, the slave chooses an action whether "work" or "shirk." If the slave works, its disutility from working is a positive constant represented by $e > 0$. However, the master cannot observe actions of the slave directly but he can check outcomes. Then levels of provisions of each period are determined in accordance with outcomes whether "good" or "bad." If the slave works, the good outcome realizes with probability α but its probability declines to $\beta < \alpha$ if the slave does not work. The repeated game is supposed to start by the non-punishment phase and the master provides the slave with the sufficient level of provisions W so long as good outcomes continue to realize. However, if a bad outcome realizes, the master punishes the slave with a low level of provisions w. Then the master begins punishments for some periods in accordance with punishment schemes—if the punishment is not inter-temporal manner, it is the one-step payment scheme. Figure 1 shows the structure of the stage game.

I also assume the slave does not work to resist if the master deviates from payment schedules from then on. Notice, resistances are not necessarily to be infinite but, in any cases, the following analysis does not change largely—what is really necessary is that the slave provides sufficient threat to the master not to deviate from providing W in the non-punishment phase. This assumption of resistance is plausible because resistances of slaves against their masters, which were usually not violent, were common on antebellum slave plantations. Those resistances were often expressed by their shirking postures (see, for example, Bauer and Bauer 1942). If they could shirk behind their masters, the assumption of imperfect monitoring neatly represents the situation on antebellum slave farms. Fogel (1989, pp195-196) also reports antebellum planters believed poor provisions would invite revolts by their slaves then they supplied more expensive provisions (see also Rees *et al* 2003 for food allocation schedules on antebellum slave plantations). It should be noticed, however, if slaves were not able to implement resistances, which might happen when those slaves were separated from other slaves that put pressures on their masters, the following arguments were invalid in reality and they might be mentally and physically exploited so severely—for example, mistresses.

On this game, w can be considered as the payoff above the outside option or the subsistence level for the slave. In particular, the slave has incentives to run away or die if payoffs are below w and the minimum level is the subsistence level. Table 1 shows numbers of freed slaves by manumissions and run-away in 1850. Those numbers show both manumissions and run-away were very rare except for Delaware. In the analysis, based on those numbers, possibilities of manumissions and run-away are excluded. It implies masters do not give incentives to their slaves using prospects of future manumissions (see, for example, Findlay 1975) and w keeps the level above their outside option—for example, getting out of the South to cross the Canadian boarder successfully to find a job in Canada.[3]

Consider the incentive compatibility condition of the slave. For simplicity, I assume the master and the slave discount their future by the common discount factor $\delta \in (0,1)$. This assumption is plausible when they have the same expectation over the probability the on-going repeated game halts—caused by bankrupt of plantations, decease of masters, abolition of slavery, and so on. Let V_0 be the continuation payoff from the next period on after a good outcome and similarly V_1 be that of after a bad outcome. Hence, if the payment is one-step as Levin, $V_0 = V_1$ holds. After a good outcome, the incentive compatibility condition is given by

(1) $$V_0 \geq (1-\delta)[\beta W + (1-\beta)w] + \delta[\beta V_0 + (1-\beta)V_1],$$

[3] In the case of free laborers, the minimum wage is the expected wage of newly finding jobs but run-away.

where V_0 is given by

(2) $$V_0 = (1-\delta)[\alpha W + (1-\alpha)w - e] + \delta[\alpha V_0 + (1-\alpha)V_1].$$

From equations (1) and (2), he incentive compatibility condition can be simplified to

(3) $$e \leq (\alpha - \beta)\left[(W - w) + \frac{\delta}{1-\delta}(V_0 - V_1)\right].$$

Subtracting δV_0 from both sides of equation (2) and rearranging terms gives

(4) $$\frac{\delta}{1-\delta}(V_0 - V_1) = \frac{1}{1-\alpha}\left[\alpha W - V_0 - e\right] + w.$$

Then equation (3) is further simplified to

(5) $$e \leq \frac{\alpha - \beta}{1-\beta}(W - V_0),$$

which tells us incentives can be given by raising W by rewards or reducing V_0 by punishments (see also Fenoaltea 1984).[4]

Suppose the master enforces the slave to work some periods in the punishment phase (simply say "enforce to work in the punishment phase") and consider its incentive compatibility conditions. The master has to provide sufficient incentives to work only by the payment in the non-punishment phase W. Then the incentive compatible payment is increasing in the sternness of punishments.[5] Therefore, if the master minimizes the payment, such a punishment scheme corresponds to the one-step payment scheme. Then the payment is given by $W = \hat{W}$ such that

(6) $$\hat{W} = \frac{e}{\alpha - \beta} + w.$$

A question here is that whether the master has an incentive to enforce the slave to work during the punishment phase and compensate his efforts during the non-punishment phase. Consider a situation such that a bad outcome has realized and the master begins punishment. Then the slave must make efforts with lower provisions for some periods expecting future compensations. Because their discount factors are common, their present values of compensations coincide with each other. Hence, any punishment schemes are indifferent for the master in the punishment phase. However, by assumption, we consider the game starting by the non-punishment phase.[6] Then the master can maximize the continuation profit by minimizing the payment in the initial period, which is $\hat{W}$. Therefore, the one-step payment scheme is the most preferable scheme for the master to implement production efficiency (see also Levin 2003).

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[4] For example, if the extra payment (bonus) to the minimum payment is at the same level through periods, by the risk neutrality assumption, W can be decomposed into the bonus b and the minimum payment; and V_0 can be decomposed into appropriately discounted bonus term with the discount factor Δ and the minimum payment. Thus $W - V_0 = (1-\Delta)b + w$ holds. Because Δ is decreasing in sternness of punishment schemes, the master can give incentives to work in the non-punishment phase either by giving more bonus payments or stipulating severer punishments.

[5] For example, consider a two-period perfect monitoring game; the initial stage starts by the minimum payment w (punishment phase) and then a higher payment W is made in the second period (non-punishment phase) to enforce working those two periods. Then W must be sufficiently higher to compensate efforts in the initial period.

[6] Notice, even if the game starts by the punishment phase and arbitrary punishment schemes are chosen, the production efficiency is unaffected and welfare is also unchanged in the long run. In those cases, provisions in the non-punishment phase tend to be huge comparing to the one-step payment scheme.

Proposition 1 *Suppose the master and the slave are risk neutral; they discount their future by the common discount factor; the game starts by the non-punishment phase; the master enforces to work in the punishment phase; and there is no budget constraint. Then the one-step payment scheme maximizes the continuation profit of the master.*

In the next, suppose the master does not intend to have the slave work during the punishment phase. In this case, the master does not have to compensate the disutility from working in the punishment phase. Hence, the master can reduce payments in the non-punishment phase to lower levels than $\hat{W}$ using fears from inter-temporal punishments, which corresponds to reduce V_0 within equation (5) to keep margins (see also Chwe 1991). In this case, losses from punishments to the master come from inefficient productions during the punishment phase. The optimum sternness of punishment schemes can be determined in terms of gains from fewer provisions during the non-punishment phase and losses from inefficient productions during the punishment phase.

We need to consider which strategies—using the one-step payment scheme or inter-temporal punishment schemes—are more profitable for the master. Let $\hat{\pi}$ be the expected profit for the master under the one-step payment scheme and $\tilde{\Pi}_0$ be the continuation profit for the master after a good outcome under inter-temporal punishment scheme of which the master does not have the slave work in the punishment phase. Then they are respectively given by

$$(7) \qquad \hat{\pi} = \alpha(Y - \hat{W}) + (1-\alpha)(y - w)$$

and

$$(8) \qquad \tilde{\Pi}_0 = (1-\delta)\left[\alpha(Y - \tilde{W}) + (1-\alpha)(y-w)\right] + \delta\left[\alpha\tilde{\Pi}_0 + (1-\alpha)\tilde{\Pi}_1\right],$$

where Y and y are profits from a good outcome and a bad outcome respectively, and Π_1 is the continuation profit for the master after a bad outcome. Note, because punishments are not one-step, $\tilde{\Pi}_0 > \tilde{\Pi}_1$ holds. Then subtracting $\delta\Pi_0$ from equation (8) to get

$$(9) \qquad \tilde{\Pi}_0 = \alpha(Y - \tilde{W}) + (1-\alpha)(y-w) - \frac{\delta}{1-\delta}(1-\alpha)(\tilde{\Pi}_0 - \tilde{\Pi}_1).$$

From equations (7) and (9), we have

$$(10) \qquad \hat{\pi} - \tilde{\Pi}_0 = \alpha(\tilde{W} - \hat{W}) + \frac{\delta}{1-\delta}(1-\alpha)(\tilde{\Pi}_0 - \tilde{\Pi}_1).$$

Therefore, we can say the one-step payment scheme is more profitable than the inter-temporal punishment scheme and the farm performs efficiently if and only if the following condition holds.

$$(11) \qquad \alpha(1-\delta)(\hat{W} - \tilde{W}) \le \delta(1-\alpha)(\tilde{\Pi}_0 - \tilde{\Pi}_1)$$

Condition (11) tells us that the one-shot payment scheme cannot be a plausible contract scheme if the principal loses less from inefficient productions in the future or needs much payment at present to employ the one-step payment scheme. They can be summarized as follows.

Proposition 2 *Suppose there is no budget constraint. The one-shot payment scheme is more profitable to the master if and only if the expected losses from punishments in the future (future costs) is larger than the difference between normalized instantaneous* *expected payments of two schemes (present costs). Otherwise, inter-temporal punishment schemes will prevail and there appear inefficient periods.*

Let me introduce a budget constraint. In order to activate the constraint, I assume the one-shot payment scheme is infeasible by the budget constraint and the master needs to consider inter-temporal punishment schemes, which infers the farm is not sufficiently profitable. It is also noted that the master has to bear inefficient periods by punishments because there is no room for compensation payments to the slave to work in the punishment phase. The corresponding payment must satisfy the incentive compatibility condition—condition (5)—as well as the budget constraint. In those cases, the master needs to control the continuation payoff of the slave in accordance with the budget constraint and incentives to work in the non-punishment phase. Specifically, since V_0 is a decreasing function of the sternness of punishment schemes, the master can reduce V_0 ultimately down to its infimum. In the case the budget constraint does not allow paying the payment of which V_0 is at the infimum, then it is impossible to implement working. With Proposition 2, the relevance between efficiency in production and profitability can be summarized as follows.

Remark 1 *Suppose farms are sufficiently profitable and they do not face any budget constraint. Then those farms perform efficiently in production if losses of profits from inefficient periods are sufficiently large. In turn, if they are not sufficiently profitable and face a budget constraint. Then they cannot perform efficiently. For slaves, they are sufficiently provided if their plantations are efficient, otherwise, they will be driven by fear from punishments with lower provisions. Bullets and a bold line on Figure 2 show those each equilibrium.*

3. Relative Efficiency of Antebellum Farms

By Remark 1, we have seen that profitability is the pivotal factor for production efficiency. Then their efficiency can be verified from the viewpoint of their profitability. A pioneering work by Conrad and Meyer (1958) estimated some financial indices and suggested profitability of antebellum slave farms were extremely high (see also Phillips 1918). On Russian serf farms, Domar and Machina (1984) also shown that they were not necessarily to be unprofitable as Marxists insisted. A general equilibrium model by Bergstrom (1971) also shows resource allocations of slave economy, which imposes restrictions on slaves' consumption, can achieve their efficiency, then, slave farms can enjoy a great deal of profit.

The Parker-Gallman sample provides the fundamental data to this section, which contains 5,228 southern cotton farms within eleven states—Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas, and Virginia—in 1859 based on the 1860 U.S. census. Within the sample, one observation is deleted because its state is ambiguous, fifty-three were because of zero output, and eighty-six observations were because zero input in accordance with following adjustments. Then 5,088 observations are used. In order to compare region by region, those states are classified into three regions—New South, Old South, and Others (see Table 3). Their profitability is estimated by a stochastic profit frontier model, which is often used in recent studies of relative efficiency of antebellum farms (see Aigner, Lovell, and Schmidt 1977). Suppose Y represents the logarithm of the sum of dollar values of each product and X represents inputs, which consist of labor L, land T, and capital K (adjustments are mentioned later). Let the production function be $f(X)$ and then the empirical model is given by

(12) $Y = a + f(X) + \varepsilon$ such that $\varepsilon = v - u$,

where $u \geq 0$ is the inefficiency term distributed as half-normal and v is the random error distributed as normal. The production function is assumed to be a trans-log form.

The price data collected and electrically published by Haines *et al* (2005) is applied to converting outputs into appropriate dollar values (see Table 3). The prices of rice cotton are reported in per pound price while the Parker-Gallman sample reports rice productions in bushels and cotton productions in bales. Here, 100 pounds per bushel and 400 pounds per bale calculate respective dollar values of rice and cotton. Prices of three sorts of molasses—maple, cane, and sorghum—are reported but there in no classification in the Parker-Gallman sample. In this study, I assume all farms produce the same ratio of each sort of molasses—maple molasses 0.095, cane molasses 0.355, and sorghum molasses 0.540—which is calculated from average share of productions in states within the sample in 1859 reported on Haines *et al*. Then the weighted average unit price of molasses is 0.625 dollars per gallon.

Labor is adjusted to the equivalent level to prime-hand slaves by the procedure of Fogel and Engerman (1975b and 1977) as follows. All slaves and free laborers of ages 0-9 and 60-over are excluded from the calculation. Weights on male slaves are 0.40 for ages 10-14, 0.88 for ages 15-19, 1.0 for ages 20-54, and 0.75 for ages 55-59. Weights on free male laborers ages 15-59 are the same as weights on male slaves. Weights on female slaves are 0.75 times the corresponding weights on male slaves. Free females ages 10-59 and free males ages 10-14 (boys) on farms with 0-5 slaves are 0.5 times the corresponding weights on male slaves. For free females ages 10-59 and free boys ages 10-14 on farms with 6-50 slaves are 0.5 times a specific discount factor γ given by the next formula.

(13) $$\gamma = 1 + \frac{5 - (\text{number of slaves})}{45}$$

Then γ is one at farms with five slaves and linearly declines to zero at farms with fifty slaves. Hence, females and free boys on farms with over fifty slaves are not counted.

For land inputs, acres of improved land are applied. In order to evaluate farm capital, Primack's ratio of which estimated "value of land" to "value of farm building" is applied (Primack 1965, p. 116). Table 4 gives those ratios for southern states—Southeast for Florida, Georgia, and North Carolina; South Central for Arkansas, Alabama, Louisiana, Mississippi, and Tennessee; and Southwest for Texas. In addition to farm buildings, farm machinery and livestock, both of which are reported in dollar value in the sample, are also added to values of farm capital. Annual input values employ adjustment rates—rate of return on capital and annual rate of depreciation—given by Fogel and Engerman's study. The rate of return on capital is 10 percent; the annual depreciation rate for building is 2 percent; and the annual rate of depreciation of machinery is 10 percent. Sums of those values constitute capital inputs of each farm.

After those adjustments, log-likelihood estimators of the production function and standard deviations of u and v, which are given by σ_u and σ_v, are given by Table 5, where $\sigma^2 = \sigma_u{}^2 + \sigma_v{}^2$ and $\lambda = \sigma_u / \sigma_v$. Those estimators calculate technical efficiencies on Table 6. Farms are classified into four classes; "huge slave farms" which possess over 51 slaves ages 10-59, "large slave farms" which possess 16-50 slaves, "small slave farms" which possess 1-15 slaves, and "free farms." Figure 3 gives its distribution with relevance to profits. On average, Table 6 shows small slave farms and large slave farms are more efficient than free farms in the same region at 95 percent confidence level except for in the Old South. In the Old South, superiority of slave farms is doubtful from the standpoint of profit efficiency of agricultural products. However, at least out of the Old South, we can say small and large slave farms performed relatively more efficiently on average to make profits in the antebellum South (see also Conrad and Meyer 1958).[7]

We can also find a sort of structural change around the point the logarithm of output value is ten, say the critical point, on Figure 3. Across the critical point, profits are almost irrelevant to efficiency on the left while they are positively correlated each other on the right. Then, according to Remark 1, those observations can be considered farms whose profits are less than the critical point cannot afford sufficient payments to implement efficient actions—although words "master" and "slave" are used in the model, the mechanism to enforce working is not altered. Suppose the critical value is 9.5, then 35.7 percent of free farms—918 out of 2,574—are below the critical value and they would not be able to implement efficient actions of their laborers while huge slave farms o f 4.5 percent—3 out of 67, large slave farms of 3.6 percent—15 out of 412, and small slave farms of 19.1percent—388 out of 2,035. In this vein, profitability and efficiency cannot be argued separately and then there is no clear answer for arguments of which slave farms were not relatively efficient but simply their scales were relatively large (David and Temin 1974 and 1976; and Fogel and Engerman 1980).[8]

In order to verify the relation between profitability and efficiency, per-capita outputs are examined. Per-capita means here output value per adjusted labor equivalent to prime-hands because rewards are determined in accordance with their productivity (see Rees *et al* 2003 for food allocations). Figure 4 shows their relations. We can find a pattern such that efficiency is extremely low in lower per-capita output below 7.2—per-capita output value of about 1,339 dollars—then it jumps up as per-capita output goes up. Total values of outputs and per-capita values of outputs correlate by 0.9640 and then 1,319 farms of which 914 free farms, 386 small slave farms, 16 large slave farms, and 3 huge slave farms still fall short of the critical value of 7.2 (see Table 7 for more detail). Technical efficiencies of farms above the critical value is provided by Table 8 and then comparisons within each region we find there is no significant difference among farms with respect to their scales and it also does not matter whether they are free or not (see also Grabowski and Pasurka 1988 and 1989).

We need to take particular note on the fact that the jump is not the cause of scale production because some staple crops such as bushels of corn and bales of cotton do not show any correlation with technical efficiency as plotted by Figure 5 and Figure 6. Applying the result in the previous section, its inefficiency can be regarded as the result

[7] On the argument of profit efficiency in the Old South, effects of slave exporting business shall be considered together (see, for example, Miller1965; and Lowe and Campbell 1976).

[8] In order to explain relative efficiency of slave farms, many others often insist the gang system—managerial method that effectively utilizes division of labor on large plantation. An interesting empirical study is provided by Toman (2005), which estimates how much productivity will be improved by exploiting comparative advantages of various types of slaves.

of insufficient provisions. In this sense, because larger farms could make potentially more profit than small farms, slave farms, which were usually relatively larger than free farms, would have sufficient rooms for providing sufficient provisions to give incentives to work and then they were likely to perform efficiently in production than free farms on average.

4. Concluding Remarks

The arguments on relative efficiency of slave and non-slave farms were also a main topic in this field. This paper tried to provide a theoretical explanation of the statement by Fogel and Engerman—slave farms performed more efficiently than free farms. In their original studies, results were followed by aggregated census data while followed studied applied newly introduced econometric methods with micro data, as such stochastic frontier models. Then the concept of "efficiency" became ambiguous; efficiency in production or efficiency in making profits as such pointed out by David and Temin.

An important contribution of this study shall be the result of which those two efficiency concepts are related; if per-capita profits are sufficiently high to cover sufficient provisions to give incentives and then those farms would perform efficiently in production. Then we can say slave farms were relatively more efficient than free farms because slave farms often maintained larger land and laborers to make more profit than free farms. With such a notion, their relative efficiency should be strongly related to the topic why larger farms preferably demanded slave labor. Its answer could not be provided in this study and still open question in general but a possible one would resort to the gang system; free laborers cannot endure hard tasks under the gang system—or, they could obtain better jobs than as a farmhand on large plantations. Unless highly organized divisions of labor seen in the gang system were feasible, large plantations could not be managed effectively as contemporary large companies divide their workers into divisions.

In the empirical section, the evidence showed the existence of the critical point of which farms perform efficiently in production or less efficiently. Those observations implied some farms could not afford supplying provisions to keep incentives to work every period—one-step payment scheme—and then those planters would manage their farms with inter-temporal punishment schemes that allows those planters to reduce payments for their laborers to give sufficient threat to work.

Along with arguments on the one-step or inter-temporal schemes, we could also recognize if threats or resistances and revolts were large and losses from those incidents were expected to be large, planters would manage their laborers using rewards. However, if those rewards were too high, threats were used to drive their labor. Therefore, treatments of slaves would not depend on benevolence of slave owners but profitability of their plantations as well as their balance of power.

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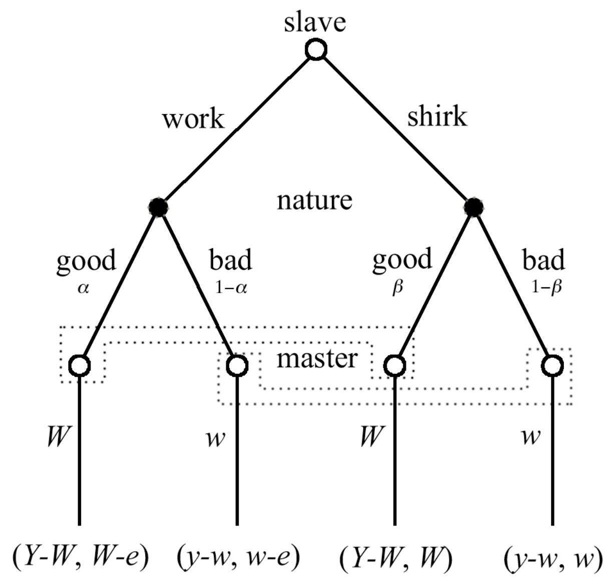

Figure 1: Game Tree

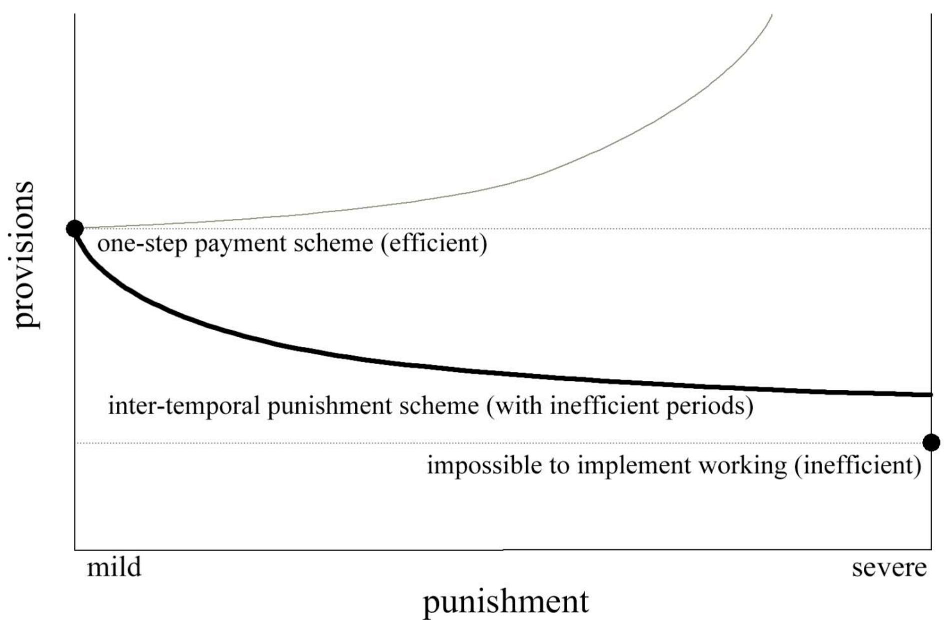

Figure 2: Equilibrium Payment Schedules and Punishments

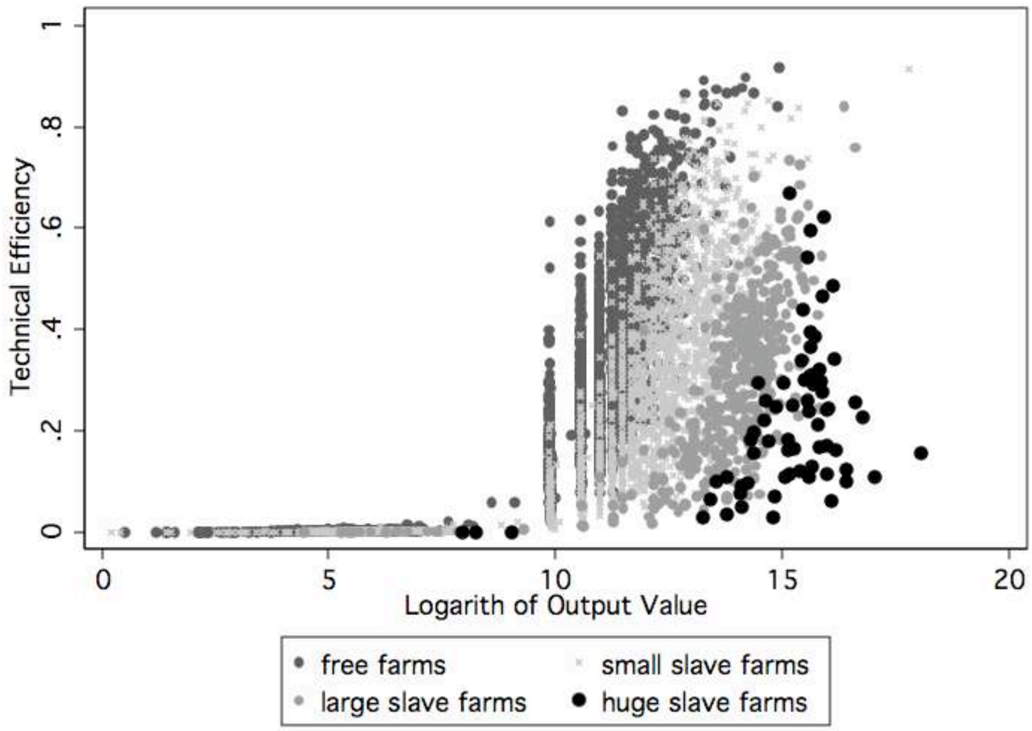

Figure 3: Distribution of Technical Efficiency vis-à-vis Output Value

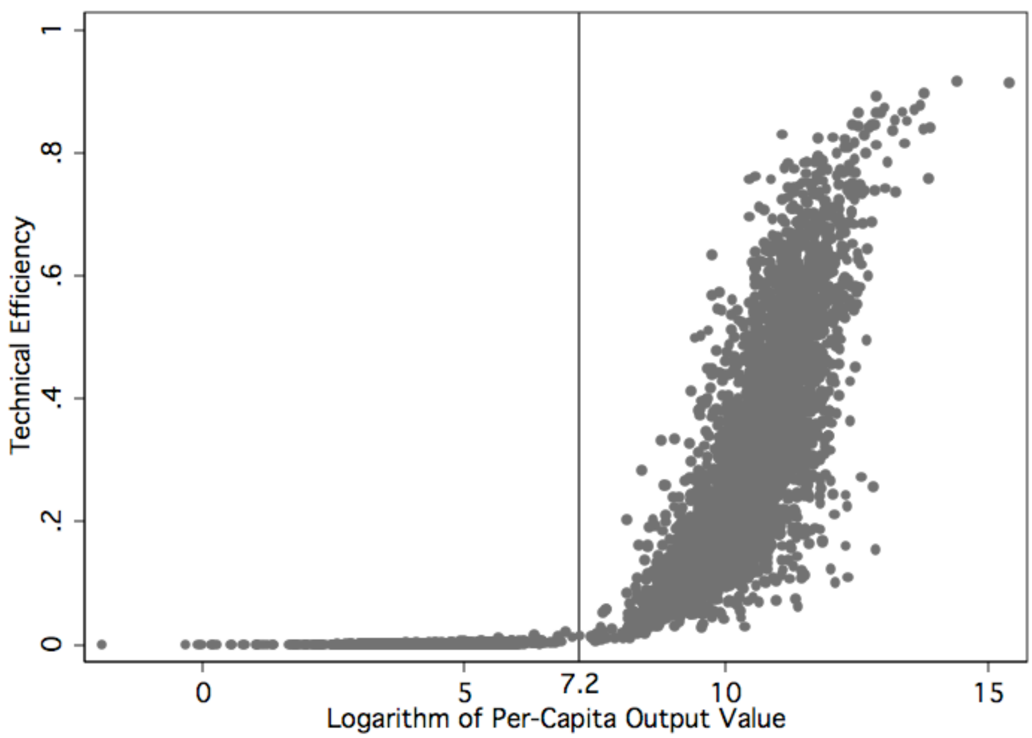

Figure 4: Per-Capita Output and Technical Efficiency

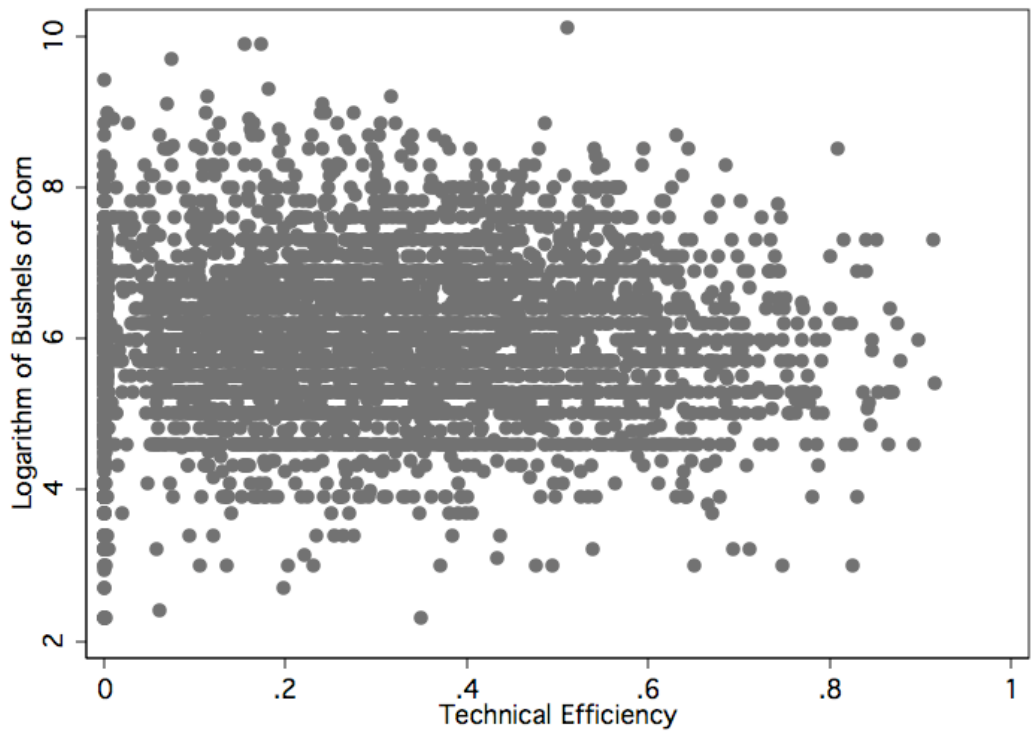

Figure 5: Efficiency and Corn Production

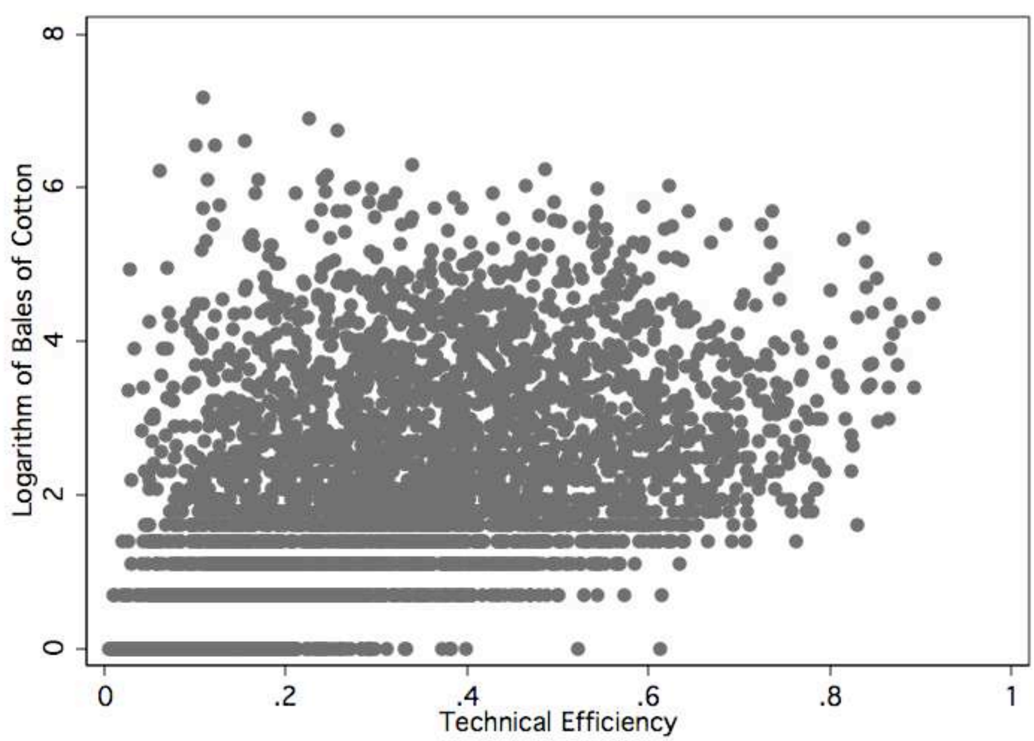

Figure 6: Efficiency and Cotton Production

Table 1: Manumitted and Fugitives in 1850

State	Manumitted	Fugitive	Slave Population
Alabama	16	29	342,844
Arkansas	1	21	47,100
Delaware	277	26	2,290
Florida	22	18	39,310
Georgia	19	89	381,682
Kentucky	152	96	210,981
Louisiana	159	90	244,809
Maryland	493	279	90,308
Mississippi	6	41	309,878
Missouri	50	60	87,422
North Carolina	2	64	288,548
South Carolina	2	16	384,984
Tennessee	45	70	239,459
Texas	5	29	58,161
Virginia	218	83	472,528

Source: 1850 U.S. Census

Table 2: Classification of Regions for Dummies

New South	Arkansas, Alabama, Louisiana, Mississippi, and Texas
Old South	North Carolina, South Carolina, and Virginia
Others	Florida, Georgia, and Tennessee

Table 3: Dollar Unit Prices of Agricultural Products

Product	Unit Price	Unit	Product	Unit Price	Unit
Wheat	1.02	*bu.*	Rye	0.77	*bu.*
Corn	0.46	*bu.*	Oats	0.34	*bu.*
Rice	*0.0232*	*lb.*	Tobacco	0.09	*lb.*
Cotton	*48*	*lb.*	Wool	0.18	*lb.*
Peas & Beans	*0.73*	*bu.*	Irish Potato	0.37	*bu.*
Sweet Potato	0.48	*bu.*	Barley	0.58	*bu.*
Buckwheat	0.52	*bu.*	Wine	0.28	*gal.*
Butter	0.083	*lb.*	Cheese	0.04	*lb.*
Hay	8.76	*ton*	Clover Seeds	5.01	*bu.*
Grass Seeds	2.78	*bu.*	Hops	0.09	*lb.*
Dew Rotted Hemp	67	*ton*	Water Rotten Hemp	67	*ton*
Other Hemp	67	*ton*	Flax	0.06	*lb.*
Flax Seeds	1.15	*bu.*	Silk Cocoons	11.94	*lb.*
Maple Sugar	0.09	*lb.*	Cane Sugar	81.25	*lb.*
Maple Molasses	0.87	*gal.*	Cane Molasses	0.273	*gal.*
Sorghum Molasses	0.82	*gal.*	Beeswax	0.29	*lb.*
Honey	0.15	*lb.*			

Source: Haines *et al* (2005) and Craig (1993)

Table4: Primack's Ratio for Southern States in 1860

Southeast	South Central	Southwest	South Carolina	Virginia
4.5	5.0	6.9	4.5	4.0

Source: Primack (1965; Table 1 and Table 2)

Table 5: Estimated Production Function

	Coef.	(Std. Err.)	*p*-value
$\ln T$	0.3403	(0.1815)	0.061
$\ln K$	0.3698	(0.1764)	0.036
$\ln L$	-0.0127	(0.2391)	0.958
$\ln T \times \ln T$	-0.0245	(0.0181)	0.177
$\ln T \times \ln K$	0.0907	(0.0442)	0.040
$\ln T \times \ln L$	-0.1780	(0.0607)	0.003
$\ln K \times \ln K$	-0.0800	(0.0316)	0.011
$\ln K \times \ln L$	0.3099	(0.0617)	0.000
$\ln L \times \ln L$	-0.0643	(0.0487)	0.187
Constant	9.5753	(0.3946)	0.000
σ_v	0.5103	(0.0172)	—
σ_u	3.9245	(0.0438)	—
σ^2	15.6617	(0.3418)	—
λ	7.6912	(0.0493)	—

Source: Parker-Gallman sample

Table 6: Estimated Technical Efficiencies

Region	Mean	(Std. Err.)	[95% Conf. Interval]	*Obs.*
Huge slave farms of over 51 slaves ages 10-59				
All	0.2194	(0.0186)	[0.1823, 0.2564]	*67*
New South	0.2152	(0.0238)	[0.1669, 0.2635]	*39*
Old South	0.1642	(0.0362)	[0.0866, 0.2419]	*15*
Other	0.2955	(0.0426)	[0.2026, 0.3884]	*13*
Large slave farms of 16-50 slaves ages 10-59				
All	0.2983	(0.0080)	[0.2824, 0.3141]	*412*
New South	0.3584	(0.0100)	[0.3386, 0.3781]	*230*
Old South	0.1711	(0.0149)	[0.1414, 0.2009]	*74*
Other	0.2574	(0.0140)	[0.2296, 0.2852]	*108*
Small slave farms of 1-15 slaves ages 10-59				
All	0.2630	(0.0046)	[0.2539, 0.2720]	*2,035*
New South	0.3262	(0.0068)	[0.3128, 0.3396]	*990*
Old South	0.1505	(0.0070)	[0.1368, 0.1642]	*455*
Other	0.2435	(0.0079)	[0.2279, 0.2591]	*590*
Free farms				
All	0.2173	(0.0044)	[0.2087, 0.2258]	*2,574*
New South	0.2490	(0.0058)	[0.2377, 0.2603]	*1,566*
Old South	0.1232	(0.0085)	[0.1065, 0.1399]	*393*
Other	0.1965	(0.0085)	[0.1798, 0.2133]	*615*

Source: Parker-Gallman sample

Table 7: Farms below the Critical Per-Capita Output Value

	All	New South	Old South	Other
All	1319	642	330	347
Free Farms	914	484	206	224
Small Slave Farms	386	151	117	118
Large Slave Farms	16	6	6	4
Huge Slave Farms	3	1	1	1

Source: Parker-Gallman sample