Optimal Share Contracts under Theft

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Abstract

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Key words: Sharecropping, cheating, agrarian contract
JEL classification code: D82, Q15, O17

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I. Introduction

There is considerable anecdotal evidence that potential theft of product in contracting affects the choice of contract and, if a share contract is chosen, the design of the contract. Yet, analysis of share contracts has principally focused on hidden actions in the provision of inputs, explaining under-provision relative to a cooperative equilibrium. This has been the hallmark of one-sided moral hazard models when effort is exclusively provided by the tenant (Newbery and Stiglitz, 1979; Basu, 1992; Hayami and Otsuka, 1993; Laffont and Matoussi, 1995), and of double-sided moral hazard models when each partner exclusively provides one non-tradable input such as supervision by the tenant and management by the landlord (Eswaran and Kotwal, 1985). However, there is another dimension of behavior arising from hidden information that has been overlooked in analyzing contract choice and contract design. Temptation to under-report output before it is shared must indeed be enormous as gains from doing so could be large for the tenant. If there is risk of theft, contracts will be designed to not only create incentives to elicit effort in production but also to restrain under-reporting in rent payment. If monitoring is exercised on the tenant's behavior, it may also be both to induce effort and to reduce theft. In this paper, we consequently explore how the choice of contract, and the design of a particular contract, will be affected by hidden actions in the provision of effort and by hidden information in the appropriation of products.

In Part II of the paper, we start by providing some factual evidence on the building blocks that we use in developing a model of sharecropping with theft. We proceed in Part III to model linear contract choice in a situation where the tenant chooses both the level of effort and the level of reporting. We extend in Part IV to non-linear contracts and show that they will not prevent theft. Finally, in Part IV, we extend the discussion on the role of theft to a number of other behavioral considerations that affect contracting.

II. Building blocks for a model of sharecropping with theft

There are five observations that we use as guidelines in modeling optimal contracting under theft. In each case we refer to some empirical evidence that supports the observations made.

Observation 1: Theft of product in share contracts is frequent and takes the form of under-reporting by the tenant before sharing occurs.

Salih (1993) reports how farmers in the Sudan from the 1950s through the 1980s had to deliver to the government a set share of their reported wheat production at a price below the free market price. This created an incentive to under-report production. The risk of being caught under-reporting was increasing with the percentage of output unreported and with the level of effort made by government agents to detect cheating, limiting the extend of cheating. Aggregate under-reporting was estimated to have reached up to 12% of harvest according to years.

Observation 2: Landlords attempt to protect themselves from theft by either expending costs in monitoring production and harvest, or by adjusting the terms of the contract, raising the tenant's share to reduce incentives to cheat.

Evidence on landlords monitoring harvest to prevent theft is plentiful. Some landlords in Bangladesh sleep in the field when harvest is approaching to prevent removing part of the crop, and will closely witness the harvest. In other situations, monitoring has to be more subtle. Hayami (personal communication) reports that, in the village in the Philippines that he monitored for the last 30 years (Hayami and Kikutchi, 1982), many landlords display "proper" behavior in showing trust in their tenants by not coming to the farm when the harvest is gathered and shared. Excessive supervision would be considered harassment, reducing the tenant's incentives to work hard through the following season. The landlord, however, knows that some cheating will result. He protects himself from excessive cheating through two mechanisms. One is coming to visit the farm under some convenient pretext before the harvest to have some visual assessment of the expected yield. The other is by inducing gossiping by villagers about the level of cheating that they would readily report if it were to exceed reasonable norms.

Evidence on adjusting the share to deter cheating is harder to come by. Casual evidence exists that tenants may bargain an honest lower share to be paid to the landlord against a dishonest higher share. Respecting norms of fairness is important in deterring retaliation through theft.

Observation 3: Landlords cannot fully observe the levels of output produced by their tenants, but they are informed that cheating occurs. Because deterring cheating through monitoring or contract adjustment is costly, the optimal contract and the optimal level of supervision involve residual cheating.

In Hayami's village context, optimal monitoring includes residual cheating, and the landlord knows this. Shares are also set in terms of fairness to prevent cheating, but adjustment is only partial, and landlords expect residual cheating to occur.

Observation 4: Tenants need to engage into costly actions to hide their theft or to dispose of stolen goods, and these costs rise with the amount diverted. In some cases, appropriation of part of the product as theft can create a gain in value of the product stolen if there is process utility in the act of stealing. Here also, there are decreasing marginal returns to theft.

Loss of value for the predator typically occurs when large amounts of money or product are being laundered. In the case of cheating on a share of the product, the product that is stolen from the landlord is not distinguishable from the product that is legally acquired as share payment. There should, therefore, not be any particular loss of value in laundering the stolen good relative to the value of the legal share. However, the tenant may have to incur costs to hide his theft from the landlord or to deter suspicion by local merchants.[1]

Theft by employees can also be motivated by the psychological desire to correct for perceptions of inequity and injustice. The process of stealing can then convey utility for the one who does it. If this is the case, the utility value of the stolen good may be higher for the worker than its monetary value. Some theft would then be in the best interest of the employer compared to higher remuneration, explaining his leniency toward some stealing.

Observation 5: Landlords typically must give limited liability insurance to their tenants, and this occurs in a context where there is little moral hazard in claiming insurance

[1] According to Platteau (personal communication), cheating on sharing of the catch with boat owners is common among artesanal fishermen in Senegal as the activity is difficult to monitor. Share partners must incur costs to hide the true catch from the owner, for instance by transshipping part of it on to other boats in high seas. See his work on fishing and social norms in Platteau (2000).

If there is no market failure else than in effort, a fixed rent contract would be chosen, avoiding the problem of theft of product. If, however, there are additional market failures, a share contract may be chosen. A classical case in the developing country context is the obligation for landlords to provide limited liability coverage to their tenants: the contract must leave to the tenant no less than a minimum subsistence level, whatever the realization of output or prices (Basu, 1992). In this case, a sharecropping contract would be offered. The share contract is written as a linear function of reported output as this is what is observed in agriculture.[2]

These five observations enable us to develop a model where the terms of the contract are set in order to simultaneously optimally induce effort, reduce the cost of insurance, and reduce the cost of cheating on declared output.

III. Optimal rental contract under moral hazard on effort and cheating on output sharing

How will a landlord exposed to cheating on output sharing set up an optimal contract? To answer this question, we develop a model in which the tenant chooses both the level of effort and the quantity of output he reports to the landlord. Production is increasing and concave in effort. Return to cheating is increasing and concave in the amount stolen. The landlord does not engage in direct supervision (at this stage of the model), and controls effort and theft through the terms of a linear contract. The contract terms influence both decisions, the share parameter representing the effective price received for the output declared to the landlord and the opportunity cost of stealing. A higher output share for the tenant induces more effort and also less stealing of the product.

The tenant produces an output q with effort e. Output is a stochastic variable, with probability density $f(q|e)$ conditional on effort e and defined over the interval $[0,\overline{q}]$. We assume that higher effort decreases the probability of having a return lower than any given value, and this with decreasing return to scale. The production function is thus represented by:

$$f(q|e), \text{ with } F_e(q|e) < 0 \text{ and } F_{ee}(q \mid e) > 0, \ \forall q \in [0,\overline{q}],$$

where F is the cumulative distribution function of q.

[2] We will show that the best general contract that would fully eliminate theft is indeed a linear contract but that, in general, it is not optimal. Hence, the equilibrium will usually be observed with residual cheating.

The tenant has the possibility of cheating the landlord on effective output, reporting a production of only $\tilde{q}$ and stealing the remaining $(q-\tilde{q})$ either to own consumption or to sale. Similar to the treatment of corruption (e.g., money laundering), we assume that the value to the tenant of stolen output is a function $k(.)$ such that:

$$k(q-\tilde{q}), \text{ with } 0 \leq k' < 1 \text{ and } k'' < 0.$$

Both landlord and tenant are risk neutral. There is a limited liability clause in the contract so that the landlord must leave to the tenant no less than a minimum amount L for any realization of output:

$$\alpha\tilde{q} + \beta + k(q-\tilde{q}) \geq L, \quad \forall q,$$

where α and β are the terms of the contract.

1. Tenant's optimal choice of effort and reporting

The tenant chooses a level of effort prior to knowing the random shock that will affect output, but reports to the landlord a level of output $\tilde{q}$ only after realized output q is known. The tenant's problem is thus solved by backward induction, first establishing the optimal cheating strategy and then the optimal effort. The optimal cheating is determined by:

$$\max_{\tilde{q}} \ \alpha\tilde{q} + \beta + k(q-\tilde{q}), \text{ at given } q.$$

The tenant allocates its output between reporting $\tilde{q}$ and stealing $s = q - \tilde{q}$ to equalize marginal returns given by the share α that the contract leaves him, provided both lie in the feasible range [0, q]. The corresponding first order condition is $k'(s) = \alpha$, and the optimal levels of stealing s and reporting $\tilde{q}$, are:

$$(\text{IC})^{c} \qquad \begin{cases} s = s^*(\alpha) \equiv k'^{-1}(\alpha), \ \ \tilde{q} = q - s^*(\alpha) \ \text{ for } \ k'(q) < \alpha < k'(0), \text{ some theft} \\ s = 0, \ \ \tilde{q} = q \ \text{ for } \ \alpha \geq k'(0), \text{ no theft} \\ s = q, \ \ \tilde{q} = 0 \ \text{ for } \ \alpha \leq k'(q), \text{ full theft.} \end{cases} \qquad (1)$$

The stealing function s^* is akin to an input demand derived from the production function $k(.)$, with α being the opportunity cost of the input $q - \tilde{q}$. It is decreasing and convex in α. The realized stealing s and reporting $\tilde{q}$ are function of both the contract share α and the realized output q, namely $s = s(\alpha, q)$ and $\tilde{q} = \tilde{q}(\alpha, q)$.

For a given realization of output, the optimal stealing and reporting are represented in Figure 1 as a function of the contract share. At low share, the tenant's optimum is to steal all output. The higher the share he gets from reported output, the less incentive he has to steal, and for a share above the return to the first unit of stolen good, the tenant will not cheat at all on output.

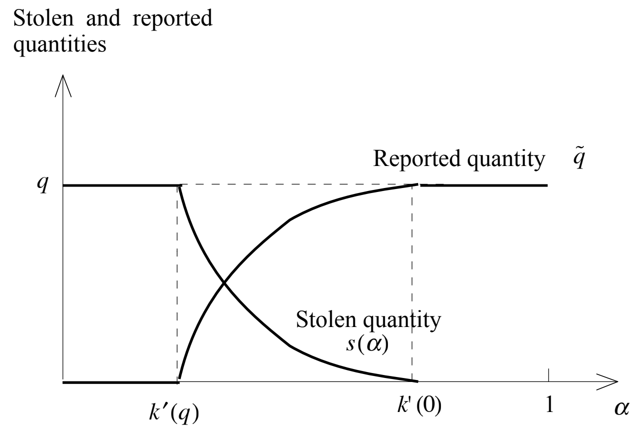

Figure 1. Optimal stealing as a function of contract term for given *q*

For a given contract share α the tenant's cheating behavior, illustrated in Figure 2, is to steal all output and declare complete loss when output realization q is small $\left(q \leq k'^{-1}(\alpha)\right)$, then to steal the optimal amount such that the marginal return to stealing is equal to the share he would received from the landlord.

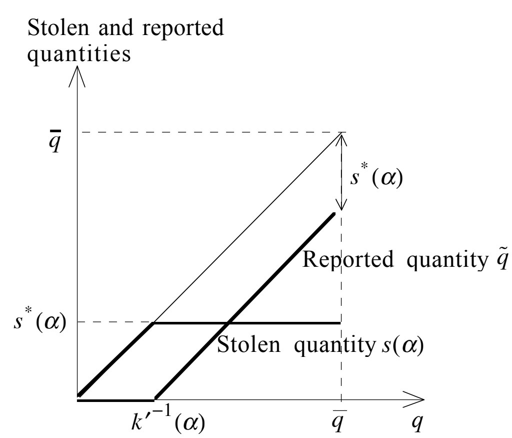

Figure 2. Optimal stealing as a function of output realization for given *a*

Prior to knowing the realization of output, expected values of stealing, return to stealing, and reporting are thus:

$$Es = E\left(q \middle| q \le k'^{-1}(\alpha)\right) + s^*(\alpha)\left(1 - F\left(k'^{-1}(\alpha)\right)\right),$$

$$Ek(s) = E\left(k(q) \middle| q \le k'^{-1}(\alpha)\right) + k\left(s^*(\alpha)\right)\left(1 - F\left(k'^{-1}(\alpha)\right)\right),$$

and

$$E\tilde{q} = E\left(q \middle| q \ge k'^{-1}(\alpha)\right) - s^*(\alpha)\left(1 - F\left(k'^{-1}(\alpha)\right)\right).$$

The tenant's optimal effort is dictated by maximization of expected income, anticipating output theft:

$$\max_{e} \quad E\left[\alpha(q - s) + \beta + k(s) - we\right],$$

where w is the opportunity cost of effort and $s = s(\alpha, q)$ is determined in (1) above.

The corresponding first order condition is:

(IC)^{e}
$$\alpha \frac{d}{de} Eq - w + \frac{d}{de} E\left(k(q) - \alpha q \middle| q \le k'^{-1}(\alpha)\right) = 0. \tag{2}$$

The third term is positive. Hence, for any given α, the optimal effort and output are higher than in a sharecropping contract without stealing. Theft thus gives the tenant a greater incentive to effort since he receives a larger share of the product of his efforts.

Figure 3 represents the tenant's decisions. Equation (2) solves for the optimal effort e and the expected supply function $Eq(\alpha)$, which is increasing and concave in α. Realized output is then q. Equation (1) gives the optimal level of output theft $s^*(\alpha)$, which is decreasing and convex in α. For very low α, theft will reach the maximum value q, while for values of α beyond the marginal return to cheating $k'(0)$, there will be no theft.

Hence there can be no contract with share parameters too low. Beyond this, and for $\alpha \le k'(0)$, the sharecropping contract entails an optimal level of cheating. And for $\alpha \ge k'(0)$, there will be no cheating.

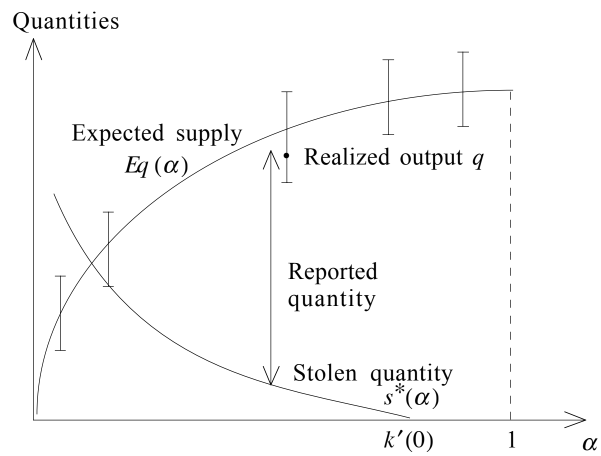

Figure 3. Tenant's choice of supply and theft from the landlord

2. Landlord's choice of contract terms

The landlord's program is to choose the contract's terms (α, β) to maximize his expected income:

$$\max_{\alpha,\beta}\ W = (1-\alpha)\int_0^{\bar{q}} \tilde{q} f(q|e)dq - \beta,$$

subject to the limited liability constraint (LL), and the effort response function (IC)^e and reported output (IC)^c being decided by the tenant:

(LL) $\quad \alpha(q-s)+\beta+k(s)\geq L$

(IC)^e $\quad \alpha E_e q + E_e\left(k(q)-\alpha q \middle| q \leq k'^{-1}(\alpha)\right) = w$

(IC)^c $\quad \begin{cases} s = s^*(\alpha) \equiv k'^{-1}(\alpha),\ \tilde{q} = q - s^*(\alpha) \text{ for } k'(q) < \alpha < k'(0), \text{ some theft} \\ s = 0,\ \tilde{q} = q \text{ for } \alpha \geq k'(0), \text{ no theft} \\ s = q,\ \tilde{q} = 0 \text{ for } \alpha \leq k'(q), \text{ full theft.} \end{cases}$

The optimal β is set to satisfy (LL) at the lowest realization of output, hence $\beta = L$. Substituting this constraint in the landlord's welfare gives:

$$W = (1-\alpha)E\left(q-s\middle|q\geq s\right)-L. \tag{3}$$

Let us first look at the optimal value if there were no cheating. The interior solution would be the solution of:

$$\frac{dW}{d\alpha} = -Eq + (1-\alpha)E_e\frac{de}{d\alpha} = -Eq + \frac{(1-\alpha)}{\alpha}\frac{E_e^2}{-E_{ee}}, \tag{4}$$

where E_e and E_{ee} are the first and second derivative of Eq with respect to effort e. The optimal share is implicitly given by :

$$\alpha^{nc} = \frac{E_e^2}{E_e^2 - E_{ee}Eq}.$$

This expression shows that whenever there is some risk in production $(Eq > q_{\min} = 0)$, the optimal contract will be a sharecropping contract with $\alpha^{nc} < 1$. The solution is illustrated on Figure 4:

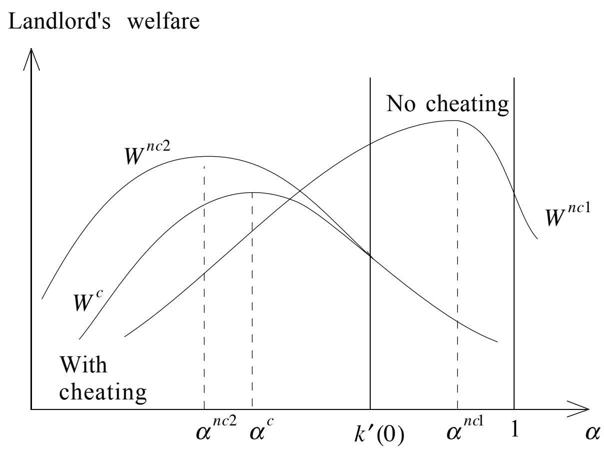

Figure 4. The optimal contract

If $\alpha^{nc} \geq k'(0)$ (as represented for the curve W^{nc1} on Figure 4), this is the optimal contract. Cheating cannot improve on the welfare that can be obtained under no cheating. If however $\alpha^{nc} < k'(0)$ (the case W^{nc2} on Figure 4), then the tenant will have some incentive to cheat at this optimal level. The best contract that can be offered to suppress cheating is to increase the share to $\alpha = k'(0)$. This solution, however, needs to be compared to the optimal contract under cheating.

Under cheating, the FOC of the landlord is:

$$\frac{dW}{d\alpha} = -E\tilde{q} + (1-\alpha)\frac{d}{d\alpha}E\tilde{q} = 0. \tag{5}$$

How do the two welfare functions of the landlord under no-cheating and under cheating compare?

$$W^{nc} = (1-\alpha)Eq^{nc} - L,$$

$$W^{c} = (1-\alpha)E\left(q^c - s\right) - L,$$

where q^{nc} and q^{c} are the optimal supplies under no-cheating and cheating, respectively. Although cheating induces some increase in the optimal effort, we assume that for any given α, the expected reported quantity $E(q^{c}-s)$ under cheating is lower than $E(q^{nc})$ under no-cheating. In that case, for any level of α, the welfare of the landlord is lower under cheating than with no cheating, and the landlord's welfare curve under cheating (W^{c}) is everywhere below the landlord's welfare curve under no-cheating (the W^{nc2} curve). For $\alpha \geq k'(0)$, it is optimal, even in the model with cheating, not to cheat. Hence the two curves are identical above this threshold $\alpha = k'(0)$. Consider now the derivative of expected reported output under the two regimes:

$$\frac{d}{d\alpha}E(q^{nc}) \text{ and } \frac{d}{d\alpha}E(q^{c}-s).$$

Both output q^{nc} and q^{c} increase with α, although q^{c} less than q^{nc} as the additional incentive given by cheating decreases. Theft s decreases with α. We make the reasonable assumption that the change in incentive given by stealing does not compensates for the decline in stealing itself, and hence that:

$$\frac{d}{d\alpha}E(q^{nc}) < \frac{d}{d\alpha}E(q^{c}-s)$$

Under these two assumptions, the derivative of the landlord's welfare with respect to the share α is higher under cheating (5) than under no-cheating (4) for all values of α. Hence, the effect of cheating is to move the welfare curve W^{nc2} to W^{c}, and to increase the contract share from α^{nc2} to α^{c}.

The intuition behind this result is the following. Suppose that in absence of cheating the optimal contract would be a share α^{nc2}. Introduce now the possibility of cheating by the tenant. The cheating takes place because the marginal value of stolen good is higher than the share. The landlord should then reconsider the terms of the contract. Reducing the share allocated to the tenant would both reduce supply and increase cheating. Therefore, any adjustment necessarily entails an increase in the tenant's share.

IV. Beyond linear contracts?

Could a more general non-linear contract $t(\tilde{q})$ prevent cheating? To address this issue, we simplify the analysis to the case where there is no moral hazard on effort. Output takes a stochastic value not under the tenant's control, and the tenant only chooses reporting. Consider a contract $t(.)$ that induces truthful reporting of the realized output q by the tenant. The contract can thus be written as a function of realized q. For the tenant not to cheat it must be the case that at any value of realized output, the marginal payment by the landlord is higher than the return to stealing any small amount of output:

$$t'(q) \geq k'(0).$$

The contract is thus:

$$t(q) = \int_0^q t'(x)dx + t_0 \geq \int_0^q k'(0)dx + t_0 = k'(0)q + t_0.$$

Adding the limited liability constraint, the lowest value for t_0 is L.

Hence, the optimal contract that would induce truthful reporting is the linear contract:

$$t(q) = k'(0)q + L$$

Yet, as we have seen above, the linear contract with truthful reporting is not always better than a contract with some cheating. The intuition for this result is that preventing cheating forces the landlord to give at least $k'(0)$ at the margin, for all values of output q, while limited liability prevents him from extracting the surplus with a lump sum tax.

Considering linear contracts, we have established that, if the optimal contract turns out to be one in which the contract share is sufficiently high for the tenant ($\alpha^{nc} \geq k'(0)$), he will have no incentive to cheat. If, by contrast, this optimal contract would provide a low share to the tenant, then he will have an incentive to cheat and, in order to reduce somewhat this cheating, the landlord will optimally raise the contract share. The outcome is a share contract with an optimal level of cheating, implying a double inefficiency, one in effort and the other in sharing. We have also shown that suppressing all cheating would not be optimum for the landlord, even under a more general non-linear contract.

V. Other aspects of cheating strategies

Introducing concerns with cheating in share contracts opens a number of new perspectives that can enrich specification of the contract. We review some in the following paragraphs.

1. Process utility in cheating and revenge

Process utility means that the tenant enjoys some utility in the process of stealing his landlord. It therefore raises the overall utility of cheating, adding process utility to the standard utility derived from the stolen good. This can be formalized as a process utility $R(z^p)$ function of some variables z^p that determine satisfaction from theft. In the model the $k(s)$ function is augmented as follows:

$$R(z^p)k(s), R_{z^p} > 0, k_s > 0.$$

A particular case of such process utility is the drive for revenge by a person who feels he has been treated unfairly in bargaining (Rabin, 1995). Applied to our case, market conditions may be such that the landlord has the bargaining power to reduce the tenant to his reservation utility and the tenant, understanding this situation, accepts the reward and enters the contract. Yet, the tenant may feel that the landlord could, if he so wanted, have given him a better deal. This resentment leads to actions of revenge (the stealing) that result in inefficiency (when the value of the stolen good is lower than the legal good). What Rabin shows is that, even in a situation of complete and perfect-information game, such inefficiency may occur if it is more costly for the principal to make an offer sufficiently generous to deter retaliation rather than bearing the consequence of retaliation. This revenge for unequal bargaining can be formalized as an additional utility $R(L)$ derived by the tenant from the stolen good, function of the reservation utility L on which the landlord has anchored the rent:

$$R(L)k(s), R_L < 0, k_s > 0.$$

In this case the utility derived from diverting s need not be lower than the value of the stolen good. In equilibrium, the tenant will cheat more, and the landlord should give him an even higher share of declared output. In comparative statics, if the reservation utility L determined by the tenant's bargaining position falls, stealing will increase, and social inefficiency will rise.

2. Supervision to prevent theft

There are always two ways of counteracting an undesirable action such as stealing. One is to offer an incentive contract, as discussed above, and the other to supervise to prevent cheating. Supervision by the landlord often entails being present in the field at harvest time, or even during a period prior to harvest to prevent the tenant from removing product before the harvest. It can be modeled as a costly input t that reduces the ability to cheat or increases the cost of cheating:

$k(s,t)$, with $k_t(s,t) < 0$ and $k_{st}(s,t) < 0$.

The equilibrium with supervision will imply less stealing, and a higher reported share of output.

Alternatively, one could have modeled supervision with a costly random checking on the tenant and a large punishment if the tenant is caught cheating. But this supervision technology does not seem frequent in the contexts we are looking at. We will see why in the next section.

3. Surveillance and vengeance

Most landlords will admit that they know their tenants are cheating. Similarly, white collar crime, provided it remains of "reasonable" magnitude, is known and accepted in the workplace (Clark and Hollinger, 1983). The argument to accept this level of cheating is that pounding too much on the cheater to fully prevent cheating may create bad relationships that would be detrimental to the quality of work (Dickens et al., 1989). The "revenge" feeling against the harsh landlord can be modeled as an increasing desire to cheat the landlord when supervision becomes more pervasive, i.e., an increase in the process utility of cheating induced by excessive supervision. The return to cheating can then be written as:

$k\left(s, z_t^p, t\right)$, with $z_t^p > 0$.

This explains why supervision is restrained, as observed above by Hayami, and why lower supervision must be compensated with a higher share.

4. Reallocation of resources toward less stealable products

If the response to theft consists in choosing activities that are less exposed to stealing, there is an efficiency cost in resource allocation (Usher, 1987). This misallocation of resources relative to the first best with no theft is similar to allocation of investment toward more liquid assets when assets have an insurance value to confront insurance market failures (Rosenzweig and Wolpin, 1993). Bias in the choice of activities creates a deadweight loss compared to the first best.

V. Conclusion

Cheating in reporting the level of product to be shared with a landlord is widely acknowledged. It is contained by social norms and by observability by the landlord of the level of product achieved. However, landlords also try to protect themselves from product theft by giving their tenants an incentive contract that will be perceived by the tenant as fair. This paper advances the literature on share contracts by adding this aspect of behavior and specifying how the landlord's optimal contract will be modified to account not only for moral hazard in inputs exclusively provided by one partner, but also to deter cheating. The optimal contract allows for both residual moral hazard and cheating. In contracting when there is product theft, the model developed in this paper predicts that contract terms will vary continuously not only with technology (fixed factor productivity such as soil quality), tenant quality (labor productivity), risk aversion by the tenant (level of insurance), and level of exposure to risk, but also with the tenant's desire and ability to steal.

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