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On share contracts and screening

Franklin Allen*

It has been suggested by Hallagan (1978) and Newbery and Stiglitz (1979) that the co-existence of rent, wage, and share contracts generates information on the abilities of tenants which allows landlords to allocate resources more efficiently. It is argued here that despite the asymmetric information in their models, it is possible to achieve an efficient allocation of resources without the use of share contracts, by having tenants organize production. An alternative model is then given where efficiency cannot be achieved in this way because the quality of land as well as the ability of tenants is unobservable. In this case the use of sets of wage and share contracts may lead to an efficient outcome.

1. Introduction

■ Share contracts often coexist with wage and rent agreements. It has been suggested independently by Hallagan (1978) and Newbery and Stiglitz (1979) that this generates information on abilities. Tenants are assumed to know their own abilities, but landlords cannot distinguish between them. The use of several contracts allows tenants to identify themselves to landlords. Those with high ability choose rent contracts so that they gain all the return to their ability; those with low ability choose the wage contract, since in this case payment does not depend on their ability, and those in between will choose the share contract. The coexistence of contracts thus generates valuable information which allows landlords to allocate resources more efficiently.

The basic reason that asymmetric information causes a problem in their models is that the landlords, who cannot observe the tenants' ability, hire other factors and organize production. However, if the tenants were to do this, the asymmetric information would not matter, since they know their own ability and can therefore organize production efficiently. This result is demonstrated in Section 2.

The important assumption of Section 2 is that there is only asymmetric information about one characteristic. If there are two or more characteristics for which this is the case, then only those aware of one of these can organize production; the fact that they cannot directly observe the other characteristics remains a problem. However, by a judicious use of sets of multiple contracts, it may be possible for them to identify these and organize production efficiently. A simple example of this type is given in Section 3.

Finally Section 4 contains some concluding remarks.

2. The organizer of production and efficiency

■ The model used is as follows. Each person has a production function where output Y depends on ability A , land K , the number of hours of labor L , and a stochastic variable θ representing random influences such as the weather:

$$Y = Y(A, K, L, \theta) \tag{1}$$

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$$Y_K, Y_L > 0; \quad Y_{KK}, Y_{LL} < 0. \quad (2)$$

The variables Y , K , and L are observable, but θ and A are not. It is the unobservability of θ which prevents A from being deduced from output.

Utility depends on consumption C and the amount of labor supplied. Problems of risk sharing are abstracted from by assuming everybody is risk neutral in consumption

$$U = U(C, L) \quad (3)$$

$$U_C > 0; \quad U_L, U_{LL} < 0; \quad U_{CC}, U_{CL} = 0. \quad (4)$$

Since people are risk neutral, it is possible to work with expected values so that (1) can be rewritten as

$$Y = Y(A, K, L). \quad (5)$$

There are two types of interpretation of ability. In the first, A is the entrepreneurial ability of the person; it is the ability to make decisions concerning the timing of particular tasks like planting, irrigation, cultivation, and harvesting. This is essentially the model of Hallagan (1978). In the second interpretation, ability, which is denoted α or π to distinguish it from A , is the quality of a factor. For example, α may be interpreted as the number of efficiency units of labor supplied within an hour. This is the model of Newbery and Stiglitz (1979).

The former model is considered first. In this case every hour of labor supplied, no matter who supplies it, is the same. Similarly for K . There are, therefore, no problems in having ordinary competitive markets for the services of K and L . The prices of these are denoted by r and w , respectively.

In this model each person is not only a consumer, but also a producer. In the latter role all consider setting up a farm. Provided each person knows his own ability and can choose his own inputs, it does not matter that his ability cannot be observed by other people. K and L are chosen by each person in his role as a producer to maximize profits:

$$\text{Max}_{K,L} Y(A, K, L) - wL - rK. \quad (6)$$

This gives the usual first-order conditions. Assuming an interior solution, these are

$$Y_K = r \quad (7)$$

$$Y_L = w. \quad (8)$$

For people with sufficiently low ability, there may be corner solutions with marginal products less than prices and zero demands for K and L .

As consumers, owners of land supply its services, and each person chooses his labor supply and consumption to maximize his utility subject to his budget constraint:

$$\text{Max}_{C,L} U(C, L) \quad (9)$$

subject to

$$C = wL + rK^* + \Pi, \quad (10)$$

where K^* is the amount of land owned and Π is the pure profit which results from being a producer. The first-order condition in this case equates the wage with the ratio of the marginal disutility of labor to the marginal utility of consumption,

$$w = - \frac{U_L}{U_C}. \quad (11)$$

It is important to make clear the relationship between each person's choice of labor input as a producer and labor supply as a consumer. It is implicit here that the quantity

demanded for production need not equal the quantity supplied as a consumer; any difference between these amounts is hired or sold on the labor market.

The model above is simply a special case of the standard neoclassical model, and its equilibrium has the usual property of being Pareto efficient (Debreu, 1959).

Hence, if entrepreneurial abilities differ, then a normal system of markets enables an efficient allocation of resources, even if these abilities cannot be observed by other people.

In the model of Newbery and Stiglitz (1979), hours of labor supplied by people of different ability α are not the same. It is the number of efficiency units of labor $\epsilon = \alpha L$ which is important as far as production is concerned. Since α is unobservable, buyers of labor are unable to identify ϵ .

It is assumed as above that everybody is risk neutral in consumption and also that everybody has a constant returns to scale production function, and the stochastic shift θ is multiplicative, so that (1) is replaced by

$$Y = \theta \epsilon y\left(\frac{K}{\epsilon}\right). \quad (12)$$

Suppose workers use only their own labor, the effectiveness of which they are aware, and hire land in a rental market. Taking $E\theta = 1$ and using the fact that everybody is risk neutral, the problem they solve is

$$\text{Max}_{K,L} U\left(\epsilon y\left(\frac{K}{\epsilon}\right) - r(K - K^*), L\right). \quad (13)$$

Assuming an interior solution, the first-order conditions for this are:

$$y'\left(\frac{K}{\epsilon}\right) = r \quad (14)$$

$$y\left(\frac{K}{\epsilon}\right) - \frac{K}{\epsilon} y'\left(\frac{K}{\epsilon}\right) = -\frac{U_L}{AU_C}. \quad (15)$$

It can be seen that the single contract market structure suggested is Pareto efficient, since everybody's K/ϵ ratios and their marginal disutilities per unit of effective labor are equated. There is no need for a market for labor, so it does not matter that buyers of labor cannot observe its quality.

In general, provided there is only asymmetric information concerning one characteristic, an efficient outcome may exist if the person who is aware of the characteristic organizes production. This is the case in both the models of Hallagan (1978) and Newbery and Stiglitz (1979).

3. Sets of contracts and efficiency

■ The crucial assumption of the previous section was that there was only one characteristic that was unobservable. If there are two dimensions to ability or the quality of more than one factor is unobservable, it will no longer be possible to achieve efficiency in the way described above. The purpose of this section is to illustrate how the use of several sets of multiple contracts may still allow this to be achieved.

The model used is similar to that above. The two factors of production are now effective labor ϵ and effective land κ . For simplicity there are taken to be two levels of productivity of labor: workers of type 1, who are more able, supply α_1 units of effective labor per hour, and workers of type 2 supply α_2 . Similarly, there are two types of land: each unit of the high and low quality land is equivalent to π_1 and π_2 units of effective land, respectively.

The production function displays constant returns to scale and is of the form

$$y = \theta \epsilon_i y \left(\frac{\kappa_j}{\epsilon_i} \right), \quad i, j = 1, 2, \quad (16)$$

where as before $E\theta = 1$, $\epsilon_i = \alpha_i L$ and also $\kappa_j = \pi_j K$, where K is the number of physical units of land.

When workers are paid a wage w_i^h per hour, the number of hours they work, L_i , is given by

$$L_i = L(w_i^h), \quad i = 1, 2. \quad (17)$$

Landlords know the productivity of their land and workers know the productivity of their labor, but these cannot be observed by other people. Landlords organize production, and there is a market for labor.

Depending on the parameters of the model, efficiency may be achieved by landlords with different qualities of land offering different sets of multiple contracts. Workers identify themselves by the choice of contract within each set, and landlords identify themselves by the set they offer. This result is demonstrated by first looking at the solution when both ϵ_i and π_j are observable and then relaxing these assumptions in turn.

For simplicity it will be assumed that landlords do not supply labor and workers do not own land. In this case the problem facing a landlord with land K^* of type j is to choose the amount of effective labor to hire to maximize his expected income:

$$\text{Max}_{\epsilon} \epsilon y \left(\frac{\pi_j K^*}{\epsilon} \right) - w^e \epsilon, \quad (18)$$

where w^e is the wage for each effective unit of labor. The first-order condition for this problem is thus

$$y \left(\frac{\pi_j K^*}{\epsilon} \right) - \frac{\pi_j K^*}{\epsilon} y' \left(\frac{\pi_j K^*}{\epsilon} \right) = w^e. \quad (19)$$

In equilibrium, therefore, the effective land to effective labor ratio will be equated across all landlords. Workers of ability α_i will receive a wage per hour w_i^h given by

$$w_i^h = \alpha_i w^e, \quad i = 1, 2. \quad (20)$$

They will work for L_i hours and will be allocated κ_i units of effective land, where this is such that κ/ϵ ratios are equated for all workers. The allocation of resources is thus efficient.

Since people are risk neutral in consumption, it is clearly equivalent if landlords specify share contracts $(\sigma_i, L_i, \kappa_i)$ (where the first term indicates the share of output received by the landlord, the second the amount of labor the worker must supply, and the third the amount of effective land the worker is allocated) such that

$$(1 - \sigma_i) \alpha_i L_i y \left(\frac{\kappa_i}{\alpha_i L_i} \right) = w_i^h L_i, \quad i = 1, 2. \quad (21)$$

Substituting from (20), it can be seen that

$$\sigma_1 = \sigma_2 = \sigma. \quad (22)$$

Provided enforcement costs are neglected, both workers and landlords will be indifferent between the share and wage contracts for their group.

Now consider what happens if it is assumed that κ_i is still observable to everybody, but workers are the only people who know their own ability. If landlords offer a share contract (σ, L_1, κ_1) and a wage contract w_2^h , then type 1 workers will choose the former and under certain conditions type 2's will choose the latter. For α_1 's this occurs because, using (21),

$$U\left((1 - \sigma)\alpha_1 L_1 y\left(\frac{\kappa_1}{\alpha_1 L_1}\right), L_1\right) = U(w_1^h L_1, L_1) > U(w_2^h L_2, L_2) \quad (23)$$

with the inequality following from the fact that consumers prefer a higher wage and $w_1^h > w_2^h$. Provided α_2 is sufficiently below α_1 and the disutility of labor is great enough, it can be shown by using (4) that

$$U(w_2^h L_2, L_2) > U\left((1 - \sigma)\alpha_2 L_1 y\left(\frac{\kappa_1}{\alpha_2 L_1}\right), L_1\right) \quad (24)$$

so that α_2 's choose the wage contract. The workers self-select by their choice of contract so that landlords are able to identify their ability and allocate resources efficiently.

So far, the productivity of land has been known by everybody. The next step is to assume that only landlords can observe their π_j directly. This implies that contracts can only specify K rather than κ . The share contracts offered to α_1 people when the land has productivity π_j will therefore have to be of the form (σ, L_1, K_j^1) , where the third term now denotes the number of physical units of land the worker is to be allocated and is given by $K_j^1 = \kappa_j/\pi_j$.

To be able to evaluate these share contracts, workers must be able to deduce π_j . The fact that efficiency requires that landlords whose land is of a different quality provide different physical amounts of land potentially provides workers with a basis for doing this. Unfortunately, since $\pi_1 > \pi_2$, it can be shown that

$$\sigma \frac{\alpha_1 L_1}{\pi_2 K_1^1} y\left(\frac{\pi_2 K_1^1}{\alpha_1 L_1}\right) > \sigma \frac{\alpha_1 L_1}{\pi_2 K_2^1} y\left(\frac{\pi_2 K_2^1}{\alpha_1 L_1}\right). \quad (25)$$

In other words, π_2 landlords receive a greater return on their land if they specify K_1^1 of land in their share contracts for α_1 's rather than K_2^1 . For workers to be able to correctly deduce π_j , the contracts must therefore be constructed so that π_2 landlords who pretend to have π_1 land have an expected penalty which outweighs this gain.

In certain circumstances this can be achieved by the wage contract for α_2 's also specifying the number of units of land to be used by the worker and the number of hours to be worked. Workers know that efficiency requires that the ratios of effective land to effective labor must be the same for α_1 's and α_2 's. Hence the share and wage contracts offered by a particular landlord must be such that the ratios are equated. If π_2 landlords pretend to be π_1 , they must be willing to provide α_2 's with less effective land than is optimal. Since these landlords still have to pay fixed wages of $w_2^h L_2$ to α_2 's, there is a penalty for pretending to be π_1 .

For this penalty to be effective, workers must be sure that the α_2 contracts will be enforced. Since the utility of α_2 workers is independent of the amount of land they are allocated, given that w_2^h and L_2 are fixed, the contracts must specify a penal transfer from landlord to worker if the quantity provisions are not enacted. The α_1 workers can then be sure that the α_2 contracts will be enforced as specified.

Efficiency will require that landlords with land of productivity π_1 will offer a set of contracts S_1 such that

$$S_1 = \{\alpha_1: (\sigma, L_1, K_1^1); \alpha_2: (w_2^h, L_2, K_2^1)\}, \quad (26)$$

where the contract for α_1 's is as described above and the contract for α_2 's specifies first the wage, second the amount of labor the worker would have chosen at that wage, and third the number of physical units of π_1 land required to provide the worker with κ_2 units of effective land. Similarly, π_2 landlords must offer the set of contracts S_2 such that

$$S_2 = \{\alpha_1: (\sigma, L_1, K_2^1); \alpha_2: (w_2^h, L_2, K_2^2)\}. \quad (27)$$

For the efficient solution to be implementable, S_1 and S_2 must be such that landlords with π_1 land will prefer the former and those with π_2 land will prefer the latter.

Now if ν_1 is the proportion of total labor supplied by α_1 's, then provided landlords are obligated to accept both the α_1 and α_2 workers who present themselves, the expected average return on their land is proportional to their expected utility. It follows that π_1 landlords will always offer S_1 rather than S_2 contracts provided

$$\begin{aligned} \nu_1 \sigma \frac{\alpha_1 L_1}{\pi_1 K_1^1} y \left(\frac{\pi_1 K_1^1}{\alpha_1 L_1} \right) + (1 - \nu_1) \left(\frac{\alpha_2 L_2}{\pi_1 K_1^2} y \left(\frac{\pi_1 K_1^2}{\alpha_2 L_2} \right) - \frac{w_2^h L_2}{\pi_1 K_1^2} \right) \\ > \nu_1 \sigma \frac{\alpha_1 L_1}{\pi_1 K_2^1} y \left(\frac{\pi_1 K_2^1}{\alpha_1 L_1} \right) + (1 - \nu_1) \left(\frac{\alpha_2 L_2}{\pi_1 K_2^2} y \left(\frac{\pi_1 K_2^2}{\alpha_2 L_2} \right) - \frac{w_2^h L_2}{\pi_1 K_2^2} \right). \end{aligned} \quad (28)$$

It can be shown by using $\pi_1 > \pi_2$ that this will always be satisfied.

Similarly π_2 landlords will prefer to offer S_2 rather than S_1 contracts if

$$\begin{aligned} \nu_1 \sigma \frac{\alpha_1 L_1}{\pi_2 K_2^1} y \left(\frac{\pi_2 K_2^1}{\alpha_1 L_1} \right) + (1 - \nu_1) \left(\frac{\alpha_2 L_2}{\pi_2 K_2^2} y \left(\frac{\pi_2 K_2^2}{\alpha_2 L_2} \right) - \frac{w_2^h L_2}{\pi_2 K_2^2} \right) \\ > \nu_1 \sigma \frac{\alpha_1 L_1}{\pi_2 K_1^1} y \left(\frac{\pi_2 K_1^1}{\alpha_1 L_1} \right) + (1 - \nu_1) \left(\frac{\alpha_2 L_2}{\pi_2 K_1^2} y \left(\frac{\pi_2 K_1^2}{\alpha_2 L_2} \right) - \frac{w_2^h L_2}{\pi_2 K_1^2} \right). \end{aligned} \quad (29)$$

This will be satisfied provided ν_1 is sufficiently small and π_1 is sufficiently above π_2 . In such cases the disadvantage of having to pay a fixed amount to α_2 's who produce using a suboptimal amount of effective land is sufficient to outweigh the advantage gained from pretending to α_1 's that the land is high quality.

Hence, provided the parameters of the model are such that (24) and (29) are satisfied, landlords can identify workers' ability from their choice within each set, and workers can identify the π_j of landlords' land by the set of contracts they offer.

A judicious use of share and wage contracts by landlords may thus allow the first-best solution to be achieved, even though the productivity of inputs cannot be directly observed. With more than two types of land and labor a similar type of solution may be feasible, but in this case there will have to be more than two sets of contracts offered by landlords, and within each set it will be necessary to use contracts with a mixture of wage and share components.

This type of example is clearly a special case, but it does illustrate the principle. In general, it may not be possible to achieve the first-best solution, and there may be problems of existence similar to those given by Rothschild and Stiglitz (1976) in the context of insurance markets. Strictly speaking, it is also not necessary to use share contracts within the sets: any type of appropriately constructed contract where compensation depends on output would have done equally well. Lastly, the example assumed that landlords organize production and that there is a market for labor. A similar solution could have been obtained if workers had organized production and there had been a market for land: in this case workers would have offered sets with rent and share contracts to hire land.

4. Concluding remarks

■ It has been shown above that in the models of Hallagan (1978) and Newbery and Stiglitz (1979) an efficient outcome is possible without the use of share contracts. An alternative model was presented in which there were two unobservable characteristics, and it was demonstrated how the use of sets of wage and share contracts could lead to an efficient outcome.

The purpose of studying simple agricultural economies is not only to understand them in their own right, but also to try to gain some insight into more complex industrial economies. The analysis of Section 2 indicates that the institution of the firm eliminates the problems resulting from people's having asymmetric information on the quality of

one type of input. Section 3 illustrates how the use of complex sets of contracts by firms may eliminate inefficiency if the quality of more than one input is unobservable.

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