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Optimal linear contracts with heterogeneous agents

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Summary

This paper examines the class of linear contracts in a simple principal–agent model in which agents are heterogeneous in their abilities to perform a task for the principal. We show that in the absence of transaction costs, the optimal linear contract is a set of individualised contracts. The fact that individualised contracts are rarely observed may be explained by the presence of transaction costs. The equilibrium that emerges depends on the costs of screening relative to the heterogeneity in agents' abilities. In the monopsony case, the dynamic incentives of the agents preclude individualised contracts even if transaction costs are not significant.

Keywords: moral hazard, heterogeneous abilities, transaction costs

JEL classification: L14, Q13

1. Introduction

When contracts are written between a principal and agents where a moral hazard problem exists, we often observe simple linear contracts although these contracts are generally not optimal. For example, in agricultural contracts with obvious hidden action moral hazard problems, such as production contracts for broilers, turkeys, and pigs, as well as some fruits and vegetables, we observe simple linear contracts based on either piece rates or tournaments.[1] Although it is clear that some information that is necessary to design the optimal contract, such as agents' preferences and the distribution of shocks, will be difficult to obtain, other pieces of information seem to be readily available. In particular, when the principal and agent contract repeatedly, the principal will know the ability of a particular agent relative

1 In this paper, tournaments will mean cardinal tournaments, also known as *payment by relative performance* (Nalebuff and Stiglitz, 1983) or *yardstick competition* (Schleifer, 1985) as opposed to rank-order tournaments as in Lazear and Rosen (1981). An important feature of linear cardinal tournaments, which distinguishes them from rank-order tournaments, is that there are no efficiency losses associated with mixing players of uneven abilities. Consequently, cardinal tournaments do not provide incentives for organisers to handicap better players or sort them into homogeneous groups.

to other agents, yet in many cases the principal does not use this information to offer individualised contracts but rather continues to offer a uniform contract.

There are many circumstances that may force the principal to compensate all agents according to a uniform payment scheme that depends on outcome but not on the agent's type. First, as argued by Olesen and Olsen (2000), agents may have some bargaining power and force the principal to use only one contract. In this case, the principal may be forced to increase the payment to all agents to attract a particular type of agents. Second, legal restrictions such as anti-discrimination clauses may prevent the principal from using all information in designing the contract. There may also be issues of perceived fairness and equity that the principal may be concerned with. Additionally, uniform contracts may be rationalised by arguing that offering individual contracts would involve substantial investment in negotiations, measurement and information-gathering costs. From the point of view of society, these transaction costs could be wasteful if information-gathering leads to the contract terms that affect only the distribution of surplus but does not increase total wealth. In this case, refined contracts benefit one party at the expense of the other party and are a deadweight loss (Milgrom and Roberts, 1992: 147). The contract is still signed and all production decisions are efficient just as would have occurred had the information not been gathered. The costs of gathering information are subtracted from the total surplus with no offsetting benefits unless the information affects the efficiency of production (optimal effort) or efficiency in participation (the allocation of a productive asset).

In this paper, we examine the transaction costs argument for the class of linear contracts in the context of a simple principal–agent moral hazard model in which agents are heterogeneous in their abilities to perform a task for the principal. This formulation is particularly relevant for agricultural contracts characterised by a long-run relationship between processors and contract growers where there is strong evidence of differences in growers' abilities that may become known over time. Interestingly, in most of these cases we mainly observe simple uniform linear contracts instead of more complicated individualised schemes.[2] The information structure in our model is different from that of Goodhue (2000), who studied agricultural contracts with heterogeneous-ability agents in a traditional adverse selection framework, where agents' abilities are unobservable for the principal. In contrast to her study, we assume that the principal either knows the agents' abilities or is capable of learning them in the sequence of tournaments by incurring some transaction costs.

We define a linear contract as a contract in which the agent's payment is an affine function of the outcome (variable cost of production or output) generated

2 Notice, however, that a simple uniform contract can be optimal if agents are homogeneous in their abilities. By modelling stochastic production technology representative of livestock production, Tsoulouhas and Vukina (1999) have shown that a two-part cardinal tournament contract is approximately optimal.

by the agent. We focus on the two most commonly observed cases. The first case is a two-part piece-rate contract where both the base payment (salary) and the marginal payment are known fixed quantities. The second case is a cardinal tournament contract that has a fixed base payment and a stochastic bonus payment determined by comparing the performance of an individual grower with the average performance of other contestants.

We show that when the principal operates in a perfectly competitive environment such that the zero profit condition binds and agents are risk-averse, the optimal linear contract is an individualised contract indexed by the abilities of the agents. The fact that the individualised contracts are rarely observed may be explained by the presence of transaction costs that a perfectly competitive integrator may face. The type of equilibrium that emerges depends on the importance of the cost of screening relative to the heterogeneity in agents' abilities. Moreover, when a principal is a monopsonist in the labour market for agents' services, we expect uniform contracts even in the absence of transaction costs.

The rest of the paper is organised as follows. In the next section, we solve for the parameters of the optimal linear contract(s) with heterogeneous agents in both the risk-neutral and risk-averse cases. In Section 3 we discuss the importance of transactions costs in two market structures that would favour the adoption of a uniform contract over individualised contracts. In Section 4, we discuss the results in reference to the production and marketing contracts currently observed in US agriculture. Section 5 concludes.

2. Optimal linear contracts

Optimal compensation schemes for groups of agents generally exhibit complicated functional forms depending on assumptions about tastes, technology and distributions of error terms. In practice, however, we frequently observe very simple linear schemes. In this section, we specify the optimal properties of linear contracts based on tournaments or simple piece rates in situations where a principal offers production contracts to many agents with different abilities.

Let us suppose that the output of agent i in time t with value $V_t > 0$ per unit of output is given by the following equation:

$$q_{it} = e_{it} + a_i + u_t + w_{it} \tag{1}$$

where $e_{it} \geq 0$ is the effort exerted by agent i in period t, a_i is the inherent ability of agent i, u_t is a common production shock occurring in period t, independent across time, and w_{it} is an idiosyncratic production shock, which is independent across agents and time. Both shocks are stochastic, realised at the end of the production cycle, with mean zero and finite variances σ_u^2 and σ_w^2, respectively. The production function (1) is a simple extension to agents with heterogeneous abilities of the model of Lazear and Rosen (1981). In what follows, we will examine one-shot contracts and henceforth drop the time index t for brevity.

We model the production contracts between a single principal and agents of different abilities, where the principal observes the agents' outputs but does not observe the level of effort; hence there exists a 'hidden action' moral hazard problem. We assume that the agents' abilities are common knowledge. Furthermore, the principal operates in a perfectly competitive environment taking prices in all markets as given. The free entry conditions prevail such that the principals jointly bid the prices including the payments for agents' services to the point where zero profit obtains. However, this assumption does not mean that all agents earn zero expected rents. In fact, because agents know their abilities, high-ability agents are expecting to earn positive rents.

To compensate the agents, the principal can either use a relative performance scheme such as a tournament: $y_i = B + r(q_i - \bar{q})$, where the cash payment y_i is determined by comparing the individual contestant's performance with the group average performance $\bar{q} = 1/n \sum_{j=1}^{n} q_j$ or an independent scheme such as a two-part piece rate: $y_i = B + rq_i$ with B denoting some level of base salary. We assume the transaction costs of contract implementation are zero.

Furthermore, we assume that all agents have the same utility function given by $U(y_i - C(e_i))$ where $C(e_i)$ represents a strictly convex function of effort (C', $C'' > 0$) and $C(0) = C'(0) = 0$. We assume concavity of the utility function ($U' > 0$, $U'' \leq 0$) and set the reservation utility for all agents to zero. Both utility and costs are continuous and differentiable.

When producers have equal ability (i.e. $a_i = a_j$ for all i, j) it is well known that in the risk-neutral case, the moral hazard problem can be costlessly avoided by shifting all risk onto the agents (Lazear and Rosen, 1981). However, when agents are risk-averse, in the absence of common shock, the optimal rank-order tournament is dominated by the optimal independent contract because the output levels of the rest of the group convey no information about the effort level of an agent. Conversely, if the distribution of the common production shock is sufficiently diffuse, the optimal tournament dominates the optimal independent contract because using a tournament eliminates a major source of noise while adding a relatively minor one (Green and Stokey, 1983). We are interested in seeing how the results for rank-order tournaments with equal ability agents extend to the case of cardinal tournaments with agents of unequal ability.

2.1. Risk-neutral agents

We begin by considering the problem faced by a risk-neutral principal who employs a group of different-ability risk-neutral agents, $i = 1, 2, \ldots, n$. We first derive the result for a simple piece rate followed by the result for a cardinal tournament. We show that in the risk-neutral case, the efficiency results for the homogeneous agents carry over to the heterogeneous case.

2.1.1. Piece rates

A principal maximises his agents' utilities while being constrained by the competitive market to make zero expected profits. As producers are risk-neutral, their utility can be written as $y_i - C(e_i)$. Under a piece-rate contract, the sufficient first-order condition for maximisation of expected utility is given by

$r - C'(e_i) = 0$. The principal's expected profit is given by $Vq_i - B - rq_i$, hence the zero expected profit constraint gives $B = (V - r)(a_i + e_i)$. When $B = 0$ and $r = V$, the expended effort is efficient, and the contract is accepted by those producers with $V(a_i + e^*) \geq C(e^*)$, where e^* is the efficient level of effort.

2.1.2. Cardinal tournaments

Now, let us suppose agents are paid according to a cardinal tournament. Given any level of effort by the other $n - 1$ participating agents, the sufficient first-order condition for maximisation of expected utility for agent i is $r(n - 1)/n - C'(e_i) = 0$. Hence, if $r = n/(n - 1)V$, effort is efficient. Let B_j be the base payment to agent j, then the principal's profit is given by $V(\sum_{j=1}^{n} q_j) - \sum_{j=1}^{n} B_j = 0$. In particular, as abilities are known to the principal, imposing the zero profit constraint per agent[3] gives $Vq_i = B_i + r(q_i - \bar{q})$. Taking expectations, substituting for r, and arranging terms, we have $B_i = V(a_i + e^*) - n/(n - 1)V(a_i - \bar{a})$, where $\bar{a} = 1/n \sum_{j=1}^{n} a_j$. Hence when contract $\{B_i, r\}$ is offered, choosing e^* is a dominant strategy for each agent, and the contract is accepted by all agents who satisfy the participation constraint $V(a_i + e^*) \geq C(e^*)$, which shows that the value of the expected production must exceed the production cost.

An interesting consequence of the above result is that the marginal reward for output in the cardinal tournament exceeds the marginal value, V. This occurs because the marginal effect of effort affects the average, so an extra incentive is required to balance this effect. This has an important implication for the information required to administer an efficient contract. Whereas the efficient piece-rate contract is a uniform one, the extra marginal incentive in the cardinal tournament requires fine tuning of the base payment to eliminate the bonus high-ability agents receive, and therefore makes the knowledge of abilities necessary for efficiency.

When a single uniform tournament contract is offered that elicits efficient effort, the revenue of efficient effort from an agent must exceed the cost by $1/(n - 1)V(\bar{a} - a_i)$ for the agent to accept the contract. To see this, let us suppose all principals offer an identical contract and hire a similar distribution of agents. It should be noted that to induce the efficient level of effort the slope parameter has to be $r = n/(n - 1)V$. If the lump sum payment is B, then the zero expected profit constraint gives $\sum_{i=1}^{n} V(a_i + e^*) = nB$, or $B = V(\bar{a} + e^*)$ where $\bar{a}$ is the mean ability of those agents who participate.[4] It should be noted that, in contrast to the optimal contract, here all contracts are identical. Agents have no incentive to change principals, so there is only one zero expected profit constraint. Agents accept the contract when the participation constraint is satisfied, i.e. when $V(\bar{a} + e^*) + n/(n - 1)V(a_i - \bar{a}) - C(e^*) \geq 0$, which can be rewritten as $V(e^* + a_i) \geq C(e^*) + 1/(n - 1)V(\bar{a} - a_i)$. Hence, when a single tournament contract is offered, some producers who should produce do not. Efficient participation can be recovered at the expense of efficiency of effort if $r = V$.

3 If the principal were not receiving zero expected profit for *each* agent, then some agent would be generating rents for the principal and be lured away by a competitor.

4 In this case $\bar{a}$ and n depend on where the participation constraint binds; see footnote 5.

2.1.3. Yardstick competition

A modification of the cardinal tournament scheme that eliminates the distortion of the marginal payment is one where the contestant whose performance is evaluated is excluded from the calculation of the average performance, such as $y_i = B + r(q_i - \bar{q}_{-i})$ where $\bar{q}_{-i} = 1/(n-1)\sum_{j\neq i} q_j$. Such a modification, also known as yardstick competition (Shleifer, 1985), eliminates the distortion of incentives created by a producer's contribution to the average. In this case, efficient effort is elicited from $r = V$ and the zero expected profit constraint gives $B_i = V(a_i + e^*) - V(a_i - \bar{a}_{-i})$, which leads to participation for those agents whose abilities generate benefits greater than total cost.

It is noteworthy that when agents are risk-neutral, for a cardinal tournament to be efficient, the principal needs to know the abilities of agents and to tailor contracts to those abilities. Under a simple piece rate or yardstick competition, efficiency can be obtained without knowledge of individual abilities by 'selling the store' to the agents.

2.2. Risk-averse agents

Next, we analyse the case of risk-neutral principal and risk-averse agents. When agents are risk-averse ($U'' < 0$), neither piece-rate contracts nor cardinal tournaments achieve the first-best. This results from the tension between the agent's preference for insurance and the principal's need to provide incentives against moral hazard (shirking).

2.2.1. Piece rates

Given the production technology in (1) and a (possibly customised) piece-rate contract $\{B_i, r_i\}$, producer i chooses effort to maximise his expected utility. The first-order condition is

$$\iint U'(y_i - C(e_i))[r_i - C'(e_i)]f_u(u)f_w(w_i)\,\mathrm{d}u\,\mathrm{d}w_i = 0$$

where f_u and f_w are the densities for u and w_i, respectively. Because utility is increasing in payment, this implies $r_i = C'(e_i)$, i.e. the marginal payment equals the marginal cost of effort. The zero profit constraint of the principal implies that the expected value of output equals the expected payment, hence $V(a_i + e_i) = B_i + r_i(a_i + e_i)$. Substituting for the fixed payment, such that $B_i = (V - r_i)(a_i + e_i)$, the principal chooses r_i to maximise the expected utility of the agents given their effort $e(r_i)$. This problem can be stated as follows:

$$\max_{r_i} \iint U[V(a_i + e(r_i)) + r(u + w_i) - C(e(r_i))]f_u(u)f_w(w_i)\,\mathrm{d}u\,\mathrm{d}w_i$$

which gives the following first-order condition:

$$\begin{aligned}\iint & U'[V(a_i + e(r_i)) + r_i(u + w_i) - C(e(r_i))][Ve'(r_i) - C'(e(r_i))e'(r_i) \\ & + u + w_i]f_u(u)f_w(w_i)\,\mathrm{d}u\,\mathrm{d}w_i \\ & = [V - C'(e(r_i))]e'(r_i)EU' + E(u + w_i)U' = 0\end{aligned}$$

where E denotes the expectations operator. Using a second-order Taylor expansion of the utility function about the mean payment, the first-order condition gives

$$r_i = \frac{V}{1 + s_i C''(\sigma_u^2 + \sigma_w^2)} \tag{2}$$

where $s_i = -U_i''/U_i'$ is the measure of absolute risk aversion at the mean payment and C'' is measured at the induced effort level $e_i = C'^{-1}(r_i)$. This expression is very similar to equation (16) in Lazear and Rosen (1981), except that here the contract depends on the ability of the producer, which determines the mean (base) payment as

$$B_i = (V - r_i)(a_i + C'^{-1}(r_i)) \tag{3}$$

and hence on the risk aversion parameter s. When utility is characterised by constant absolute risk aversion, contracts for producers of different abilities have the same marginal payment ($r_i = r_j$ for all i, j) but different base payments in contrast to the risk-neutral case (when $s_i = 0$ and $r = V$, $B = 0$).

2.2.2. Tournaments

When payment is made through a cardinal tournament with parameters $\{B_i, r_i\}$, given any choices of effort by the $n-1$ other agents, agent i solves

$$\max_{e_i} \iint_{\Re^n} U[B_i + r_i(q_i - \bar{q}) - C(e_i)] f_u(u) f_w(w)\, \mathrm{d}u\, \mathrm{d}w$$

where $w = (w_1, \ldots, w_n)$ and $f_w(w) = \prod_{j=1}^n f_w(w_j)$. The first-order condition gives

$$\left[r_i \left(\frac{n-1}{n} \right) - C'(e_i) \right] \iint_{\Re^n} U'[B_i + r_i(q_i - \bar{q}) - C(e_i)] f_u(u) f_w(w)\, \mathrm{d}u\, \mathrm{d}w = 0.$$

Hence, effort is given by $(n - 1/n) r_i = C'(e_i)$ independent of the choices made by the other agents, i.e. it is a dominant strategy. The zero expected profit condition for the principal gives $V(a_i + e_i) = B_i + r_i(a_i + e_i - \bar{a} - \bar{e})$ where $\bar{e}$ is the average effort of all agents. To maximise agents' utility, the principal solves

$$\max_{r_i} \int_{\Re^n} U[V(a_i + e_i(r_i)) + r_i(w_i - \bar{w}) - C(e_i(r_i))] f_w(w)\, \mathrm{d}w.$$

It should be noted that the common production uncertainty is filtered away by the tournament. The first-order condition gives

$$\int_{\Re^n} [V e_i'(r_i) - C'(e_i(r_i)) e_i'(r_i) + (w + \bar{w})] U'[V(a_i + e_i(r_i)) + r_i(w_i - \bar{w}) - C(e_i(r_i))] f_w(w)\, \mathrm{d}w = 0$$

which we can rewrite as

$$[V - C'(e_i(r_i))] e_i'(r_i) EU' + E[(w_i - \bar{w}) U'] = 0.$$

Applying a second-order Taylor series expansion about the mean payment, we obtain

$$r_i = \left(\frac{n}{n-1}\right)\left(\frac{V}{1 + sC''\sigma_w^2}\right) \tag{4}$$

which resembles the term for the piece-rate contract except for the elimination of the effect of common production uncertainty and the inflation term $n/(n-1)$ to balance the effect of effort on the average. Inserting (4) into the zero expected profit condition gives the expression for the base payment:

$$B_i = (V - r_i)\left(a_i + \frac{n-1}{n}C'^{-1}(r_i)\right) + r_i(\bar{e} + \bar{a}). \tag{5}$$

As in the piece rate contract, when preferences exhibit constant absolute risk aversion, the marginal payment is uniform and contracts vary by the base payment according to ability. It should be noted, however, that in both tournaments and piece rates, if agents are heterogeneous in their attitude towards risk, then marginal payments (and hence induced effort) will vary across agents.

The optimal contract under yardstick competition exhibits essentially the same form, with the most notable difference being the absence of the adjustment term $n/(n-1)$.

3. Uniform contracts and market structure

An important consequence of the optimal piece-rate and tournament contracts is the need to customise them to the ability of the agent when agents are risk-averse. In the preceding section, we assumed that agents' abilities were common knowledge and that the transaction costs associated with implementation of contracts were zero. In this section, we relax both these assumptions. First, we admit that abilities are the agents' private information and that principals may learn them only at some cost. Second, the transaction costs of offering contracts are never zero, and offering individualised contracts will generate higher transaction costs in the form of information-gathering (the principal probably receives only a noisy signal about the agents' abilities) in addition to legal, administrative and accounting costs.

When the principal offers a uniform contract instead of individualised contracts, any heterogeneity in the abilities of the agents contracting with a particular principal will induce subsidies from those agents who are above the average to those agents who are below the average. This stems from the blunting of incentives induced by risk aversion (i.e. from $r < V$, when n is at least moderately large[5]). If there is a free entry of principals into the

5 From equation (4), we see that given some level of risk aversion and non-negligible idiosyncratic shocks ($\sigma_w^2 > 0$), $r < V$ for large enough n. The empirical literature on agricultural production contracts (Knoeber and Thurman, 1995; Martin, 1997; Levy and Vukina, 2001) uniformly finds that idiosyncratic production shocks are significant. In poultry tournaments, n is typically about 25, and so these conditions hold.

market for agents, those agents receiving lower rents than they would receive from an individualised contract could be systematically lured away by other principals willing to incur certain costs to learn their types. However, when all principals offer uniform (but different) contracts there is an adverse selection problem for those principals who offer better terms. Better terms in this case means the higher base payment *B*, as the slope parameter *r* should be the same for all agents because, by assumption, they are all equally risk-averse.

A focal equilibrium in the perfectly competitive case obtains when all principals offer an identical contract and each principal draws a representative sample of growers whose abilities satisfy the participation constraint.[6] As the average ability of agents is constant across principals, no agents have an incentive to defect and all principals are constrained to earn zero expected profit.

Another interesting possibility is the emergence of mixed equilibria in which some principals invest in 'screening' of agents to determine their abilities and subsequently offer individualised contracts.[7] This is likely to happen in situations where the screening costs are low relative to the variation in agents' abilities. As the principal offering these contracts would bear additional transactions costs, the contract terms will only be attractive to agents of high ability. This is because the principal's zero profit condition for each agent forces him or her to deduct those additional costs from the agent's base payment. This leads to a hybrid labour market where we observe uniform contracts targeting agents who make up the lower tail of the distribution of abilities as well as individualised contracts targeting exceptional agents.

The second type of market structure is one where principals have significant monopsony power on the market for agents' services. In contrast to the competitive (free entry) case, here contracts are optimised to capture surplus for the principal subject to the participation constraint of the agents. When a monopsonist principal offers a uniform contract, the cost of offering a uniform contract is the excess rents paid to agents of above-average ability (who gain rents through the marginal payment) as all agents exert the same effort and, by assumption, all have equal reservation utilities. In a static framework, a monopsonist could extract rents from the high-ability agents (if ability were known) by customising their contract to a lower base payment. However, dynamically this destroys the incentives to exert effort for high-ability agents if the principal learns agents' abilities through observing their earlier performance. If above-average performance leads to a lowering of the base payment, then the high-ability agents will collect their rents by

6 The uniform contract would offer a base payment equal to the expected output of the average grower who participates (this follows from the zero profit condition). Because this in turn specifies the participation constraint, the contract will be the solution to the equation

$$\int_{\Re^n} U(V(\bar{a} + e^*) + \bar{r}(\underline{a} - \bar{a} + w_i - \bar{w}) - C(e^*)) f_w(w)\, dw = 0$$

where $\underline{a}$ is the lowest ability that participates, $\bar{a}$ is the average ability of all agents with ability in excess of $\underline{a}$, $\bar{r}$ is given in (4) and e^* is the optimal effort determined in the previous section.

7 This case was brought to our attention by an anonymous referee.

shirking to mimic the low-ability agents. For this reason, we do not expect to see individualised contracts in situations where principals have monopsony power. Even if we ignore the dynamic incentive effects of custom contracts, in a more realistic scenario where agents' reservation utilities vary positively with their abilities, the rents earned by high-ability agents are likely to be fairly small.[8]

4. Empirical evidence

Production and marketing contracts for agricultural commodities are widely used in livestock industries, especially broilers, turkeys and hogs, and fruit and vegetable industries. In livestock contracts a processor company (called an integrator) contracts the production (grow-out) of animals with many independent farmers (growers). Growers typically provide land, housing facilities, utilities (electricity and water), and labour, whereas the integrator company provides animals to be grown to processing weight, feed, medications, and services of field men. Large national companies such as Smithfield Foods or Tyson dominate livestock contract production and typically run their contract production through smaller profit centres located throughout the country. Each profit centre typically has a feed mill and processing plant, and would contract with independent farmers in a geographical area around the processing plant. The size of the processing plant gravitation area, and hence the competition for growers, is determined by how far live animals can travel before reaching the processing plant. Different areas of the country are characterised by different levels of competition for growers. In some areas the competition for growers is rather fierce, in other areas the choice of integrators offering contracts is rather limited.

Each profit centre typically offers a uniform, take-it-or-leave-it linear contract to all its prospective growers. It is interesting to note that the individual contracts do not change over time despite the fact that the growers' relative ability can be measured by comparing their historical performance with the average. Moreover, there is significant empirical evidence that growers are heterogeneous in their abilities (Knoeber and Thurman, 1994; Levy and Vukina, 2001), so the integrator could possibly benefit by offering them different contracts that are tailored according to their individual abilities. Yet, offering individualised contracts, to the best of our knowledge, never happens. Our theoretical results provide two possible explanations for the overwhelming presence of uniform contracts in livestock industries: the monopsony power of the integrators on the market for growers or, alternatively, in the competitive environment, the high screening costs relative to the variation in growers' abilities.

8 As pointed out by an anonymous referee, when reservation utilities and abilities are positively correlated, the rents may also go to the low-ability agents. However, this is likely to happen only in a fairly atypical situation where the power of the incentives is very low and the payment mechanism is dominated by the base salary.

Fruit and vegetable contracts have been used in US agriculture for many years. For example, in California, lettuce have been grown almost entirely under contract since the 1930s, when it became technologically feasible for California farmers to ship fresh lettuce to cities in the East. Similarly, contracting has long been the primary means of procuring raw product in processing and canning industries (Hueth *et al.*, 1999). The contracts are written by shippers or other intermediaries, who contract for the delivery of produce with independent farmers. The shipper then markets the produce either to the final consumer or more often to some other customer (e.g. supermarket, restaurant chain or broker). These contracts are generally short term (one season or one harvest). In addition to written contracts, contracting can also occur through a less formal mechanism that is enforced only implicitly through conventions, reputation and repeated interaction. Even in the case of written contracts, there may still be a number of provisions that are only implicitly understood by both parties (Hueth *et al.*, 1999).

Unlike with the livestock contracts, the preferential treatment of certain agents is more common in the fruit and vegetable industries. For example, growers who can secure larger volumes or more consistent quality of produce are sometimes offered better deals.[9] These observations seem consistent with our theoretical result of mixed equilibria on the labour market for growers, which occurs in situations of relatively low screening costs and/or high variation in growers' abilities. The heterogeneity of growers is largely caused by differences in quality management because these commodities are very likely to be inspected and evaluated by consumers in their primary and unprocessed form. However, quality is also important for processed fruit and vegetables, where factors such as sugar content, acidity, ripeness and consistency, among others, are highly valued by processors. On the other hand, the quality issues are entirely absent in livestock contracts because the production process is highly standardised and quality differences of the final product (such as fat content in meat, texture, colour) are determined either by the quality of inputs (genetic material and feed) or by processing practices. Both the provision of inputs and the meat processing are the responsibilities of the integrators and as such are beyond growers' influence. Therefore, it is reasonable to believe that the heterogeneity in growers' abilities is more pronounced in fruit and vegetables than in livestock contracting, which may be a critical driving force separating the two equilibria in the market where processors are competing for growers' services.

5. Conclusions

In this paper we specified the optimal properties of one-period linear contracts based on cardinal tournaments or simple piece rates in situations where a risk-neutral principal offers production contracts to many agents

9 As mentioned by an anonymous referee, favoured growers are treated better, offered more services, and promised continued contracting opportunities in the future but the grower-specific elements of the contract are just not explicit.

with different but observable abilities. We show that when the principal operates in a perfectly competitive environment with no transaction costs, the optimal linear contract is customised to the ability of the agents when they are risk-averse. The same is true even for risk-neutral agents but only when their payments are determined in a tournament setting. However, any transaction cost associated with the optimal linear contract would cause some principals to offer a uniform contract to all their growers. In a market characterised by the competition for growers, we anticipate two possibilities for equilibria. In an equilibrium where all principals offer uniform contracts, the contracts should be essentially identical across principals. Alternatively, in situations where the screening costs are low relative to the variation in agents' abilities, mixed equilibria could emerge in which some principals invest in 'screening' of agents to determine their abilities. This leads to a hybrid labour market where we observe uniform contracts targeting agents who make up the lower tail of the distribution of abilities as well as individualised contracts targeting exceptional agents. Additionally, uniform contracts are likely to prevail when principals have monopsony power even if transaction costs are completely absent.

We also examined the validity of a transaction costs explanation for why we mostly observe uniform contracts when the optimal linear contract is a customised contract. We focused on industries characterised by a long-term relationship between a firm and its agents where there is evidence of differences in agents' abilities that the principal can assess through the settlement of the series of contracts over time, yet we mainly observe short-term uniform contracts. The theoretical results and intuition developed seems to be supported by the empirical evidence provided by agricultural contracts in the United States.

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