Production Control and Production Contracts: Why Do Integrators Control Inputs?

Rachael E. Goodhue

Presented at Western Agricultural Economics
Association 1997 Annual Meeting
July 13-16, 1997
Reno/Sparks, Nevada

Production Control and Production Contracts:

Why Do Integrators Control Inputs?

Rachael E. Goodhue

Department of Agricultural and Resource Economics

University of California at Berkeley

Abstract: In broiler and hog production contracts the integrator provides or specifies major non-labor inputs. Previous work attributed this pattern to quality considerations, which does not explain widespread concern among producers regarding loss of management control. I demonstrate that integrators reduce payments to producers by controlling inputs, regardless of quality considerations.

Production Control and Production Contracts:

Why Do Integrators Control Inputs?

Abstract: In broiler and hog production contracts the integrator provides or specifies major non-labor inputs. Previous work attributed this pattern to quality considerations, which does not explain widespread concern among producers regarding loss of management control. I demonstrate that integrators reduce payments to producers by controlling inputs, regardless of quality considerations.

Contracting has long accounted for the vast majority of broilers produced and is the norm for many processed vegetables. Recently, contracting has expanded its share of output in other products, particularly pork. Barkema & Cook (1993) indicate that 10 to 15% of the nation's hogs were produced under contract in 1990, double the share under contract in 1980. The increasing importance of production contracts and the accompanying potential for thinning spot markets has focused public concern on the effects of contracting. The Economic Research Service (ERS) of the USDA has identified three major concerns regarding the spread of contracting: the environmental effects of contract production, the concentration of control of production associated with contracting, and the distribution of the benefits of contracting (Economic Research Service, 1996). Relatively little is known about the underlying incentives and fundamental forces that govern the forms and effects of production contracts. An understanding of these incentives is required in order to determine whether there is an economic basis for public concerns and perceptions regarding the effects of these production contracts. This paper examines integrators' control of major non-labor inputs.

Input control is an important feature of broiler and hog production contracts. The division of major inputs between producers and integrators is consistent across contracts. The integrator supplies the chicks, pigs or breeding hogs, feed and management guidelines (Goodhue, 1996; Knoeber, 1989; Martin, 1994). The producer provides labor and integrator-specified capital equipment. Based on the consistency of this division, I address the following question: Why do integrators choose to supply or specify major

non-labor inputs? I then address producers' concerns regarding the structure of these contract. Loosely speaking, contracts are a means by which farmers protect themselves against income risk while sacrificing control and potentially returns. Many producers are resistant to the idea of yielding control over the production process and effectively becoming labor on their own land. Why are producers so concerned about sacrificing control? Is this due to cultural factors, or is there an underlying economic rationale?

This paper uses an agency theoretic model of production contracts to evaluate the incentives underlying integrators' control of key inputs and provide insight into farmers' concerns regarding their loss of production control. The risk shifting properties of production contracts have been examined for the broiler industry (Knoeber and Thurman, 1994) and the hog industry (Martin, 1994). Here I abstract from risk considerations to focus on the issue of production control and the effect on farmer returns.

The standard explanation for vertically coordinated production control focuses on product quality and innovation (Hennessy 1996, Knoeber 1989). These explanations do not directly address why producers should be concerned about the transfer of production control to integrators. Rather, they provide reasons why control is desirable for the integrator and may increase returns. In contrast, this paper considers input control in the context of the producer-integrator relationship. It demonstrates that input control increases the integrator's returns and lowers the returns to producers as a group when producers are heterogeneous, even in the absence of any considerations related to quality or innovation.

Previous Literature

Previous analytical work on production contracts has focused on the risk-related properties of these contracts and the compensation measures they use in the context of homogeneous producers. Knoeber and Thurman (1995) find that on a per flock basis broiler production contracts shift most price and production risk from growers to integrators, compared to spot markets. Martin (1994) performs a similar risk-shifting analysis for pork production contracts, and finds that producers who choose to contract reduce their income variability.

Mitra, Netanyahu and Just (1996) develop a bargaining model of horizontal and vertical integration which they apply to the historical development of the broiler industry in the Delmarva peninsula. In their formulation contracting imposed homogeneity on producer technology and productive capacity. In another paper, Netanyahu, Mitra and Just (1996) attribute the evolution of contract terms over time to a two-sided moral hazard problem. This analysis takes the allocation of input control as given.

Knoeber (1989) analyzes the role of relative compensation in broiler contracts in the industry's rapid post-war technical progress. Input control allowed the integrator to impose technical innovations. These papers all discount the role of grower heterogeneity.[1] Similarly, with the exception of Knoeber, the incentives underlying the pattern of input control are not examined. This paper focuses on precisely the issues neglected in this previous work; input control and producer heterogeneity.

---

[1] Grower heterogeneity is considered in Knoeber and Thurman (1994) for purposes of testing tournament theory, but the effects of heterogeneity on the integrator's decision problem are not explored.

Producer heterogeneity is an important feature of the agricultural sector. Farmers differ in terms of their farm size, income sources, and management abilities. Heterogeneity across producers is an important factor in major agricultural production decisions (Just & Zilberman 1983, Caswell & Zilberman 1986). For broilers, observers note that some growers consistently perform better than the average while others consistently perform worse. This paper incorporates a recognition of heterogeneity in producer management abilities into the integrator's contracting decision.

The control of non-labor inputs has been neglected in the general agency theory literature. In contrast to this paper, which examines the principal's control of non-labor inputs as a means of minimizing the information rents paid to agents, the agency theory literature generally has assumed that there is no substitutability between labor and other inputs when considering the principal's incentive problem. Khalil & Lawarree (1995) examine a related neglected issue, residual claimancy as a source of information rents. When input and output monitoring are equally costly but feasible the principal will prefer monitoring labor when she is the residual claimant and monitoring output when the agent is the residual claimant. Maskin & Riley (1985) compare input to output monitoring when the agent is the residual claimant, and find that output monitoring is preferred, since high-ability agents will exert more effort when their marginal incentives are not distorted.

Modeling the Role of Input Assignment in Contract Farming

The starting point of mechanism design theory is that an individual known as the principal would like to base her actions on private information held by other individuals,

4

called agents. The agents will not truthfully provide this information unless the principal

gives them incentives to do so; since it is costly to extract this information, an inefficient

allocation often results. Mechanism design is concerned with identifying the optimal

contract that accounts for this tradeoff between informational and allocation costs. Under

the optimal hidden information contract, the principal chooses an allocationally

inefficient contract menu in order to minimize the sum of information and production

costs. This paper establishes that when the principal assigns or specifies input use, as

agricultural integrators do, she increases her profits by limiting the information rents high

ability agents (producers) can extract in exchange for truthfully announcing their types.

The model consists of a single risk-neutral principal facing n risk-neutral agents.

Agents are one of two types: high ability h with probability p and low ability l with

probability 1 - p. These probabilities are known to everyone.. Output is observable.

Agents' types and input use are unobservable to others. The only way that the principal

can control input usage is to directly administer inputs. A contract can not be written

contingent on input usage, since inputs are unobservable. Production by an agent of type

i is a function of the agent's type-specific productivity parameter t_i, effort a_i and an

input Q_i that may be provided by the processor or the producer at a constant unit cost of

c. Output for type i is assumed to be constant returns to scale and is specified as follows:

(1) $x_i = Q_i^\rho a_i^\phi t_i$

The principal maximizes profits. The agents maximize utility, which is separable

in income and effort. Agents face an increasing marginal disutility of effort. The agents'

utility is defined as follows:

5

(2)   Utility = income - v(effort)

where the first and second derivatives of v with respect to effort are positive. Attention is restricted to affine compensation functions, so income is defined as the sum of the piece-rate payment multiplied by output and a lump-sum transfer.

(3) $y_i = w_i x_i + T_i$

The timing of the model is as follows: the processor offers a menu of contracts, growers announce their types by choosing a contract, production occurs, output is observed, and growers are compensated.

Profit Maximization: Input Assignment

The integrator provides two necessary inputs, animals and feed, to producers. The integrator chooses the amount and quality of the input and when it is supplied. Capital equipment, although owned by producers, must be built and maintained according to integrator requirements. This paper analyzes a single composite input and establishes that the principal increases profits by specifying input amounts. When agents' types are unknown, the principal's need to provide incentive compatible contracts drives a wedge between her cost of a specified pair of output levels for the two agent types and the agents' utility-maximizing (and production cost minimizing) production decisions. When the principal controls the input, she can reduce this wedge. Control over the input reduces the cost of maintaining incentive compatibility for high productivity agents.

In contrast to the broiler and hog contracts considered here, in some sharecropping contracts the landlord pays a share of the cost of variable inputs such as seed and fertilizer, but allows the sharecropper to choose the input levels. These

arrangements may be chosen because the principal's knowledge of production is less accurate than the agent's, or production knowledge is relatively expensive for the principal to collect, so that losses due to information rents are relatively small compared to the cost of reducing them. I do not consider this possibility. The principal has the same information regarding production and profit-maximizing input use as the agents, but can not correctly assign agents to one of the two contracts. Contracts must induce agents to reveal their types.

To provide insight into the nature of the informational advantage of input control, I begin by analyzing the principal's choice of contracts in the first best case when types are known. When types are known, the principal's ability or inability to control the input does not affect her choice of contract. When types are unknown, Proposition 1 shows that the principal increases her profits by assigning the input, which reduces the cost of maintaining incentive compatibility for the high ability agent.

Known Types.

The case of known types is the theoretical benchmark for evaluating the hidden information case. When the principal can restrict heterogeneous agents to their reservation utility levels, she can increase profits by designing different contracts for the different types. When there is no hidden information, however, the principal does not gain from controlling the input in addition to specifying the output level. The principal and the agent have identical production costs, and there are no information costs so both will choose the input combination that minimizes production costs, the "neoclassical" allocation, for any output level.

Fact: *When types are known, the principal's ability or inability to control the input does not affect her profits or choice of contracts.*

Proof. When the principal knows agents' types and can restrict agents to their reservation utility level, the production cost of a given level of output is its total cost. The principal does not face any incentive compatibility constraints, so the maximization problems may be solved by substituting the agent's individual rationality constraint into the principal's objective function.

Consider first the case where the principal assigns the input. Using the principal's first order conditions and the definition of a_i derived from the agent's cost minimization problem, the following expression is obtained for the ratio $\dfrac{x_i}{a_i}$.

(4) $\qquad \dfrac{x_i}{a_i} = \left(\dfrac{p\rho}{c} \right)^{\frac{\rho}{\phi}} t_i^{\frac{1}{\phi}}$

When the agent chooses the input, the principal's first-order condition and the agent's first-order condition result in the following expression for the ratio $\dfrac{x_i}{a_i}$:

(5) $\qquad \dfrac{x_i}{a_i} = \left(\dfrac{p\rho}{c} \right)^{\frac{\rho}{\phi}} t_i^{\frac{1}{\phi}} .$

The ratios when the principal chooses the input in (4) and when the agent chooses the input in (5) are identical. Since v( ) is everywhere increasing in a, the ratio $\dfrac{x_i}{a_i}$ corresponds to a unique level of output, and the same output and input levels are selected regardless of which party controls the input in the first-best case.

Unknown Types.

In the first-best case, the agent and the principal face the same production costs. Whoever controls the input will select the neoclassical production cost-minimizing ratio of effort and the input. In the hidden information case, information costs drive a wedge between the cost of any level of output for the low ability agent and for the principal. The agent faces the same costs of production as in the first-best case, but the principal faces information costs in addition to production costs. When types are unknown, the principal's choice of inputs is affected by these incentive considerations. In particular, for a fixed level of output the principal provides proportionately more of the input relative to agent effort than she does in the first-best case, in order to reduce the high ability agent's information rents, which are a function of the gap between the effort a low ability agent must exert and the effort a high ability agent must exert to produce the specified level of output x_l. Hidden information increases the cost of low agent effort relative to the cost of the input for every specified pair of output levels for the two types. When the principal assigns the input, she can respond to this change in her relative input prices by adjusting the input mix away from effort and toward the input for the low ability contract. When the agent controls the input, the principal can not adjust her input mix. Consequently, profits under hidden information are lower when the agent controls the input.

Proposition 1. *When types are unknown, the principal increases profits by assigning input levels according to type rather than allowing agents to choose their own input levels.*

Outline of Proof: First, the agent's decision problem and the principal's decision problem are considered in the first-best case where types are known. Then the decision

problems are considered for the case where the agent chooses the input. Comparing this system to the first-best system, the low ability agent's output level is reduced, but the input ratio is the same as the first best input ratio *for that second-best output level.* The contract for the high ability agent requires him to produce the first best level of output, but pays him information rents in order to prevent him from choosing the low-ability agent's contract. Finally, the case where the principal chooses the input is evaluated. Comparing this system to the first-best case, the low ability agent's output is reduced, and the principal chooses relatively more of the input and less low agent effort than she would in the first-best case for that specified output level. That is, information costs distort the principal's input choices away from the first-best, or neoclassical, ratio. These results are used to compare the principal's profits under the two second-best cases. The principal's profits are higher when she assigns inputs rather than allowing the agents to choose their input levels. This completes the outline of the proof. (The complete proof is available form the author upon request.)

The proposition is illustrated by a numerical example. The following specifications are used: $t_l = 1$, $t_h = 2$, price = 1, c = 2, p = 1 - p = 0:5, $v(a) = a^2$, and $\phi = \rho = 0.5$. Effort, input and output levels for both types and the ratio of input use to effort for the low ability agent are summarized in the table for the first best case and the second best cases where the principal assigns the input and the agents choose the input. Note that the ratio of input use to effort is distorted upward when the principal controls the input relative to the first-best ratio for that level of output. When the agent controls the input, in contrast, the ratio is not distorted. The principal's choice of x_l is distorted

downward when the agent controls the input relative to when the principal herself controls the input.

Table 1. Proposition 1 Example

Var.	First Best	P Controls Q	A Controls Q
a_h	0.5	0.5	0.5
Q_h	0.5	0.5	0.5
x_h	1	1	1
a_l	0.125	0.06452	0.00806
Q_l	0.03125	0.01613	0.01053
x_l	0.0625	0.03226	0.02764
Q_l / a_l	0.25	0.25	0.14512
Q_l / a_l (first-best)	---	0.04021	0.14512

This result provides an incentive-based reason why principals, such as agricultural integrators, may choose to supply their agents with inputs. The principal can reduce information rents and increase profits by controlling the input. This solution highlights a different dimension of the relationship between growers and processor than traditional explanations do, such as differential access to credit, different costs for obtaining the input and agent liquidity constraints.

Conclusions and Implications

Using an agency theory framework, this paper establishes that integrators may drive low-ability growers to their reservation utility level and that they can effectively reduce the information rents received by high-ability agents through their control of inputs. This outcome has an important implication for the effects of contract farming and its role in agricultural industrialization. It will increase the integrator's profits if she can reduce agents' reservation utility levels. Thus if a processor with market power in the spot market for growers' output also contracts for production, her decisions in the two markets will be linked not only by total input needs but also by the effect that expected spot prices have on growers' expected profits as independent producers. Independent production determines growers' reservation utility level, so if the processor depresses the returns to independent production she reduces her cost of contract production. (Her ability to do so is limited, of course, by the outside opportunities available to growers.) This effect supports producers' intuition that contract farming adversely affects independent producers.

While vertical coordination of agricultural production may indeed aid in obtaining raw materials with the attributes necessary to meet the needs of ever more finely defined final markets, it also has real consequences for the pattern of returns across levels of the production chain. Integrators reduce their payments to producers by controlling non-labor inputs regardless of any quality considerations. Farmers' concern regarding the loss of management control embodied in these production contracts is based on real economic effects; losing production control is costly for producers.

References

Barkema, A. & Cook, M. L. (1993). "The Changing U.S. Pork Industry: A Dilemma for Public Policy." *Economic Review* 78(2): 49-66.

Caswell, M. F. & Zilberman, D. (1986). "The Effects of Well Depth and Land Quality on the Choice of Irrigation Technology." *American Journal of Agricultural Economics* 68(4): 798-810.

Economic Research Service, Farm Business Economics Branch, Rural Economy Division, United States Department of Agriculture. (1996). "Farmers' Use of Marketing and Production Contracts." Agricultural Economic Report 747. Washington, DC.

Goodhue, R.E. (1996). "Contracting in the Broiler Industry." Working paper. Department of Agricultural and Resource Economics, University of California at Berkeley.

Hennessy, D. A. (1996). "Information Asymmetry as a Reason for Food Industry Vertical Integration." *American Journal of Agricultural Economics* 78(4): 1034-1043.

Just, R. E. & Zilberman, D. (1983). "Stochastic Structure, Farm Size and Technology Adoption in Developing Agriculture." *Oxford Economic Papers* 35: 307-328.

Khalil, F. & Lawarree, J. (1995). "Input versus Output Monitoring: Who is the Residual Claimant?" *Journal of Economic Theory* 66(1): 139-157.

Knoeber, C. R. (1989). "A Real Game of Chicken: Contracts, Tournaments, and the Production of Broilers." *Journal of Law, Economics and Organization* .

Martin, L. L. (1994). *Pork...The Other White Meat?* Ph.D .thesis, North Caroline State
University, Raleigh, North Carolina.

Maskin, E. & Riley, J. (1985). "Input versus Output Incentive Schemes." *Journal of
Public Economics* .

Mitra, S., Netanyahu, S. & Just, R. E. (1996). "A Bargaining Theory Approach to
Industry Integration." Presented at 1996 AAEA annual meetings.

Netanyahu, S., Mitra, S. & Just, R. E. (1996). "Behavioral Risk: An Explanation of
Contracts in the Broiler Industry." Presented at 1996 AAEA annual meetings.