ELSEVIER

International Food and Agribusiness
Management Review 3 (2000) 339–352

International Food and Agribusiness Management Review

Rent sharing mechanisms in production alliances

Brian P. Cozzarin[a,]*, Randall E. Westgren[b]

[a]*Institute for Innovation Research and Department of Management Sciences, University of Waterloo, 200 University Avenue West, Waterloo, Ontario, Canada N2L 3G1*
[b]*Department of Agricultural and Consumer Economics, University of Illinois, 1301 West Gregory Drive, Urbana, IL 61801, USA*

Abstract

U.S. hog production has become an industrialized process. New technology has caused the scale of operations to increase, and the organizational form of hog farms to change. One of the new organizational forms can be found in North Carolina and Colorado where vertical integration and/or franchise-like production methods prevail. This type of production may not be possible or appealing to some producers. Instead, they may be able to reap some of the benefits of specialization by forming strategic alliances. The purpose of the paper is to answer the question: is it possible to create the same sort of control mechanisms in a production alliance that exist in a vertically integrated firm? Production risk is potentially one of the greatest problems in an alliance. We represent production risk with two measurements of performance—pig weight, and pig mortality. We find that high mortality has severe consequences for pig production. But, with appropriate rent allocation mechanisms, the member who causes under-production will be forced to bear most of the consequences. © 2001 Elsevier Science Inc. All rights reserved.

1. Introduction

U.S. hog production is evolving organizationally because the technology lends itself to large-scale production practices (Grimes & Rhodes, 1995; Lawrence, 1997). Boehlje and Hurt (1996) characterize the industrialization process as a shift from commodity production to the manufacture of food products, a shift from hog production as an art to a reproducible scientific endeavor, a shift from small-scale lumpy processes to a systems approach with sophisticated batch process technologies. Very large, vertically integrated hog farms found

* Corresponding author. Tel.: +1-519-888-4567, x3291; fax: +1-519-746-7252.
E-mail addresses: bpcozzar@engmail.uwaterloo.ca (B.P. Cozzarin), r-westg@uiuc.edu (R.E. Westgren)

1096-7508/00/$ – see front matter
PII: S1096-7508(01)00052-0

in North Carolina, Colorado, and elsewhere, take advantage of scientific production methods. Vertically coordinated systems are more capable of identity preserving product characteristics and of passing information through marketing channels than traditional spot markets.[1] As hog production evolves small scale producers with limited finances are faced with a dilemma—either leave the industry or become employees of vertically integrated firms.

Westgren (1994) identified another option for enhancing the competitiveness of producers—the formation of strategic alliances. A three-firm hog production alliance, designed to take advantage of the science embodied in the new technology would seem to be a viable alternative to the vertically integrated model. However, a major concern for producers is how to share the rents from an alliance to ensure good performance from all members. Game theoretic sharing rules may provide the necessary structure within an alliance to accomplish the task.

The objectives of the paper are twofold: to compare outcomes for various rent sharing mechanisms within an alliance under varying conditions, and also to explain the results. The paper is organized as follows: section two discusses related research on alliances. Section three characterizes the contractual nature of the alliance organizational form. Section four gives a description of the simulation method used in the analysis. Section five discusses the simulation model. Section six delineates the experiments. Section seven summarizes the data and assumptions. The results of the simulations are presented in section eight, and the conclusion follows.

2. Related literature

Cozzarin and Westgren (2000) demonstrate that production problems, and agency problems in three-site hog production could be more easily dealt with in a franchise (sometimes called an "integrator") rather than in an alliance.[2] The franchise has mechanisms to control and mitigate agency problems, such as management replacement clauses, 30-day cancellation clauses, and penalties for poor feed conversion. It was demonstrated that the financial burden placed on production stages causing underproduction was higher in a franchise than in an alliance (Cozzarin & Westgren, 2000).

The resource-based theory of the firm (Mahoney, 1992; Mahoney & Pandian, 1992; Conner, 1991) maintains that certain resources within a firm can lead to sustainable competitive advantage because they are inimitable. Barney (1991) notes that resources earn sustained rents if they are—valuable, rare, nonsubstitutable, and inimitable. Mahoney and Pandian (1992) typify a firm's ability to capture and maintain rents as due to distinctive competences (which relate to resources). It is the organizational capital of an alliance that is the most difficult resource for a competitor to imitate (Westgren, 1994). It can be a sustainable source of quasi-rents for the members. In terms of an agricultural production alliance the contractual nature of the rent sharing mechanism is one of the key resources that could earn and sustain rents. For this reason the rent sharing mechanism is in our view paramount to a successful and long-lived alliance.

3. Contractual form

An alliance is an important organizational form midway between complete vertical integration and spot market transactions (Peterson & Wysocki, 1998). Members of the alliance generally finance their own capital and equipment purchases for their production stage. They can therefore increase the scale of their individual operations (through specialization) without having to amass huge sums of equity that would be required for a typical vertically integrated hog farm. They are also able to retain most of their autonomy (they are of course still bound by the contractual commitments that they have within the alliance). Alliance contracts are proprietary, and little is known about the magnitude of differences in these specifications and about their performance implications. In the absence of this empirical information, employing models of hypothetical contracts may aid in future contractual design.

Fisher[3] (1998), Kliebenstein and Lawrence (1995), and Koehler, Lazarus, and Buhr (1996) provide the starting point for the contractual nature of the alliance. The rent-sharing nature of the alliance form is based on cost of production sharing rules (Fisher). The three alliance members are joint residual claimants—profit is computed on the day pigs are sold, and is divided according to *a priori* sharing rules. Specifically, facilities at each stage of production are individually owned. Feed is purchased individually by each producer at each stage of production. Replacement gilts are purchased rather than bred on farm. Revenues are used to pay each member's costs of production, and then the residual rent (profit) is shared based upon each firm's relative cost per pig (based on a historical average). Profits and/or losses are shared jointly at the end of each period and the sharing rule for all three members co-operating is based upon each firm's relative cost of production per unit.

There are two game theoretic payoff structures, one is used for pig weights, and the other is used when underproduction occurs. Weight monitoring of pigs (as they transfer from one stage to the next) is assumed to be a sufficient statistic for inferring management effort, and ability. Members who do not supply pigs at the minimum weight receive compensation only for their production costs for that particular batch (they receive no profits). The second payoff structure is used to punish a member who causes underproduction in the system because of high pig mortality. The member responsible for low productivity or low pig weights surrenders his share of the profits to the others.

We will now discuss the weight payoff structure in detail. The pigs are weighed (as a batch) at each transfer point. If the current batch of market pigs has met the contractual weight specifications at each transfer point then total profit is computed (stage three's revenues minus the sum of stage one, two and three's costs), and then for simplicity we make the assumption that it is split between the members based on the cost of production sharing rules (λ_i).[4] This is a version of the "split the difference" rule discussed by Sutton (1986).[5] If the pigs transferred from stage one were underweight then stages two and three take one-half each of stage one's profits (stage one receives no profit). If pigs from stage two were underweight upon the transfer to stage three, then stage one and stage three share stage two's profit equally (stage two receives no profit). Similarly, if pigs from stage three are underweight then stages one and two divide stage three's profits. If two members supply underweight pigs, then the third member gets 100% of the profit. If all members are at fault the

Table 1
Game theoretic sharing rules for mortality and weight monitoring

Case	Sharing rules (λ_i)	Calculated sharing rules
(a) S1, S2, S3 responsible	$(\lambda_1, \lambda_2, \lambda_3)$	(0.25, 0.15, 0.60)
(b) S1 responsible; S2, S3 not responsible	$(0, \lambda_2 + ½ * \lambda_1, \lambda_3 + ½ * \lambda_1)$	(0, 0.275, 0.725)
(c) S2 responsible; S1, S3 not responsible	$(\lambda_1 + ½ * \lambda_2, 0, \lambda_3 + ½ * \lambda_2)$	(0.325, 0, 0.675)
(d) S3 responsible; S1, S2 not responsible	$(\lambda_1 + ½ * \lambda_3, \lambda_2 + ½ * \lambda_3, 0)$	(0.55, 0.45, 0)
(e) S1, S2 responsible; S3 not responsible	(0, 0, 1)	(0, 0, 1)
(f) S1, S3 responsible; S2 not responsible	(0, 1, 0)	(0, 1, 0)
(g) S2, S3 responsible; S1 not responsible	(1, 0, 0)	(1, 0, 0)
(h) S1, S2, S3 cooperate	$(\lambda_1, \lambda_2, \lambda_3)$	(0.25, 0.15, 0.60)

S1 = breeding, gestation, and farrowing, S2 = nursery, S3 = finishing.

residual rents (or more likely, loss) will be shared equally. The eight sharing rules are presented in Table 1.

The second game theoretic payoff structure is designed to penalize the production stage that has low productivity (caused by high mortality). The profit sharing rules (λ_i) based on capacity are the same as those used for monitoring pig weights (Table 1). Because of the sequential nature of the production process some of the sharing rules are irrelevant. In other words, stages two and three should not be punished for high mortality in stage one. Similarly, stages one and three should not be punished for high mortality in stage two. Hence only sharing rules (b), (c), and (d) are relevant from Table 1.

4. Simulation technique

System dynamics is a simulation method that has been used extensively to model production processes (both batch and continuous), as well as financial, and management control processes within firms (Lyneis, 1980). There are three major components in a dynamic system: state variables, control variables, and feedback loops. State variables that are conserved (accumulated) represent a stock, while state variables that are not conserved are indicators of some condition of the system at a given instant (*dt*). Control variables update or change the state variables with the passage of each time step. Feedback loops can be of two types: positive feedback loops reinforce the variable that causes a change in the state variable, while negative feedback loops counteract the initial change in the state variable. The interactions between positive and negative feedback loops can be complex because both types can be nonlinear, and hence their interactions can cause nonlinear (possibly unexpected) results.

5. Model

A 300-sow high technology operation was modeled with 14-day, segregated early weaning, split-sex, phase feeding and all-in/all-out production technologies. The rationale for choosing a 300-sow operation was based on the fairly low capitalization requirements, which would make the system accessible to most small-scale hog producers.[6]

The breeding, gestation, and farrowing unit (S1) has a sow herd consisting of 329 pigs. Sows become pregnant at a rate of 2.063 per day (this is an abstraction having a fraction of pregnant sows, however, it is resolved because only integer values of hogs are marketed) and then move on to the gestation unit (264 head capacity). The sows remain in the gestation unit until it is time to farrow (for 115 days). On the 116th day the sows move to the farrowing unit where they are assumed to farrow immediately. The sows and piglets remain in the farrowing unit for 14 days. Then the piglets move on to the nursery unit, and the sows return to the breeding herd where they may be culled, die or return to estrus. The weaned pigs spend 56 days in the nursery (S2), and are then transferred to the finishing unit (S3), where they remain for an additional 126 days. The output from the finishing unit is market pigs. Market pigs are subject to a packer's pricing grid (pigs are valued in terms of backfat and live weight and penalties are imposed for underweight pigs and/or fat pigs) obtained from Lee (1994). The weight submodel draws an initial mean weight for the stage one group of pigs (pigs move through the system on a daily basis in groups—thus if we omit deaths for expository purposes, 2.063 farrowings occur per day, and 9.27 piglets survive per litter, then 19.12 pigs move from the farrowing unit to the nursery unit). In stage two a stochastic daily gain is added to the stage one final weight over the time interval spent in the nursery. The stage three weights are computed in the same manner.

The model calculates the consumption and cost of ten feeding rations. Feed consumption is a fixed amount per day per animal, depending on whether it is part of the breeding stock, a nursery pig, or a feeder pig. The breeding stock is fed a gestation diet year round; the only exception is when sows farrow, in which case they are fed a lactation diet. Four diets are fed to the market pigs in the nursery (segregated early weaning starter, transition starter, phase II starter, and phase III starter). Four diets (of decreasing lysine content) are fed to the pigs in the growing and finishing stage (grower 110, grower 100, finisher 90, and finisher 75). The cost of production for feed has actual (historical) input prices for the two main ingredients—soybean meal (48% protein), and corn. Replacement gilts are valued at $240 each.[7] Each batch of pigs is tracked from one stage to the next so that costs (especially feed related costs) can be properly allocated. The costs in each stage include: feed costs for each ration, a fixed labor charge per head, a building cost, and other costs (utilities, hauling, veterinary and medicine, supplies, operating interest, and miscellaneous).[8]

The model was simulated over the last complete pig cycle as identified by Kenyon and Purcell (1996). The cycle was from November 1988 to November 1994. At the start of the cycle in November 1988, the price for market hogs was $36.33/cwt; the peak of the cycle (in terms of price) was attained in May, 1990 at $62.59/cwt. The end point of the cycle was reached in November 1994 with a price of $28.17/cwt.

6. Experiments

The simulation experiments in the paper take contractual design and the behavior of the agents as exogenous.[9] Alliance members are assumed to cooperate with each other by supplying high quality pigs, unless there is an exogenous increase in the mean of the death rates in a particular production stage. Barring an increase in mortality, the outcome or total surplus will be the same in each experiment. What will differ is the way in which the surplus is divided among the members.

Two types of experiments were conducted: full capacity, and undercapacity. The two full capacity experiments were done to give baseline returns for each organizational form. The undercapacity experiments were designed to simulate the effects of one stage (with poor management ability) that causes low productivity (viz., high mortality). Different experiments examine the potential for inflicting financial penalties on the member responsible for low quality (low pig weights) and low productivity (underproduction due to high mortality).

In experiments 1 and 2, the simulation models operate at full capacity. The first (baseline) experiment does not have penalties for underweight pigs. The second experiment has game theoretic sharing rules for monitoring the weights of pigs leaving each stage of production.

Additional experiments were conducted in which an alliance member causes undercapacity in the system. Experiments 3 to 8, have a profit sharing rule designed to punish the party that underproduces but no penalties (bonuses) for under- or overweight pigs. If biological data were obtainable, it would be possible to add the extra costs necessary to bring a group of underweight weaned pigs to 60 lbs. during their 56-day stay in the nursery. According to Vinson[10] (1997) such biological data do not exist, so the extra costs could not be included in the model.

In Experiment 3, S1 may have high mortality, but no penalties are imposed. Low productivity was modeled by increasing mortality in the farrowing unit (the same result could have been obtained by having a stochastic farrowing rate). The death rate was modeled as a uniform density with 1% as the minimum and 45% as the maximum. On average the number of pigs marketed over the 6-year period of the contract is 30,300.[11]

In Experiment 4, if S1 is undercapacity, and total profit is positive, then S1's share of the profit falls to zero (sharing rule (a) in Table 1), otherwise if there are losses, S1 must share in them (sharing rule (d)). In Experiment 5, S2 causes undercapacity by having a stochastic death rate in the nursery (uniform density, bounded by a minimum 2.5% death loss and a maximum 45.66% death loss resulting in an average of 30,300 pigs marketed over the 6-year period).[12] There is no penalty for being undercapacity, and there is no monitoring of pig weights. Experiment 6 is the same as Experiment 5, except that when S2 is undercapacity and total profit is positive then S2's share of the profit is zero (sharing rule (b)), otherwise S2 must share in the alliance's losses (sharing rule (d)). In Experiment 7, S3 may produce below capacity by having a stochastic death rate in the finishing barn (uniform density, bounded by a minimum of 4% death loss and a maximum of 47.12% death loss resulting in an average of 30,300 pigs marketed over a 6-year period). There is no penalty for undercapacity nor is there monitoring of pig weights. Experiment 8, is the same as Experiment 7, except that when S3 is undercapacity and total profit is positive then S3's share of the profit is zero (sharing rule (c)), otherwise S3 must share in the alliance's losses (sharing rule (d)).

Until this point, the experiments have used only one game theoretic structure at a time. In experiments 9 to 14 the weight and capacity payoff structures are combined. The added complication of two bonus-penalty schemes requires that profits must be split in some manner between them. In Experiment 9, S1 may be undercapacity (high mortality). Pigs marketed over the 6-year simulation period total 30,300. There is monitoring of pig weights (using the earlier penalty structure for underweight pigs), and there are penalties for underproduction. Total profit is split between two profit pools. The first profit pool uses sharing rules to distribute profit based on capacity performance. The sharing rule between alliance members when S1 is undercapacity is the same as before: when S1 is undercapacity and profits are positive then S1 receives zero profit from the capacity performance pool, and S2 and S3 share profits via sharing rule (a), otherwise, if profits are negative then sharing rule (d) comes into effect. The second profit pool distributes profit based on weight performance. Initially, we assume that profit is split with 75% going into the profit pool for capacity performance and 25% going into the profit pool for weight performance. Experiment 10, is the same as Experiment 9 except the profit is split with 25% going into the capacity pool and 75% into the weight performance pool. Experiments 11 and 12 are the same as experiments 9 and 10 in terms of profit distribution, however, S2 experiences high mortality instead of S1. Experiments 12 and 13, again are the same as experiments 9 and 10 with respect to profit distribution, except S3 is responsible for high mortality. The experiments are summarized in Table 2.

7. Data and assumptions

The hog price used for the analysis was the Omaha terminal market cash price $/cwt. The corn price was the East-Central Illinois cash price for #2 Yellow $/bushel. The soybean meal price was the Decatur Illinois cash price with 48% protein on the rail in $/ton. Daily price data were obtained from the Office for Futures and Options research. The data covered the period from 4 January, 1988 to 30 November, 1994 and were averaged to form a monthly time series. The production cost model by Vinson (1994, 1997) was the basis for computing dynamic production costs for each stage of production.[13] The mean weaned pig weight was 10 lbs. (normally distributed with standard deviation of 2 lbs.). The feeder pigs exiting from S2 had a mean weight of 60 lbs. (normally distributed with standard deviation of 8.3 lbs.). The finished pigs were sold at 196 days of age with a mean market weight of 250 lbs. (normally distributed with standard deviation of 17.9 lbs.).[14] The 300-sow system under normal conditions has 753 litters per year, which translates into 6,230 pigs marketed per year. In terms of weekly sales, 119 pigs are sold per week.[15]

8. Results

The results from the simulations are reported in three tables. Table 3 summarizes the first two full capacity experiments. Table 4 summarizes the six experiments that have penalties for underproduction. The six experiments that include two profit sharing schemes, one for high pig mortality, and one for low pig weights are exhibited in Table 5.

It is evident from Table 3, Experiment 2, that profit is redistributed from S1 and S2 to S3 when the rent-sharing scheme includes a weight bonus. Table 4 demonstrates the effectiveness of the capacity penalty. In experiments 3 and 4, S1 experiences high pig mortality. With

Table 2
Summary of experiments

Experiment	Weight monitoring	Capacity	Under-Capacity Penalty	Transfer Payment
Full capacity experiments				
1	No	Full	No	Cost of production for S1, S2, and S3 paid out of total revenue. Remainder is profit (allocated based on sharing rules).
2	Yes	Full	No	Same as exp 1.
Under-capacity experiments				
3	No	S1 Below	No	Cost of production for S1, S2, and S3 paid out of total revenue. Remainder is profit (allocated based on sharing rules).
4	No	S1 Below	Yes	Same as exp 3, except when S1 is below capacity and total profit is positive then S1's profit is zero, else S1 pays its share of losses.
5	No	S2 Below	No	Same as exp 3.
6	No	S2 Below	Yes	Same as exp 3, except when S2 is below capacity and total profit is positive then S2's profit is zero, else S2 pays its share of losses.
7	No	S3 Below	No	Same as exp 3.
8	No	S3 Below	Yes	Same as exp 3, except when S3 is below capacity and total profit is positive then S3's profit is zero, else S3 pays its share of losses.
9	Yes	S1 Below	Yes	When S1 is below capacity and total profit is positive, then S1's profit is zero, else if profits are negative, S1 pays lambda as a proportion of losses. 75% profit to capacity pool, 25% to weight pool.
10	Yes	S1 Below	Yes	Same as exp 9, but 25% profit to capacity pool, 75% to weight pool.
11	Yes	S2 Below	Yes	Same as exp 9.
12	Yes	S2 Below	Yes	Same as exp 10.
13	Yes	S3 Below	Yes	Same as exp 9.
14	Yes	S3 Below	Yes	Same as exp 10.

a capacity penalty in place, S2 and S3 avoid the 40% profit decline that occurs in Experiment 3. In experiments 5 and 6, S2 experiences high mortality and profit declines by 93%. With the capacity penalty, S2 loses 163% of its profit relative to the baseline, while S1 and S3's losses are reduced from 93% each, to 72% and 84% respectively. In experiments 7 and 8, S3 has high mortality. S3 loses 171% profit relative to the baseline with the capacity penalty, while S1 and S2's losses are reduced from 125% each, to 70% and 33% respectively.

The last six experiments, shown in Table 5 incorporate penalties for both mortality and low weight gain into the rent sharing mechanism. If Experiment 9 is compared to Experiment 4, the addition of a weight bonus/penalty redistributes profit from S2 and S3 to S1. In Experiment 10, when a higher proportion of profit is devoted to the weight monitoring mechanism, even more profit is redistributed to S1. In Experiment 11, S2 is the cause of underproduction. S2 loses almost as much profit (159%), as occurs in Experiment 6.

Table 3
Full capacity experiments (six-year simulation)

	Payment mechanism	Mean payment ($/head)			Profit ($)			Total profit
		S1	S2	S3	S1	S2	S3	
Exp 1 (base)	Profit share	28.38	17.11	61.29	94,986	56,992	227,966	379,944
		0.15*	0.15	0.18	82.27**	49.36	197.44	
Exp 2	Profit share + weight bonus	27.85	16.97	62.01	72,841	51,541	255,562	379,944
		0.25	0.39	0.19	134.29	124.32	209.53	
Change from base		−2%	−1%	1%	−23%	−10%	12%	0%

* Coefficient of variation for payment.
** Standard deviation for profit.

However, in Experiment 12, S1 loses more profit than is the case in Experiment 6 (with just a capacity penalty), while S3 receives more profit than in Experiment 6. So, in experiments 11 and 12, S1 loses relatively more profit than S3. In experiments 13 and 14, S2 loses relatively more profit relative to S1 when compared to Experiment 8. It is evident that the weight mechanism redistributes profit away from the alliance member who causes underproduction.

9. Conclusion

Production risk is an important potential difficulty within an alliance. In this paper, we represented production risk with two measurable variables—pig weight, and pig mortality. It is clear that high mortality has severe consequences for pig production. Not only does total profit decrease but risk sharing varies significantly depending upon the internal structure of the alliance. The results show firstly, that capacity problems are more serious the further we move downstream, secondly, that with a capacity penalty the offending member will be punished for high mortality. Thirdly, the results indicate that with the additional complication of a weight monitoring mechanism coupled with a capacity penalty, it would be better to put a smaller proportion of total profits into the weight profit pool than into the capacity penalty pool. This would ensure that the member who causes underproduction will bear most of consequences.

Resource-based theory can help in interpreting the results of the simulation experiments. The joint resource portfolio of the alliance members must be superadditive relative to portfolios that are individually held otherwise there is no incentive to form an alliance. In order for the portfolio to possess superadditivity, it will undoubtedly require a complementary mix of the members' organizational and human resources. The rents from the alliance represent returns to human and organizational capital, which is central to the capacity of the alliance to earn and sustain rents. The unique combination of resources within the alliance is critical to its survival. If one of the three members does not possess the necessary skills and abilities the sharing of the rent stream should reflect that.

Table 4
Experiments with penalty scheme for under-capacity (six-year simulation)

	Payment mechanism	Stage below capacity	Mean payment ($/head)			Profit ($)			Total profit
			S1	S2	S3	S1	S2	S3	
Exp 3	Profit share	S1	28.45	17.14	60.55	56,575	33,945	135,781	226,301
			0.16*	0.17	0.21	78.05**	46.83	187.31	
Change from base			0%	0%	−1%	−40%	−40%	−40%	−40%
Exp 4	Profit share + capacity penalty	S1	25.85	18.47	61.94	−34,021	79,244	181,079	226,302
			0.10	0.24	0.23	37.89	73.78	213.44	
Change from base			−9%	8%	1%	−136%	39%	−21%	−40%
Exp 5	Profit share	S2	26.06	16.17	56.51	6,964	4,178	16,713	27,855
			0.15	0.18	0.22	76.34	45.81	183.22	
Change from base			−8%	−5%	−8%	−93%	−93%	−93%	−93%
Exp 6	Profit share + capacity penalty	S2	26.55	15.01	57.11	27,050	−35,993	36,799	27,856
			0.17	0.11	0.23	89.75	24.40	196.47	
Change from base			−6%	−12%	−7%	−72%	−163%	−84%	−93%
Exp 7	Profit share	S3	25.31	15.29	54.03	−24,051	−14,431	−57,723	−96,205
			0.15	0.15	0.23	74.08	44.45	177.78	
Change from base			−11%	−11%	−12%	−125%	−125%	−125%	−125%
Exp 8	Profit share + capacity penalty	S3	26.58	16.59	50.78	28,536	38,157	−162,898	−96,205
			0.22	0.27	0.18	112.56	84.49	126.18	
Change from base			−6%	−3%	−17%	−70%	−33%	−171%	−125%

* Coefficient of variation. ** Standard deviation.
Profit = 0 for stage producing below capacity when total profit > 0, otherwise stage below capacity pays its share of the alliances losses.

Table 5
Experiments with penalty schemes for weight and under-capacity (six-year simulation)

	Payment mechanism	Stage below capacity	Mean payment ($/head)			Profit ($)			Total profit
			S1	S2	S3	S1	S2	S3	
Exp 9	Profit share + wt bonus + capacity penalty	S1	26.29	18.04	61.92	−17,190	65,773	177,719	226,302
			0.13*	0.26	0.21	53.17**	75.84	202.00	
Change from base			−7%	5%	1%	−118%	15%	−22%	−40%
Exp 10	Profit share + wt bonus + capacity penalty	S1	27.18	17.19	61.87	16,472	38,833	170,998	226,303
			0.24	0.37	0.20	101.11	97.99	192.17	
Change from base			−4%	0%	1%	−83%	−32%	−25%	−40%
Exp 11	Profit share + wt bonus + capacity penalty	S2	26.25	15.00	57.53	14,748	−33,903	47,010	27,855
			0.18	0.20	0.21	91.73	42.67	185.22	
Change from base			−8%	−12%	−6%	−84%	−159%	−79%	−93%
Exp 12	Profit share + wt bonus + capacity penalty	S2	25.66	14.99	58.37	−9,855	−29,723	67,434	27,856
			0.23	0.43	0.20	111.37	90.72	175.08	
Change from base			−10%	−12%	−5%	−110%	−152%	−70%	−93%
Exp 13	Profit share + wt bonus + capacity penalty	S3	26.05	15.97	52.36	6,356	13,065	−115,625	−96,204
			0.21	0.28	0.17	107.32	84.19	124.68	
Change from base			−8%	−7%	−15%	−93%	−77%	−151%	−125%
Exp 14	Profit share + wt bonus + capacity penalty	S3	24.98	14.73	55.52	−38,006	−37,118	−21,080	−96,204
			0.24	0.38	0.18	116.13	105.41	147.34	
Change from base			−12%	−14%	−9%	−140%	−165%	−109%	−125%

* Coefficient of variation. ** Standard deviation.
Profit = 0 for stage producing below capacity when total profit > 0, otherwise stage below capacity pays its share of the alliances losses.

The rent sharing structure in this paper rewards organizational and human capital, by monitoring performance of alliance members and removing rents from those who do not perform to a minimum standard. The proposed rent-sharing structure may also act as a screening device so that prospective alliance members will self-identify. This is similar to the problem of mechanism design where insurers design contracts with specific coverage, indemnity, premiums, and deductibles that ensure that high-risk agents will choose the proper insurance plan. Measures of organizational and human capital are imperfect. Education is usually a signal of a high quality individual, however, that is not always the case.[16] Measures of organizational capital are historical in nature (observation of past performance while functioning in a similar role; reputation effects are another indicator). By having an *a priori* mechanism that punishes poor performance within the alliance, those with low organizational and human capital will self-identify by not agreeing to sign a contract with such mechanisms in place.

Notes

1. Schrader and Boehlje (1996) and Koehler, Lazarus, and Buhr (1996) identify seven more reasons for forming alliances: access to technology, market access, increased quality, information sharing, risk reduction, efficiency, and the ability to increase off-farm work.
2. Usually the stage one (breeding-gestation-farrowing) owner is called an "integrator." Stage two (nursery) and stage three (finishing) is often contracted out to other producers. It is accurate to call the owner a franchisor. As an organizational form a franchise is one step removed from complete vertical integration. See for example Cozzarin and Barry (1998).
3. Gary Fisher is President of AgAnalysis, a farm management firm based in Perth, Ontario. He was the only consultant (that we spoke to) who would discuss the financial and organizational structure of a functioning swine alliance.
4. The sharing rules are based on costs of production computed with the Vinson model using the one year average corn price (average daily price from 21 February, 1996 to 21 February, 1997 was $3.66/bushel) and soybean meal price (average daily price from 21 February, 1996 to 21 February, 1997 was $239.84/ton).
5. We assume that animals will be weighed and counted upon exiting each stage. This assumption results in a complete and symmetric information set that is known to all the players. A symmetric information set means that no player has information different from the others when he moves, while a complete information set is one where nature does not move first or that nature's initial move is observed by all the players. Other sharing rules could be devised depending on assumptions about the player's information sets (asymmetric and/or incomplete) and whether we want to consider mixed strategy equilibria or pure strategy equilibria. The solution to such games is the realm of noncooperative bargaining theory, which will not be discussed here.
6. A reviewer pointed out that 1200 or 2400 sow operations are now the industry norm.

Whether the results are reported for a 300 sow operation or a much larger operation is a matter of scaling, the sharing rules would result in the same distribution of profits and losses.

7. We are assuming that replacement gilts are purchased from an external supplier of high quality genetic lines such as DeKalb. We could not find enough data to fit a distribution, so a deterministic price was used instead.
8. See Cozzarin (1998) p. 149 for an example.
9. We chose to run the simulations through a typical hog cycle running from 1988 to 1994. The choice of time period is not critical for the analysis since our only purpose is to compare how rents are allocated between different organizational forms.
10. Dr. Ralph Vinson DVM, is a swine management consultant located in Oneida, Illinois. The College of Veterinary Medicine at the University of Illinois recommended him.
11. We could not obtain industry data that documented possible death losses (due to disease) at each production stage. As such, a uniform density was assumed. The death rates differ slightly for the different stages in order to keep total production (30,300) the same for each experiment.
12. See footnote 9.
13. The data from Vinson agrees for the most part with Boehlje et al. (1995).
14. The original carcass weight adjustments were for warm carcass weights. These were converted to live weight by dividing the mean hot carcass weight by the mean slaughter weight (from Lee) to obtain 0.74. The bonus for low backfat ranges from $1.00 to a maximum of $7.00 and the penalty for high backfat ranges from -$1.00 to -$7.25. There is no bonus for backfat less than 1.2 inches with a pig weighing less than 218 lbs. The backfat premium is added to the market price received for the hog in $/cwt.
15. 2.063 litters are born per day. The calculation is based on the following: 329 sows times 2.29 farrowings/sow/year = 753 litters/year, divided by 365 days to obtain 2.063 litters born per day. Summing the time spent in S1, S2, and S3, it takes 311 days until the first group of pigs is marketed. Sales occur on a daily basis (a simplification). It takes 310 days for the model to reach full production. Since the concern is with the full productive capacity of the system, the time span from Day 1 to Day 310 is not included in the profit calculations.
16. Sometimes low and high quality individuals choose different education levels to signal their quality. This results in a separating equilibrium. While in other cases, low and high quality agents choose the same education level resulting in a pooling equilibrium (Spence, 1974).

Acknowledgment

We would like to thank the editor Greg Baker and two anonymous reviewers for their constructive comments that have substantially improved the paper.

References

Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management, 17* (1), 99–120.

Boehlje, M. (1995). Vertical coordination and structural change in the pork industry: discussion. *American Journal of Agricultural Economics, 77,* 1225–1228.

Boehlje, M., Boland, M., Clark, K., Cline, T. R., Foster, K., Hale, J., Hurt, C., Jones, D., Schinkel, A., & Singleton, W. (1995). *Positioning your pork operation for the 21st century.* Purdue Cooperative Extension Service.

Boehlje, M., & Hurt, C. (1996). *Industrialization of the U.S. swine industry.* Kernkamp Lecture: September, 22.

Conner, K. R. (1991). A historical comparison of resource-based theory and five schools of thought within industrial organization economics: do we have a new theory of the firm? *Journal of Management, 17* (1), 121–154.

Cozzarin, B. P. (1998). Essays on organizational form and function in agricultural production alliances. Ph.D. dissertation, University of Illinois at Urbana-Champaign.

Cozzarin, B. P., & Barry, P. J. (1998). Organizational structure in agricultural production alliances. *International Food and Agribusiness Management Review, 1* (2), 149–165.

Cozzarin, B. P., & Westgren, R. E. (2000). Rent sharing in agricultural production alliances. *American Journal of Agricultural Economics, 82* (February), 25–37.

Fisher, G. (1998). President, AgAnalysis. Personal communication.

Fulton, J., & Gillespie, J. (1995). Emerging business organizations in a rapidly changing pork industry. *American Journal of Agricultural Economics, 77,* 1219–1224.

Grimes, G., & Rhodes, V. J. (1995). 1994 marketings of the nation's medium and very large producers of hogs. University of Missouri: Agricultural Economics Report 1995–7.

Kenyon, D., & Purcell, W. (1996). Short and long term marketing issues and opportunities in the pork sector. Paper presented at National Pork Lending Conference, National Pork Producers Council.

Kliebenstein, J. B., & Lawrence, J. D. (1995). Contracting and vertical coordination in the United States pork industry. *American Journal of Agricultural Economics, 77,* 1213–1218.

Koehler, B., Lazarus, B., & Buhr, B. (1996). Swine production networks in Minnesota: resources for decision making. Staff Paper P96–6, Department of Applied Economics, University of Minnesota.

Lawrence, J. D., Rhodes, V. J., Grimes, G. A., & Hayenga, M. L. (1997). Vertical coordination in the U.S. pork industry: status motivations and expectations. *Agribusiness: An International Journal, 13* (January/February), 21–32.

Lee, Kyu Hee. (1995). Evaluation of packers' pricing mechanisms in the hog industry: a simulation approach. MS thesis, University of Illinois at Urbana-Champaign.

Lyneis, J. M. (1980). *Corporate planning and design: a system dynamics approach.* Cambridge MA: Pugh-Roberts Associates.

Mahoney, J. T. (1992). Organizational economics within the conversation of strategic management. In P. Shrivastava, A.S. Huff, & J. Dutton (Eds.), *Advances in strategic management,* Vol. 8. Greenwich, CT: JAI Press.

Mahoney, J. T., & Pandian, J. R. (1992). The resource-based view within the conversation of strategic management. *Strategic Management Journal, 13,* 363–380.

Office for Futures and Options Research. (1997). University of Illinois. Personal communication. Peterson, H.C., and A. Wysocki. 1998. Strategic choice along the vertical coordination continuum. Staff Paper 98–16, Department of Agricultural Economics, Michigan State University, July.

Schrader, L. F., & Boehlje, M. (1996). Cooperative coordination in the hog-pork system: examples from Europe and the U.S. Staff Paper 96–21, Department of Agricultural Economics, Purdue University.

Spence, A. M. (1974). *Market signaling.* Cambridge, Mass: Harvard University Press.

Sutton, John. (1986). Non-cooperative bargaining theory: an introduction. *Review of Economic Studies, 53,* 709–724.

Vinson, Ralph, A. (1994). Pork production enterprise guidelines for cost of production. Mimeo.

Vinson, Ralph. (1997). Personal communication.

Westgren, R. E. (1994). Creating value in a strategic alliance: a resource-based approach to inter-organizational decision making. Discussion Paper, George Morris Center.