International Food and Agribusiness Management Review
Vol 6 Iss 2 2003

Evaluation of Alternative Coordination Systems Between Producers and Packers in the Pork Value Chain

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1. Introduction

The traditional organization of the hog production/slaughter and processing system, characterized by independent producers and open market coordination with packers, is changing. The use of production and marketing contracts, weight/leanness premium and discount (P&D) pricing schedules, and packer owned and operated hog production facilities are now pervasive in the sourcing and pricing of hogs.

In theory, the innovation of a P&D schedule "signals" to producers the hog weight and leanness characteristics that are valued in the marketplace. In fact, Hayenga et al. (1995) argue that carcass merit P&D schedules may have contributed to improvements in pork carcass leanness. In conjunction with other information, the production sector uses the P&D information and expected price levels in future periods to optimally plan hog flows. However, actual hog flows, in terms of carcass volume, may differ from what packers desire. This mismatching is attributable to producers and packers having differing objectives. Furthermore, the lack of information in a coordination mechanism can result in misalignment for the production of output-specific characteristics in the short-run (Cloutier). When the product flow does not coincide with the information flow from the P&D schedules, the system's

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profit may be sub-optimal, providing an opportunity to increase overall system profits by realigning product and information flows and incentives.

To combat product and information flow mismatches, and other difficulties associated with the use of spot markets, producers and packers have been using contract and vertical integration mechanisms to secure product flows and improve information flows between the producer and packer. Vertical integration and coordination may occur for several additional reasons including stable supplies, better quality control, improved flow scheduling, and reductions in price risk (Paarlberg et al, 1999.). Numerous analysts have described the changing coordination mechanisms and other structural changes occurring in the pork production-packing sub-sector -- the changing nature of the information flows, the linkages between the stages in the pork supply chain, the potential drivers of (or reasons for) these changes, and the potential impact of the changes on consumers, producers, processors and systems performance.[1] However, there have been few empirical or numerical analyses of these structural changes.

This analysis focuses on quantifying the benefits of information sharing and improvements in profitability associated with alternative coordination mechanisms that more tightly align live hog production with slaughter and processing. The objectives are: 1) to determine potential differences that arise from the use of spot markets, contracts, and vertical integration coordination mechanisms in terms of information and product flows, and 2) to assess potential benefits from using coordination mechanisms other than spot markets, such as providing packers with a more consistent and higher quality live hog flow, increased producer and packer margins, and less uncertainty associated with total system margins relative to the spot market system.

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[1] Previous Studies that have focused on describing the structural changes in the live hog production sector (Hayenga; Grimes and Rhoades; Rhoades and Grimes; Lawrence, et al (1998)); the drivers or forces resulting in those structural changes (Barry, Sonka and Lajili; Sporleder; Rhodes; Reimund, Martin, and Moore; Hobbs; and Frank and Henderson; Boehlje, et al; Kliebenstein and Lawrence; USDA 1996a, USDA 1996b; Hennessy and Lawrence); describing the structural changes in hog slaughter and processing (MacDonald, et al;); the drivers or forces resulting in those structural changes (Hayenga, et al (1995); Hayenga, et al (1998); Johnson and Foster; Barkema, Drabenstott, and Welch; Barkema and Cook; Perry, Banker and Green; MacDonald and Ollinger; Melton and Huffman; Onal, Unnevehr, and Bekric); the forces underlying vertical integration, coordination and contracting (Azzman; Parrlberg, Haley and Pritchett; Cloutier and Sonka; USDA 2000; Grimes and Meyer); and the implications of concentration and coordination on spot market performance (Martin; Lawrence, Grimes and Hayenga).

2. Model Overview

Three models of hog producer-packer systems are used to evaluate the impacts of increased vertical coordination. The coordination mechanisms evaluated are spot markets, contracts, and vertical integration. Spot market transactions are defined as sales between producers and packers where the only transfer of information is a P&D grid for weight and leanness characteristics. Contract market transactions are sales of live hogs from the production sub-sector to the packing sub-sector by means of pre-arranged sales contracts. The contracts are "shackle space" agreements that assure producers of a place to market live hogs. The contract design is such that producers are paid a fixed payment per hog delivered ($5/head) in addition to the market price for live hogs plus (less) any premiums (discounts) for weight and leanness characteristics. The premium and discount schedule is identical to the spot market. In essence, in the contract system the packer has a call option for delivery of the live hogs and guarantees that all hogs will be marketed within a fixed period of time. In the vertical integration (VI) system, the packer owns the live hogs from feeder through slaughter and makes the sole determination as to when they are transferred from production to packing; the production division is paid a fixed fee per hog transferred ($20/head).[2]

Model Components

There are five main components to the system models (Figure 1). The components are: a pricing model, feeder pig placements, biological growth equations, marketing decision models, and primal cut storage/sales decision models. This section briefly explains each component. [3]

The first component is the live hog and primal cut pricing models. These models use time-series modeling techniques to forecast industry wide prices and quantities over the two-year simulation period. The time series equations were estimated using 156 weeks of data covering the 1998 through 2000 period. The market prices for live hogs and primal cuts are used in the system models for both current and expected future prices. All coordination system models face the same prices for all inputs and outputs, except in the case of live hogs for the vertical integration system where live hog prices are irrelevant.

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[2] Both the $5/head buyer's call option fee for the contract system and the $20/head fee for the vertical integration system come from Lawrence, et al. (1997).

[3] Length requirements of this paper preclude a detailed discussion of the components. A more detailed description of the models is available from the authors upon request.

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The second component is the placement of feeder pigs as determined by a stochastic process modeled using state-space time series techniques. Feeder pig placements depend on feeder pig prices, expected future live hog prices, the price of corn, industry sow inventory, and a 6-month Treasury bill rate. Separate feeder pig placement models were used for each of the system models reflecting the alternative coordination mechanism structures. In the third component, feeder pigs mature into market weight hogs according to biological growth equations based on those used by Craig and Schinckel; these growth equations have two unique characteristics, 1) weight, and 2) leanness. The growth equations were estimated with data from feeding trials, and a non-linear mixed effects model was used for estimation to better quantify the variation in animal growth between each pig and between groups of pigs.

The fourth component of the system models is an optimal live hog marketing model. The various coordinated systems implement live hog marketing decisions differently. In the spot market system producers determine optimal live hog flows to the packer based on maximizing returns over variable costs from finishing feeder pigs. The producer makes these marketing decisions based on an expectation of market prices in the future. These expectations are modeled using time series forecasting techniques where the producer only has information based on current and historic live hog prices, current hog inventories, and packer provided premium and discount schedules.

In the contract system model, the packer determines optimal hog flow from maximizing returns over variable costs from processing live hogs into primal cuts. The packer determines optimal hog flow based on expectations of primal cut values and live hog procurement costs. The packer's expectations are formed based on time series model where the packer has information on current and past live hog and primal cut prices as well as current inventory levels of live hogs and primal cuts. This larger information set may allow the packer to make more accurate flow scheduling decisions than the producer could make given the producer's limited information set.

Finally, the vertical integration system model does not market live hogs; rather the packer transfers hogs from their finishing unit to their slaughter and processing unit based on maximizing returns over variable costs from processing feeder pigs into primal cuts. In this case, the packer makes optimal decisions based on expected primal cut prices and the costs of finishing feeder pigs. The time series model used to form expectations in this case does not contain live hog prices since they are irrelevant.

The fifth component of the system models is the packer's primal cut sale/storage decision model – the packer produces six primal cuts: hams, bellies, loins, picnics, ribs, and butts. In all system models the packer determines optimal primal cut sales/storage by maximizing their returns over variable costs from slaughter and processing given a predetermined live hog supply.

Simulation Mechanics

The estimated feeder pig placement and biological growth models are simulated on a weekly basis over a period of 176 weeks for 100 stochastic iterations to determine inputs to the live hog marketing model.[4] The variance of the feeder pig placement and biological growth models were simulated as univariate normal distributions with a mean of zero and standard deviation equal to the standard deviation of the residuals from the estimation equations. The live hog marketing and primal cut sales/storage optimization models are then solved sequentially given the simulated inputs. The outputs from these models are optimal marketing of live hogs and optimal sales of primal cuts solved using the General Algebraic Modeling System (GAMS). The packer's behavior is specified by each coordination mechanism and prohibits them from exhibiting any form of non-competitive behavior. Additionally, the use of the state-space input and output market price models further restricts both producers and the packer from exploiting market power.

3. Results

To evaluate the performance of each system model, two main groups of outputs will be analyzed. First, the physical flows of each system will be examined to see if differences exist in the quantity and quality of the live hogs delivered to the packer. Physical flows refer to the feeder pigs placed in finishing barns, quantity of hogs delivered to the packer, and the corresponding pounds of lean pork associated with those live hogs. Second the financial flows of each system will be analyzed. Financial flows include producer, packer, and system margins. The performance measures are evaluated based on probability distributions and illustrated graphically using cumulative density functions.

Physical Flows

Table 1 summarizes the physical flow results from the system models. For each of the system models, average feeder pig placements and standard deviations appear similar. The deliveries of live hogs to the packer for all system models maintained packer operations at approximately 80 percent capacity utilization.[5] On average the vertical integration system reduces relative variability in head delivered, as

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[4] The feeder pig placement and input/output price models were estimated using 156 weeks of historical data. The biological growth model was estimated from feeding trials on 128 barrows. The estimated equations were then used to forecast 176 weeks of placements, growth, and prices, using the errors from the estimated equations to represent the stochastic nature.

[5] The marketing decision model allows for choice in the timing of delivering finished hogs. Thus, head delivered is slightly lower than feeder pig placements reflecting the fact that at the end of the simulation period some of the feeder pigs placed 13 and 14 weeks earlier were still being held to heavier weights in some simulations.

measured by the coefficient of variation (CV), by 3 percent compared to the spot market system. This reflects a more stable flow of hogs to the slaughter plant as coordination becomes tighter.

The more tightly coordinated system models are able to consistently deliver leaner live hogs to the packer. To packers, this translates into more pounds of primal cuts per hog delivered. Figure 2 shows the consistency in pounds of lean pork delivered by the various systems. The contract and vertical integration coordination systems are able to delay the marketing of less valuable lighter pigs, which yield less usable pounds of lean pork, longer than the spot market system. The vertical integration system's distribution of lean pounds delivered first-order stochastically dominates the spot market. Using a more tightly aligned coordination mechanism could be viewed as a strategy to reduce the risks associated with physical flows. Of all the physical product flows in the model, the main difference between the three system models is the characteristics of hogs transferred to the slaughter plant. The spot market system sends hogs with less usable pork than the contract and vertical integration systems, highlighting the differing objectives of producers and packers even under a grade and yield grid pricing system. The combination of more efficiency and uniformity can create a strategic benefit to producers and packers in vertically aligned systems by allowing them to deliver a higher quality more consistent product to the marketplace.[6]

Financial Flows

The financial performance of each system was measured as per pig returns over variable costs, referred to here as margins. The summary results in Table 2 show that producers in the contract system attain the highest margins of all three systems. Packers clearly favor the vertical integration system as it has the highest margins and the lowest risks of all three systems, as measured by the standard deviation and coefficient of variation (CV). At the system level there seems to be little difference among the three systems[7]. While the contract system has the largest expected total margins, they are only slightly better than the vertical integration system.

On average, producers in the spot market system faced over 50 percent relative risk (CV) associated with finishing feeder pigs. This risk was significantly reduced by more than 20 percent in the contract system and eliminated in the vertical integration system (see Table 2). The contract and vertical integration systems also

[6] This study does not account for any additional premiums that might accrue to systems that have higher quality and more consistent products. However, there are companies that pursue segments of the market that are willing and able to pay premiums for higher quality and more consistent products suggesting that some premiums may exist for vertically coordinated systems.

[7] A statistical test of significant differences revealed that system margins were only significantly different for spot market versus contract market system margins. In the text, the statement "do not differ greatly" is synonymous with "not statistically significantly different." The authors chose the non-technical wording for readability.

eliminated much of the downside risk faced by producers. The CDF of producers' margins illustrates the shifting of the margin distribution when the spot market is compared to the contract system (see Figure 3), and shows that producers have a higher probability of receiving larger margins in the contract system than in the spot market system. While the average producer (or production division) margins for the spot market and vertical integration systems do not differ greatly, the vertical integration systems does eliminate the risks associated with finished feeder pigs (Table 2 and Figure 3). The contract system also reduces a large portion of downside risk in producer margins compared to the spot market. The contract system increased the minimum payment from a loss of $69.46 by over $40 to a loss of $28.49. The producer margin results indicate that there are gains to be made from using coordination mechanisms other than spot markets.

The packer does not fare as well as the producer in the contract system. Margins are reduced from $16.29 in the spot market system, to $4.78 in the contract system. The reduction in margins for the packer is a function of the $5 buyer's call option fee and the packer's willingness to pass through any additional value gains associated with access to primal cut marketing information. The packer's margins in the vertical integration (VI) system were larger than in the spot market system, and the packer faced less risk in the vertical integration system. The VI system minimized downside risk by truncating the distribution of margins at a loss of $40.15 (see Figure 4), $10 above the contract system and $34 above the spot market system. The vertical integration system had the lowest occurrence of negative margins for the packer (18 percent), 8 percent better than the spot market system and 25 percent better than the contract system (see Table 2).

In general, packer margins are more volatile than producer margins, regardless of the coordination mechanism. However, the packer may be able to reduce volatility in margins by gaining control over its inputs through vertical coordination. This reduction in risk when combined with the higher consistency in product attributes (previous section's analysis) might be the primary reasons for the packing industry's recent push for more vertical coordination.

The system's total margins and risk measures show that all three systems perform similar to one another. The relative risk in each system as measured by the CV is about 20 percent and the probability of negative margins occurring is less than 3 percent for each system. The spot market and contract system had identical minimum margins, and they were larger than the minimum margin for the vertical integration system (see Table 2). There is a slight reduction in risk associated with the average total system margins. From a total system perspective, these results indicate that the contract system has advantages over the spot market and vertical integration systems with both higher margins and lower risk.

Coordination Preferences

Certainty equivalents (CE) were used to compare the three coordination mechanisms over different levels of relative risk aversion. The CE can be thought of as the minimum payment required to sell a gamble. The larger the CE, the more the gamble is preferred to a fixed payment. Finding which coordination mechanism maximizes the CE identifies the preferred coordination mechanism. The power utility function was used in this analysis.[8] Relative risk aversion (λ) was varied from 0 to 5, where λ represents an individual who is risk neutral and 5 is an individual who is extremely risk averse. While the power utility function is not defined when λ equals 1, 1.0001 was used instead for computational purposes.

Certainty Equivalents

The producer's CE's for each coordination system are graphed in Figure 6. Producers maximize CE's under contract coordination at all levels of relative risk aversion, and as relative risk aversion increases among producers their CE's decrease. As producers become more risk averse ($\lambda \geq 1.00$), spot market coordination is the least preferred method of marketing live hogs. This indicates the potential for producers to receive higher risk adjusted margins under alternative coordination systems.

The CE's for the packers are graphed in Figure 7. The CE's for packers show that they prefer vertical integration coordination mechanisms at all levels of relative risk aversion. Furthermore, at all levels of relative risk aversion, packers prefer spot market coordination to contract coordination because of the significantly lower margins they receive in the contract coordinated system.

In summary, these results indicate that the contract and vertical integration coordination mechanisms are preferred to spot market coordination mechanisms. While producers and packers do not prefer a common coordination mechanism, both do prefer a coordinate more tightly system over spot markets. In both of the preferred coordination mechanisms, information from the primal cut market aids in determining which live hogs are brought to market. This sharing of information from markets further down the value chain improves the physical flow of pigs in terms of the pounds of usable meat. In addition, the information sharing leads to more efficient marketing of live hogs and meat products that reduces the costs of supply shortages.

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[8] The power utility function was used in this analysis because it exhibits constant relative risk aversion over different levels of wealth. The power utility function cannot be evaluated for negative returns. To address this, initial wealth for producers was set to the investment required to build a 1,000 sow farrow-to-finish hog operation ($144.20 per head). For packers initial wealth was set to the investment required to build a 1,250 head per day hog packing facility ($110.04 per head). The system level of investment was set equal to the producer investment plus the packer investment, $144.20 + $110.04 = $254.24.

Coordination Incentives

Producers maximize risk-adjusted margins in the contract system while the packer maximizes risk-adjusted margins in the vertical integration system. Thus, there are economic motivations for spot market systems to change over time to more tightly coordinated systems. To gain a further understanding of these dynamics, two specific cases of change are examined. In the first case, producers attempt to achieve their best outcome by moving from a spot market coordination mechanism to a contract coordination mechanism. In the second case, packers move from a spot market to one that is vertically integrated.

The results of the first case are presented in Table 3. In this case the analysis solved for the maximum payment producers are willing to make to packers to change the coordination mechanism from spot market to contract coordination with a $5 buyer's call payment. Producers need to compensate packers for this change because as shown earlier, packers prefer the spot market to a contract coordinated market. Additionally, the analysis solved for the lowest payment packers are willing to accept for this change in system coordination to occur. These two payments represent the boundaries over which negotiations could occur. No assumptions are made as to the results of these negotiations; the purpose is only to identify cases where producers willingness to pay intersects packers willingness to accept.

Column 2 in Table 3 shows the maximum producers are willing to compensate packers for switching from a spot market system to a contract coordinated system in certainty equivalent value. Under spot market coordination mechanisms producers are willing to forfeit from $18.25 to $73.25, at varying levels of relative risk aversion, in exchange for a marketing contract with a $5 buyer's call option fee from the packer. At low levels of relative risk aversion ($\lambda \leq 1.000$) packers would not offer a contract unless producer's provided them with additional compensation per head ($4.81 to $11.51). At all levels of relative risk aversion the packer's required compensation is less than the producer's maximum willingness to pay, and there are always positive benefits to move from spot to contract coordination (see column 5 and 6 of Table 3). Thus, it is always in the producer's best interests to compensate packers for their lost margins by moving from a spot market system to a contract coordinated system. In fact, the producer is willing to give up more than the $5 buyer's call option fee that was originally assumed packers would pay to producers. This results in a Pareto improvement for producers, packers, and the system as a whole.

The results of the second case are presented in Table 4. In this case the analysis solved for the maximum payment packers are willing to make to producers to change the coordination mechanism from spot market to vertical integration. Additionally, the analysis solved for the lowest payment producers are willing to accept for this change in system coordination to occur. As in the previous section these two payments represent the boundaries over which negotiations would occur.

As relative risk aversion increases packers are willing to compensate producers at higher levels, and producers require less compensation to change to a vertical integration system (see column 3 of Table 4). To participate in a vertically integrated system, relatively risk neutral (($\lambda \leq 0.50$) producers would require a flat fee of $21.46 to $22.95. Producers who are more risk averse (($\lambda \geq 1.00$) would be willing to accept the flat fee of $20.00 and would even be willing to negotiate a lower flat fee per head. Over varying levels of relative risk aversion, packers buying on the spot market are willing to pay $25.47 to $43.64 per head as a flat fee to producers who choose to join them in a vertically integrated system. At all levels of relative risk aversion the compensation offered by packers is sufficient for producers to be willing to change from a spot market system to a vertically integrated system. Additionally, there are benefits to the system from this change at all levels of relative risk aversion (see column 4 and 5 of Table 4). The aforementioned illustrates the economic benefits for the live hog market to move to a vertically coordinated system.

4. Conclusions

The results of this empirical analysis of various coordination mechanisms (spot market, contract, vertical integration) between producer and packer in the pork industry suggest a number of conclusions. First, coordination systems that are more closely aligned do not necessarily result in more hogs marketed and slaughtered, but they do provide the information and incentives to produce and market hogs that yield more usable pounds of primal cuts than the spot market system. The vertical integration system markets live hogs that yield the most usable pounds of primal cuts. Also, in the vertical integration system, hog marketings have the lowest variability of all three systems. The largest gains from better coordination come from placing and marketing the feeder pigs that will produce more primal cuts, and little additional value is added from just coordinating live hog physical flows.

The choice of coordination mechanism does not alter total system performance dramatically as measured by margins and their volatility, but the coordination mechanisms differ in how they distribute the risks and returns to producers and the packer. Spot markets and contracting had the same variability associated with producer margins, as the marketing contract arrangements modeled were intended to only provide market access and not reduce risks. Contracting offered producers the highest margins on average, while vertical integration eliminated all risks associated with producer (or production division) margins. Producers deciding between the spot markets and contracting can receive higher margins and reduce margin volatility with contracting.

For the packer the lowest average margins and highest average volatility of margins were realized from using contracting. Marketing contracts did not offer packers any margin risk reduction over spot markets, but they did increase the pounds of usable pork per hog delivered and reduced the variability of the pounds of usable pork per hog delivered compared to the spot market. For the packer the spot market and vertical integration system had equivalent margins, but the vertical integration system had the lowest relative volatility associated with margins.

The results suggest that the primary benefit from more tightly aligned coordination or governance systems is risk reduction. The reduction in risk results from more accurate information transmission between the primal cut market and the live hog market. Primal cut prices transmit information that helps reduce risks in packer/producer systems only if the system is aligned to use this information; the spot market does not allow for accurate information sharing which results in sub-optimal solutions for both producers and packers. Clearly, the results indicate that there is potential to negotiate the sharing of risks and rewards in a more tightly coordinated system. Thus, the impacts of different forms of coordination on both physical and financial flows (both in terms of levels and volatility) suggest significant motivation for further development of vertical coordination in the producer/packer sector of the pork industry.

Analysis of the certainty equivalent measures indicated producers and packers preferred to participate in a system that had improved information sharing. There was no relative risk aversion level in which producers and packers would not negotiate to move from spot market coordination to either contract coordination or to vertically integrated coordination mechanisms. Both the producer's and packer's preference for the contract coordinated and vertically integrated systems suggest that there are economic and financial benefits to reorganizing from a spot market coordination system to a more closely aligned contract or vertical integration coordination system. This analysis provides an alternative explanation to the market power/competitiveness behavior argument for the increased vertical alignment experienced in the pork production and packing industries over the past few years.

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Table 1. Summary Model Results – Physical Flows (Averages Over 100 Two Year Iterations, negative values in parentheses)

	Coordination Mechanism		
	Spot Market	*Contract $5/Head Buyer's Call Option Fee*	*Vertical Integration $20/Head Flat Fee*
Number of Feeder Pigs Placed			
Average	73,410	74,250	74,183
Std Dev	4,831	5,259	4,927
CV	6.58%	7.08%	6.64%
Min -- Max	40,866 -- 101,818	41,602 -- 109,978	37,838 -- 107,378
Head Delivered to Slaughter Plant			
Average	73,394	74,155	74,144
Std Dev	6,964	5,402	4,841
CV	9.49%	7.29%	6.53%
Min -- Max	41,085 -- 98,745	42,820 -- 108,544	38,736 -- 103,948
Pounds of Lean Pork			
Average	188.93	200.47	201.90
Std Dev	2.74	0.43	0.12
CV	1.45%	0.21%	0.06%
Min -- Max	182.30 -- 201.66	198.62 -- 201.93	201.59 -- 201.95

Table 2. Summary Model Results – Financial Flows (Averages Over 100 Two Year Iterations, negative values in parentheses)

	Coordination Mechanism		
	Spot Market	*Contract $5/Head Buyer's Call Option Fee*	*Vertical Integration $20/Head Flat Fee*
Producer Margins			
Average	$22.95	$41.20	$20.00
Std Dev	$12.62	$13.28	$0.00
CV	54.98%	32.24%	0.00%
Min – Max	($69.46)--$102.66	($28.49)--$109.37	$20.00--$20.00
P(Margin > 0)	78%	90%	100%
Packer Margins			
Average	$16.29	$4.78	$21.76
Std Dev	$11.06	$11.51	$9.38
CV	67.92%	241%	43.11%
Min – Max	($74.24) -- $93.31	($50.89) -- $63.06	($40.15) -- $79.62
P(Margin > 0)	76%	57%	82%
System Margins			
Average	$39.24	$45.98	$41.76
Std Dev	$8.63	$9.37	$9.38
CV	21.99%	20.37%	22.46%
Min – Max	($9.38) -- $80.13	($9.38) -- $101.98	($20.15) -- $99.62
P(Margin > 0)	98%	97%	98%

Table 3. Margins Required to Induce a Change from Spot System to Contract Coordinated System

Relative Risk Aversion	*Producer's Max Margin Willing to Forfeit*	*Packer's Min Margin Needed to Change*	*Change in System Margins*	*Change Possible & Beneficial to Both*
0.00	18.25	11.51	6.74	Yes
0.10	18.25	11.49	6.73	Yes
0.50	18.27	11.36	6.71	Yes
1.00	18.30	11.08	6.69	Yes
1.25	18.32	10.89	6.68	Yes
1.50	18.36	10.65	6.67	Yes
2.00	18.48	10.02	6.64	Yes
3.00	19.04	7.99	6.59	Yes
4.00	20.36	4.83	6.53	Yes
5.00	22.79	0.72	6.47	Yes

Table 4. Margins Required to Induce a Change from Spot System to Vertically Coordinated System

Relative Risk Aversion	*Producer's Min Margin Needed to Change*	*Packer's Max Margin Willing to Forfeit*	*Change in System Margins*	*Change Possible & Beneficial to Both*
0.00	2.95	5.47	2.52	Yes
0.10	2.66	5.61	2.49	Yes
0.50	1.46	6.26	2.40	Yes
1.00	-0.08	7.23	2.29	Yes
1.25	-0.87	7.79	2.23	Yes
1.50	-1.69	8.40	2.18	Yes
2.00	-3.39	9.80	2.07	Yes
3.00	-7.22	13.41	1.86	Yes
4.00	-11.89	18.13	1.65	Yes
5.00	-17.70	23.64	1.45	Yes

Figure 1. Graphical Overview of the System Models

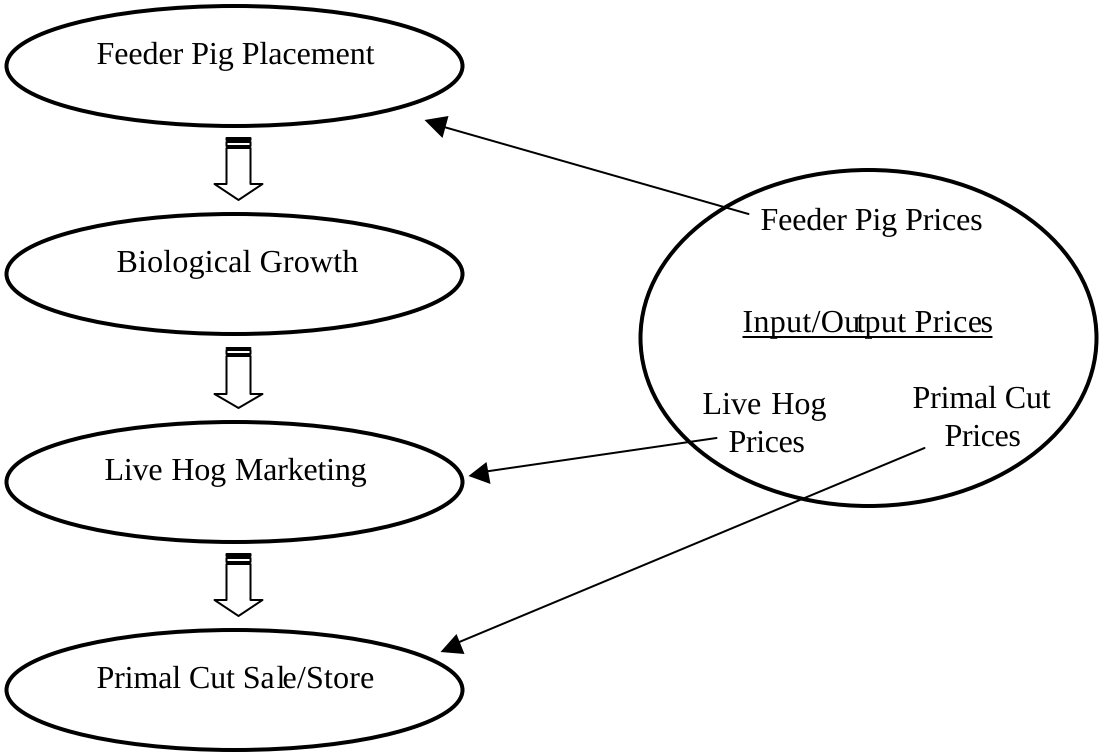

Figure 2. Cumulative Density Function of Average Pounds of Lean Pork under Each Coordination System.

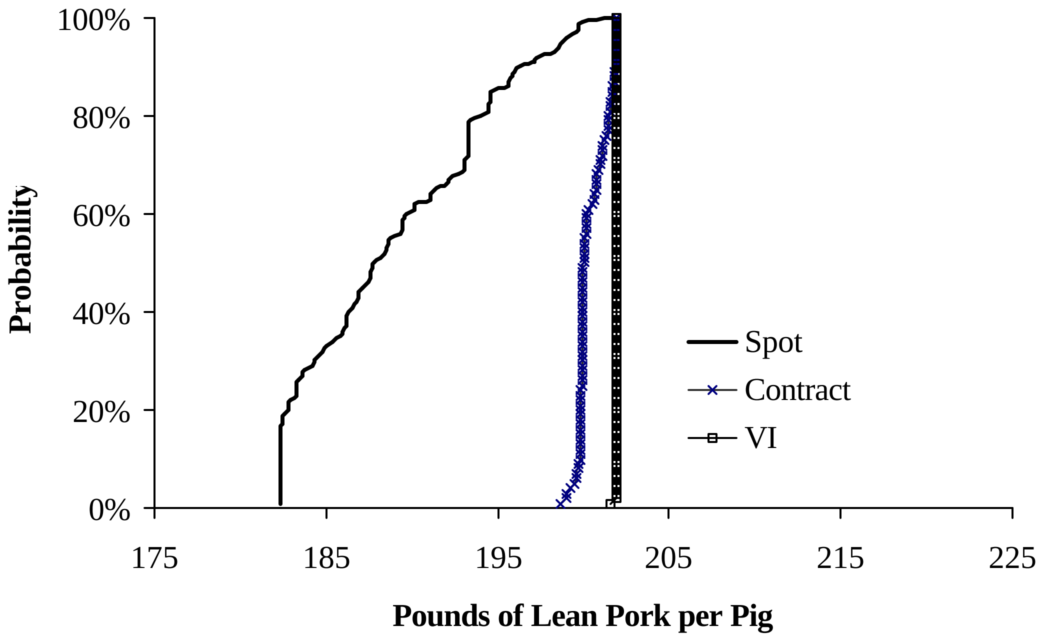

Figure 3. Cumulative Density Function of Average Producer Margins under Each Coordination System.

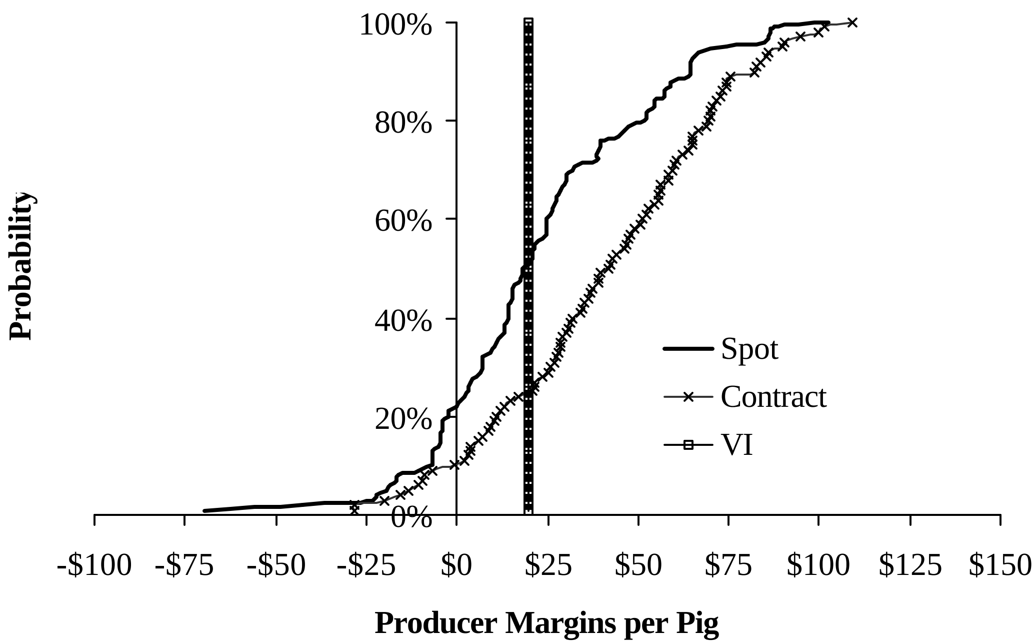

Figure 4. Cumulative Density Function of Average Packing Margins under Each Coordination System.

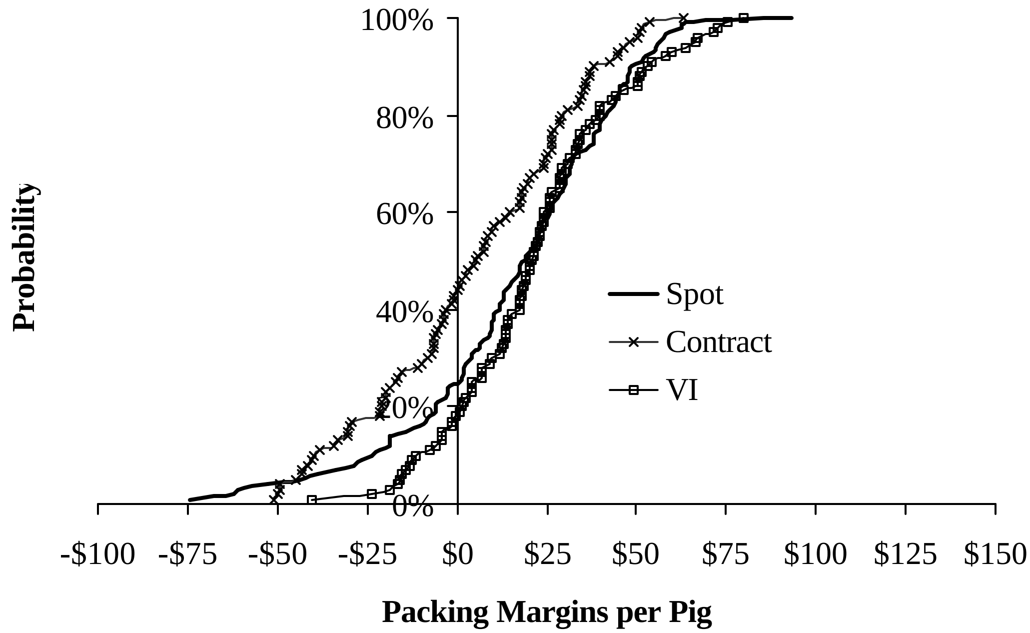

Figure 5. Cumulative Density Function of System Margins under Each Coordination System.

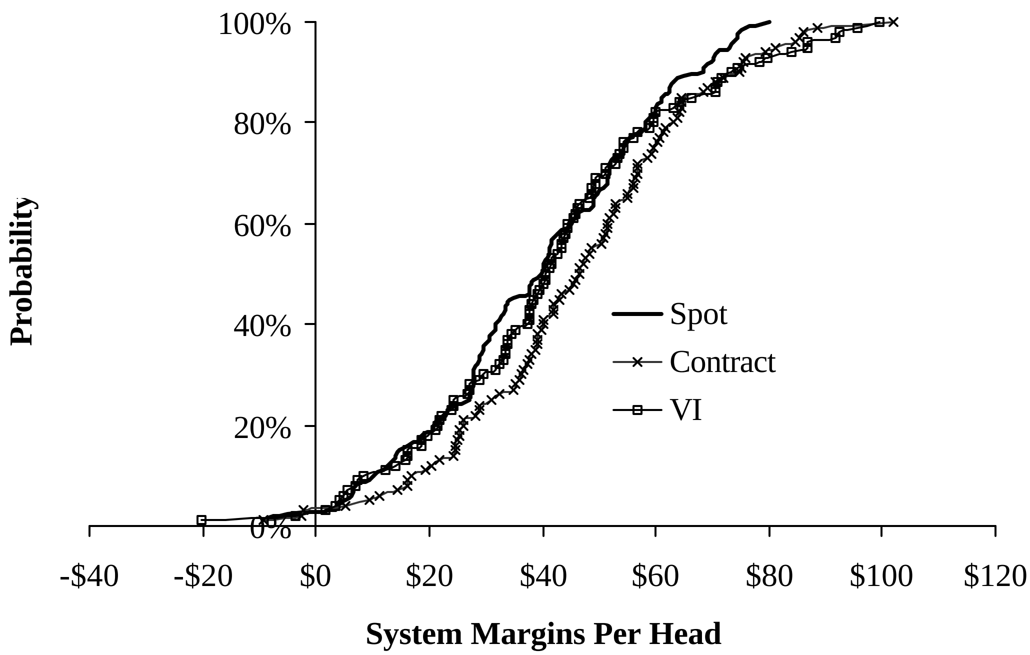

Figure 6. Producer Certainty Equivalents Under Different Levels of Relative Risk Aversion for each Coordination Mechanism

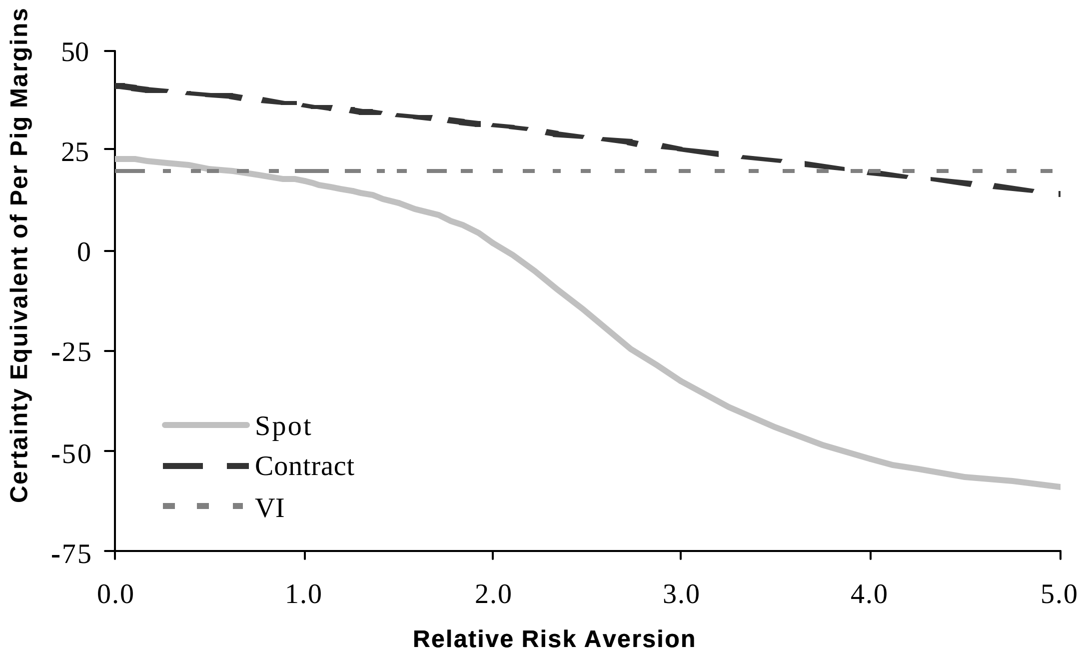

Figure 7. Packer Certainty Equivalents Under Different Levels of Relative Risk Aversion for Each Coordination Mechanism