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Abstract:
Despite the dramatic change in the organization of the US hog industry over the past two decades, the existing literature offers little insight into the decision by pork packers to use long-term marketing contracts, which represent the dominant form of hog procurement transactions. Existing studies focus instead on the efficacy of incentive mechanisms for which contracts are neither necessary nor sufficient, on hog producers' motivations for accepting contracts, or on packers' use of production contracts or vertical integration, which represent a relatively small share of slaughtered hogs. This paper offers a framework to explain pork packers' adoption of marketing contracts based on packers' downstream strategic market positioning and their resulting demands for specific hog quality attributes. Based on an analysis of hog procurement contract terms and of survey data related to packers' procurement practices, we provide support for the argument that packers' use of contracts is driven by issues of measurement costs and demand for intertemporal consistency of quality rather than by technological and market structure factors associated with asset specificity arguments.

Achieving consistency in hog quality has been one of the greatest challenges in the US pork industry. Packers, processors and retailers all ranked lack of uniformity in live hogs, carcasses, and retail cuts with regard to size and backfat as the most important quality issue facing the industry in the mid 1990s (NPPC, Pork Quality Audit, 1994), and quality consistency continues to be a leading industry concern (Martinez and Zering, 2004).

The past 15 years have also witnessed dramatic changes in the organization of the US hog industry. In 1993, over 83% of hogs were sold through spot markets while 11% were sold under marketing contracts. By 2005, only 11% of hogs were sold through spot markets, with 67% sold under marketing contracts and over 20% owned by packers through formal integration or production contracts. Production contracts differ from marketing contracts in that the packer (contractor) owns the hogs throughout the production process and typically exerts a degree of managerial control over the production process while under marketing contracts the growers owns the hogs and retains managerial control of the production process.[1]

This shift in hog industry organization has been the subject of great interest from agricultural economists, politicians, and industry participants alike. In a Congressionally-mandated study by the Grain Inspection, Packers and Stockyards Administration (GIPSA), Vukina, et al., (2007) provide a detailed description of the use of what they call alternative marketing arrangements (AMAs), including various types of contracts and vertical integration. While that study provides a rich descriptive analysis and attempts to offer some economic rationale for the use of AMAs, they do not provide or test a theoretical explanation for the choice of AMA. Instead, the focus is on the broader economic impacts of AMA use along the lines of Xia and Sexton (2004) and Wang and Jaenicke (2006).

Although there is a large literature on the change in US hog industry structure, there is very little theoretical or empirical evidence to explain the role of marketing contracts in the production-processing stage of the pork value chain. By and large, research has focused on the risk-shifting attributes of contracts and idiosyncratic preferences of hog producers, using production contracts made between hog growers and hog production firms or pork packers for the production and exchange of baby pigs or slaughter hogs, respectively. Johnson and Foster (1994) and Kliebenstein and Lawrence (1995) argue the primary reason for contractual agreements in the hog industry is risk-reduction. Zheng, et al., (2008) examine the role of risk aversion in contract choice and find that growers choosing to produce under production contracts have higher measures of risk-aversion than those producing for the cash market or under marketing contracts, but they fail to distinguish between those who use spot markets and marketing contracts. Gillespie and Eidman (1998) and Davis and Gillespie (2007) find risk aversion as well as growers' preferences for autonomy are important in hog producers' choice of business arrangements. However, these studies do not specifically focus on the producer-packer interface, nor do they consider packers' motivations for contracting.

At the packer level, Martinez (1999) and Hayenga (1998) suggest that modern, high-speed processing plants require tight control over inflow of live animal inputs because they have more sharply-sloped short-run average cost curves. Both studies suggest that increasing use of non-traditional organizational arrangements has been forced by increases in physical asset specificity or temporal specificity resulting from investments in idiosyncratic slaughtering plants and market concentration in hog production. However, there is little empirical evidence to indicate the nature or degree of asset specificity, or the size and potential appropriability of any associated quasi-rents.

Measurement costs have also been considered to explain the choice and structure of hog marketing contracts. For example, Martinez and Zering (2004) argue that the input requirement and monitoring provisions frequently found in hog marketing contracts reduce the costs to measure pale, soft, exudative (PSE) and safety attributes of hogs. Although Martinez and Zering's analysis of a small sample of long-term hog marketing contracts offers plausible clues to understand the design of the contracts, there remains a need to empirically study the heterogeneity of pork packers' use of alternative organizational forms for slaughter hog procurement.

We propose a theoretical explanation for the use of the dominant institutional form, namely long-term marketing contracts, in the presence of buyer-specific quality attributes in an otherwise commoditized industry. This theoretical framework draws from and builds upon the theory of price discovery costs (Coase, 1937; Cheung, 1983). In particular, the paper develops an idea that accounts for the use and structure of long-term marketing contracts to increase intertemporal quality consistency in hog procurement. The paper links the packer's decision to move from spot-market transactions to long-term marketing contracts to the packer's downstream product differentiation strategy. Based on a review of marketing contracts filed with GIPSA and on an analysis of original survey data from packing plant managers, we provide empirical evidence to support the argument and its explanatory power relative to existing theories including multi-task agency theory (Holmstrom and Milgrom, 1991) and asset specificity consideration (Williamson, 1996). We conclude with suggested extensions and broader applications of the theoretical and empirical results.

Downstream Product Differentiation and Contracting for Consistency

The US pork industry has experienced significant changes on both the supply and demand sides during the past three decades (Lawrence, et al., 1997; Martinez and Zering, 2004; Vukina, 2007). On the demand side, increased competition among pork packers in downstream product design has added to the traditional type of price competition. Pork packers' involvement in product differentiation activities can be viewed as an attempt either to avoid price competition (Tirole, 1988) or to meet diverse consumer preferences (Lancaster, 1966; Rosen, 1974). Based on a large body of descriptive industry publications on changes in the demand for pork products, we adopt the view that competition on pork product design has been mainly driven by the change and heterogeneity in consumers' value functions for pork products in domestic and foreign markets. In addition, it is widely accepted that the competition on pork product design has been enhanced by competition with chicken products.

Consumers' value functions for pork products have changed to emphasize three types of pork product attributes: leanness; meat quality attributes such as marbling, muscle color, and meat tenderness; and the consistency in the size and leanness of pork cuts and other quality attributes.[2] The diversity in consumers' value functions has developed within and along market segments, such as between domestic and foreign markets and between case-ready branded fresh pork products, boned or boxed pork products and further-processed pork products. These different market segments induce packers' demand for different hog (quality) characteristics. For example, in the domestic market pork packers specializing in processed meats prefer a lighter carcass while others prefer a heavier carcass for boned or boxed products. Restaurants prefer relatively small loins, which come from 230-pound hogs compared to the standard 270-pound hogs (Martinez and Zering, 2004). Marbling is desirable

for fresh loins, but less so for processed products. In the export market, lighter hogs with more tender meat and more marbling are preferred at the Japanese consumer markets, for example (Ray and Cravens, 2002; Miller, et al., 1999).

While the existing literature links the emergence of hog marketing contracts to pork packers' needs to procure hogs of high quality in general (Kliebenstein and Lawrence, 1995; Lawrence, et al, 1997; Vukina, et al, 2007), it fails to explain the need for marketing contracts to attain high quality. We argue that packers' downstream product competition strategies affect the relative costs of spot markets versus long-term contracts in upstream hog procurement. Specifically, we argue three factors combine to explain packers' use of marketing contracts based on their specific demand for quality attributes.

First, growing market segmentation and increasing differentiation activities in consumer pork products have resulted in escalating heterogeneity in the specifications of pork packers' desired hog quality attributes. As buyers desire to procure a class of idiosyncratic products, the effectiveness of auction markets, a traditional form of spot market, is significantly diminished because auction markets function based on a presumption that the products to be exchanged are defined *ex ante* among all potential traders. Moreover, auction markets function based on "lots" or batches of animals rather than on individual animals, thus pricing is based on the average quality of animals in the lot.

Alternatively, individual pork packers may adopt posted-price form of exchange, for instance, by announcing *ex ante* a carcass merit program to buy hogs with idiosyncratic quality attributes based on the buyer's private grade and standard. Although such a posted price mechanism might be considered form of informal contract, it is so only in the sense that prices

are generically offered prior to exchange and it need not necessarily require a formal marketing contract to be implemented between the packer and any individual hog producer.

Thus the detrimental impact on auction market efficiency of packers' heterogeneous demand for quality attributes is not enough to explain the prevalent use of hog marketing contracts, and especially *long-term* marketing contracts with durations ranging from 3 to 10 years (Martinez and Zering, 2004). So why are long-term contracts the dominant form of contract for hog marketing transactions? This question leads us to the second factor based on pork packers' downstream marketing strategy, namely packers' need for intertemporal quality consistency. While packers' downstream product quality strategies may be diverse (and therefore also their demand for specific hog quality attributes), maintaining consistent product quality within a brand has become increasingly important, especially for a pork packer whose target consumers are fairly sensitive to the specific quality attributes and their intertemporal consistency. We elaborate on how the packer benefits from the use of long-term contracts later in this section.

The third factor influencing the choice of hog procurement contracts is related to the limitation of spot markets with regard to creating an incentive price scheme when certain quality attributes are difficult to measure. This factor becomes relevant when pork packers' product differentiation activities are based on difficult-to-measure meat quality attributes such as meat color, marbling, and tenderness. This factor will be discussed in the following section. Here we focus on the first two factors, which are relatively underexplored.

Measureable Quality Attributes and the Limitations of Carcass Merit Programs

Hogs in the US are not typically graded by USDA standards, but by a matrix of measurable quality attributes of carcass, namely carcass merit programs (Vukina et al., 2007). Packers

create a menu of premiums and/or discounts for combinations of attributes relative to the price of a standard "base hog." The base price of a hog is paid on a per-pound basis while quality premiums and discounts apply on a head basis, a pricing scheme for quality performance based on measurements of carcass weight and lean percent or backfat of individual hogs. Premiums or discounts for those two quality attributes of individual hogs are made on the in-or-out status of the individual hog's carcass weight and percent lean relative to the target ranges set in the packer's carcass merit program. These adjustment rates are established as either a percentage of base price or an absolute dollar amount on a head basis. Therefore, producers have an incentive to sort hogs into groups that meet the target weight and groups that requires further feeding.[3] The premium and discount rates induce hog producers to sell hogs at different times because it may be more profitable to sell some hogs today and keep the remaining hogs on feed for additional days or weeks.

While premiums and discounts in carcass merit programs provide producers with incentives to deliver hogs based on packers′ idiosyncratic demand values, the strength of these incentives fluctuates based on variation in relevant market prices. For example, an increase in the feed price may weaken the quality incentive scheme by increasing the costs of attaining the target weight range. Similarly, an increase in the base hog price encourages producers to feed more, which may result in overweight hogs. Depending on the nature of the quality price matrix and the relative magnitude of the market price fluctuations for feed and base hog weight, producers may no longer have incentive to deliver the packer′s desired hog quality. Thus, the market price volatility induces an erosion effect on the quality price incentives.

This erosion takes place since individual hog weight itself is a choice variable for producers' profit maximization. Given a three-week marketing horizon, hog producers

determine the weight of individual hogs by adjusting the timing of marketing in response to the unit price of hogs, feed price, and the feed conversion ratio. Therefore, variation in hog weights per batch and over time is a natural result of hog producers' profit maximization behavior given the biological and economic constraints (Poray, 2002).

Figure 1 illustrates the case described above. The y-axis represents the net value of hog weight to the producer. The net value of hog weight initially increases with hog weight, but increases at a diminishing rate over the marketable window of the hog's maturity as feed conversion efficiency declines. Eventually the net value may begin to decrease since the feed quantity per unit of weight gain increases after a certain point of maturity. A producer would choose to market the hog at the peak of the function, all else equal. The baseline case is represented by the continuous, inverted U-shaped line.

The dotted line in Figure 1 illustrates the adjustments to the net value function associated with a packer's premiums and discounts relative to the target weight range, denoted by the lower bound, W_b^L, and the upper bound, W_b^U. This incentive increases the marginal net value of "feeding out" smaller hogs to attain the target weight range and decreases the marginal net value of continuing to feed hogs beyond the desired weight range. As a result, the density function of hogs marketed in the desired weight range should increase, all else equal.

<Insert Figure 1 about here>

Finally, the erosion effect associated with volatility in the base hog price and the price of feed is also illustrated in Figure 1. The dashed line represents the change to the net value function (including quality incentive adjustments) associated with either an increase in base hog price or a decrease in feed price. At a sufficient magnitude of price change, the equilibrium hog weight, $W_s^{*\prime}$, is greater than upper bound of hog weights targeted by a hog

buyer, W_b^U. We may also imagine the opposite effect of delivering underweight hogs when the base hog price declines or the feed price increases. Either case results in hog weight outcomes that deviate from the buyer's target range of carcass weights. Thus changes in these relevant prices erode the incentive power of the quality premium and discount scheme expressed by the dotted line. The erosion effect can be measured by the difference between the two equilibrium hog weights. It is easy to see that the potential for adverse outcomes is higher when the target weight range, W_b^U - W_b^L, is narrower and/or when the variance of base hog and feed prices is higher, respectively.

Contract Specifications on Intertemporal Consistency of Measurable Quality Attributes

As shown above, a carcass merit program in itself may not be fully effective for ensuring consistency in hog quality because of volatility in hog and feed prices. Obviously, pork packers could adjust the intensity of the quality incentive to changing market circumstances surrounding hog producers by manipulating the adjustment rates. However, such readjustments are inefficient for at least two reasons. First, it is costly to continually calculate optimal adjustment rates in response to market price variations and to communicate those changes to producers. More importantly, a volatile pricing system makes it more difficult for hog producers to determine the optimal timing for marketing over a three-week window, thereby reducing the effectiveness of the incentive system. For these reasons, one does not observe frequent changes in packers' adjustment rates relative to the volatility of the hog and feed markets. Given the costs associated with quality price incentive systems in spot markets, alternative transaction modes are required to effectively increase consistency of hog quality.

Because long-term hog procurement contracts effectively bundle multiple transactions or deliveries, they can be used to create intertemporal incentives to mitigate the incentive erosion

problem. In order to begin understanding how long-term contracts address the erosion effect, we analyze contract data from the GIPSA's Swine Contract Library website. GIPSA established the library under of the Livestock Mandatory Reporting Act of 1999 (LMRA). The contract disclosure requirements apply to packers that purchase at least 100,000 swine per year and slaughter at packing plants with a federally inspected slaughter capacity of 100,000 swine or more per year. This covers 54 plants owned or used by 32 packers as of December 1999. The hogs procured by these packers accounted for 96% of the total U.S. hog slaughter in federally inspected plants.

Due to the confidentiality restrictions of the LMRA, the contracts themselves and other proprietary information are not available. The GIPSA instead provides a summary of the information by contract type and region. Nonetheless, the contract information provided permits us to draw an overall picture of the hog procurement contracts governing the vast majority of hog marketing transactions. Data on these contracts were retrieved from the Swing Contract Library on January 4, 2007.

Contracts in the GIPSA library reveal two contractual instruments that address quality-incentive erosion. First, a large portion includes quality-based provisions to create and enforce intertemporal incentives. Packers establish target quality performance standards for hog producers that span multiple deliveries or periods of time. For instance, performance may be based on the average live or carcass weight per load on a weekly, monthly and/or annual basis. The objective is to achieve the target average of carcass weights and lean percentages and to minimize the standard deviation of individual carcass weights and lean percentage, per load and over the duration of the contract (see Table 1).

<Insert Table 1>

The logic behind these incentive and enforcement instruments is that the future reward and penalty scheme is based on intertemporal performance, not only spot market conditions. Therefore, the quality-adjusted price of hogs transacted through long-term contracts is determined by a multipart pricing scheme that includes quality incentives at time t (QA_t, almost identical to spot market incentives) plus quality incentives for performance over the contract period (QA_T, incentives in long-term contract transactions):

$$Total\ P(hog) = P_t(base\ hog) + QA_t + QA_T$$

The second set of contractual instruments for that reduce quality-incentive erosion have to do with base-hog price determination structures such as "window or floor price" and "cost-plus price" formula. The "base price" in long-term hog procurement contracts is set in a variety of ways, but can be classified into three types. The first is "a swine or pork market price" formula in which base price is determined by the spot market swine or pork price at the time of delivery. The second is a window or floor price formula. Window price formulas include floor and ceiling prices set at the time of signing the contract and a sharing rule if the reference price falls outside of the window zone. Cost-plus price formulas use corn and soybean prices to determine hog production cost. Hog procurement contracts using cost-plus formulas also specify a fixed payment (per head) added to the production cost estimates.

The latter two types of base-price determination structures (window/floor and cost-plus) reduce producers' incentive to adjust market timing in response to changes in spot market hog prices (in the window/floor price formulas) or feed prices (in cost-plus price formula) because the contract base-price paid is more stable than spot market hog prices or compensate for changes in feed price. In this regard, the pricing structure of the contracts helps significantly

reduce the opportunity costs of market timing decisions in a way to align producers' incentives with pork packers' objective of hog quality consistency.

It is important to note that the foregoing explanation for the use of long-term contracts is not dependent on investments in relationship-specific durable assets and risks of opportunism. This is not a moral hazard issue in the traditional sense, but rather an issue of transaction costs in identifying and implementing state-contingent optimal prices to induce provision of a particular quality of product attributes, highlighting the costs associated with the price determination process (Coase, 1937). Because long-term contracts can be used to bundle multiple "spot" transactions and make quality incentives interdependent over time, they are more effective than spot markets in creating incentives that lead to a more consistent supply of hog quality attributes.

In summary, pork packers' downstream product differentiation strategies induce demand for narrower ranges of measurable hog quality attributes in upstream hog supply markets. The narrower a buyer's target range of attributes (i.e., the greater the specificity of hog attributes to the buyer's needs), the greater the likelihood that spot market incentive pricing mechanisms will suffer erosion effects and fail to provide sufficient incentive in light of volatile base-hog and feed prices. In such cases, packers have incentive to use long-term marketing contracts (and other forms of vertical control such as production contracts and vertical integration) to resolve the incentive erosion problem. Given heterogeneity in packers' downstream market positions and differentiation among packing plants, we offer the following hypothesis:

Hypothesis 1: The share of hogs purchased for a given packing plant using spot market transactions is negatively related to degree of specificity at the plant of measurable hog quality attributes.

Difficult-To-Measure Quality Attributes and Contracting for Input Control

Increasing consumer demand for meat characteristics associated with difficult-to-measure hog quality attributes creates another challenge for pork packers' transactions for slaughter hogs. Hog quality attributes such as meat color, marbling, and tenderness are not impossible to measure, but they are costly to measure on an individual hog basis in high-speed slaughter lines. Furthermore, the measurement of quality attributes post-slaughtering involves potential moral hazard issues since quality outcomes result from a sort of team-production among the producer, transporter, and packer (Alchian and Demsetz, 1972). Information asymmetry based on the fact that the producer cannot directly observe the quality measurement adds yet another layer to the moral hazard problem, since packers have an incentive to under-report quality performance.

Given these information asymmetry issues, it is impractical for packers to implement pecuniary incentives based on objective performance measurement of individual hogs to ensure the desire meat characteristics. To make matters worse, incentives for the measurable quality attributes discussed earlier, such as leanness and size, may adversely affect the difficult-to-measure quality attributes, since hog producers have strong incentives to invest in the outcome of the former attributes at the sacrifice of the latter attributes, particularly when selecting genetics and feeding programs (Holmstrom and Milgrom, 1991).

These challenges cannot be resolved through spot market transactions. An incentive system theory of the firm suggests unification of ownership between production and slaughtering as a solution, highlighting a firm's ability to better manage incentives for workers (Holmstrom, 1999). Vertical integration, therefore, is a potential solution since wage workers for hog

production under managerial control have little incentive to engage in the *contractual externality* (Baker and Hubbard, 2001).

However, long-term contracts also provide a mechanism for reducing contractual externalities based on difficult-to-measure product attributes. If there is a high task-programmability between process and outcomes (Ouchi, 1979; Eisenhardt, 1985), the principal can design production practice rules for agents to follow that will ensure (or increase the likelihood) that the desired quality of product is produced. In our case, the correlation between hog meat quality attributes and particular hog genetics and nutrition programs create a degree of task-programmability in hog quality production and permits packers to use hog procurement contracts to control hog quality attributes. A review of the long-term marketing contracts in the GIPSA Swine Contract Library confirms the intuition, revealing that marketing contracts include terms concerning the selection of genetics and nutrition programs as well as the design and management of production facilities that affect meat quality attributes of hogs.

Since contractual externality is not observable, we have to identify proxies for the likelihood of contractual externalities. The existing literature on meat products suggests that fresh pork cuts are the most sensitive to meat quality attributes of hogs that are difficult to measure at the time of exchange (Miller, et al., 1999; Smith, 1999; Martinez and Zering; 2004). A pork packer that markets branded fresh pork products, therefore, is likely to be more sensitive to variation in meat quality attributes of hogs slaughtered than other packers that market case-ready frozen products, boxed fresh or frozen products, and processed products because the marginal negative effects of the variation are substantially higher for fresh pork products. This leads to our second hypothesis related to specific quality attributes:

Hypothesis 2: Pork packing plants that market case-ready fresh pork products will purchase a smaller share of their hog requirements through spot market transactions.

Temporal Specificity and Using a Formal Contract to Check Opportunism

Asset specificity has been argued as one reason for the increased use of contracts in hog production, therefore we include a test for asset specificity in our empirical model. In particular, slaughter hog transactions between pork packers and hog producers may involve temporal asset specificity. Unlike many manufacturing operations, it is inefficient for pork packers to hold a buffer inventory of live hogs to absorb volume fluctuations and permit work to continue at the hog slaughter stage in the event of supply disruptions, due to the extremely high cost of maintaining live animals ready for slaughter. Similarly, an inventory of carcasses is feasible, but refrigerated storage and meat quality deterioration make such a solution costly. Therefore, the non-storability of live hogs requires pork packers and hog suppliers to coordinate the product flow in a timely manner given the sequential nature of hog production and processing. Buyers who do not secure an appropriate quantity of hogs for slaughter are subject to the opportunity cost of idle slaughtering operations. Delivery schedules specified in long-term hog procurement contracts have been attributed to such hold-up concerns.

Transaction cost economics suggests that temporal specificity increases with the buyer's cost of switching from an extant hog supplier to alternate hog suppliers at the last minute, thus increasing the probability of hold up by suppliers (Masten, et al, 1991; Nickerson and Silverman, 2003). The pork industry literature suggests that temporal specificity increases with two factors: slaughter plant technology and thinness of the local hog market. First, modern, high-speed packing plants, especially those adopting a double-shift technology, are more exposed to higher temporal specificity than those adopting a single-shift technology because

the former has sharply sloped short-run average cost curves (Hayenga, 1998, Martinez, 1999). Second, it is also assumed that switching costs tend to increase when the quantity of hog supply is concentrated in a small number of producers. Martinez (1999) and Lawrence et al (1997) claim that a processor that locates in a geographic region with a few large hog producers is more likely to be subject to opportunistic behavior by the producers.

Based on these observations, we propose two hypotheses related to temporal specificity.

Hypothesis 3-1: Pork packing plants using a double-shift technology will use long-term contracts or in-house production for a larger share of their hog procurement.

Hypothesis 3-2: The more concentrated the local hog market, the more likely a plant will use long-term contracts or in-house production for a larger share of its hog procurement.

Data and Methods

To test our hypotheses, we conducted a survey of 108 pork packing plants representing over 96% of slaughtered hogs in the U.S. between October 2007 and March 2008. Hardcopy surveys were mailed to plant managers, who were given the option of completing the survey online or by return mail. Follow-up cards and phone calls were made to non-respondents. We obtained 25 responses, three of which were omitted due to high incompleteness, resulting in an effective response rate of 20%. Our respondent sample is moderately representative of the distribution of medium and large scale packing plants. Variable definitions as they relate to our hypotheses are listed in Table 2.

Two features of our data deserve mention. First, 12 packing plants out of 22 respondents simultaneously use multiple organizational forms for procuring hogs while 10 plants rely on only one form of hog procurement. This feature is consistent with observations in the existing literature (Vukina, et al., 2007). One may maintain that there would be an optimal portfolio of

alternative organization forms used. Second, contrary to most published research regarding the joint use of carcass merit programs and contracting, our sample data indicate that some packers use carcass merit programs in spot market transactions, while some packers use contracts that do not include carcass merit programs.

Among the 22 usable responses, nine had missing data either on market share of large producers (a proxy for temporal specificity) or on target range of carcass weights (the proxy of product specificity). In order to most effectively use the limited number of responses, we constructed five alternative imputation rules and conducted sensitivity analyses around those constructs. The choice of imputation rule has little effect on the regression results.

Given the nature of the relations we are examining, we follow the existing empirical contracts literature (see Sykuta, 2008, for a review) in specifying a reduced form model to estimate and test the effects of variables representing the three alternative explanations for pork packers' choice of organization form. We specify the following equation:

$$\textit{Spot markets (SM)}_{it} = \beta_0 + \beta_1 \textit{ Product specificity (TRW)}_{it} + \beta_2 \textit{ Measurement difficulty (CRFP)}_{it} + \beta_3 \textit{ Temporal specificity(ST)}_{it} + \beta_4 \textit{ Temporal specificity (MSLP)}_{it} + \beta_5 \textit{ Control variable (PS)}_{it} + \varepsilon_{it}.$$

This model does not specifically test for the choice of spot markets versus long-term marketing contracts. Rather it tests for the choice between spot market and non-spot market organizational forms (AMAs) more generally. Most of the existing research focuses specifically on the adoption of production contracts, a form of vertical quasi-integration, rather than the adoption of marketing contracts. By focusing on the spot versus non-spot end of the organizational spectrum, this paper contributes to the literature by explaining contracting more generally, and not vertical (quasi-)integration specifically.

We employ two statistical methods to address potential issues of omitted variables and corner solution outcomes. First, much of the empirical research on organizational choice suffers from potential unobserved individual firm-specific factors which might be correlated with the error term (Hamilton and Nickerson, 2003). This kind of correlation may bias the coefficient estimates. In order to address this concern, we designed a survey that requires plant managers to respond to the same question item at two different points of time, 2003 and 2006. This survey strategy would allow us to deal with the potential omitted variable bias issue by using first differences estimation, a special case of the fixed effects model, which effectively controls for any time-invariant plant-specific factors in our panel data (Wooldridge, 2002: 279-285). However, it turns out the dependent variable of spot market share does not vary much across time in our data. Packers rarely changed their procurement strategy over this period. As a result, the first-differencing model is not practical since many variable values go to zero. Instead, we include year dummy variables in the regression to create a time-specific fixed effects model rather than firm-specific fixed effects model (Wooldridge, 2002: 272-274).

The second potential issue arises when a large portion of dependent variable values are censored above or below at some values. It turns out that 13 observations in our sample data are corner solution outcomes at the top, 100%, and six observations at the bottom, 0%. Given these censored observations, OLS estimators would be biased and the *t*-statistics would not be reliable because the expected value of the dependent variable conditional on the independent variables cannot be linear and the regression variance is probably not homoskedastic (Wooldridge, 2002: 517-529). Given these twin challenges, we employ a double-censored Tobit model[4] with Huber/White heteroskedasticity robust standard error estimates including year dummy variables.

Results

Table 3 reports the results of alternate regression models including pooled OLS, dummy variable regressions, and the Tobit model.[5] There is little difference between the first two models, suggesting time-specific unobserved effects are not significant in our data. As expected, the estimate of the standard deviation of error in the Tobit model is statistically significant at 1% level, which implies that the presence of corner solution outcomes of 44% significantly affects the regression results. Since the meaning of the coefficient estimates is different between the OLS and Tobit models, a direct comparison of the magnitude of the estimates between the two is not appropriate.

<Insert Table 3>

The results support the primary hypotheses concerning the specificity of hog characteristics to packers' downstream product differentiation strategies. First, the narrower the packer's target carcass weight range (i.e., the more specific the ideal hog weight to the packer's operations), the lower the share of hogs procured through the spot market. This rejects the null of Hypothesis 1 regarding measurable product specificity. Likewise, packers producing case-ready fresh products (i.e., for whom measurement difficulty is a more significant problem) are also more likely to use non-spot market forms of transactional structures, as suggested in Hypothesis 2.

In contrast, and contrary to much of the existing literature, neither of the variables associated with temporal asset specificity (Hypothesis 3) appears to be statistically significant in explaining the choice of spot versus non-spot transaction forms. The explanation that double-shift slaughter technology adoption and increasing market share of large hog producers negatively influence the share of spot markets in pork packers' portfolio of organization forms

is not corroborated with our data. While the coefficient on slaughter technology at least has the expected sign, the coefficient on market share actually changes signs between the models. Since market share arguments underlie much of the policy debate, this lack of statistical significance is particularly noteworthy.

There are a few possible explanations for the lack of statistically significant results on these terms. First, the relatively small sample may not allow sufficient degrees of freedom to discern a statistically sound relation. Second, most research supporting asset specificity arguments has focused on the choice of production contracts or vertical integration, not contracting more generally or marketing contracts in particular. Since this study focuses on the choice of spot versus non-spot market transactions, asset specificity may simply not play a significant role at our point of analysis. Finally, it may be that previous research did not properly controlled for alternative transaction cost incentives for the adoption of non-spot market organizational forms and thus errantly identified a spurious relation with asset specificity.

Conclusions

Despite the dramatic change in the organization of the US hog industry over the past two decades, the existing literature offers little insight into the decision by pork packers to use long-term marketing contracts, which represent the dominant form of hog procurement transactions. Existing studies focus instead on the efficacy of incentive mechanisms for which contracts are neither necessary nor sufficient, on hog producers' motivations for accepting contracts, or on packers' use of production contracts or vertical integration, which represent a relatively small share of slaughtered hogs.

This paper fills a gap in the literature by providing a theoretical framework to explain packers' adoption of marketing contracts based on packers' downstream strategic market

positioning and their resulting demands for specific hog quality attributes. We provide an analysis of contracting practices revealed in GIPSA's Swine Contracts Library to illustrate how contract terms create incentives for intertemporal quality consistency that cannot be achieved through traditional spot market transactions. Survey data from pork packing plant managers provides additional empirical support to the hypotheses that contracting is preferred when packers desire a more specific set of hog attributes and when packers specialize in downstream products that are more affected by difficult-to-measure hog quality characteristics.

Our results do not support existing arguments relating to asset specificity between hog producers and pork packers. The empirical results suggest that the dramatic change in organization form in the pork industry may be better explained by the changes in downstream markets (demand side) rather than structural changes in the upstream markets (supply side). From the theoretical perspective, the pork industry case of contract and vertical integration choice can be better explained by costs associated with providing appropriate incentives *ex ante* rather than safeguards against *ex post* opportunism.

These results are important for potential policies governing the hog industry. Debate around the organization of the hog industry has largely revolved around arguments of market concentration and asset specificity. Our results suggest that such arguments fail to explain the primary mode of contracting in the hog industry, namely marketing contracts. Instead, our results suggest that marketing contracts serve to reduce transaction costs associated with determining appropriate quality prices to incentivize hog producers and with measurement costs for hog carcass characteristics related to meat quality attributes. Understanding packers' motivations for adopting alternative organizational forms is critical to developing reasonable and effective regulatory policies.

Finally, although our empirical results indicate new findings for explaining the costs of spot markets, we acknowledge the research is subject to some limitations. Like most transaction cost empirical studies, we do not directly test Williamson's transaction cost economics theory, contractual externality theory, and the relationship between adjustment costs of quality price and product specificity. As noted above, our findings cannot rule out the importance of potential Williamsonian transaction costs, which might be more relevant for pork packers' choice between contracts and vertical integration rather than spot markets versus non-spot markets. Data limitations, particularly lack of detailed data on pork packers' strategic market positioning in the downstream markets, may reduce the power of the regression results. In addition, the relatively small sample size makes the results less robust. Given the relatively small size of the relevant plant population, obtaining data on a long time period panel for even a small number of pork packers or conducting an in-depth case study would be promising for further studies

Figure 1. Erosion effects of volatility of base-hogs and feed prices on weight consistency incentive price

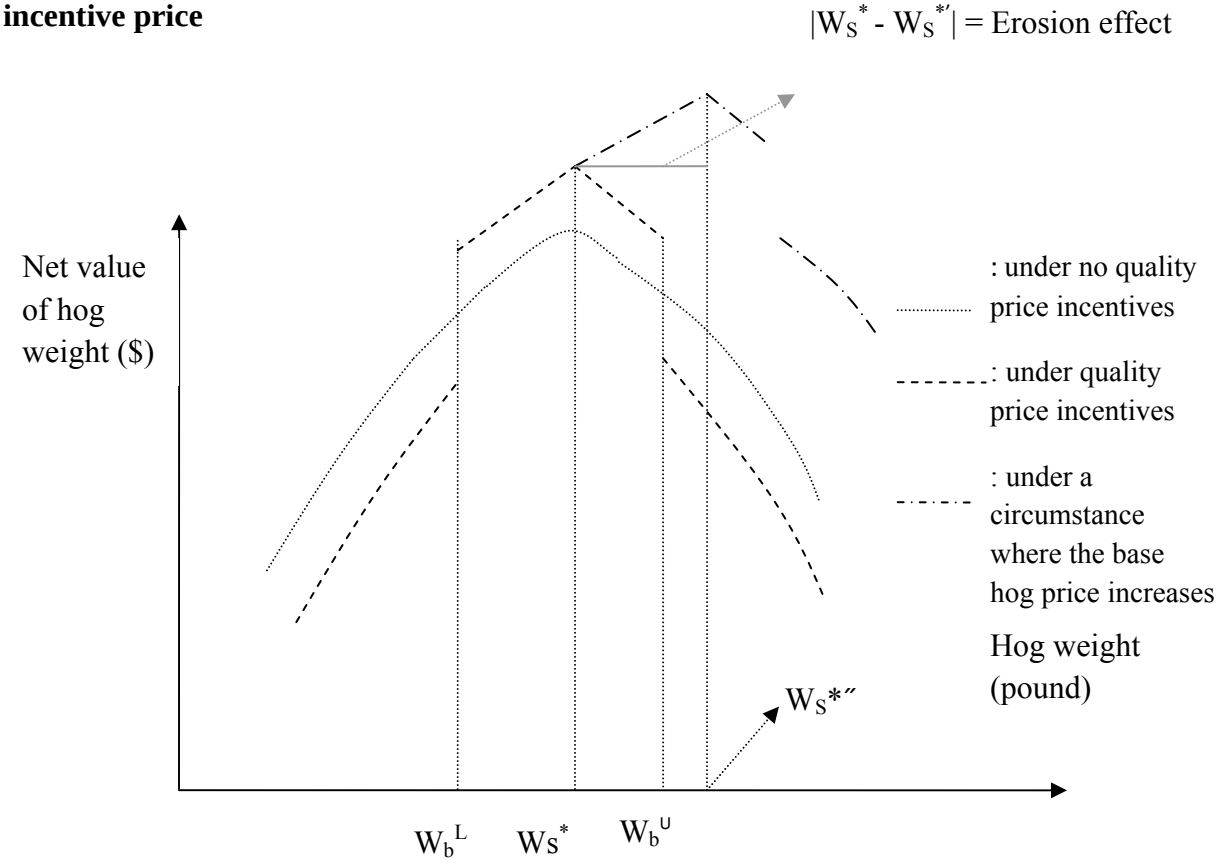

Table 1. Intertemporal target carcass weights specified in long-term procurement contracts

Individual hog base (pounds)	Load base (pounds)	Weight distribution base
152-259; 163-215; 155-237; 170-222; 175-206; 164-215; >155; 163-215; 189; >167; 111-222; 155-241; 160-249; 170-221; 168-205; 160-270; 170-222	<229 in average per load; <222 in average per load; 178-200 in average per load; 163-192 in a weekly average; 189-211 in a weekly average & >200 in an annual average; ≥ 190 in monthly average	Standard deviation of individual carcass weights delivered each week should be no greater than 17 pounds
18 observations	6 observations	1 observation

Table 2. Definition of variables

Dependent variable	Spot market share	Number of hogs procured through spot markets divided by total number of hogs procured by plant *i* during year *t*. (SM_{it})
Theoretical variable	Temporal specificity	Slaughter technology (ST_{it}): 1 if plant *i* uses double shift, 0 otherwise Market share of top 5% large producers surrounding plant *i* ($MSLP_{it}$) based on the plant manager's estimate
	Measurement difficulty	Case-ready fresh products ($CRFP_{it}$): 1 if plant *i* markets case-ready fresh products, 0 otherwise
	Product specificity	Target range of carcass weights (TRW_{it}): calculated by high bound minus low bound of the range and then the inverse of product specificity are calculated by dividing individual target ranges with the highest target range in our sample
Control variable	Plant size	Yearly slaughter capacity (PS_{it}): categorized by range from 1 to 8

Table 3. Comparison among alternative regression models (dependent variable: spot market share)

	POLS (White SE)	Dummy Variable Regression (White SE)	Tobit (Huber/White SE)
Plant size (Control)	-2.2442 (7.9063)	-2.19613 (7.9970)	-2.3716 (14.6713)
Target range of weights (Product specificity)	57.2417** (27.5978)	57.6196** (28.2944)	78.5959* (46.7592)
Case-ready fresh products (Measurement difficulty)	-23.3828* (13.3062)	-23.4331* (13.4781)	-38.8152* (21.8335)
Slaughter technology (Temporal specificity)	-13.4483 (21.6597)	-13.6354 (21.9686)	-21.1753 (37.0926)
Market share of large producers (Temporal specificity)	0.0953 (0.2076)	0.0904 (0.2142)	-0.0055 (0.3384)
Year dummy1		31.5145 (50.6193)	41.8222 (88.1055)
Year dummy2		16.6378 (24.7284)	42.4139 (86.5027)
Constant	32.5462 (49.1980)		
Standard deviation of error			49.1488*** (7.9803)
N (Censored observations in parentheses)	44	44	44 (6: 13)

*p<0.1, **p<0.05, ***p<0.01 (Standard Errors in parentheses)

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[1] Production contracts are also used by hog production firms for production of either baby pigs or slaughter hogs. Though, the difference in contractors' position in pork supply chain has received little attention.

[2] An emphasis on leanness had emerged in the 1980s, with human health research reports linking fat and cholesterol to cardiovascular disease in people (Martinez and Zering, 2004). Meat quality attributes to difficult to measure and the consistency attributes have been becoming valuable in pork packers' branded fresh pork products and products sold to food service chains, which feature repeated purchase and thereby reputation (Miller, et al., 1999; Smith, 1999). The market share of branded fresh pork products and pork products used at food service chains has been increasing particularly since the late 1980s (MacDonald, et al, 2000; Vukina, et al, 2007).

[3] Furthermore, hog producers have incentives to choose an alternative genetics and feeding program which produces a lower variation in the growth rates of individual hogs but with some opportunity costs of the choice.

[4] One may claim that the sequential decision Tobit model would be the most promising. In the Tobit II model, for example, it is assumed that pork packing plant managers first decide whether they use spot markets or not, and then they decide the fraction of the procurement quantity that is obtained through spot markets or non-spot markets. In order to implement this model, data should include different explanatory variables that may affect the first-stage decisions and the second-stage decisions. The lack of this data prevents the adoption of the Tobit II model. Therefore, the doubly-censored Tobit I model would be the second best alternative. The doubly-censored Tobit model has been widely used in the empirical studies in organizational economics

that involve dependent variable of fractional form and corner solution outcomes (see Lafontaine, 1993; Nickerson and Silverman, 2003 among others).

[5] We also conducted sensitivity analysis of alternative imputation options. The analytical results can be summarized as follows. First, the coefficient estimates of plant size and market share of top 5% largest producers are not stable across alternative imputation options and alternative regression models whereas those of slaughter technology, case-ready fresh products, and target range of carcass weights are stable. Second, more interestingly, the coefficient estimates of plant size, market share of large producers, and slaughter technology are not statistically significant in all of the imputation options and alternative regression models while those of case-ready fresh products and target range of carcass weights are statistically significant.