Contracting for Consistency: Hog Quality and the Use of Marketing Contracts

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Introduction

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 82% 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. This change in industry structure has not gone unnoticed by agricultural economists.

A large body of literature examines the relations between hog quality and newly developed organization modes, particularly production contracting and vertical integration. A variety of theoretical frameworks and empirical approaches have been employed, whether using surveys (Kliebenstein and Lawrence, 1995), simulation techniques (Poray, 2002), contract document analysis (Martinez and Zering, 2004), and quality outcome analysis (Muth, et al., 2007). However, research focusing on production contracts and formal vertical integration fails to address the dominant institutional form, namely marketing contracts. Likewise, research focusing on market-based incentive mechanisms fails to provide a consistent explanation for the use and design of long-term hog marketing contracts.

We propose a theoretical explanation for the use of 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 existing theories of contracting and organizational economics. In particular, the paper develops an analytical model 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. We provide empirical evidence to support the model and its explanatory power relative to existing theories.

The paper proceeds with a brief overview of the existing literature demonstrating the theoretical and empirical gaps as relate to the use and design of marketing contracts.

We then offer a refinement to the existing theories, building on previous work by Poray (2002) and Anderson and Trapp (1999). The model explains how variations in production-related prices erode market-based incentive mechanisms and promote the use of long-term marketing contracts. We then provide evidence based on a review of marketing contracts filed with the Grain Inspection, Packers and Stockyards Administration (GIPSA) and on an analysis of original survey data from packing plant managers. We conclude with suggested extensions and broader applications of the theoretical and empirical results.

Background

Finished hogs for slaughter are sold under one of three types of marketing arrangements: cash (or spot) markets, marketing (or procurement) contracts, and production contracts. Cash (or spot) markets are the traditional mechanism for transacting hogs between growers and packers (Lawrence, et al., 1997).[1] However, spot market transactions between production and processing stages fell from 82.5% of total hog sales in 1993 to 10.6% in 2005.[2]

Over the same period, transactions through various types of marketing contracts increased from 11% to 65.6%. These marketing contracts specify the price (or pricing mechanism) and provide growers with a guaranteed market for their finished hogs. Marketing contracts may also specify quantities, delivery schedules and terms, and additional quality characteristics desired by the packer. Under marketing contracts, the grower owns the hogs and retains managerial control of the production process. Growers' decisions regarding production and marketing are based on market prices and the incentives (if any) built into the marketing contract for various (quality) performance outcomes.

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. The grower provides hands-on management as well as facilities and related inputs (Muth, 2005). Thus, while production contracts are considered a form of market transaction, the transaction is not

[1] Based on the survey results of the 19 largest pork packers conducted in 1993, Lawrence, et al, reported that transactions through spot at plant or buying station share 68% of total slaughter hogs, 17% were from those through dealer or buyer, and 2% were from those through terminal or auction. They also mentioned the ongoing trend of the shift from terminals and auction markets to direct movement of hogs to packers within spot market organization.

[2] These data are sourced from USDA AMS information regarding hog transactions for 32 largest packers' procurement of slaughter hogs, which account for 93.5% of total number of slaughter hog in 1999. Therefore, the data tend to somewhat underestimate spot market transactions because it does not account for hog transactions made by a large number of small pork packers.

for the sale of hogs per se, since the hogs are already owned by the packer. In this sense, production contracts are a form of vertical quasi-integration. From 1993 to 2005, the use of production contracts and formal integration grew from 6.4% to 23.8% of slaughter hogs.

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 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), Wang and Jaenicke (2006), and Zheng and Vukina (2008).

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 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. . 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. The latter also finds that asset specificity at the farm level plays a role in the decision to contract. 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. Given the inefficiency of holding buffer stocks of live hogs for slaughter, Hayenga argues contracting allows packers to smooth and coordinate hog deliveries to make efficient use of processing plant capacity. Martinez and Zering (2004) argue that changes in hog production practices requiring growers to invest in specialized facilities create problems of asset specificity. They suggest contracts, particularly production contracts, are used to

encourage investment in these specific assets. However, as noted above, production contracts still represent a relatively small share of total US hog production and there is little empirical evidence to indicate just how specific these assets are, or size and potential appropriability of any associated quasi-rents. Moreover, asset specificity arguments do not suggest much about the structure of the contract terms themselves.

Despite its breadth, the extent literature on contracting the hog industry provides little insight on the use and structure of contracts, especially the use of marketing contracts that comprise the large majority of slaughter hog transactions. While the literature offers several possible components of a more consistent, holistic theory for hog marketing contracts, there is no unifying concept.

Downstream Product Differentiation and Contracting for Consistency

Pork packers' increasing competition in product design has added to the traditional type of price competition and has also considerably affected transaction characteristics in the upstream markets. Pork packers' involvement in product differentiation activities can be viewed as an attempt to avoid price competition or to meet diverse consumer preference.[3] According to a large body of the descriptive industry publications on characteristics of the changing consumer market for meat products, competition on pork product design has been mainly driven by the change and heterogeneity in consumers' value function of pork products in the domestic and foreign markets. Furthermore, it is widely accepted that the competition on pork product design has been facilitated by competition with chicken products.

Consumers' value function of pork products has changed to emphasize three classes of pork product attributes: leanness; meat quality attributes difficult to measure including marbling, muscle color, and meat tenderness; and the consistency in the size and leanness of pork cuts and other quality attributes.[4] The diversity in consumers' function

[3] Traditional industrial organization economists have suspected firms' product differentiation activities as strategic behaviors to avoid price competition and have examining equilibrium results of the imperfectly competitive market structure on optimal product diversity (See, Tirole, 1988 and Lancaster, 1990 for a survey of the literature). On the other hand, a group of economists including Lancaster (1966) and Rosen (1974) viewed products as a bundle of characteristics and developed competitive market equilibrium of differentiated products called as hedonic price model. Based on a large body of descriptive literature on the change in the demand side of pork industry, our research adopts the latter approach, admitting the heterogeneous value function of attributes of a class of products across consumers or groups of consumers. See also Antle (1999), for highlighting the impacts of agricultural product differentiation on the costs of production.

[4] 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

of pork products has developed with market segments for example, between domestic and foreign markets and between case-ready branded fresh pork products and boned or boxed pork products or further-processed pork products. For example, at the domestic market level, 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 21230 pound hogs compared to the standard 270-pound hogs (Martinez and Zering, 2004). Marbling is desirable for fresh loins, but less for processed products. At the export market level, lighter hogs with more tendered meat and more marbling are preferred at the Japanese consumer markets, for example (Ray and Cravens, 2002; Miller, et al., 1999).

The challenge for packers is how to procure a supply of consistent quality hogs that meet packers' downstream product differentiation strategies. Martinez and Zering (2004) identify the demand for quality hog inputs as one of the drivers for production contracts. Packers attempt to secure more consistent quality hogs by requiring producers to follow specific production practices which include investment in specialized facilities. They appeal to transaction cost economics (Williamson 1985, 1996) and argue contracts serve to protect the value of these transaction specific investments. However, this argument does not extend to use of marketing contracts more generally. More importantly, this argument suggests nothing about packers' incentives to secure specific hog quality characteristics. We argue three factors combine to explain packers' use of marketing contracts based on their specific demand for quality attributes.

Measureable Quality Attributes and Carcass Merit Programs

Hogs in the US are not typically graded by USDA standards, but by a matrix of measurable quality attributes (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. Base price is set in a variety of ways, but can be classified into four types. The first is a swine or pork market 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. The reference price adopted in the window price formula is similar to that of swine or pork market formula. The third type, called a cost-

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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; Muth, et al, 2005).

plus price formula, uses corn and soybean prices to determine hog production cost. Hog procurement contracts using this formula also specify a fixed payment added to the production cost estimates. The last type of base price determination is related to futures or option market prices. The Chicago Mercantile Exchange (CME) Lean Hog futures price is frequently used in this type, where hog sellers instruct packers to lock in a price relative to the CME Lean Hog futures prior to the beginning of the delivery period.

Price of hog quality comprises two parts in relation to the definition of attributes of hogs: price on measurable quality attributes of individual hogs and price on the distributional quality attributes of a group of hogs. All of the observed hog procurement contracts include a carcass merit program table, a pricing scheme for measurable quality performance based on measurement of carcass weight and lean percent or backfat of individual hogs. Prices for those two quality attributes of individual hogs is paid in the form of premiums and discounts which are made on the in-or-out status of the individual hog's carcass weight and percent lean from the target range set by a pork packer. Premiums and discounts, or adjustment rates, are established either as a percentage of base price or an absolute dollar amount on a head basis. The target ranges for the two carcass characteristics (that is, the range of values receiving the highest premiums) and the adjustment rates are dissimilar across contracts.

The second part of the pricing of hog quality, based on the distribution of quality attributes across a group of hogs, is associated with the third dimension of hog attributes described above. A number of hogs may be grouped into a load or lot, or a period of delivery time. For example, packers assess the distribution of carcass weights and lean percentages across all hogs from a specific producer over a weekly, monthly, quarterly, or yearly basis. This aspect of the pricing of quality has not received much attention in the existing literature. To get a sense of how contracts specify the pricing, some quotations from actual contracts would be beneficial.

Carcass merit programs

Hypotheses

Temporal Specificity Hypothesis

The slaughter hog transactions between pork packers and hog producers feature temporal specificity. Unlike most manufacturing operations, it is inefficient for pork packers to hold a buffer inventory of live hogs to absorb fluctuations and permit work to continue at the hog slaughter stage when problems in certain hog production units arise, due to the extremely high cost of maintenance of live animal ready to slaughter. Alternatively, an inventory of carcasses is feasible but costly and limited due to meat quality concern. 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 in time could suffer from idle operation of the slaughtering plant.

The existing literature points out that the temporal specificity tends to increase with modern, high-speed packing plants, especially those adopting a double-shift technology, because they have sharply sloped short-run average cost curves (Hayenga, 1998, Martinez, 1999). The claim parallels survey results that producers and packers use long-term contracts or vertical integration to reduce uncertainty in quantity flow. Additionally, delivery schedules specified in long-term hog procurement contracts have been attributed to hold-up concerns. TCE suggests that temporal specificity grows with the costs of buyers' switching from an extant hog supplier to alternative hog suppliers. It is also assumed that the switching costs tend to increase with hog supply quantity concentration among a small number of sellers. Martinez (1999; 15) claims that a processor that locates in a geographic region with few hog producers would be subject to opportunistic behavior by the producers.

Therefore, we generate two hypotheses related to temporal specificity.

Hypothesis 1-1: A pork packing plant that adopts double shift technology is more likely to choose long-term contracts or in-house production.

Hypothesis 1-2: A pork packing plant that is surrounded by a small number of sellers is more likely to shun spot market transactions to procure slaughter hogs.

Measurement Difficulty Hypothesis

Increasing consumer demand for meat characteristics associated with hog quality attributes that are difficult to measure have created 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 the quality attributes post-slaughtering involves potential moral hazard issues since quality outcomes result from a sort of team-production among the economic agents in the production, transportation, and slaughtering stage of the value chain. Therefore, it is virtually impractical for packers to implement pecuniary incentives based on objective performance measurement of individual hogs. To make things worse, providing incentives for measurable quality attributes such as leanness and size may adversely influence the outcome of the difficult-to-measure quality attributes hog producers have strong incentives to invest in the outcome of the former attribute at the sacrifice of that of the latter attribute, particularly when selecting genetics and feeding programs. This challenge is not likely to be resolved through spot market organization because it features instantaneous and anonymously disconnected exchange.

Since independent contracting parties have strong incentives to maximize their own profit even at the cost of the other parties, suboptimal outcomes may take place in terms of joint-surplus

maximization (Holmstrom and Milgrom, 1991; Holmstrom, 1999). Pork packers that value the less-contractible quality attributes, therefore, are likely to shun spot markets and instead adopt contracts through which they create instruments to lessen potential contractual externality. A review of the marketing contracts in the GIPSA Swine Contract Library reveals that marketing contracts include terms concerning the selection of genetics and nutrition programs and designing of production facilities that affect meat quality attributes of hogs. One step further, contract growers under production contracts are subject to the contractor's decision with regard to the selection of inputs for hog production. Obviously, wage workers for hog production under managerial control have little incentive to engage in the contractual externality because they are not residual claimants. Therefore, spot markets are different from long-term contracts, production contracts, or vertical integration in that the former does not allow for pork packers to interfere with the decisions of hog producers with regard to input use.

Hog carcasses are used to create a variety of meat products, ranging from processed meats, to frozen boxed meats, to fresh pork cuts, each of which has different consumer quality characteristics. Previous research 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; Muth, et al., 2005). A pork packer who heavily relies on a high portion of fresh pork branded product, therefore, is more vulnerable to be hurt from variation of meat quality attributes of hogs slaughtered than others that market case-ready frozen products, boxed fresh or frozen products, and processed product because marginal negative effects of the variation on the packer are substantially higher than otherwise.

Hypothesis 2: A pork packing plant that markets case-ready fresh pork products is more likely to choose long-term contracts or in-house production.

Product Specificity Hypothesis

A long-term contract may be required for pork packers when the incentive price for certain measurable hog quality attributes posted by individual packers does not meet the producers' calculation of first order condition for production of the quality attributes of hogs which should be constantly marketed. This suboptimality may take place when the factors influencing the marginal costs of the quality attributes are volatile at the same time as the quality incentive price is rigid. If a contract can be structured to help redress the suboptimality, pork packers would be likely to offer the contract to producers.

The advantage of long-term contracts can be realized when pork packers want to procure intertemporally consistent quality hogs. Achieving consistency in hog quality has been one of the greatest challenges in repeated transactions of slaughter hogs, pork cuts, and processed pork products. 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 (NPPC, Pork Quality Audit, April 1994). From pork packers' standpoint,

consistency has to do with variances within a group of hogs delivered from a seller, across hog sellers, and over time.

Given the volatile nature of the unit price of slaughter hogs and the feed price, intertemporal variance in certain quality attributes cannot be controlled only by static quality incentive prices built in carcass merit programs. The concern arises from the erosion effects of volatility in market prices of a base hog and feed prices on the incentives (premiums and discounts based on carcass weights and percent lean) since changes in the market price of a base hog or in the price of feed will change the net return function for hog producers given a 3-week marketing horizon within which hog producers determine the timing to market hogs. Depending on the nature of the quality price matrix and the relative magnitude of market price fluctuations, producers may no longer have an incentive to deliver the desired quality hog.

Figure 1-A, B, and Figure 2 illustrate the case described above. Given any quality pricing structure, changes in market price of a base hog or in the price of feed (or other variable inputs) will change the net return function for producers. Figure 1-A shows that a high productivity-producer's optimal decision on the timing to market tends to result in marketing a hog of overweight for a pork packer when the base price of a slaughter hog is increasing at the marketing time horizon. In contrast, a low productivity-producer's optimal decision may bring about delivering a hog of underweight for a pork packer when the base price of hogs is decreasing or the feed price is increasing at the marketing time horizon (see Figure 1-B). Both Figure 1-A and 1-B cases result in deviation from target range of carcass weights valuable to a downstream firm. The consequential effects on the distribution of carcass weights are expressed in the Figure 2. Therefore, upstream firms' optimal decision under the volatility of feed and base-hog prices may result in an insufficient supply quantity of hogs of target quality. We label this deviation as the erosion effects of price volatility. Intuitively, we can conclude on a proposition: The higher a pork packer's hog quality specificity, the larger the erosion effects are likely to be. The proposition entails that a pork packer with a narrower target range of carcass weights is more likely to get hurt from the erosion effects.

<Insert Figures 1-A, B, and 2 here>

How do long-term hog procurement contracts help reduce the erosion effects? The observed provisions of the long-term hog procurement contracts include setting intertemporal target quality, providing contract premium, and enforcing intertemporal target quality performance. In addition, it is found that contract base-hog pricing structures observed in some long-term contracts also help producers to make a decision on intertemporally consistent hog weights. The former indirectly contributes to inducing hog producers to adjust their decision on timing to market to pork packers' expectation while the latter directly influences the price variables comprising first order condition for the producers' decision. We expect that long-term contracts increase the density of desired hogs relative to the volatile price environment and come up with the product specificity-related hypothesis.

Hypothesis 3: The proportion of spot market transactions used by a pork packing plant is negatively influenced by hog quality specificity to the plant.

Measurement of Variables

The choice of organization form

It is difficult to observe pork packers' choice of organization form per transaction. Given the nature of pork packing plant operation continuously slaughtering hogs, accumulated results of the choice of organization form for a specific period of time, or a year, are observable. Therefore, the choice of spot markets, long-term contracts, or in-house production can be measured by the number of hogs procured by each organization form divided by total number of hogs procured by plant *i* during a year.

Temporal specificity

Temporal specificity in our model is measured by two proxies: slaughter technology and small number bargaining condition. According to Hayenga (1998)'s analysis of cost structure differentials between double-shift versus single shift slaughter plants, double-shift plants are more vulnerable to the seasonal and biological vagaries of spot market hog supplies than single-shift ones. He argued that when the number of hogs purchased is too small to fully employ workers for the guaranteed hours, packers often are willing to bid significantly higher prices to increase their capacity. Therefore, it is suggested that a double-shift pork packing plant is more likely to use long-term contracts or vertical integration into hog production. The survey asks the mangers of packing plants whether they adopt single-shift or double-shift technology.

As a large body of transaction cost empirical literature utilizes it, small number of bargaining condition may come into play in the transactions of slaughter hogs. As compared to a large number of small hog producers, a few large hog producers may influence the bargaining condition between the producers and pork packers, increasing potentials of producers' opportunistic behaviors. This story is suggested by Lawrence, et al. (1997). It is therefore proposed that a pork packing plant that is surrounded by higher market share of top 5% largest hog producers is more likely to shun spot market transactions.

Measurement difficulty

Based on existing literature regarding the correlation between case-ready fresh pork products and the value of meat quality attributes difficult to measure, The survey asks the managers of pork packing plants about the outputs including carcass, boxed fresh products, boxed frozen products, case-ready fresh products, case-ready frozen products, and processed products such as sausage, smoked or cured ham, and lunch meat.

Hog quality specificity

Hog quality specificity to a pork packer may be measured with a couple of proxies: narrowness of target range of carcass weights set by plant *i*; and lower bound of target range of lean

percentages set by plant *i*. Among the two proxies, the research adopts narrowness of target range of carcass weights. Given the biological variation in hog weights per batch and for certain period of time, it is expected that a packing plant that adopts narrower range of target weights is more likely to choose long-term contracts or in-house production shunning spot markets. The survey includes questions of whether they adopt a carcass merit program for procuring slaughter hogs and of indicating target carcass weights range.

Control variables

We establish two control variables: plant size and geographic region of plant. Plant size is measured by slaughter capacity of a packing plant and is categorized with 8 intervals in our survey questionnaire. The geographic region where a pork packing plant is located is classified into 3 categories, including Midwest, East, and others.

<Insert Table 1 here>

Data Collection

We obtained data to test our hypotheses through a survey of 115 pork packing plants based on information collected from the National Pork Board (NPB), USDA Food Safety and Inspection Service (FSIS), American Meat Institute (AMI), and National Meat Association (NMA). Among the sample, 69 plants were derived from data posted at the website of the National Pork Board. The data include the name and slaughter capacity of 69 largest pork packing plants which exceed slaughter of 25,000 heads per year as of 2004. According to "Livestock Slaughter Summary 2006," (NASS, USDA), the 53 pork packing plants which slaughter over 100,000 head per year shared 97% of total US slaughter hogs. The address information was obtained from "Lists of Plants Approved to Receive Immediate Slaughter Animals, August 2007" posted at the website of USDA FSIS. In order to meet the balance of our sample and population of pork packing plants, which includes 561 packing plants yearly slaughtering below 100,000 heads, we collected an additional sample of 46 packing plants from FSIS, AMI, and NMA. The survey was conduct between October 2007 and March 2008.

We obtained 25 responses from 108 eligible pork packing plants that received our survey packets. We removed 3 responses from the 25 responses due to high incompleteness, resulting in an effective response rate of 20%. Table 2 indicates the distribution of the size of the sample packing plants that will be utilized in our analysis. Our respondent sample is moderately representative of the distribution of medium and large scale packing plants. A potential bias associated with our sample responses should be mentioned. It may be supposed that pork packers that believe the information we ask is more confidential are more unlikely to respond to our survey. This issue may be relevant in the meat industry where competition in multiple attributes of meat quality is increasing and the source of quality differentiation partly resides in the way of hog procurement. Particularly, pork packers' concern on this issue is more closely related to the questions of product specificity than other information that we request, such as

slaughter technology and an estimate of degree of producers' market concentration. Therefore, our sample may under-represent the pork packers who have high correlation between organization form choice and product specificity.

Two features of our data deserve mention. First, the sample data indicate that 12 packing plants out of 22 sample respondents simultaneously use alternative organization forms while 10 plants rely on one form of organization to procure slaughter hogs.[5] This feature of our sample is not different from observation results of existing literature (Muth, et al., 2007). One may maintain that there would be an optimal portfolio of alternative organization forms to use. Second, unlike existing descriptions on the relation between contracts and carcass merit programs, the sample data indicate that carcass merit programs are used in spot markets by some packers and some contracts do not involve the programs.

<Insert Table 2 here>

Among the 22 usable responses, nine responses had missing data in the questions of MSLP (a proxy for temporal specificity) and TRW (the proxy of product specificity). In order to most effectively use the limited number of responses, we use several imputation rules and test the robustness of our results.[6]

Traditional approaches to missing data include dropping variables or subjects with missing data or employing statistics to imputing scores that are missing (Cohen, et al., 2003). The first approach is rather impractical since the variables stained by missing data in our model are essential to the theory being tested. Before going into the second approach, we investigate the reason why the data is missing in order to make a decision on which one is more appropriate between the second or third approach.

The original survey responses include nine missing cases in TRW variable. All nine subjects replied that they did not use a carcass merit program where a target carcass weight range is specified. Our hypothesis suggests that the narrower the target range is, the greater the potential erosion effect. Since the value of TRW is calculated from the target range of hog carcass weights, there was no basis from which to calculate a TRW value for these nine subjects.

We separate the nine missing cases into three categories in terms of the subjects' use of organization form since the reasons that they did not use carcass merit program are different from each other. Eight missing cases took place in the responses from packing plants which used either spot markets only (6 cases) or in-house production only (2 cases), for their procurement of slaughter hogs. The final missing case was found in the response from a packing plant that used both spot markets and long-term contracts. The 6 missing cases in the responses from pork packers who used spot markets only took place because they did not have a target range of hog

[5] This feature of organizational structure in the pork industry may be one of the factors that make it inappropriate to adopt a traditional empirical approach to organizational choice using a dichotomous variable (see Klein, 2004, for a survey of the literature).

[6] For more detailed description of the data and data management issues, see Jang (2008).

carcass weights. In order to estimate the 6 missing cases, we construct three alternative imputation rules and implement a sensitive analysis.

First, we estimate the 6 missing cases from the data provided by two respondents that procured slaughter hogs through spot markets only and used carcass merit programs (Imputation Rule I). We pick a larger value among the target ranges set by the two packing plants because we assume that a larger value of the target range is closer to a hypothetical value of no target range. The imputed values turn out to be 52 and 44 pounds in 2003 and 2006, respectively. The second alternative imputation rule is constructed based on selecting the largest value in our entire sample rather than the sub-sample used in the first alternative imputation rule (Imputation Rule II). The imputed values appear to be 52 and 52 pounds in 2003 and 2006, respectively. The last alternative imputation rule is established based on estimates from a large sample of carcass merit programs and sorting schedules that has been available at the USDA GIPSA Swine Contract Library website (Imputation Rule III). The carcass weight ranges after excluding the extreme weights in the 31 samples are distributed from 50 ((17225) to 140 (110-250) pounds in 2003 and 30 (179-209) to 149 (100-249) pounds in 2006 (refer to table 3). We calculate average ranges because they are most likely to be the numbers close to representing actual ranges of carcass weights excluding outliers that pork packers receive under no carcass merit program. We apply this imputation rule to the 1 missing case observed in the response from a pork packing plant which simultaneously used long-term contracts and spot markets because they did not use a carcass merit program. It may be assumed that the packing plant's choice of long-term contracts was made from other reasons.

As in the other extreme case, thetwo missing cases appeared in the responses from pork packers that entirely relied on in-house production to procure slaughter hogs because they also did not use a carcass merit program. However, the specific reason might be different. While packers that use spot markets only and do not use a carcass merit program do not much care about the variation of carcass weights, packers that adopt in-house production for all hogs and establish a target range of carcass weights do not have to create a carcass merit program since they are equipped with managerial control, and the employees in the hog production units has little incentives to take advantage of deviating from the target range. Therefore, we estimate the 2 missing cases from the data provided by two respondents that 97.5% of their slaughter hogs were procured through vertical integration but 2.5% of the hogs were purchased through spot markets and the carcass merit programs set by the packers. We obtain the estimate values of 26 and 22 pounds in 2003 and 2006, respectively, averaging the two target ranges set by the two packing plants.

Finally, three missing data in MSLP have been found in the survey responses from packers who procured slaughter hogs by only spot markets or short-term contracts in both 2003 and 2006. We scrutinized any potential reasons that the three packing plants did not respond to the survey question. The most plausible reason for the occurrence of the missing data is that the three packers do not have sufficient information to respond to the following question: "what is your best estimate of market share of 5% largest hog producers within the geographic region

surrounding your plant? Please indicate it with 10% interval." In this case, the most frequently used is to code cases with missing data at the mean value in the sample (Cohen, et al.: 442).[7] We plugged in the data set the mean values of MSLP, which are 53% and 58 % in 2003 and 2006, respectively. In the next section the research analyze the sensitivity of alternative imputation rules.

Model Specification and Statistical Methods

The research specifies an econometric model to estimate and test the effects of variables representing the three alternative explanations of pork packers' choice of organization form as follows:

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

This model is not used to test spot markets versus long-term contracts or vertical integration or contracts versus vertical integration, but rather spot markets versus non-spot markets. Therefore, the expected results from an econometric analysis of the model using data collected from pork packers would represent what factors influence pork packers to eschew the choice of spot markets. Since the model does not distinguish between contracts versus vertical integration, the two organization forms are regarded as alternative substitutes for spot markets in our model. The model does not tell about why vertical integration instead of contracts and vice versa is chosen when spot markets is avoided but inform why spot markets are shunned as evaluated by the marginal effects of independent variables on the share of spot markets in the organizational portfolio.

The research estimates the organizational choice model using two statistical methods that addresses potential issues of omitted variables and censored data. As most of the organizational choice empirical research may suffer from potential unobserved variables which are correlated with the error term (Hamilton and Nickerson, 2003; Yvrande-Billon and Saussier, 2005), our empirical model may involve unobserved individual firm-specific factors which might be correlated with the right-hand side variables. This kind of correlation may bias the coefficient estimates. In order to address this concern, the research designs a survey that requires plant managers to respond to the same question item at two different points of time, 2006 and 2003. This survey strategy is able to deal with the potential endogeneity issue by using first differencing estimation, a special case of the fixed effects model, which effectively controls for any time-invariant plant-specific unobserved factors in our panel data (Wooldridge, 2002: 279-

[7] Cohen, et al. put a caveat that the plugged mean can produce a lower standard error of the variable in question and is a source of concern when the difference between the two alternative standard errors is significant (p. 444).

285). However, it turns out that the dependent variable of share of spot market use in our sample data does not vary much across time. In this case, the first-differencing model is not practical since many zero values in right-hand side in the first-differencing transformation cause a singularity issue. The research instead adopts a dummy variable regression model which is equivalent to the fixed effects model (Wooldridge, 2002: 272-274).

The second potential issue arises when part of dependent variable is censored above or below at some values. It turns out that 13 observations in our sample data are corner solution outcomes on the top, 100%, and 6 observations, on the bottom, 0%. OLS estimators ignoring data censoring issues in our sample data would be biased and the t statistics are not 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). The research therefore adopts the double-censored Tobit model with Huber/White heteroskedasticity robust standard error estimates including year dummy variables.

Analysis of Estimation Results

We begin with the results of the sensitivity analysis of alternative imputation rules. As Table 3 exhibits, the estimation results are fairly sensitive to the three alternative imputation options. The coding target weights range values increased by the imputation option II and III not only changes the signs of coefficient estimates in plant size (PS) and market share of large producers (MSLP) variable but also increases the statistical significance of target weights range (TRW) variable. However, the different imputation rules do not much influence the coefficient and standard error estimates of slaughter technology (ST) and case-ready fresh products (CRFP) variables, which suggest that the estimates of the two variables are robust to the three alternative imputation rules. As we can see through the Table 3, the facts that pork packers market case-ready fresh products decrease the share of spot markets in their organizational form portfolio for procuring slaughter hogs. Narrowing target range of carcass weights also decreases the share of spot markets. Pork packers' adoption of double-shift technology decreases the choice of spot markets, but the coefficient is not statistically significant.

<Insert Table 3 here>

Given the sensitivity analysis results, it can be safe to say that the hypotheses of measurement difficulty and product specificity received statistical support from our data but the temporal specificity hypothesis representing by ST, one of the two proxies, is not supported by the data. In addition, another commonality among the results from applying the three imputation rules is that the coefficient estimates of product specificity variable are statistically significant at least above 90% confidence interval while the coefficient estimates of MSLP, one of the proxies for temporal specificity, are not statistically significant across the alternative imputation rules. Lastly, given the suppression effects of coding increasing values of TRW on the estimators of

some variables, it is safe to pick the imputation option I for the rest of the statistical analysis even if the imputation option III seems to be logically more reasonable.

Next, we report the results of another sensitivity analysis considering two alternative imputations of dropping all missing subjects and missing subjects of both MSLP and TRW. As Table 4 shows, the two alternative imputation options also influence the estimation results of the model. One of the obvious reasons is that dropping all missing subjects causes a loss of a considerable portion of the information regarding organizational choice behavior of pork packers whose organizational portfolio includes spot markets only. Comparing the estimation results of between imputation option I and imputation option IV, two major features deserve to receive attention. First, the signs of PS and MSLP are not consistent across imputation option I, IV, and V while the signs of ST, CRFP, and TRW are consistent, which is same as seen in the sensitivity analysis of imputation I, II, and III. Second, in terms of statistical significance, the coefficient estimates of PS, ST, and MSLP are not statistically significant across the three alternative imputation options, which is also similar to the sensitivity analysis results of imputation I, II, and III. In addition, it turns out that the significance level of coefficient estimates of CRFP and TRW changes across the alternative imputation options. The coefficient estimates of CRFP are statistically significant in the imputation option V but not significant in imputation option IV. Those of TRW are statistically significant at the 90% confidence level in the imputation options I and IV.

<Insert Table 4 here>

Finally we report the results of alternative regression models. Looking at the results of pooled OLS and dummy variable regressions, there is little difference between those two models. Therefore, the time-invariant firm-specific unobserved effects have not been found to be significant in our data. As expected, it turns out that the estimate of the standard deviation of error is statistically significant at 99% confidence level, which implies that the presence of corner solution outcomes of 44% significantly affects the regression outputs. Since the meaning of the coefficient estimates between the OLS and Tobit models is different from each other, the direct comparison of the magnitude of the estimates between those two is not practical. Two interesting features are striking. The sign of estimates of MSLP in Tobit model is opposite to that in the OLS model. One of the reasons may attribute to the fact that the magnitude of the estimates is extremely small. Second, the relative magnitudes of the standard errors of almost all of the coefficients are larger in the Tobit model as compared to the OLS model. A final finding to receive attention is that the coefficient estimates of CRFP and TRW variables are statistically significant across the alternative regression models while those of ST and MSLP variables are not statistically significant.

<Insert Table 5 here>

We summarize the overall results from the sensitivity analysis and comparison of alternative regression models. 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 except in cases where the former is imputation option IV (dropping missing subjects of both MSLP and TRW) and the latter is imputation option V (dropping all missing subjects). Therefore, we conclude as follows.

Measurement difficulty hypothesis (H2) is supported by our survey data, which implies that pork packers positioned on downstream markets of case-ready (mostly branded) fresh products are more likely to increase the share of contracts and vertical integration in their organizational form portfolio. In addition, our survey data support product specificity hypothesis (H3). The narrower the target carcass weights are, the lower the share of spot markets in their portfolio is. In contrast, the temporal specificity hypothesis (H1) is not supported by our data. The explanation that double-shift slaughter technology adoption and increasing market share of large producers negatively influence the share of spot markets in pork packers' portfolio of organization forms is not collaborated with our data.

Conclusions

The research attempted to empirically test the two existing explanations of rapid transition from spot markets to contracts and vertical integration in the U.S. pork industry: temporal specificity and measurement difficulty. Our survey data support the latter but does not the former theory. More interestingly, the data support the product specificity hypothesis constructed based on the analysis of long-term hog procurement contract documents and the costs associated with optimal pricing. The empirical results suggest that the dramatic change in organization form in the pork industry may be better explained by the change in the downstream markets (demand side) rather than the structural change in the upstream markets (supply side). From the theoretical perspective, the pork industry case of contract and vertical integration choice is better explained by costs associated with providing appropriate incentives *ex ante* rather than *ex post* safeguard function against opportunism.

The empirical findings are well collaborated with the main findings in the analysis of hog procurement contract documents described in previous chapter. Pork packers' choice of long-term contracts can be better explained by the organizational capabilities of the contracts to create contractual instruments for intertemporal quality consistency under volatile production costs of consistency in hog weights and allowing contracting for decision rights under measurement difficulty of hog quality. Considering the fact that long-term contracts are the vast majority of organizational forms for transactions of slaughter hogs, the empirical evidence supporting the measurement difficulty and product specificity hypotheses suggests that the analysis of contract documents is essential for an empirical study of contract choice.

Finally, although the empirical results of our research indicate new findings for the explanation for the costs of spot markets, the research is subject to a number of limitations. Like most transaction cost empirical studies, we do not directly test Williamsonian transaction cost theory, contractual externality theory, and the relationship between adjustment costs of quality price and product specificity. Particularly, our findings cannot rule out the importance of potential unobserved Williamsonian transaction costs. Finally, the limitations from the use of our survey data should be mentioned. In particular, the combination of a relatively small size of sample data and missing data in two variables makes the results less robust.

<Table 1> Definition of Variables

Dependent variable	Spot market	Number of hogs procured through spot markets divided by total number of hogs procured by plant *i* during year *t.* (SM)
Theoretical variable	Temporal specificity	Slaughter technology (ST): 1 if plant *i* uses double shift, 0 otherwise Market share of top 5% large producers surrounding plant *i* (MSLP) based on the plant manager's estimate
	Measurement difficulty	Case-ready fresh products (CRFP): 1 if plant *i* markets case-ready fresh products, 0 otherwise
	Product specificity	Target range of carcass weights (TRW): 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): categorized with range from 1 to 8

<Table 2> Population and sample of federally inspected pork packing plants, 2006

Size group	Population		Sample
	Plants	Head	Plants
	Number	*1,000 (%)*	*Number*
1-999	380	124 (0.1)	0
1,000-9,999	118	322 (0.3)	0
10,000-99,999	63	2,727 (2.6)	6
100,000-499,999	20	4,817 (4.6)	6
500,000-999,999	5	3,702 (3.6)	1
1,000,000-2,499,999	15	32,566 (31.4)	4
2,500,000-3,999,999	3	10,329 (10.0)	3
4,000,000+	10	49,099 (47.4)	2
Total	614	103,689 (100.0)	22

Source: Livestock Slaughter Summary, NASS, USDA

<Table 3> Sensitivity Analysis of Alternative Imputations (Dependent Variable: Spot Market Share)

ML-Censored Normal (Tobit) (Huber/White SE)	**Imputation option I**	**Imputation option II**	**Imputation option III**
Plant size (Control)	-2.3716 (14.6713)	1.0402 (14.5238)	12.4999 (12.0351)
Slaughter technology (Temporal specificity)	-21.1753 (37.0926)	-27.1563 (35.8682)	-28.2614 (25.9413)
Market share of large producers (Temporal specificity)	-0.0055 (0.3384)	-0.0179 (0.3362)	0.0853 (0.3071)
Case-ready fresh products (Measurement difficulty)	-38.8152* (21.8335)	-36.8504* (20.6793)	-31.4099* (18.9836)
Target range of weights (Product specificity)	78.5959* (46.7592)	89.2462** (45.5498)	156.1485*** (40.5575)
Year dummy1	41.8222 (88.1055)	18.7297 (87.4190)	-58.3066 (65.9486)
Year dummy2	42.4139 (86.5027)	15.9078 (87.8464)	-29.8090 (32.9996)
Log-likelihood value	-149.04	-148.06	-141.44
Standard deviation of error	49.1488*** (7.9803)	47.8093*** (7.4465)	41.5316*** (5.8671)
N (Censored observations in parentheses)	44 (6: 13)	44 (6:13)	44 (6:13)

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

<Table 4> Sensitivity Analysis of Alternative Imputations (Dependent Variable: Spot Market Share)

ML-Censored Normal (Tobit) (Huber/White SE)	**Drop all missing subjects**	**Drop missing both MSLP and NTRW**	**Imputation option I**
Plant size (Control)	1.2110 (12.2523)	-0.2091 (14.7360)	-2.3716 (14.6713)
Slaughter technology (Temporal specificity)	-7.4489 (27.2676)	-19.8237 (35.7174)	-21.1753 (37.0926)
Market share of large producers (Temporal specificity)	0.1987 (0.2664)	0.0339 (0.3184)	-0.0055 (0.3384)
Case-ready fresh products (Measurement difficulty)	-47.9382** (22.3364)	-26.0256 (22.1729)	-38.8152* (21.8335)
Target range of weights (Product specificity)	17.4521 (20.4822)	72.4726* (41.5746)	78.5959* (46.7592)
Year dummy1	52.8475 (67.9312)	18.7575 (87.0267)	41.8222 (88.1055)
Year dummy2	48.7593 (66.5623)	19.9392 (86.2785)	42.4139 (86.5027)
Log-likelihood value	-112.76	-140.66	-149.04
Standard deviation of error	33.5539*** (5.4080)	47.9907*** (7.6450)	49.1488*** (7.9803)
N (Censored observations in parentheses)	26 (2:2)	38 (6:8)	44 (6: 13)

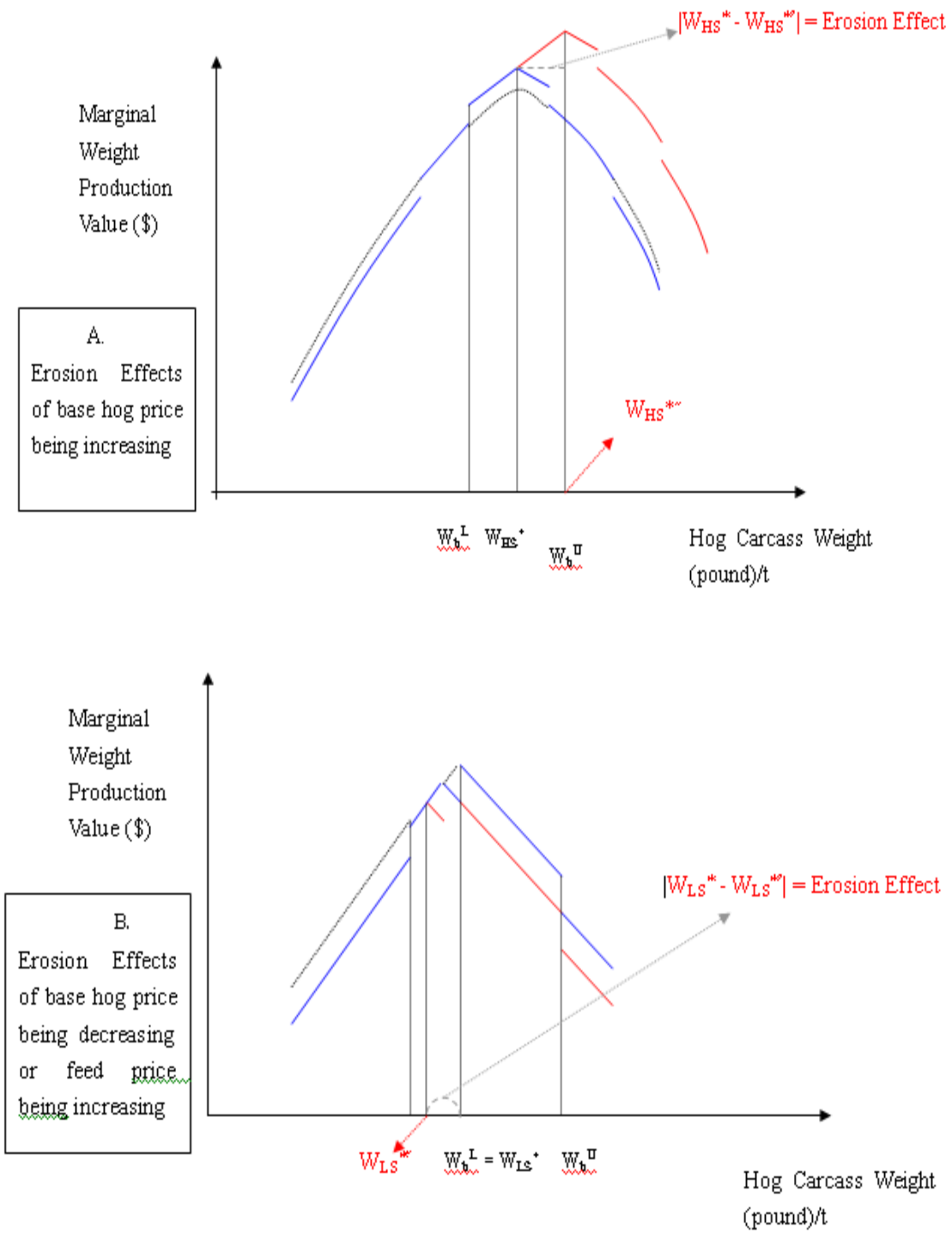
*p<0.1, **p<0.05, ***p<0.01 (Standard Errors in parentheses)

<Table 5> Comparison among Alternative Regression Models (Dependent Variable: Spot Market Share) Using Imputation Option I

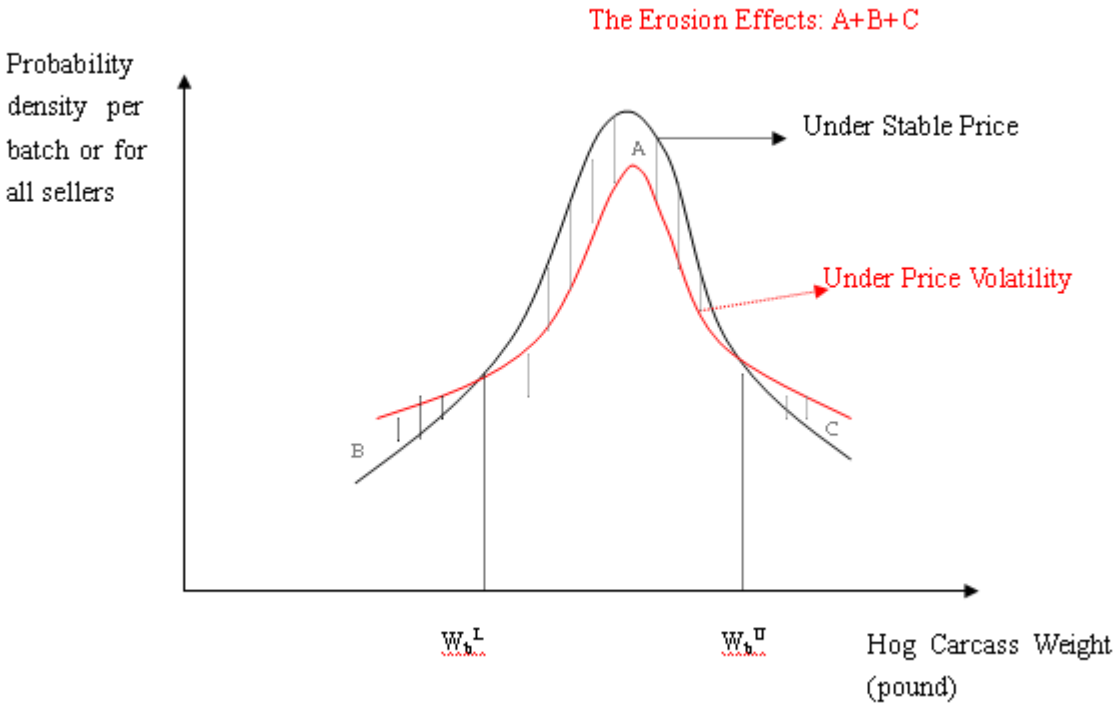
	POLS (White SE)	**Dummy Variable Regression (White SE)**	**Tobit (Huber/White SE)**
Plant size (Control)	-2.2442 (7.9063)	-2.19613 (7.9970)	-2.3716 (14.6713)
Slaughter technology (Temporal specificity)	-13.4483 (21.6597)	-13.6354 (21.9686)	-21.1753 (37.0926)
Market share of large producers (Temporal specificity)	0.0953 (0.2076)	0.0904 (0.2142)	-0.0055 (0.3384)
Case-ready fresh products (Measurement difficulty)	-23.3828* (13.3062)	-23.4331* (13.4781)	-38.8152* (21.8335)
Target range of weights (Product specificity)	57.2417** (27.5978)	57.6196** (28.2944)	78.5959* (46.7592)
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)

<Figure 1> Erosion Effects of Price Volatility of Base Hog and Feed on Quality Incentives



<Figure 2> Erosion Effects on Distribution of Carcass Weights



References

Kliebenstein, J. B., and J.D. Lawrence. "Contracting and Vertical Coordination in the United States Pork Industry." *American Journal of Agricultural Economics* 77 (December 1995): 1213–18.

Vukina, T., M.K. Muth, N.E. Piggott, C. Shin, M.K. Wohlgenant, X. Zheng, S.C. Cates, M.C. Coglaiti, S.A. Karns, J. Lawrence, J.L. Taylor, and C.L. Viator. "GIPSA Livestock and Meat Marketing Study, Volume 4. Hog and Pork Industries," Report prepared for USDA, Grain Inspection, Packers and Stockyards Administration, Washington, DC. (January 2007).

Wang, Y., and E.C. Jaenicke. "Simulating the Impacts of Contract Supplies in a Spot Market-Contract Market Equilibrium Setting." *American Journal of Agricultural Economics* 88 (November 2006): 1062-0717.

Xia, T. and R. J. Sexton. "The Competitive Implications of Top-of-the-Market and Related Contract-Pricing Clauses," *American Journal of Agricultural Economics* 86 (February 2004): 124-138.

Zheng, X., and T. Vukina. "Do Alternative Marketing Arrangements Increase Pork Packers' Spot Market Power? Estimating Conjectural Variations with Mandatory Price Reporting Data." Working Paper, North Caroline State University (February 2008).