Bargaining, Search and Price Dispersion: Evidence from the Live Hogs Market*

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Abstract

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Key words: intra-day price dispersion, bargaining theory, search cost, asymmetric information.

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Using a unique panel data on individual transactions between buyers and sellers in the spot market for live hogs, we found large degree of intra-day price dispersion. Motivated by this empirical puzzle, we offer an explanation rooted in bargaining theory with search. We formulate three hypotheses involving the role of farmers' search cost, bargaining parties' patience, and asymmetric information that we believe can explain the observed phenomenon. Empirical analysis shows strong support for all three of the stated theoretical predictions indicating that bargaining theory with search explains at least 31% of the observed intra-day price variation in this market.

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Introduction

In contrast to the standard neoclassical theory, in many markets we often observe that the same good is sold for different prices at different outlets. Starting with the original work of Stigler (1961), numerous studies have been devoted to explaining the phenomenon of price dispersion in markets for seemingly homogenous good. Several possible explanations are put forward.[1] One prominent explanation is the existence of search cost. Consumers incur positive search cost when searching for low prices, and in equilibrium consumers who search more pay a lower price than those who search less (e.g. Reinganum 1979; MacMinn 1980). Another explanation is based on informational asymmetry: some consumers are aware of the low price and some are not and hence different consumers end up paying different prices (Varian 1980; Baye and Morgan 2001). Yet another explanation is rooted in various theories of imperfectly competitive markets. For example, Borenstein and Rose (1994) study dispersion in the prices an airline charges to different passengers on the same route and argue that the data supports models of price discrimination in monopolistically competitive markets.

Using the individual transactions data between buyers and sellers in the hog market, we found a large degree of intra-day price dispersion. These prices are negotiated in the so called direct trades between farmers and pork packers. Even a casual observer of this industry would not be surprised by the high degree of price variation knowing that live animals are not homogenous goods, so why would they command a uniform price. The reason why this is a puzzle is because the prices that we use are the so called base prices which are negotiated between a farmer and a packer before the quality has been measured. The actual price that a farmer will receive for his hogs is the sum of the negotiated base price and various premiums and discounts which will be added to the base price after the animal has been slaughtered and various quality attributes have been precisely measured. Our main objective is to try to explain this intra-day base price dispersion in a geographical segment (state of Iowa) of the live hogs market.

[1] This literature has been thoroughly reviewed by Baye, Morgan and Scholten (2007).

Although it is hard to contest the empirical observation that observed prices for otherwise homogeneous products differ across buyers and sellers in the same market and the same time, this does not necessarily mean that “the law of one price” should be automatically rejected. As pointed out by Baylis and Perloff (2002), price dispersion may be “illusory,” a result of “hidden” price differentiation. That is, the same product sold in different transactions may actually be a differentiated product because the heterogeneity of buyers and sellers ends up being reflected in the product itself.

We formulate a theoretical explanation for the observed phenomenon using the insights from the bargaining theory with search. The empirical literature on bargaining with non-experimental (field) data is mainly concerned with labor unions and strikes (see: Ausubel, Cramton and Deneckere, 2002). Outside the labor union contracts negotiations, the empirical bargaining papers mainly focus on socio-economic characteristics of the bargaining parties that effect bargaining outcomes (e.g., Ayres and Siegelman 1995; Harding, Rosenthal and Sirmans 2003; Harding, Knight and Sirmans 2003). Contrary to the above empirical bargaining papers, our study is primarily focused on explaining the observed price dispersion, and as such is related to empirical papers by Chen (2006); Clay, Krishnan and Wolf (2001); Dahlby and West (1986); Hortaçsu and Syverson (2004); and Sorensen (2000) who addressed the role of consumer search in explaining price dispersion in homogeneous good markets.

Using the theoretical predictions from the bargaining with search models, we formulate three empirically testable hypotheses about the role of farmers’ search cost, bargaining parties’ patience, and asymmetric information in explaining price variation in the hog market. We test these propositions with a panel data where buyers and sellers are uniquely identified such that each observation represents one pair-wise transaction and such transactions are observed repeatedly. Empirical analysis shows very strong support for all three of the stated theoretical predictions indicating that bargaining theory with search explains at least 31% of the observed price variation in this market.

Industry Description

Traditionally, hog production in the United States occurred on small diversified farms where hogs provided price risk protection for grain production. Starting in the 1950s, many farmers adopted new technologies that allowed them to grow and specialize in grain production. Some farmers discontinued hog production because the opportunity cost of time and land increased, and risk protection for feed grains had been supplemented by income and price supports. Hogs are now commonly produced by specialized operations that separate production facilities for each phase of production, and purchase or process their animal feed. Hog production has historically been concentrated in the Corn Belt States (Iowa, Illinois, Minnesota, Indiana, and Nebraska). However, by 1994, a geographical shift in production became noticeable with North Carolina jumping to the second largest hog inventory state in the country, trailing only Iowa (USDA/NASS, 1998). As the location of hog inventories has changed, so has the location of slaughter facilities. In 1990, almost 60% of U.S. slaughter capacity was located in Iowa and surrounding states. By 2003, North Carolina had become the second largest state in slaughter capacity.

The agricultural commodity that we analyze in this paper is the live market hogs.[2] After being sold, hogs are shipped to a slaughter facility (packer). As with all meat types, hog carcasses are inspected for wholesomeness by the U.S. Department of Agriculture (USDA)/Food Safety and Inspection Service (FSIS) or by a state government inspection system. However, unlike beef, pork is rarely quality graded by USDA/Agricultural Marketing Service (AMS). Instead, packers rely on other measures of quality, such as lean percentage, back fat, and loin eye depth. After the hogs have been slaughtered, the carcasses are chilled and then sent to the fabrication area of the plant where they are broken down into pork cuts. Some packers only slaughter hogs and sell the carcasses to a separate processor or breaker; however, the majority of packers have their own

[2] The attribute “market hogs” is used to identify finished (ready for slaughter) animals that are about 25 weeks old and typically weigh between 250 and 290 live pounds. The market hogs (barrows and gilts) are distinguished from younger animals (weaned pigs and feeder pigs) and from inferior categories of adult animals (sows, boars, and stags). Market hogs constitute over 96% of all pigs slaughtered in the U.S. (USDA/GIPSA, 2002).

fabrication facilities. In fiscal year 2002, there were 558 federally inspected plants that slaughtered at least 50 market hogs. However, the four largest packers slaughtered over 50% of the hogs under federal inspection since 1997 (USDA/GIPSA, 2002).

The transaction of live market hogs between producers (sellers) and packers (buyers) occur via cash or spot market transactions and the alternative marketing arrangements (AMAs). Cash or spot market transactions include auction barn sales; video or electronic auctions; sales through dealers and brokers; and direct trades. AMAs refer to all possible alternatives to the cash or spot market. These include arrangements such as procurement or marketing contracts, production contracts, and packer owned production facilities. Production contracts specify the division of production inputs supplied by the two parties and the type of the remuneration mechanism for the grower. The hogs are owned by the contractor (packer or integrator), who controls the volume of production and production practices, assumes most of the risk, and becomes the residual claimant on the enterprise profits. Marketing contracts refer to an agreement that establishes a price or pricing mechanism and an outlet for the product prior to harvest. Most management decisions remain with the growers because ownership of animals is retained until harvest. Producers also assume all production risk but share price risk with a contractor. Forward contracting and price setting after delivery based on a predetermined formula that reflects quality grades and yields are examples of marketing contracts. There are significant regional differences in the observed patterns of use of various selling/procurement practices: a stronger reliance on cash/spot markets and marketing contracts is apparent in traditional production areas (Midwest) and a stronger reliance on production contracts and packer ownership in the new areas (North Carolina).

In this study we focus on the spot market for hogs and in particular on the segment of the spot market known as direct trades. Direct trades materialize in two similar ways. Typically, a producer will call a packer asking him for a today’s quote. After receiving a bid (which usually comes with delivery conditions), the producer may decide to sell the hogs immediately or may place another call to obtain another bid from another packer. Delivery conditions vary based on the timing and the place of delivery as well as who pays for the transportation costs. Eventually, the producer would call back the best bid packer, strike the deal, and deliver the hogs either to a buying station or directly to a plant. Another mechanism through which the direct trades occur is through plants' country buyers. These people drive around the state and visit farms with hogs and negotiate with farmers to buy their hogs. In both cases, the price that is actually negotiated is always the base price (with certain delivery conditions), whereas the premiums and discounts for quality are determined when hogs are killed and measured. The seller always gets the printout of every carcass explaining how the final price has been calculated.

In most instances, the total price that the producer will receive for his hogs is the combination of the base price and various quality premiums and discounts. Some plants pay high base prices and low quality premiums, others do the opposite. Sometimes the premiums are paid in dollars per pound, other times they are paid as a percentage of the base price. Absolute dollar amounts are better for producers in low price markets, percentage premiums are better in high price markets. The total payment to producer for a lot of hogs is determined by adding the packer's standard quality grid to the negotiated base price, multiplied by either the live weight or the carcass weight of hogs delivered. In a typical carcass merit matrix each element is a price index obtained by intersecting various combinations of a particular quality attribute (e.g. percent lean) and either the live weight or the carcass weight.[3] Carcass pricing programs increase producers' costs associated with evaluating alternative packers' bids. Some packers prefer lighter carcasses, whereas others who specialize in boxed products may prefer heavier carcasses.

The Data

In 2003, Congress funded a comprehensive analysis of the causes and effects of the alternative marketing arrangements in the livestock and meat industries (see Vukina et al. 2007). As part of the study, the major packers' individual transaction procurement

[3] As an example from one plant indicates, for the leanest carcasses (between 60 and 60.9 percent lean), and the live weight ranging between 232 and 263 pounds (which corresponds to 172-175 pounds of carcass weight), the grower would receive a price premium of 5% over the base price (index 105). The same weight category carcasses that are only 42-42.9% lean will receive a penalty of 8% below the base price (index 92).

records were obtained for the period between October 8th, 2002 and March 31st, 2005.[4] For the purpose of this analysis we extracted the data on the individual purchases of market hogs for the procurement method "direct trades." This channel accounts for about 8.9% of the total transactions in the sample period. Despite its relatively small share in total industry purchases, direct sales are very important for the industry-level price formation and discovery for two reasons. First, in some traditional hog producing regions in the Midwest many farmers still rely on spot markets (mainly direct sales and to a lesser degree auctions and dealers) as the only marketing channel for their animals. Secondly, spot market price frequently enters the pricing formulas used to determine the settlement price in some widely used marketing contracts.

The transactions used in the study are only those where the seller resides in the state of Iowa. Iowa is picked as the state has the largest transaction volume in the spot market. The data set consists of 76,850 individual transactions (lots) involving a total of 4,822,634 hogs. Each buyer and seller in the data set is uniquely identified such that each observation represents one pair-wise transaction. During a two and a half year period, different buyers and sellers engaged in different number of transactions and hence the panel is unbalanced. The data collection protocol requested that for each transaction the packers report two different dates: the date when the hogs were purchased and the date when they were slaughtered. As mentioned before, the critical date when the base price is negotiated is the purchase date. However, for 10,117 observations, the information about purchase date is missing and these observations had to be deleted.

Next, for each lot, packers were supposed to report the total number of heads of hogs broken down by categories into barrows and gilts (market hogs), sows, boars and stags. Because we are only interested in market hogs, we had to prescreen the data to eliminate other inferior categories. For those plants who reported the number of heads by each category, we delete those observations where the total number of hogs is greater than the number of barrows and gilts (2,271 observations). For those plants who do not report the

[4] For details about the data collection protocol and the summary results, see Cates et al. (2007).

number of heads by categories, we exclude observations where the average weight per hog is either unavailable or outside the reasonable range for market hogs of 150-350 pounds live weight (7,480 observations). In addition, we also excluded all transactions with five or fewer market hogs, fearing that very small volume lots may not be arms-length transactions or may represent some custom slaughter orders or some other special arrangements (1,944 observations).

Each transaction in the data is recorded with the base price (average base price per head paid for the lot), price adjustment (average merit-based adjustments, such as premiums and discounts), and the pricing units. Because the base price is the price that is actually negotiated, in everything that follows we used the base price. We eliminate those observations where data on the base price are missing (2,746 observations). The pricing units are either the live weight or the carcass weight. Some plants use both pricing units and some only use one type. To save as much data as possible, prices had to be converted into common units. To this end, we constructed the live weight price series in $ per 100 pounds live weight by using the live weight prices whenever they are reported and converting the prices reported on the carcass weight basis into the live weight basis using the reported carcass weight to live weight ratio (percentage yield) for that transaction. Because even after prescreening for unusual weights and small lot transactions, a substantial number of outlier prices remained, we decided to delete all observations outside the $20 to $100 per 100 pounds of live weight (494 observations). After these additional data cleaning steps, we have a total of 51,798 transactions involving 3,548,609 hogs.

In terms of the number of economic agents involved in these transactions, we identified 9 buyers (packers) and 2,353 sellers (farmers) in the dataset. These 9 packing plants are owned by 6 different companies. On average, a farmer conducts 18 transactions over the sample period, selling a total of 1,508 live hogs.

To get the first impression about the magnitude of the price dispersion, we compute the mean, the range (defined as the maximum price minus the minimum price), and the standard deviation of the transaction prices for each day. Originally, there were 819 days with recorded transactions in the cleaned dataset. We further eliminated the days with fewer than 5 transactions (lots) per day because the summary statistics based on few observations are not very reliable. This practice eliminated a total of 171 transactions and 77 days, which reduced the sample to 51,627 observations with a total of 3,527,930 hogs. Most of the eliminated days are Saturdays and Sundays. Table 1 reports the summary statistics for the resulting 742 means, ranges, and standard deviations. As can be seen, price dispersion is quite strong. On average, on any given day, the price range is around $15, accounting for about 25% of the mean of the transaction prices. Furthermore, the maximum range in one day's transaction prices can be as high as $73. The standard deviation statistics provides roughly the same information.

As the hog prices change every day due to changing demand and supply conditions in the hog markets as well as in the downstream pork markets, the evidence of price dispersion based on the price range and standard deviation may be inflated by those transaction days when the prices for hogs are particularly high or particularly low. To make these statistics independent of the shifts in the absolute price levels, we compute two other price dispersion measures: the range/mean ratio and the standard deviation/mean ratio (coefficient of variation) of the transaction prices for each day. This allows us to compare the price dispersion across different trading days. Figure 1 plots the time series graph for the range/mean ratio series. Although, this measure exhibits occasional spikes, most of the time it remains around 0.3 indicating that the price dispersion in the spot market for live hogs is consistent rather than sporadic. Figure 2, where we plot the coefficient of variation, shows a similar pattern.

A Conceptual Framework

Bargaining models that most closely resemble the mechanism of direct trades in the hog market are the bargaining and search models where the buyer is allowed to search for, and hold on to, the outside options while bargaining (Lee, 1994; Chatterjee and Lee, 1998). Contrary to the standard results of bargaining and search models (e.g. Wollinsky, 1987; Chikte and Deshmukh, 1987), they found that complete information does not guarantee the immediate resolution to bargaining (without costly delays), and that the effect of changing the buyer's search cost on each player's bargaining outcome is unpredictable. In our direct trading environment, the roles are reversed, but the results carry over completely. The buyer who searches in the above models becomes our seller (farmer), and the seller in the above models becomes our buyer (packer). The important feature of direct trades in hogs is that a farmer can temporarily suspend the negotiation process with a given packer to search for price bids from competing packers. We are interested in the comparative statistics result that relates seller's (farmer's) search cost to the share of the surplus that he can obtain in the negotiation.

In the standard search models that attempt to explain the equilibrium price dispersion in a homogeneous good market (e.g. Reinganum, 1979; MacMinn, 1980), farmers with relatively low search cost would search more and would receive higher price than those with higher search cost who would search less. Surprisingly, based on results from the bargaining with search models, neither search cost nor equilibrium search behavior are monotonically related to the share of the surplus obtained by the seller. Consequently, the existing bargaining with search theory establishes a relationship between a farmer's search cost and the actual price ultimately obtained from competing packers, but the direction of this effect remains undetermined.

While the role of search in bargaining is an important factor that can determine the observed price dispersion, there are other factors that influence bargaining outcomes that may explain the observed phenomenon as well. Two of these are patience and the role of information about the other side's reservation price. As it turns out, for both of those factors, bargaining theory generates precise theoretical predictions that can be tested with our data.

In models where bargaining is modeled as a dynamic process (e.g. Rubinstein, 1982), the bargaining party's patience (discount factor) is positively related to the share of the surplus she obtains. While Rubinstein (1982) is a model of complete information, this result extends to the models with private information (e.g. Ausubel, Cramton and

Deneckere, 2002). In the context of our paper, we hypothesize that farmers who are more patient while bargaining will receive higher price for their hogs than farmers who are less patient, and equivalently, that packers who are more patient will pay lower price for their hogs than those packers who are less patient.

Most of the bargaining literature is primarily concerned with economic efficiency. This means that the central focus of most papers is whether bargaining leads to inefficient outcomes which can happen because no agreement has been reached in equilibrium despite gains from trade or because of the costly delay. However, if one is interested in explaining the observed price dispersion in a market for a homogeneous good, the distributional issues become central. In this case, one will be interested to find out how is the division of surplus affected by informational asymmetries between the bargaining sides. In the static bargaining framework, Chatterjee and Samuelson (1983) have shown that an increase in one party's uncertainty about the other party's reservation price makes that party worse off. This result essentially extends to dynamic models of bilateral negotiation (see e.g. Fudenberg and Tirole, 1991). These models suggest that a negotiating party with incomplete information about its opponent will obtain a smaller share of the surplus than if it were better informed. In the context of direct trading of hogs, we hypothesize that the seller (farmer) who has better information about what may be the buyer's (packer's) reservation price will obtain higher price for his hogs than other farmers who have less price information about the packer's reservation price.

Empirical Evidence

What causes the price dispersion in the hog market? As mentioned in the introduction, various theories, or a combination of different theories, can be put forward to explain the data. After extensive studying of the swine industry procurement practices, bargaining theory with search emerged as a very good candidate for describing hog farmers selling practices in the so called direct trades. The main purpose of relying on a theory is to organize our thinking about possible explanations for the observed phenomena and to formulate empirically testable hypotheses. However, before introducing bargaining as a possible explanation for the price dispersion in the live hogs market, the price data need to be purged of factors (macro-economic influences as well as packers' and regional heterogeneities) that could significantly contribute to price dispersion, but for which we do not have enough information to model them in a more systematic fashion.

First, our data come from a two and a half year sample period. Prices of market hogs on different trading days can be different because of different demand and supply conditions on the input market for hogs and the output market for pork. As the main purpose of this article is to examine the intra-day price variation, we first run a regression of the price variable on a set of daily dummies. The residuals from this regression are then used as the dependent variable in all our subsequent regression analyses. This step is very important as it helps us eliminate a host of different theories aimed at explaining various low frequency (daily, weekly) price variations from further considerations. For example, Warner and Barsky (1995) show that absolute prices go down during periods of high aggregate demand. Weekends and holidays sales are good examples of this type of pricing behavior.[5]

Secondly, as mentioned before, when it comes to determination of the final price that farmers receive for their hogs, the packers do not act uniformly. Some plants pay high base prices and low quality premiums, others do the opposite. Some packers prefer lighter carcasses, whereas others may prefer heavier carcasses. Some packers pay for the transportation, others require farmers to deliver their hogs at their own expense. The specific information about packers' idiosyncrasies are not available in the data and the only way to deal with these unobserved heterogeneities is to estimate the model with packers' fixed effects.

Finally, there are good reasons to believe that there may be some systematic, yet unobserved differences across regions in Iowa. The concentration of hog farms in a given area may be a good thing if farmers can exert some degree of collective bargaining power, or can be a bad thing if the farmers compete among themselves for the limited

[5] The theories explaining these phenomena are, however, far from being in unison. Most likely, the reader has his/her own favorite theory explaining why turkeys sell very cheaply in the days immediately preceding the Thanksgiving holiday.

shackle space (slaughter capacity). The proximity to a processing plant may be a positive factor since hogs from those farms can be called to delivery on a very short notice. Last but not the least, the tradition and experience in growing hogs in certain areas may result in a consistently higher quality of hogs which will not be captured by the standard carcass merit matrix. In order to control for potentially very important unobserved regional heterogeneities, our preliminary regression includes regional dummy variables as well. Regional dummy variables are specified based on the first 3 digits of the seller's zip code.

Similarly to the inclusion of daily dummies, the pre-processing of data with plant and regional fixed effects automatically eliminates a number of different theories that hinge on packers' differential market power because the plant and regional dummies would pick up these effects automatically.[6]

The adjusted R^2 of regressing the intra-day base price variation on the set of plant and area dummies is 0.0616, indicating that all these fixed effects account for a modest 6% of the intra-day price variation in the live hogs market in Iowa. Interestingly enough, the necessary pre-processing of the price data by plant and regional dummies also filtered away any theory that would hinge on packer/regional differential market power because the plant and regional dummies would pick up these effects automatically. In the remainder of the paper, what is left of the price variability is now explained using the insights from the bargaining theory with search.

As stated before, existing bargaining theory with search leaves the direction of the effect of the farmers' search cost on the actual price they receive as an empirical question. However, regardless of the sign of the regression coefficient relating the price received by a farmer to his search cost, its significance and the percent of the variability in price that this variable can explain could serve as an indirect validation of the received theory. The cost of search in our model is measured by the number of hogs in a given transaction (lot). We claim that the cost of searching for outside options is inversely related to the

[6] Some variant of the market power explanation for the observed price dispersion was suggested by both referees.

number of hogs sold in any given transaction. This assertion is perfectly reasonable since searching for bids from other packers involves certain activities (phone calls, faxes, etc.) which are independent of the number of hogs the farmer intends to sell. Therefore, the greater the number of hogs available for sale, the lower the unit cost of search per head sold.[7] As seen from Table 2, on average each transacted lot contains 68 hogs with the minimum of 6 and the maximum of 394.

In industrial organization literature, the quantity variable in price equation is often endogenous. However, this is not likely to be the case here because the decision on the number hogs to be sold (lot size) is determined by the number of weaned pigs or feeder pigs placed on feed, the decision that has been made six month earlier. Hence, in the spot price equation for live hogs, the lot size is clearly exogenous. As seen in Table 3, the estimated coefficient on the number of head of hogs sold is positive and significant. Increasing the lot size by one hog will increase the price the farmer receives by 1.07 cents per 100 pounds live weight. The obtained result is of course in line with bargaining with search theory since bargaining theory is silent about the direction of this effect. However, the obtained results is also in line with the standard search literature which predicts that in equilibrium the sellers with lower search cost will obtain higher price.

The second testable proposition deals with patience (discounting of future payoffs). Bargaining theory predicts that bargaining parties with more patience (i.e., those that discount future payoffs with a lower discount rate) should receive higher price in equilibrium. With the available data we can test patience of both parties in the bargaining game. We claim that the patience of the seller (farmer) can be measured by the average weight of hogs in the lot intended for sale. As mentioned before, the weight of the hogs in our sample ranges between 150 and 350 live pounds, and the carcass merit matrix typically penalizes carcasses which are too heavy by paying the producer lower per pound price. In addition to receiving lower price, the famer is also incurring additional

[7] As pointed out by one referee, larger lots could be preferred by packers and perhaps could command higher unit prices, a phenomenon unrelated to search cost. However, the lot size should impact the price mainly via the transportation cost. Since the data does not contain precise information on transportation cost and which party pays for it, this issue could have not been addressed systematically.

costs associated with hogs eating extra feed beyond the point of marginal revenue equaling marginal cost. Finally, mature hogs are also unnecessarily occupying barn space thus delaying the commencement of a new production cycle. Therefore, once animals start approaching the ideal weight, the farmer will become anxious to sell them as soon as possible. Not being able to finalize the sale in a timely fashion, his impatience will grow as hogs become heavier.

As far as the buyers (packers) go, we claim that their patience can be measured by the number of hogs coming from the alternative marketing arrangements. Since operating the packing plant at high capacity utilization is of paramount importance for profitability, AMAs are a part of every packer's overall supply chain management strategy (see: Vukina, Shin and Zheng, 2009). Market hogs coming through AMAs are predetermined in the sense that these contracts are typically long-term and could have been signed months or even years prior to today's decision on how many hogs to buy on the spot markets. As such these channels are largely immune from the supply volatilities inherently present in the spot markets. Of course, various accidents, disease outbreaks and other possible failures to deliver hogs can never be completely ruled out, but personal interviews with packers indicated that the AMA deliveries for the entire week are always scheduled by Thursday of the previous week, so buying needs on the spot market are largely determined as the residual between the full plant capacity and the predetermined supplies from AMAs. The packer patience variable is measured as the ratio between the number of live hogs from AMA channels and the packing plant daily processing capacity. We hypothesize that the higher this ratio, the higher the packer's patience and the lower the price that she would be willing to bid.

Again, the results are presented in Table 3. The hypotheses about the patience are partially supported by the data. The coefficient associated with the weight variable is negative and significant, indicating that less patient farmers in their bargaining are likely to receive lower prices. An increase in the average live weight of the lot by one pound will reduce the received base price by 1.73 cents per hundred pounds live weight. However, the coefficient associated with the AMA variable is insignificant, so the prediction about packers' patience is not supported by the data, which will be looked into more carefully below.[8]

Finally we incorporate into the regression analysis a measure of the information asymmetry. We hypothesized that those farmers who have better information about packers' reservation prices will obtain higher price for their hogs. Since the availability of information cannot be directly measured, we approximate it with the number of different packers that a given farmer has transacted with during the sample period. The idea here is that those farmers who had historically (during the period covered by the data) done business with multiple packers should be better informed about packers' idiosyncrasies than farmers who always or most of the time sold their hogs to one packer. Again, the theoretical prediction is supported by the data. As seen from Table 3, the information variable is positive and significant indicating that farmers who are better informed about packers' reservation prices receive higher prices for their hogs. Conducting business with one extra packer increases the average received base price by about 43 cents per hundred pounds live weight.

The above measure of information asymmetry across farmers is probably not very accurate and it is likely to be endogenous. A possible source of endogeneity for the INFO variable may come from the fact that certain unobserved characteristics of the farmers are correlated with farmers' decisions on how many packers to deal with. An alternative approach would be to replace the INFO variable with individual farmers' fixed effects.[9] This approach will distinguish generally well informed farmers from poorly informed farmers, and at the same time control for their other characteristics. However, different farmers may have different information about different packers. In other words, one farmer may have a very good idea about what one particular packer's reservation price

[8] To the best of our knowledge the only other empirical test of the bargaining theory involving the patience of bargaining parties is Morton, Zettelmeyer and Silva-Risso (2004). However, unlike our two-sided patience measures which are indirectly revealed by the bargaining parties' circumstances or actions, their one-sided measure of patience is self-reported in a post-purchase survey of new car buyers.

[9] Of course, the regression cannot include farmer and area dummies at the same time because an area dummy is a linear combination of the farmer dummies for those farmers in the area, which would cause perfect collinearity. Therefore, area dummies are dropped when farmer dummies are included in the estimation.

may be, but would have rather limited information about other packers' business environments. Therefore, instead of dummying individual farmers, a better approach could be to dummy individual buyer/seller (farmer/packer) links.[10] Dummying the farmer/packer links would capture some of the otherwise unobservable features of the bilateral bargaining process.

The asymmetric information hypothesis could be restated in the opposite direction, i.e., we could hypothesize that those packers who have better information about farmers' reservation prices will manage to pay lower prices for their hogs. As it turns out, the quality of packers' information about farmers' idiosyncrasies can be also approximated by farmers' and farmer-packer links dummies. There could be something about farmers' characteristics (unobservable by an econometrician but observable by packers) that sends a signal about his reservation price. Also, some packers may be better than others in deciphering these signals, hence the need for the packer-farmer link dummies.[11]

As seen from Table 3, using either individual seller's dummies or buyer/seller link dummies improved the goodness of fit of the regression considerably. Also, the packers' patience variable became negative and significant, as predicted by the theory, indicating that more patient packers in bargaining are likely to pay lower prices for the procurement of their hogs. The results related to other predictions remained qualitatively identical.

The comparison of the improvement in the adjusted R^2 from the OLS regression containing only the plant and regional fixed effects with the adjusted R^2 from the regression containing all bargaining variables shows the improvement of 31%. However, the best adjusted R^2 of 0.3731 shows that the bargaining model with search still leaves about 63% of the variation in intra-day price unexplained. So, what may be the empirical content of this unexplained variation? A possible drawback of the above attempt to

[10] There are 3,658 such links in the data. For the same perfect collinearity reasons, plant dummies are dropped when link dummies are included in the estimation.

[11] Notice that our third hypothesis based on bargaining theory is actually empirically indistinguishable from the prediction based on the first-degree price discrimination theory. Provided that packers have good information about farmers' reservation prices they can offer them different prices thereby extracting all or most of their producer surplus.

capture the informational asymmetries among bargaining parties is that the individual farmers' and the farmer/packer link dummies do not capture the dynamic (repetitive) nature of the undergoing bargaining processes. Recall that on average, a farmer conducted 18 transactions (bargaining) over the sample period. It is quite likely that during this two and a half year period, the individual farmers' as well as packers' economic circumstances could have fundamentally changed and that their reservation prices changed accordingly. To capture these dynamic effects, the model needs to allow for information-time interactions. Given the fact that there are 2,353 farmers and 3,658 farmer/packer links in the data, estimating such interactions that would allow informational asymmetries to evolve over time is not feasible.

Conclusions

This paper is a study of the US pork packing industry, which is currently experiencing substantial structural changes in the organization of its inputs procurement practices. Using the data on the so called direct or negotiated trades in market hogs between pork packers and farmers in Iowa, we found a large degree of intra-day price dispersion. On average, on any given day, the base price range is around $15, accounting for about 25% of the mean price. Our main objective is to determine to what degree a received economic theory can be used to explain the observed phenomenon.

In trying to explain this price dispersion we resort to bargaining theory. The bargaining models that most closely resemble the mechanism of direct trades in the hog market are the bargaining models where the buyer is allowed to search for, and hold on to, the outside options while bargaining. With an objective to explain the observed price dispersion, we formulated three hypotheses involving the role of farmers' search cost, bargaining parties' patience, and asymmetric information. All three hypotheses were strongly supported by the regression analysis. In particular we found that farmers who have lower unit search cost receive higher prices. Farmers who are more patient while bargaining receive higher prices and packers who are more patient are likely to pay lower prices for the procurement of their hogs. Finally, farmers who are better informed about packers' reservation prices receive higher prices in bargaining. The above three hypotheses alone jointly explain 31% of the variation in the intra-day hog prices, so one can argue that bargaining theory explains the observed price dispersion in the hog market reasonably well.

What distinguishes this paper from the rest of the empirical literature on bargaining, search, and price dispersion is its unique panel data set where each buyer and seller is uniquely identified such that each observation represents one pair-wise transaction, and these transactions are observed repeatedly. In our empirical analysis we exploit the time series and the cross-sectional features of the data set. The main drawback of the data set is the fact that we have no information about the individual farmers. This prevented us from addressing questions about the impacts of various socio-economic variables such as race, gender, age, etc., on the bargaining outcomes, all undoubtedly very interesting questions. Instead, we focus more on the institutional details of the industry and contribute to the ongoing debate about the impact of concentration and industrialization of agriculture on small family farms. In particular, being able to measure packers' degree of patience as an important variable determining bargaining outcomes, our results show that high percentage of hogs secured through alternative marketing arrangements is likely to have negative impact on spot market prices.

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Table 1: Summary Statistics on Measures of Daily Price Dispersion

Variables	Mean	S. D.	Min	Max
Mean	59.3490	12.1282	35.9928	83.2271
Range	14.8086	9.1846	0	73.0297
Standard Deviation	2.6802	0.9182	0	8.5774

Table 2: Summary Statistics of Variables in Regressions

Variables	Mean	S. D.	Min	Max
PRICE	57.4066	12.6352	22.8594	98.6565
HEAD	68.3350	60.1714	6	394
WEIGHT	263.5402	19.5869	150	347.4193
AMAs	0.7253	0.3923	0	1.7033
INFO	1.8741	0.8583	1	6

PRICE: per head base price ($ per 100 pounds live weight) for the lot.

HEAD: number of hogs in the lot.

WEIGHT: average live weight for hogs in the lot.

AMAs: ratio of number of live hogs from AMA channels to packing plant's daily processing capacity.

INFO: number of different packers a seller (farmer) has transacted with during sample period.

The sample size is 51,627.

Table 3: Estimation Results

Variables	Estimate	S. E.	Estimate	S.E.	Estimate	S.E.
Plant dummies	Included		Included			
Area dummies	Included				Included	
Adjusted R^2	0.0616					
HEAD	0.0107*	0.0002	0.0042*	0.0003	0.0034*	0.0003
WEIGHT	-0.0173*	0.0006	-0.0459*	0.0009	-0.0469*	0.0009
AMAs	0.0536	0.0689	-0.5559*	0.0670	-0.5162*	0.0668
INFO	0.4309*	0.0178				
Farmer dummies			Included			
Link dummies					Included	
Adjusted R^2	0.1347		0.3406		0.3731	

* denotes significance at 1% level.

Figure 1: Time series plot of the range / mean series

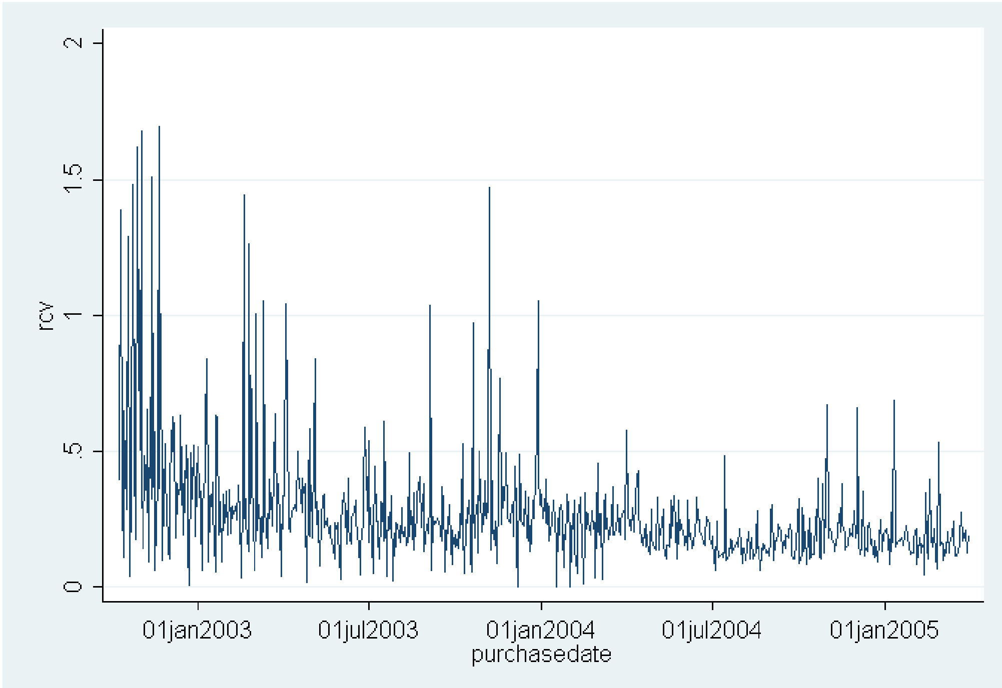

Figure 2: Time series plot of the coefficient variation series