Merger in a Bidding Market:
Quantifying the Unilateral Effects

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Abstract

This paper evaluates the unilateral effects of horizontal mergers in second-price auctions with asymmetric firm sizes. The proposed technique assumes that multiple auctions are held for sales of homogenous products and that each potential buyer has a random participation in each auction. The analysis calibrates the participation probabilities to generate frequencies of winning bids that correspond to the buyers' market shares. We apply the technique to auction markets for sales of cattle from feedlots to packing plants for the production of boxed beef.

I. Introduction

This paper evaluates the unilateral effects of a horizontal merger in a bidding market. We propose a technique for quantifying the unilateral price effects of a merger when firm sizes are asymmetric. Our approach was inspired by several recent acquisitions in the U.S. beef processing industry, and while that industry has some novel features, the techniques described here are applicable to other industries in which firms purchase an intermediate

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input in an upstream bidding market and sell finished products in competition with one another downstream.[1]

In markets of this sort, sales upstream in the supply chain sometime occur using an auction mechanism. In other cases, the transactions emerge from an informal process of haggling between buyers and sellers that nevertheless resembles an auction in certain respects. To the extent that auctions provide a reasonable approximation to how these markets operate, we can draw on the extensive theoretical and empirical research on auctions. A key feature in our analysis is stochastic participation by potential bidders, which we employ to model bidders' differential demands. We motivate the analysis with the illustration of recent actual and proposed acquisitions in the U.S. beef packing industry, although this exercise is not a description of the competitive effects of any actual or proposed merger. In particular, this analysis ignores coordinated conduct that can be significant in a market such as the market for fed cattle in which a few buyers engage repeatedly in transactions for a homogeneous product.

The next section describes the general features of the market at issue and reviews relevant prior literature on modeling bidding markets as auctions and the effects of mergers in such markets. We summarize relevant auction theory that treats uncertain bidder participation. We then provide a description of the beef processing industry and the historical trends in concentration through merger before turning to a model of the principal economic features of that market with a focus on the market for fed cattle. Feedlots group cattle that are ready for processing into lots and offer these lots on a weekly basis for sale to packing plants. Packers differ in size and hence their demand for cattle, and not every packer in a geographic region bids for every lot of cattle offered by a feedlot.

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[1] Antitrust authorities frequently review mergers in bidding markets. Klemperer (2008) states "The UK Office of Fair Trading has identified bidding markets in about one-quarter of the merger cases it has handled since it started publishing decisions in 2000." Also, Dalkir, et al. (2000) estimate that "As a subset of unilateral effect analysis, we estimate auction models to be potentially applicable to a third to a half of the mergers that concern the antitrust agencies."

These factors lead us to propose allowing random participation to account for differing sizes of packers, and to evaluate the role that random participation plays in estimating the unilateral effects of a merger. Using that model we simulate the effects of a merger in a hypothetical industry, first composed of equal-sized firms and then for mergers in which firm sizes differ pre and post-merger.

II. Problem statement and relevant literature

In the particular market at issue, cattle are sold by feedlots to packing plants in a market that resembles an open cry auction. More specifically, every week packers submit bids for cattle that are offered in designated lots that vary in size but generally average about 200 head.[2] Packers submit bids by fax, telephone or sometimes the Internet and the entire lot generally is sold to the highest bidder at its offer price. While the market mechanism has elements of a first-price sealed bid auction, there is haggling between feedlot owners and the highest bidders for each lot, which suggests that the auction can be approximated as a second-price English (ascending price) auction.[3]

The value of a lot of cattle to a packer depends on many factors including the quality of the cattle, the packer's production and opportunity costs, and the downstream demand for beef and beef products. Some of these factors are unique to each packer while others are common to all packers. It is well known that strategic interdependencies among bidders can arise when they receive signals about common values, as evidenced in the "winner's curse."[4] Sophisticated bidders should allow for the possibility that their information overestimates the true value of the object being sold. However, common values do not create strategic interdependencies if bidders share the same estimate of the

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[2] Crespi and Sexton (2004).

[3] Crespi and Sexton (2004) characterize the auction as a first-price with sealed bids, however they note that feedlots often negotiate with the highest bidders prior to the final sale of the lot. This "bid and quibble" process has elements of a second-price ascending auction. Further research will investigate whether a first-price auction is a better description of the market mechanism.

[4] See, for example, Milgrom and Weber (1982), Bulow and Klemperer (2002), and Thaler (1988).

common value. This appears to be a reasonable approximation in the market for beef. Much of the variation in the demand for beef is caused by factors such as weather, which affects the demand for grilling, or trends in consumers' diets. These common values do not create strategic interdependences if bidders have the same information about their values, for example, by using the Farmer's Almanac to predict the weather.[5] Thus, as in Brannman and Froeb (2000), we model each packer's demand for a lot of cattle as the sum of a fixed private value $\tilde{v}_i$ and a common value $\tilde{Y}$ that is the same for every packer.[6] Without loss of generality, we define the private value as $\tilde{V}_i = \tilde{v}_i + \tilde{Y}$.

The unit of trade in the upstream market is a lot of "fed cattle", *i.e.,* cattle at feedlots that are ready for processing. Buyers purchase more than one lot and vary in the number of lots that they buy. The theoretical auction literature has incorporated variable demand in a number of distinct ways. One approach is the supply function equilibrium in which bidders specify the amounts that they will sell (or buy in our case) at every relevant price (Klemperer and Meyer, 1989, Green and Newbery, 1992). However, packers do not indicate the amounts they will purchase at different prices, but instead generally compete to purchase entire lots. Ausubel (2004) and Perry and Reny (2005) describe an auction for indivisible units (such as cattle) in which bidders have downward sloping demands and commit to purchase specified amounts at different prices. Perry and Reny (2005) describe an auction mechanism that efficiently allocates a fixed supply of indivisible units to bidders even if the bidders have mixtures of private and affiliated common value information. It is not clear whether this mechanism is a good description of the market for fed cattle since cattle are bundled together in a lot for sale at a single price. Nevertheless, the mechanism could characterize the sale of multiple lots to different packers. Unfortunately, testing this

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5 Reinforcing the notion of identical common values is the large amount of data disseminated by the Department of Agriculture.

6 Undoubtedly this formulation ignores some information about common values that is not the same for all bidders. For example, packers may have different information about the quality of a lot of cattle offered for sale. These signals can create strategic interdependencies if they are affiliated and is a subject for further research.

hypothesis requires data on the sale of each lot to each packer, but the available data are limited to the distribution of winning prices for lot sales.

We model variation in demand by allowing bidders to select the frequency with which they attend auctions and submit bids so as to realize their observed market shares: the more often they participate in auctions, the more often, on average, they will win. Differences in participation rates thereby capture the relative sizes of firms. There is evidence that this assumption reasonably characterizes bidding for fed cattle. Crespi and Sexton (2004) report that in any given week typically only a fraction of the packers within 150 miles of a feedlot actively bid for cattle from that feedlot.

There is an existing literature on auction markets with random participation. The focus in this literature is on how bidders should formulate their bids when the number of competitors in the auction is not known with certainty. See, for example, Levin and Ozdenoren (2004), Athey and Haile (2005), and Harstad (2005). This "*ex ante* bidding" contrasts with a situation in which bidders' participation decisions are stochastic, but bidders know the number of other bidders when they compete for a lot of cattle ("*ex post* bidding"). Whether bidding is *ex ante* or *ex post* is not material to the analysis. In a second price auction, it is a dominant strategy for bidders to bid their actual values in either case. Levin and Ozdenoren (2004) show that with risk-neutrality, both cases yield the same expected bids in a first-price auction.

A merger reduces the number of bidders but also affects the derived demand of the merged firm and its competitors.[7] A merger can change the distribution of private values for the merged firm, and may also affect competitors' inferences of common values and the demand from the merged firm in a manner consistent with its values and capacity constraints.

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[7] *Ceteris paribus*, in a private value auction—whether it is first price or second price, or sealed bid or open cry—the expected winning bid (weakly) falls with reduction in the number of bidders. See, *e.g.*, Klemperer (2008).

The literature on mergers in bidding markets has sought to capture some of these effects. Thomas (1999) considers mergers among sellers that are stochastically ordered by their Bernoulli draws of the marginal cost of satisfying the unit demand of a buyer. This formulation allows for some asymmetry across bidders. He finds that, among other results, a merger between the most efficient firm and another firm is always profitable.

In Froeb, Tschantz and Crooke (2001), firms draw private values from a power-related distribution. A merger then constitutes a stochastic shift that generates the combined pre-merger market shares of the merging parties. Waehrer and Perry (2003) propose a model of procurement bidding in which each supplier draws a cost from a distribution that depends on a parameter that they call its "capacity." The merged firm draws a cost from the distribution that depends on the summed capacities of the merging parties.

Asymmetries can have complex implications for equilibrium outcomes in common value auctions when bidders' have imperfect but affiliated signals about the value of the object offered for sale. Affiliation means that if one bidder has a high valuation for the object, then it is likely that other bidders also will have high valuations (Milgrom and Weber, 1982). Affiliated values create a risk of a winner's curse. As in an auction with private values, a merger in a common value auction encourages bidders to bid less aggressively because each bid has a higher probability of success. However, merger in a common value auction also can encourage bidders to bid more aggressively by reducing the risk of the winner's curse. With fewer competitors, there is a smaller probability that a bidder will win the auction merely because her valuation exceeds the true value of the object. The net effect of these two opposing incentives is, in general, unclear (see, *e.g.,* Bulow and Klemperer, 2002 and Goeree and Offerman, 2003). Nonetheless, Klemperer (2008) argues that mergers are likely to make bidding less aggressive and reduce competition in common value as well as private value auctions. Mares and Shor (2008) offer empirical support for the conclusion that a reduction in the number of bidders causes the remaining bidders to compete less aggressively, *i.e.,* the pure numbers effect dominates the winner's curse effect in their experiments.[8]

We model the effect of the merger as a change in the firms' participation probabilities. We make the strong assumption that the merged firm's demand is the sum of the demands of the firms pre-merger and the merger has no effect on the demands of non-merging firms. In addition, we assume that every firm's value for cattle sold at auction, including the merged firm's value, is a draw from the same distribution. In particular, we do not assume that the merged firm does not realize a benefit nor does it incur a cost by combining the value distributions of the merging firms. We justify this assumption because the merger does not change the underlying cost structure of the merging firms, but merely puts them under a single procurement authority.

III. The Beef Processing Industry

According to a complaint filed by the U.S. Department of Justice and several states, packers in the United States produced and sold more than $20 billion of USDA-graded boxed beef products in 2007.[9] Boxed beef is the wholesale product that includes cuts of beef other than ground beef. Annual per-capita consumption of boxed beef has trended down from an average of about 43 pounds in 1980 to about 38 pounds in 2006.

Beef travels from pasture to dinner table along a supply chain having a series of clearly defined stages. We are concerned here with two stages of the beef supply chain: the "finishing" of cattle in feedlots and the slaughter of fed cattle and fabrication of boxed beef by beef packing plants. The schematic in Figure 1 illustrates these two stages with beef

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8 Mares and Shor (2008) treat a merger as a symmetric redistribution of a fixed number of signals of the auction item's common value. As a result, symmetry across firms is preserved before and after merger.

9 United States of America, et al. v. JBS S.A. and National Beef Packing Company, LLC, Amended Complaint, US District Court, Northern District Of Illinois, Eastern Division, Civil Action No. 08-CV-5992, filed 11/07/2008.

packers in the central role. The remainder of this section describes the features of the markets involved in these stages.

A. Market Structure of Beef Processing

Cattle growers typically raise cattle on grass or forage for several months before shipping them to feedlots, where they are fed corn, alfalfa and other feeds until they are ready for slaughter. Cattle raised for USDA-graded boxed beef are usually steers (castrated male cattle) or heifers (young females that have not had a calf). Fed cattle refer to cattle sold from feedlots to packers, while feeder cattle are the cattle sold by growers to feedlots.

Cattle are ready for slaughter after 3-4 months at the feedyard and reach a finished weight of approximately 1,250 pounds. Fed cattle are less valuable for meat production if they exceed that age by more than a few weeks.[10] Consequently, the short-run supply of cattle is highly inelastic in any week. In the long run, the supply of cattle can be elastic as growers respond to price incentives.

The supply of boxed beef is rigidly determined by the purchase of cattle. The production of boxed beef is described with a high degree of accuracy by a fixed coefficients production function. One hundred pounds of cattle plus the labor and capital required to "disassemble" the carcass yields, on average, 66 pounds of boxed beef. Packers have only limited ability to vary the relationship between the supply of cattle and the supply of boxed beef.[11] They can store carcasses in a chiller for an extra week or so, but the total amount of storage capacity in the market in excess of what is required to maintain anticipated delivery rates is limited. Packers also can purchase cattle that grade out differently from

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10 The fat content that determines the extent of desirable "marbling" of processed beef declines after a certain time in the feedlot. Prior to the peak time, the ratio of bone to meat is too high.

11 Consistent with folklore, packers make use of virtually all of the fed cattle when processing beef. In addition to the boxed beef, the so-called "drop credit" which includes the offal, the hide and other byproducts makes up the difference.

the average (*i.e.,* more choice and prime cuts), but this is rarely done to adjust the supply of boxed beef.

Feedlots offer about half of their fed cattle for cash purchase; the remainder are sold under prior marketing agreements which apply formula pricing using a pricing "grid." Still other cattle are owned by the packer but "finished" by the feed yard under a contract. We ignore forward contracts, while acknowledging that these forward contracts can influence the competitiveness of the spot market. Spot transactions operate on a weekly cycle.

Feedlots group cattle for sale in lots that average about 200 head, although the numbers can vary considerably. After making cattle available for inspection by the buyers, the feedlot solicits offers and makes counteroffers in person, over the phone and via email. Upon arriving at an agreed price, the cattle are scheduled for shipping to the packing plant at either the packer's expense or at the feedlot's expense; either way the transportation cost is taken into account when settling on a price.[12]

B. Mergers and the Consolidation in U.S. Beef Processing

The beef packing industry experienced considerable consolidation over the past few decades, with the Herfindahl-Hirschman Index for nation-wide sales of boxed beef increasing from 1,220 in 1980 to 2,208 in 1995 (Figure 2). The nation-wide HHI for purchases of fed cattle that are turned into USDA-graded boxed beef has increased from 561 in 1980 to 1,982 by 1995. At present, estimates of the nation-wide C4 index for boxed beef is approximately 80%.

Much of the increased concentration in U.S. beef processing can be attributed to mergers and acquisitions. Each one of the leading packers achieved its current position in the industry through some combination of mergers, acquisitions and joint ventures. In

[12] As a rule of thumb, it costs about $50 per head to ship fed cattle 800 miles when diesel fuel is $2 a gallon. A truck holds 50,000 pounds which translates into about 45 fed cattle.

2001, Tyson acquired IBP (Iowa Beef Packers) which, at that time, was the largest beef packer in the country. In the same year, Smithfield Beef was formed when Smithfield purchased Moyer Packing and Packerland, and went on to acquire ConAgra's feedlots three years later. In 2007, JBS—the giant meat-packing company based in Brazil—entered the U.S. market when it acquired the beef packing assets of Swift.[13] The Swift acquisition made JBS the third largest supplier in the U.S. of boxed beef.[14]

A year later, in 2008, JBS announced the purchase of the beef packing assets of National Beef and Smithfield. At the time of that announcement, Tyson was the largest U.S. beef packer, followed closely by Cargill (which operates its beef packing under its Excel Corporation subsidiary).[15] The U.S. Department of Justice ("DoJ") did not object to the acquisition of Smithfield by JBS, but filed a complaint to prevent JBS from acquiring National Beef. The DoJ asserted that the acquisition of National Beef would create an oligopoly in which three firms (JBS, Tyson, and Cargill) would control over 80% of the nation's fed cattle packing capacity.

C. Data on Cattle Transactions

Compared to many other industries, beef processing has a vast amount of publicly available data on transactions. The USDA's Grain Inspection, Packers and Stockyards Administration (GIPSA) collects daily data on the number of head and average price of fed cattle sales in various geographic regions of the U.S.[16] These transactions are further divided by the type of cattle (steer, heifer, mixed), grading (percent choice), and selling

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13 Swift had its roots in ConAgra Beef which, in turn, was formed by combining Swift itself and Monfort Beef Co. in 1987.

14 In 2005, ContiBeef and Smithfield Beef merged their feeding operations into a single company, Five Rivers. One exception to the string of mergers was Cargill's aborted attempt to acquire Beef America in 1994-1995 after the DOJ announced an investigation.

15 Cargill acquired Missouri Beef in 1979 and Spencer Beef in 1986.

16 For fed cattle data see: http://mpr.datamart.ams.usda.gov/menu.do?path=Species\Cattle. GIPSA also reports daily data on boxed beef transactions including average price per load (40,000 pounds) and by choice and select grading.

basis (live or dressed). In addition to the average price, GIPSA reports low and high transaction prices.

Figure 3 shows frequency distributions of daily average transaction prices reported by GIPSA for the five principal regions that it tracks (Colorado, Kansas, Nebraska, Minnesota-Iowa and Texas-Oklahoma-New Mexico) during the year 2008. These prices were weighted by the headcounts corresponding to the reported average selling prices. A normal approximation was fitted to each distribution in Figure 3 to provide a visual summary of the distribution. During 2008, selling prices typically fell in the range of $83 to $103.[17]

IV. Modeling the Beef Processing Industry

A. The purchase of cattle and the supply of boxed beef

Given the production conditions, the fabrication of boxed beef can be described by a fixed-proportions production relation:

$$\begin{aligned} &y_{it} = \min\{\alpha_{1i}x_{it}, \alpha_{2i}l_{it}, \alpha_{3i}m_{it}\} \\ &\text{Subject to:} \quad y_{it} \leq K_{it} \end{aligned} \tag{1}$$

Here y_{it} is the output of boxed beef at time t by packer i and x_{it} is the input of fed cattle. The inputs l_{it} and m_{it} are the labor and materials, respectively, devoted to beef packing. The output is the minimum of these appropriately weighted inputs provided that output does not exceed the total plant capacity given by K_{it}.

17 Given the fine granularity of the GIPSA data, we constructed frequency distributions for prices on a monthly, weekly and daily basis. Of course, the shorter the time period, the more sparse the distribution of prices. Those distributions showed a much greater variety of pricing patterns than the unimodal distributions in Figure 3, as one would expect from the Central Limit Theorem (absent other fluctuations over the selected time periods).

The production technology coefficients $(\alpha_{1i}, \alpha_{2i}, \alpha_{3i})$ are assumed to be invariant over time but possibly differ across packers and their packing plants. The production function implies the short-run cost function (ignoring the cost of capital):

$$c(y_{it}) = (\alpha_{1i} p_{ct} + \alpha_{2i} w_t + \alpha_{3i} p_{mt}) y_{it} \text{ when } y_{it} \leq K_{it} \text{ and } +\infty \text{ otherwise} \qquad (2)$$

Given the fixed proportions relationship between the supply of cattle and the supply of boxed beef, the competitive effects in the market for boxed beef from market power exercised by beef packers derive from their procurement decisions in the market for fed cattle. The supply of cattle in any week is the number of cattle that are ready for slaughter in that week. This supply is highly determined by the number of cattle that were raised on ranches and sent to feedlots. The supply is essentially fixed in the short run because the feedlot has only limited ability to change the availability of cattle for slaughter.

Assuming that the supply of cattle is fixed, the exercise of market power by beef packers affects only the division of the economic rent between packers and the suppliers of cattle. Any exercise of market power by packers does not affect the price of boxed beef because the fixed supply of fed cattle dictates the quantity of boxed beef and hence the market price of boxed beef that will equate supply and demand.

This outcome is illustrated in Figure 4. Given the supply of fed cattle, $q_t = \sum_i x_{it}$, the market price of boxed beef is p_t provided that: (i) demand at p_t is less than the total plant capacity $K_t = \sum_i K_{it}$ and (ii) marginal revenue from the sale of boxed beef exceeds the marginal cost of production at a zero cattle price, shown as C_0. If factor prices are constant and packers do not differ in factor utilization, $C_0 = \alpha_2 w + \alpha_3 p_m$. If condition (ii) were not satisfied, packers would purchase fewer cattle than are tendered for sale even if the price of cattle fell to zero.

In the short-run, the supply function for boxed beef is given by the L-shaped function in Figure 4 labeled *S(p_t)*. The price of boxed beef has to be large enough to cover the marginal cost of beef packing other than cattle, which means that the price has to be at least C_0 to elicit any boxed beef supply. But in the short run, the supply of cattle is fixed and that determines the maximum supply of boxed beef provided that packing capacity is large enough to process all of the available cattle.

In the normal functioning of the beef market, total packing capacity is adequate to meet the demand for boxed beef and the demand for cattle is equal to the supply.[18] Yet this does not imply that beef packers are unable to influence the supply of fed cattle. The supply of fed cattle is positively related to price over a planning period of one to two years, the time it takes to raise a steer or heifer for slaughter. Independent estimates suggest that the supply elasticity of beef cattle over a period of one to two years is about +1.8.[19]

Figure 5 incorporates price elasticity in the supply of cattle over the longer run of about two years, corresponding to the time required to raise cattle for purchase by feedlots. The supply function S(p_t) is the incremental cost of supplying another unit of boxed beef. It includes the cost of cattle and the cost of other inputs, such as labor and materials in beef packing. Over a planning horizon of one to two years or so, higher prices bring more cattle to market.

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[18] The cost function in Figure 4 is a simplification. In fact beef packers can expand capacity by adding additional shifts, and so output can expand above K_{it} though at a significantly higher cost.

[19] Schroeter (1988) estimates a price elasticity of fed cattle supply of +1.69 using annual U.S. data, 1951-1983. Zhang et al. (2006) find a fed cattle supply elasticity of +1.81 using a model in which feedlots hold rational expectations regarding future prices. Marsh (1994) reports several price elasticities of fed cattle supply depending on the time horizon. His estimates range from -0.17 for the short run (2 months) up to +3.24 in the long run (longer than 18 months) with an estimate for the intermediate run (18 months) of +0.61. A negative supply elasticity is not unexpected over a very short time period, because growers hold back heifers for breeding in response to a permanent increase in fed cattle prices, increasing cattle on feed and reducing the supply of fed cattle. Our chosen value of +1.8 falls within the mid range of these various estimates measured over a time period of one to two years.

If cattle were purchased by a single packer with a low discount rate, the packer would choose prices taking into account the effects of prices on the future supply of fed cattle. Let $c(q) = S^{-1}(q)$ be the marginal cost of purchasing a head of cattle when the total supply of cattle is *q.* This is derived from the inverse of the long-run cattle supply function, where the long run refers to a period of one to two years. Assuming that factor prices do not change and packers do not differ in factor utilization,[20] over a period of one to two years the total marginal cost of producing boxed beef is $c(q) + C_0$, where C_0 accounts for inputs other than cattle while holding packer capacity fixed. The marginal expenditure function is $ME(q) = c(q) + C_0 + c'(q)q$. A single beef packer would purchase cattle until the marginal expenditure is equal to the price of boxed beef. This is shown as the point (q^M, p^M) in Figure 5 corresponding to the output and price. Output is lower and price is higher than competitive levels, which correspond to (q^*, p^*). A monopsony packer would pay b^M for each unit of boxed beef, of which cattle producers would receive $b^M - C_0$ when the payment is translated into a derived value for beef on the hoof.

Note that, as in the simplified Figure 4, we ignore the possible exercise of market power in the downstream market for boxed beef. We justify this because a good approximation is that packers process all of the cattle that they buy. That is, given the sunk cost of acquired cattle, the incremental revenue earned from processing another animal exceeds the incremental cost (up to the number of cattle acquired). This assumption is reasonable since the cost of cattle account for a large fraction (about 90%) of the total cost of boxed beef and the firm-specific demand for beef is elastic. Hence the purchase of cattle determines the supply of boxed beef.

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20 This is a reasonable assumption except when production is near capacity and requires extra shifts, which likely will result in higher unit labor costs.

B. The bidding market for fed cattle

The market for fed cattle is a bidding market rather than a market with a single purchaser. We model this bidding market as a second-price English auction with private values. The private values represent differences in processing costs for each packer. Packers likely share common information in their valuations of cattle based on their estimates of the applicable retail prices for boxed beef and other products produced from the cattle they buy. Common value auctions raise complications discussed in Section II. We reserve for future research the empirical analysis of the cattle market as auctions where packers have common values. We also assume that bidders are myopic. The supply of cattle is fixed in the short run and bidders ignore the dependence of their bid prices on the future supply of fed cattle. This dynamic interaction is another potential topic for future research.

In a second-price auction an object is sold to the highest bidder at the second-highest bid. An ascending price English auction has the characteristic of a second-price auction because the bidding stops when the second-highest bidder will no longer increase her bid. In a second-price auction with private values, bidders have incentives to bid their true willingness-to-pay for the object because a high bid increases the probability of winning the auction but does not affect what they pay. Furthermore, if they bid more than their willingness-to-pay, there is a risk that they might win when the second-highest bidder offers more than the object is worth to them. Therefore, bidding an amount up to, but no more than, a bidder's willingness-to-pay is a dominant strategy for every bidder.

If bidders are *ex ante* identical in the sense that their private values are draws from the same distribution, then observations of actual bids in a second-price auction with private values should correspond to the second-order statistic of the distribution from which private values are drawn. That is, if bidders bid their actual values and bidders' values are drawn from the same distribution, then the distribution of observed winning bids corresponds to the second-order statistic of the distribution of bidder values, which is the distribution of the second-largest value in the population.

We make the following assumptions:

A.1 Each auction offers a given lot of cattle, with the lot size normalized to unity.

A.2 The auction proceeds as an oral ascending price (English) auction, with the lot sold to the winning bidder at the price bid by the second-highest bidder.

A.3 Each of N bidders simultaneously and independently draws private values $V_i, i = 1,2,\ldots,N,$ from an identical distribution that has a cumulative distribution function $F(v) = \int_0^v f(w)dw$.

A dominant strategy for a bidder in an English ascending bid auction (as well as for a second-price sealed-bid auction) is to bid the true value: $B_i = V_i$. In that case, the bidder with the highest value will win the lot and pay the second highest value, $V_{N-1:N}$, where the notation $V_{n:N}$ denotes the n^{th} order statistic out of N draws.

Given these properties, the expected winning bid is the expectation of the $N\text{-}1^{\text{st}}$ order statistic of $F(v)$. Let $F_{N-1:N}(v)$ represent the distribution of this 2nd price statistic. The probability that 2nd highest valuation is less than v is the sum of probabilities that all the valuations are less than v, which equals $F(v)$, and the probability that N-1 valuations are less than v and the other is greater than v. This can happen N ways, and therefore the winning bid has the distribution function:

$$F_{N-1:N}(v) = F(v) + N[F(v)]^{N-1}[1-F(v)] = N[F(v)]^{N-1} - (N-1)[F(v)]^N \tag{3}$$

with probability density

$$f_{N-1:N}(v) = N(N-1)[F(v)]^{N-2}[1-F(v)]f(v)\,. \tag{4}$$

The expected winning bid is then:

$$EV_{N-1:N} = N(N-1)\int_0^{+\infty} w[F(w)]^{N-2}[1-F(w)]f(w)dw \tag{5}$$

In this symmetric case, the unilateral effect of an *N*-to-(*N-1*) merger measured in terms of the change in the expected price is: $EV_{N-2:N-1} - EV_{N-1:N} < 0$. Since all bidders are identical, they have an equal chance of winning before and after the merger. The effect of the merger on the shares of any participant is therefore equal to $\Delta s_i = \frac{1}{N-M+1} - \frac{1}{N}$ where $M \geq 2$ is the number of merging firms.

We can derive closed-form expressions for the bidding outcomes when bidders draw from a uniform distribution: $f(v) = \frac{1}{b-a}$ and $F(v) = \frac{v-a}{b-a}$ on the interval $v \in [a,b]$. In that case, the second-highest value is distributed as a $Beta(N-1,2)$ random variable having density $f_{N-1:N}(v;a,b) = \frac{N!}{(N-2)!}\frac{1}{(b-a)^{N+2}}(v-a)^{N-2}(b-v)$. Then the expected value of the winning bid is

$$EV_{N-1:N} = \frac{N-1}{N+1}\left(b + \frac{2a}{N-1}\right) \tag{6}$$

and the (expected) unilateral effect of eliminating one bidder through merger is given by

$$EV_{N-2:N-1} - EV_{N-1:N} = \frac{2(a-b)}{N(N+1)} < 0\,. \tag{7}$$

C. Asymmetric bidders

The merging firms differ from each other and from other bidders not only in their values for a given lot of cattle but also in the number of lots of cattle that they intend to purchase. We model the latter distinction by assuming that packers differ in the number of auctions in which they participate.

Suppose, for example, that cattle are sold in 100 separate auctions with equal lot sizes. Furthermore, suppose there are three packers, $j = 1,2,3$. Packer j=1 has a demand for 50 lots while packers j=2,3 each have demands for 25 lots. If each packer has a private value drawn from an identical, independent distribution, then packer 1 has to participate in twice as many auctions as either packer 2 or 3. One possibility is that packer 1 participates in all 100 auctions while the other packers participate in 50 non-overlapping auctions, so that each auction has only two participants. Since each has an equal probability of winning, the expected purchases of j = {1,2,3} are {50,25,25}. In this scenario, the participation decisions of bidders are statistically correlated. In what follows, we do not allow for such correlation. We will assume that each bidder chooses a frequency of participation and then randomly decides whether to attend an auction independently of all other bidders.

D. Bidding Markets with Random Participation

Our understanding of the fed cattle market is that while there is geographic specialization in fed cattle purchases by packers, there is also overlap in their auction participation. We model this overlap by assuming that packer j chooses to participate in *every* auction with some probability π_j. The π_j are chosen to give packer j its pre-merger share of cattle purchases, s_j.[21] If packers 1 and 2 merge, we assume the merged firm's post-merger market share equals the sum of their pre-merger shares $s_{1+2} = s_1 + s_2$ and the

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[21] The fixed proportions production function implies that a packer's share of cattle purchases equals its share of wholesale boxed beef sales.

shares of non-merging firms s_j are unchanged for $j \neq 1,2$.[22] Under this assumption, firms must adjust their post-merger participation probabilities to ensure that their share of auction wins correspond to their combined shares.[23] This assumption overstates the amount of competition in cattle procurement in some auctions pre and post merger if packers are geographically specialized in their purchases.

More formally, we construct a model of bidding markets that extends the standard representation as a second-price private-value auction by having potential bidders randomly decide whether to participate. That decision is made according to a bidder-specific participation probability that is unrelated to bidders' private values, as if bidders committed to participating prior to drawing a private value. The auctioneer lists an item for sale knowing that the number of bidders is uncertain.[24]

As explained above, if two or more bidders decide to participate in an auction, the winner is the firm with the highest valuation and the price paid is the willingness to pay for the bidder with the second-highest valuation. In the case of a single buyer, we assume that the "auction" results in a sale at the seller's reservation price, which we set equal to the minimum possible private value. We condition the analysis on the assumption that at least one buyer chooses to participate. An auction with no buyer is a non-event and seems unlikely in the beef market given that feedlots have strong incentives to sell cattle when they are ready for processing.

The time line of decisions and events is as follows:

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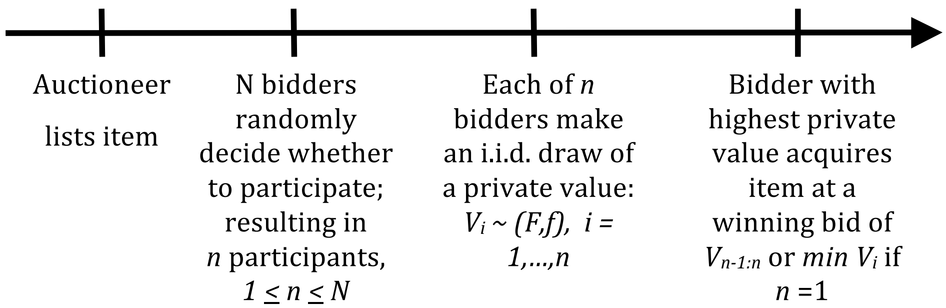
22 This assumption is not unreasonable with fixed packer capacities if packers fill their plants to capacity and do not add extra shifts to expand capacity.

23 In theory, a large firm may be unable to achieve its market share even if it participates in 100% of the auctions. If this is the case, it suggests that the assumption of symmetric values is not an accurate description of bidders.

24 The seller's decision is entirely deterministic.



Each bidder i decides whether to participate in a given auction with probability π_i where $0 \le \pi_i \le 1$. Bidders make their participation decisions independently of one another and their private values. Below we refer to bidders who decide to attend an auction (and place a bid) as "participants." Note that the number of participants n will vary across auctions, whereas N is the fixed maximum number of possible bidders.

The number of participants is distributed as a sequence of Bernoulli draws. Conditional on the participation of at least one bidder, the probability of n participants of the entire population of N potential bidders is, for n = 1,…,N,

$$p(n,N) = \sum_{\left\{d:\sum_j d_j = n\right\}} \left(\prod_{\{j:d_j=1\}} \pi_j \right) \left(\prod_{\{j:d_j=0\}} (1-\pi_j) \right) \div \left[1 - \prod_j (1-\pi_i) \right] \tag{8}$$

where the *d*'s are indicators of whether a bidder participates: $d_j = 1$ for a participant and $d_j = 0$ for a non-participant. Given n participants, each one makes an independent draw of a (nonnegative) private value from a common distribution: $V_i \sim (F, f)$, $i = 1,\ldots,n$.

In the symmetric case when all bidders use the same participation probability (*i.e.,* $\pi_1 = \cdots = \pi_N = \pi$), the (discrete) density of the number of bidders is binomial:

$$p(n,N) = \frac{N!}{n!(N-n)!} \frac{\pi^n (1-\pi)^{N-n}}{\left[1-(1-\pi)^N\right]} \qquad n = 1,\ldots,N. \tag{9}$$

Assume that the participants draw their private values from identical, independent uniform distributions *F(v) = v* with support $v \in [a,b]$.[25] For a standard second-price, private-value auction with n bidders, the winning bid is the second-highest value of *n* uniform draws, $V_{n-1:n}$. From equation (6), the expected winning bid conditional on *n > 0* bidders is

$$EV_{n-1:n} = \frac{n-1}{n+1}\left(b + \frac{2a}{n-1}\right).$$

With uncertain participation, in the symmetric case the unconditional expected winning bid is

$$E_{n|N}\left[EV_{n-1:n}\right] = \sum_{n=1}^{N} \left[\frac{n-1}{n+1}\left(b + \frac{2a}{n-1}\right)\right] p(n,N) \tag{10}$$

where the first expectation operator is the expectation over the number of firms that participate given *N* potential bidders. In the symmetric case, the unilateral effect from a merger of two firms is $E_{n|N-1}\left[EV_{n-1:n}\right] - E_{n|N}\left[EV_{n-1:n}\right]$.

The expected bid conditional on the number of bidders is a concave function of the number of bidders. By Jensen's inequality, it follows that

$$E_{n|N}\left[EV_{n-1:n}\right] = \sum_{n=1}^{N} \left[\frac{n-1}{n+1}\left(b + \frac{2a}{n-1}\right)\right] p(n,N) < \frac{\overline{n}-1}{\overline{n}+1}\left(b + \frac{2a}{\overline{n}-1}\right)$$

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25 The more general uniform case on an arbitrary closed interval $[a,b]$ can be derived by performing the transformation $w = (b-a)v + a$.

where $\bar{n} = E_{n|N}[n]$ is the expected number of participants. The expected winning bid when participation is uncertain is lower than the expected winning bid in an auction in which the expected number of bidders shows up with certainty.[26]

V. Applying the Bidding Model to Hypothetical Mergers

In this section we apply our auction model to mergers in some hypothetical bidding markets. We begin by establishing a benchmark in which two of a number of equal-sized firms merge and reach a new, symmetric equilibrium. In this case, as with the simple oligopoly model, the merged entity gains no size or cost advantage relative to its non-merging rivals as a consequence of the merger.

A. Equal Pre-Merger Market Shares

We compute the expected winning bid for a second-price auction with *N* equal-sized firms. This calculation allows us to consider the impact of an *N* to *N*-1 merger on price assuming that firms have equal market shares before and after the merger. We assume that bidders make independent draws from a common uniform distribution on the interval [\$90, \$110]. In that case the expected winning bid with $N \geq 2$ firms is, from equation (5)

$$EV_{N-1:N} = \frac{N-1}{N+1}\left(110 + \frac{180}{N-1}\right) = \frac{110N + 70}{N+1} \tag{14}$$

[26] This comparison treats the numbers of bidders as continuous variable and ignores the integer constraint.

This value can be computed before and after a merger to assess the impact on expected prices yielding the unilateral effect equal to $EV_{N-2:N-1} - EV_{N-1:N} = \frac{-40}{N(N+1)} < 0$. The unilateral price effects are given in Table 1 and range from a 0.68% reduction for a 7-to-6 merger to a 6.90% reduction for a 2-to-1 merger.

This exercise assumes symmetric firms pre- and post-merger that participate with probability one in the auction. We next calculate post-merger expected winning bids in which the merged firm achieves a post-merger market share equal to the combined market shares of the merging firms before the merger and the shares of non-merging firms are unchanged by the merger. We model this asymmetry by computing auction participation rates for merging and non-merging firms that give each firm its assumed post-merger share of auction wins.

First we fix the participation rate of the largest post-merger firm because we have one extra degree of freedom and the largest firm will always participate more frequently than any other smaller firm.[27] We then search for participation rates of the remaining firms so as to minimize the sum of squared residuals between the fitted and actual market shares. As in the preceding section, the unilateral effect from the merger is

$$E_{n|N-1}\left[EV_{n-1:n}\right] - E_{n|N}\left[EV_{n-1:n}\right]$$

where the probabilities are determined to generate the corresponding pre-merger and post-merger market shares.

In the symmetric case pre-merger, each firm wins $1/n$ of the auctions in which n firms participate. Each firm has an expected pre-merger market share equal to

27 There is an extra degree of freedom because there are N probabilities and N-1 independent shares, since the shares must sum to one.

$$s(N) = \sum_{n=1}^{N} \left(\frac{1}{n}\right) p(n,N).$$

where the probabilities are given by equation (9).

If firms *i* and *j* merge, post-merger we assume that the merged firm's share is $s_i' = s_i + s_j$ and the shares of non-merging shares s_k are unchanged for $k \neq i, j$. The Appendix describes the calculation of the relation between the assumed shares of each potential bidder and the bidder's participation probability in each auction. Results are reported in the right panel of Table 1 for the case of symmetric pre-merger market shares.

Notice that we find large unilateral price effects compared against those for the case in which market shares are symmetric before and after the merger. Expected prices fall by 3.55% for 7-to-6 merger compared to 0.68% with symmetric post-merger shares.[28] Figure 6 illustrates the effect of mergers on expected winning bids for different values of *N*.

B. Asymmetric Pre-Merger Firm Sizes

This exercise illustrates how our bidding model takes account of a merger's impact on concentration. We next apply our approach to mergers that occur in industries in which firms do not have equal market shares prior to the merger. We use as our benchmark case a six-firm industry in which firms are distributed roughly according to the power distribution of market shares.[29] We calibrate the participation rates that generate the market share distributions both before and after the merger occurs. As before, the merged entity commands a market share equal to the sum of the pre-merger market shares of the merging parties, while the market shares of the non-merging firms are unchanged. We

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28 Table 1 reports the participation rates that were calibrated for the non-merging firms. Notice that these rates increase as the industry becomes more concentrated. Note that, since pre-merger market shares are all equal shares, the merged firm is the largest firm after the merger and its participation rate is set to 100%.

29 Specifically, each firm is two-thirds as large in market share as its next largest rival.

again assign a 100% participation rate to the largest firm, but with unequal firm sizes that is not necessarily the merging firm. This assumption results in a downward bias in the unilateral effects from a merger relative to different participation rates that yield the same pre and post-merger shares. The reason is that, for any assumed pre and post-merger shares, assigning a 100% participation rate to the largest firm maximizes the number of firms that compete in any auction and hence minimizes the competitive effect from the merger.

Table 2 reports all possible pairs of merging firms among the six original firms and the impact of each merger on the expected winning bid. As expected, the unilateral effects are correlated with the change in HHI caused by the merger (given by $\Delta HHI = 2s_i s_j$), with the various potential acquisitions by the largest firm (firm A having a 37% pre-merger market share) leading to the largest impacts.

We note that these examples are only illustrative and do not reflect predictions of any actual merger. In particular, we note that auctions for fed cattle occur weekly in a market with little new entry. This creates opportunities for coordination that are not captured in a model of competitive bidding.

VI. Unilateral Price Effects in the Downstream Wholesale Boxed Beef Market

The preceding analysis shows how varying bidder participation in auctions can quantify the unilateral price effects of a merger in a bidding market. Accounting for differences in firm sizes, both before and after hypothetical mergers, results in larger unilateral price effects compared to the case of symmetric firm sizes pre and post merger. We now turn to quantifying how much the lower bids for fed cattle will affect wholesale prices for boxed beef—a product that is closer to the retail product purchased by final consumers.

As discussed earlier, the fixed proportions technology of boxed beef production and the perishability of fed cattle combine to ensure a negligible supply response to lower average bids for fed cattle—at least in the short run.[30] With time, however, cattle stock will be cut back and the result will be fewer fed cattle for sale. Empirical studies find estimates of the price elasticity of fed cattle supply in the vicinity of +1.8 over a one to two year horizon. A merger that leads to a 5% reduction in expected fed cattle prices translates into a 9% reduction in sales of cattle after a year or two. Because of the production technology for boxed beef has strict fixed proportions with cattle as an input, a 9% reduction in the supply of cattle implies an equal reduction in the total amount of boxed beef.

The reduction in the volume of boxed beef moving through the supply chain will lead to higher wholesale prices for boxed beef. The magnitude of this price effect depends on the elasticity of the wholesale demand for boxed beef, estimated to be -0.52.[31] Consequently, a 9% reduction in the quantity of boxed beef corresponds to a +4.7% rise in wholesale prices for boxed beef.

Most beef must undergo another stage of processing and distribution before it is purchased by the consumer, although some packers do prepare so-called case-ready beef. Assuming there is no significant market power in this stage, the rise in wholesale boxed beef prices will flow through to higher retail prices for beef. If there is market power at this final stage, the pass-through rate to retail prices will depend on the elasticity of retail demand, and may be more or less than the increase in the wholesale price.

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30 In fact, as Marsh (1994) reports, the supply of cattle may rise initially in response to a lower price paid for fed cattle as feedlots choose not to breed as many heifers.

31 Lusk, et al. (2001) estimate a linear factor (derived) demand for wholesale beef (plus pork and chicken) using monthly U.S. wholesale production data over the period 1987-1999. They report own elasticities for choice and select beef of -0.432 and -0.633, respectively. We take a volume-weighted average of these two elasticities to arrive at an estimate for wholesale beef of -0.52.

VII. Conclusions

A merger among bidders in an ascending price oral auction in which the bidders have private values for the object offered for sale reduces expected prices by lowering the likely value of the second-highest bid. This paper applies the theory of second-price auctions with private values to the sale of fed cattle to packing plants for the production of boxed beef. The market has the interesting feature that the supply of cattle determines the supply of boxed beef through a fixed proportions production technology. Furthermore, the supply of cattle is approximately fixed in the short-run. Therefore, the price of cattle has no immediate implications for the price of boxed beef, as the latter is determined by the supply of capital in the absence of downstream capacity constraints and with limited capacity for storage. Nonetheless, there is an effect on prices in the longer run as cattle supply falls in response to lower auction prices.

Cattle are offered for sale in distinct lots. Thousands of lots are sold over a period of several weeks or more and packing plants differ in their demands for cattle. We capture this asymmetry in demand by allowing each packer to participate in every auction with some probability. The participation probabilities are calibrated to generate frequencies of winning bids that correspond to the packers' market shares.

The analysis in this paper is primarily an exploration of bidding theory for markets in which bidders have different demands. It is not an estimation of the competitive effects of any actual or proposed merger in the beef industry, although the beef industry has some interesting features that inform the model. In particular, the analysis is not intended to represent key competitive interactions in the beef industry such as might emerge from repeated contacts between and among beef packers and feedlot owners. Furthermore, actual bidding for cattle in the beef industry may correspond more closely to a first-price auction with common values. This is a subject for further exploration.

Tables

Table 1: Unilateral Effects of Merger Depending on Whether Share are Equal Post-Merger

	Equal Shares Before and After Merger				Asymmetric Shares After Merger		
Merger	Pre-merger market shares	Pre-merger average price	Post-merger average price	Merger impact on average price	Post-merger average price (asymmetric shares)	Merger impact on average price	Non-merging firms calibrated participation rate
7 to 6	14.29%	$105.00	$104.29	-0.68%	$101.27	-3.55%	58.0%
6 to 5	16.67%	$104.29	$103.33	-0.91%	$100.29	-3.83%	59.3%
5 to 4	20.00%	$103.33	$102.00	-1.29%	$98.94	-4.25%	61.1%
4 to 3	25.00%	$102.00	$100.00	-1.96%	$97.11	-4.79%	63.4%
3 to 2	33.33%	$100.00	$96.67	-3.33%	$94.44	-5.56%	66.7%
2 to 1	50.00%	$96.67	$90.00	-6.90%	$90.00	-6.90%	N/A

Table 2: Pairwise Mergers in a Asymmetric Size Distribution Industry

		B	**C**	**D**	**E**	**F**
		24%	*16%*	*11%*	*7%*	*5%*
A	*37%*	-5.66%	-4.45%	-3.57%	-2.96%	-2.54%
B	*24%*		-2.56%	-1.81%	-1.76%	-1.76%
C	*16%*			-1.74%	-1.72%	-1.74%
D	*11%*				-1.71%	-1.74%
E	*7%*					-1.76%
F	*5%*					

Figures

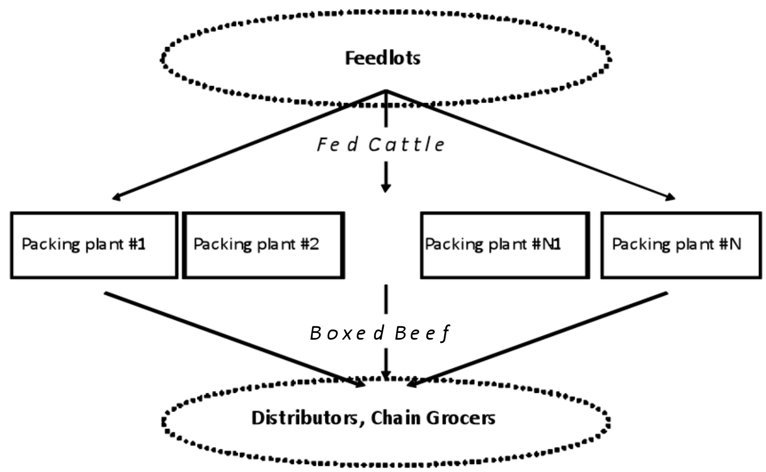
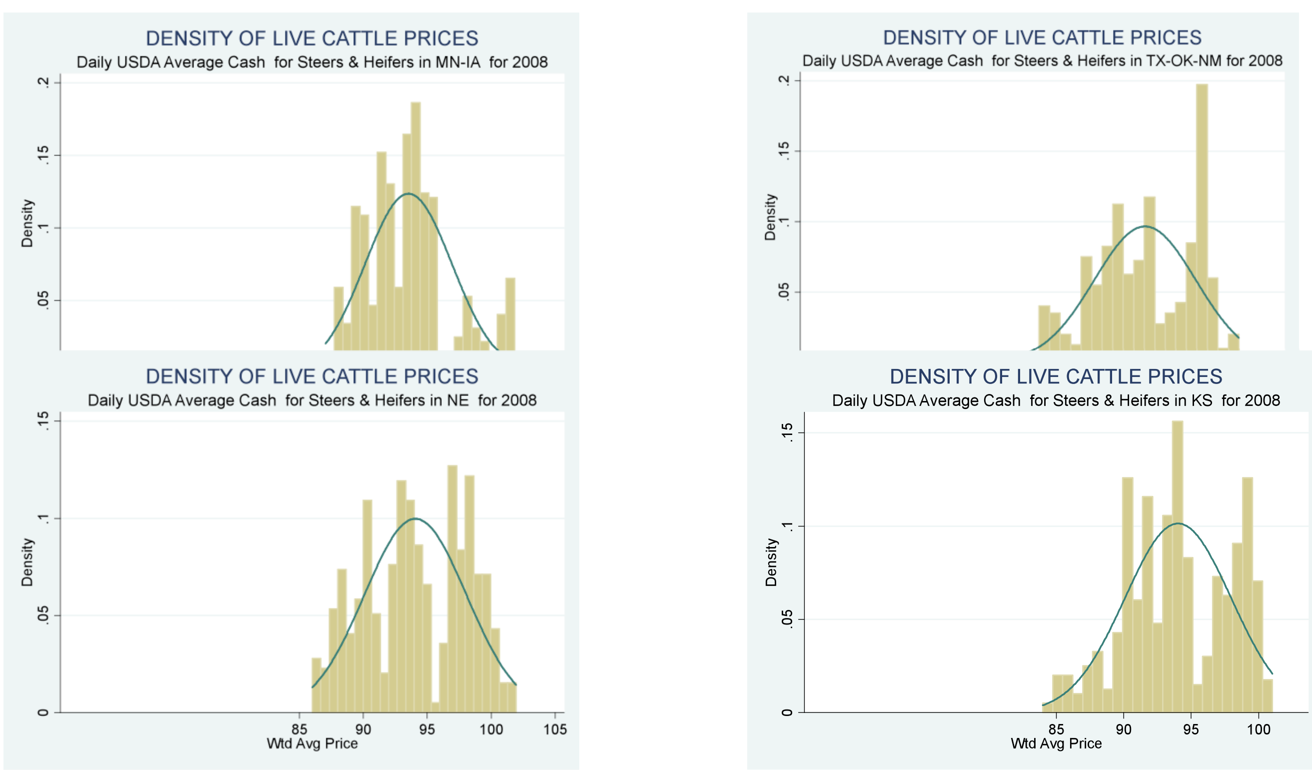


Figure 1. Vertical structure of beef processing

Figure 2. HHI's for boxed beef and purchases of steers & heifers

Figure 3: Distribution of Fed Cattle Purchase Prices in 5 USDA Regions in 2008



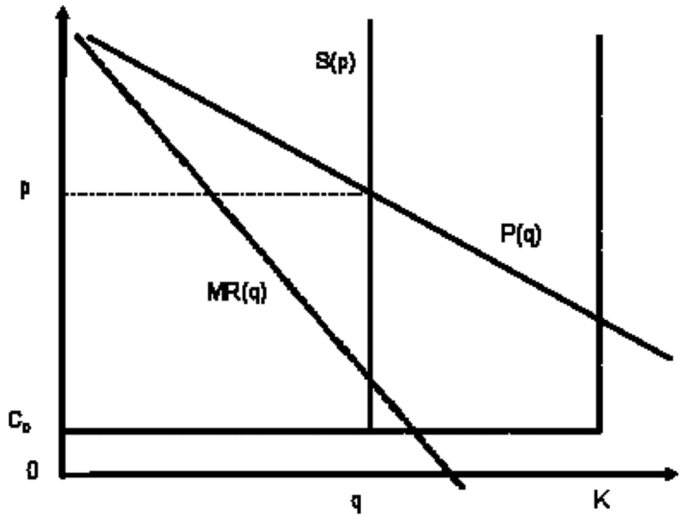


Figure 4. Market price of boxed beef with inelastic cattle supply

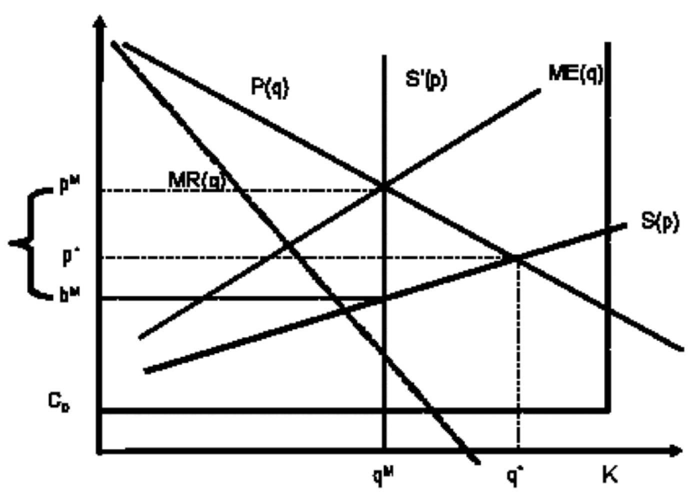
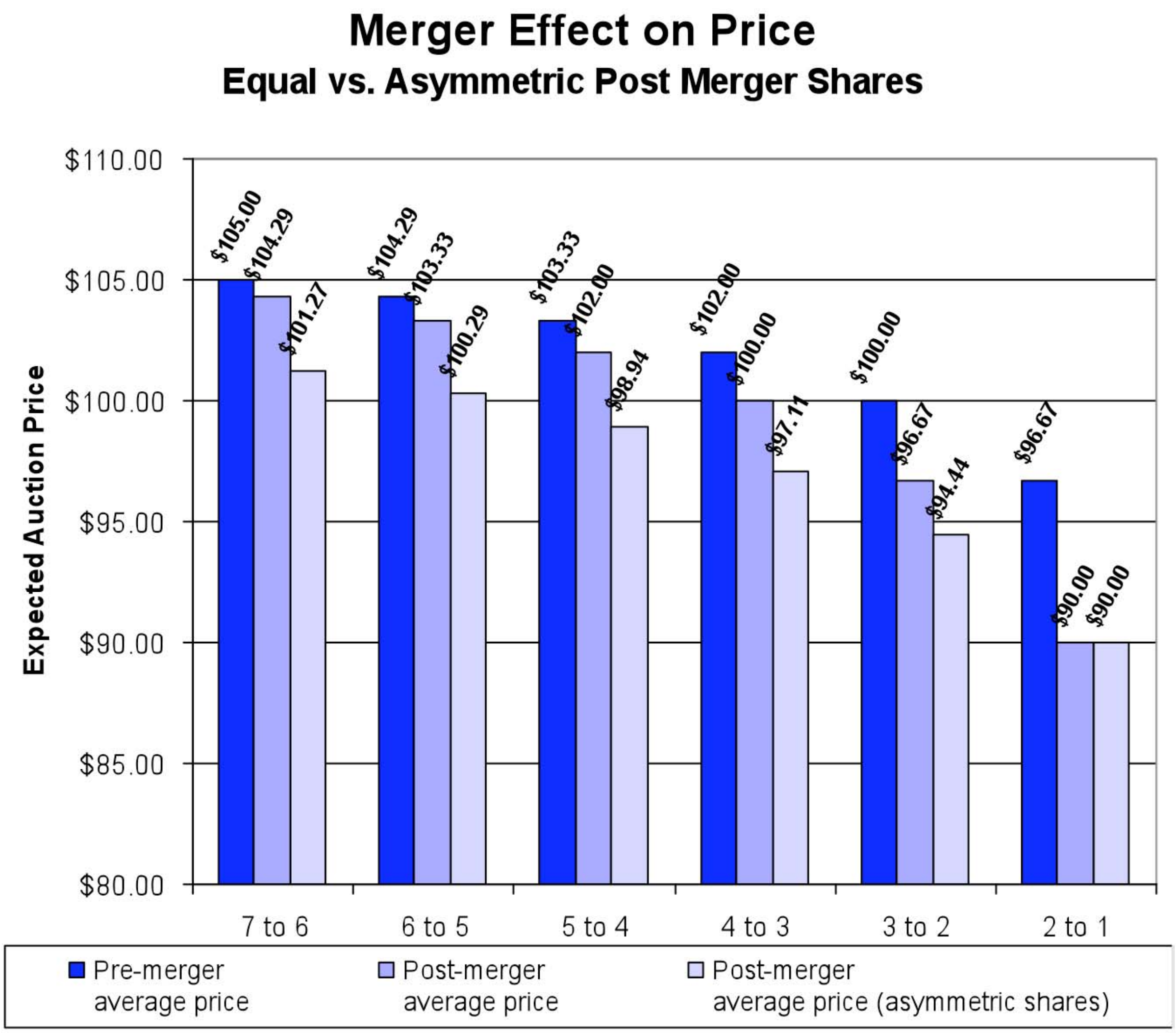


Figure 5. Market price of beef with elastic cattle supply

Figure 6


Merger Effect on Price
Equal vs. Asymmetric Post Merger Shares
Expected Auction Price
$110.00
$105.00
$100.00
$95.00
$90.00
$85.00
$80.00
$105.00
$104.29
$101.27
$104.29
$103.33
$100.29
$103.33
$102.00
$98.94
$102.00
$100.00
$97.11
$100.00
$96.67
$94.44
$96.67
$90.00
$90.00
7 to 6
6 to 5
5 to 4
4 to 3
3 to 2
2 to 1
Pre-merger average price
Post-merger average price
Post-merger average price (asymmetric shares)

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Appendix

This Appendix describes the calculation of bidders' participation probabilities corresponding to their assumed market shares.

The probability that bidder *i* participates in an auction of size *n* is equal to the probability that bidder *i* participates, π_i, times the probability that n-1 other bidders participate. That latter probability is given by

$$p_{\sim i}(n-1,N) = \sum_{\left\{(d_j)_{j\neq i}:\sum_{j\neq i} d_j = n-1\right\}} \left(\prod_{\{j:d_j=1\}} \pi_j\right)\left(\prod_{\{j:d_j=0\}} (1-\pi_j)\right) \quad \text{(A.1)}$$

Multiplying (A.1) by the probability that bidder i will participate (*i.e.,* $\pi_i \times p_{\sim i}(n-1,N)$) gives the *ex ante* probability the bidder *i* will be one of the n participants of the auction.

Bidders who show up to the auction have an equal chance of winning. As a result, the relationship between a bidder's market share and the participation rates is given by the expression:

$$s_i = \pi_i \sum_{n=1}^{n=N} p_{\sim i}(n-1,N)\left(\frac{1}{n}\right) \quad \text{((A.2)}$$

for $i = 1,\ldots,N$. To emphasize the relationship between market shares and participation rates, write market shares as a function of participation probabilities: $s_i = h_i(\pi_1,\ldots,\pi_N;N)$ for $i = 1,\ldots,N$. This gives N equations in N unknowns, *i.e.,* the π_i's. But note that the market shares must add up to 1, $\sum_i s_i = 1$, in which case we lose one degree of freedom. In our simulations we fixed the participation probability of the largest firm to 100%, so if firm 1 is the largest then $\pi_1 = 1$ and we calibrate the values for the remaining *N-1* bidders.

We adopt the strategy of adjusting the participation probabilities $(\pi_1,\ldots,\pi_N)$ so as to minimize the "distance" between the *fitted* markets shares $\hat{s}_i$'s and the *actual* market shares s_i's . We measure this distance by the sum of the squared differences between the two sets of market shares:

$$\underset{\pi}{\text{Minimize}} \sum_i (s_i - \hat{s}_i)^2 \qquad \text{Subject to} : 0 \le \pi_i \le 1 \tag{(A.3}$$

Note that this program cannot guarantee that actual and fitted market shares will be exactly equal for any firm.

The numerical solution to program (A.3) gives the calibrated participation probabilities, $\hat{\pi}_i$'s. We then enter those values back into the formula for expected winning bid under random participation:

$$\sum_{n=1}^{n=N} \hat{p}(n,N) E\left(V_{n-n:n}\right) = \sum_{n=1}^{n=N} \left\{ \sum_{\left\{d : \sum_j d_j = n\right\}} \left(\prod_{\{j:d_j=1\}} \hat{\pi}_j \right) \left(\prod_{\{j:d_j=0\}} (1-\hat{\pi}_j) \right) \div \left[1 - \prod_j (1-\hat{\pi}_j) \right] \right\} \left\{ \frac{n-1}{n+1} \left(b + \frac{2a}{n-1} \right) \right\} \tag{(A.4}$$

where we have inserted the expected value of the winning bid for the case when bidders draw from a uniform distribution $U[a,b]$, *i.e.,* $E\left(V_{n-1:n}\right) = \frac{n-1}{n+1}\left(b + \frac{2a}{n-1}\right)$. We use this uniform case in our merger simulations, *e.g.,* $(a,b) = (\$90,\$110)$. The unilateral price effects given in Tables 1 and 2 are the differences in expected winning bid calculated using (A6) for the pre- and post-merger industry structure.