Stigler, George J. "A Theory of Oligopoly." *Journal of Political Economy* 72 (February 1964): 44–61.

Trial Transcript of *U.S.* v. *Michael D. Andreas et al.*, U.S. District Court, Northern District of Illinois, Eastern Division, No. 96 CR 762, July–September 1998.

Warren-Boulton, Frederick R. "An Evaluation of 'The Cost to U.S. Animal Feeds Manufacturers of an Alleged Price-Fixing Conspiracy by Lysine Manufacturers, 1992–1995.'" Master File 95-C-7679, U.S. District Court for Northern Illinois, Eastern Division, 1996.

Wells, Wyatt. *Antitrust and the Formation of the Postwar World*. New York: Columbia University Press, 2002.

Werden, Gregory J. "Expert Report in *United States* v. *Interstate Bakeries Corp. and Continental Baking Co*." *International Journal of the Economics of Business* 7 (July 2000): 139–148.

White, Lawrence J. *Declaration of Lawrence J. White, In re Amino Acid Lysine Antitrust Litigation*, Master File 95-C-7679, U.S. District Court for Northern Illinois, Eastern Division, 1996.

White, Lawrence J. "Lysine and Price Fixing: How Long? How Severe?" *Review of Industrial Organization* 18 (February 2001): 23–31.

CASE 12

Bidding, Bid Rigging, and School Milk Prices: *Ohio* v. *Trauth* (1994)

Robert H. Porter and
J. Douglas Zona*

INTRODUCTION

Sometime between May and August every year, school district officials throughout the country independently solicit bids on annual supply contracts for milk and other products. In response to the solicitations, dairies that are in a position to supply school milk submit bids for procurement contracts. The majority of these procurements employ sealed-bid auctions, in part because federal guidelines require the purchasing method to be as competitive as possible. Typically, the low bidder is selected to supply milk in half pints to the schools during the following school year. According to a study by the U.S. Department of Agriculture, 86 percent of dairy purchases for the 1996–1997 school year used a formalized bidding procedure. The value of the contracts totaled more than $700 million.

In 1993, representatives of two dairies from Cincinnati, Ohio (Meyer Dairy and Coors Dairy), confessed to rigging bids in school milk auctions in the 1980s. These individuals testified that they had rigged bids with each other and with Trauth Dairy. Their testimony was offered as part of a settlement of the criminal and civil cases against them. Together they paid several million dollars to settle the cases. The bid-rigging scheme described in their testimony was one of respecting incumbencies. If one of the cartel members had served a particular school district in the previous year, then

*The authors consulted for the state of Ohio in the matters described in this chapter.

other conspirators were to submit high complementary bids that would not undercut the incumbent firm's bid, or else refrain from bidding. The testimony described frequent communication among these competitors as the specific details of the scheme were worked out through the bidding season.

Trauth Dairy, another Cincinnati dairy that was implicated by the whistle-blowers, maintained that there was no conspiracy. Instead, it claimed that the statements by its competitors were designed to ruin it and drive it from these markets, to the benefit of the whistle-blowers. It maintained its innocence through several trials, criminal and civil.

In 1994, the state of Ohio charged thirteen dairies, including Meyer, Coors, and Trauth, with collusion and bid rigging in school milk auctions for the years 1980 through 1990 inclusive.[1] Collusion in auctions is an agreement among a group of firms that is designed to limit competition between the participants. The analysis of collusion or communication among bidders is more difficult than the analysis of competitive bidding, in part because the nature and effects of conspiracy depend on the specifics of the situation.

Because the direct evidence of the extent of the conspiracy was disputed, economic evidence was gathered in addition to other kinds of evidence as the state set out to make its case. Three types of economic evidence were collected: (1) evidence on the incentives to collude in these markets; (2) evidence as to whether the behavior of the alleged conspirators was more consistent with competition or collusion; and (3) evidence on the extent of damages caused by the alleged bid rigging.[2]

The first category of economic evidence concerns the incentive to collude. As we describe below, the details of the procurement process, the nature of milk processing and delivery, and the characteristics of demand for school milk are such that collusive agreements among suppliers may be relatively easy to reach and maintain. Collusion appears to be a pervasive phenomenon in school milk auctions.[3] There have been investigations of price fixing in auctions for the provision of school milk in more than twenty states, beginning with a Florida bid-rigging case in 1988. More than 130 federal criminal cases have been filed, and many states have also filed charges. Guilty pleas have been entered in at least a dozen states, and fines have been levied in excess of $90 million. About ninety people have been sent to jail for average sentences of six months.

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[1] *Ohio* v. *Louis Trauth Dairy*, 856 F. Supp. 1229, 1237 (S.D. Ohio 1994).

[2] Our analysis complements a recent empirical literature on the detection of bid rigging. Porter and Zona (1993) describe bid rigging in New York State highway paving jobs on Long Island in the early 1980s. Pesendorfer (2000) examines school milk bidding data from Florida and Texas. Hewitt, McClave, and Sibley (1996) and Lee (1996) also analyze the Texas data. Lanzillotti (1996) describes bidding for school milk contracts in Kentucky. The papers by Baldwin, Marshall, and Richard (1997) and Bajari and Ye (2003) compare collusive and noncooperative bidding for Forest Service timber contracts and Minnesota highway improvement jobs, respectively.

[3] See, for example, Henriques and Baquet (1993) and Lanzillotti (1996).

We then analyze the behavior of the defendants relative to a competitive benchmark. We conclude that the bidding behavior of the accused dairies was more consistent with collusion than with competition. For example, some of the defendants exhibit patterns of both local and distant bid submissions. That is, they submit bids relatively near their plants and they also submit bids well beyond their local territories. Further, the distant bids by the defendants tend to be relatively low. In contrast, bids by a group of firms that were not named as defendants are an increasing function of the distance from the school district to a firm's nearest plant. These features of bidding by the defendants are consistent with territorial allocation of districts close to the dairies' plants to restrict competition and relatively competitive bidding at more distant locations, which were perhaps outside the area of territorial allocation. If bidding for local districts had been competitive, local bids should have been lower than distant bids, because shipping costs were lower and because the Cincinnati area has several potential local suppliers. The relationship between bidding behavior and distance is notable, because processed milk is relatively expensive to ship (since its value is low relative to its weight) and competition is therefore localized.

Third, we also analyze the effect of the collusion on prices paid by the school districts in Ohio as a result of the collusion as identified. We estimate that collusion caused school districts to pay about 6.5 percent more for school milk in the affected area during the period analyzed, and much more than that in some locations.

CHARACTERISTICS OF OHIO SCHOOL MILK MARKETS

Market outcomes are determined by three factors: the nature of demand, the nature of the production process, and the nature of competitive interaction among suppliers. In the case of school milk, demand and cost characteristics are relatively easily described. The more difficult problem is determining the nature of competitive interaction given the demand and cost characteristics; that is the focus of a subsequent section.

There are more than six hundred school districts in Ohio. Most districts award annual contracts for the supply of school milk. For example, a district will indicate that it expects to purchase fifty thousand half pints of whole white and thirty thousand half pints of whole chocolate milk. (This corresponds to a student population of about 450.) A bid submission consists of a list of prices for the various products. In addition to specifying categories of milk, the district may require its supplier to provide coolers (for the refrigeration of milk), straws, or napkins. Escalator clauses with price indexed to the price of raw milk are also provided in some bid requests to reduce the risk to the dairy that is associated with submitting a bid on an annual contract, since the price of raw milk can fluctuate substantially over a year.

Demand for school milk is relatively insensitive to the price charged. School milk programs are subsidized, and milk demand may be inelastic in any event. An estimate of the responsiveness of school districts' demand for milk to price, using data on a cross-section of school districts in Ohio, indicates that price is not a statistically significant determinant of demand despite substantial variations in price. If school district purchasing is inelastic, a firm that controls the supply of milk for a particular district could profit from a substantially higher price in that district.

The competitive price will depend on the costs of potential suppliers. We now describe the most important components of these costs. Dairy processors receive raw milk from dairy farmers in the area. The price charged for raw milk is typically regulated through an elaborate federal marketing order (FMO) system based on location and type of milk. Although some milk producers are unregulated, the market would tend to produce a single price for both regulated and unregulated raw milk in the long run. The cost of the raw milk contained in a typical half pint purchased by a school district is about seven cents. (This figure varies seasonally and from year to year.) Raw milk is processed by standardizing the butter fat content (e.g., 2 percent or skim) and then pasteurizing, packaging, and delivering it. Typically, potential suppliers of school milk pay about the same amount for raw milk, and they use much the same technology to pasteurize, package, and deliver. Many firms use the same suppliers of packaging materials, typically paying about two cents per half pint for packaging. As described below, we would expect incremental costs to be similar across different suppliers or potential suppliers. Any differences in long-run incremental costs would likely arise from differences in distance from the plant to the district.

When bids are solicited by school districts, firms in a position to supply will submit a bid. Which firms are in a position to supply the district? A firm must have access to a supply of school milk. The potential suppliers of school milk fall into one of two categories: processors, which process and package raw milk in the half pint containers demanded by schools; and distributors, which often purchase milk wholesale from the processors and resell it to a school district.[4] For any firm interested in selling its own milk in school milk markets, the costs of a processing plant may represent a substantial entry barrier. For those processors for which we have data, the school milk business represents a small fraction of their total revenues, typically less than 10 percent. Although a processing plant is necessary to process

[4]There are many distributors active in Ohio school milk markets, but the relationship between processors and distributors can be classified into relatively few categories. First, some distributors are granted exclusive territories and offer bids using the affiliated processor's name or stationery. Second, some distributors purchase milk wholesale from one or more processors and sell it to schools using their own name. These distributors often switch processor affiliations from year to year, presumably to get better terms. Finally, but not as frequently, distributors can provide delivery to the processor for a fee. Since all three arrangements coexist in the market, any particular type of distributor/processor relationship is unlikely to convey a competitive advantage.

school milk, school milk is only one of many products. To our knowledge, no firm has ever built a processing plant solely to supply school milk.

Thus, the decision to build a plant hinges on considerations in other product markets, such as supplying wholesale to supermarkets or to other institutions such as restaurants. (It should also be noted that there was substantially more exit than entry of processing plants in Ohio during the 1980s.) The costs of the processing plant that are directly attributable to school milk are therefore quite small. We conclude that only those firms that have access to a milk processing plant, largely put into operation for other reasons, would have the ability to enter the school milk business selling their own product.[5]

If a firm has a plant that is relatively close to the school district in question, what costs would be incurred should the firm submit a bid and win the contract? For example, are there any important fixed costs associated with serving school districts? Because data on the fixed costs of supplying school milk are not available, we analyze the size distribution of firms in Ohio. For those companies participating in school milk markets, the scale of operations ranged from one firm supplying milk to about 1 percent of Ohio public school students annually to another that supplied about 7 percent of the students. Firms producing on vastly different scales coexist in these markets, even though marginal costs seem to be quite similar, indicating that the fixed costs associated with the school milk business for a dairy serving other customers are likely to be relatively small.

Given that a firm has a processing plant and is in the school milk business, there are incremental costs associated with starting service to a new school district, such as the costs associated with providing a cooler and adding the district to existing delivery routes. The delivery portion of total incremental cost may also be related to the number of deliveries per week for the new district and how well it fits with the firm's existing route structure.[6] There are three main options for delivery: some dairies have dedicated school milk routes; others add school deliveries to their regular retail commercial routes; and other dairies use local delivery subcontractors for these services. Frequently, a dairy will utilize more than one option. Of course, delivery costs vary with distance. A typical delivery cost is on the order of a penny per half pint for local deliveries.

The cost of coolers is small relative to the other costs of school milk. For example, a sixteen-case cooler can be purchased currently for $1100. Using an eight-year depreciation schedule, which probably underestimates a cooler's useful life, this figure implies a cost of about 0.2 cents per half pint for a cooler that chills approximately seventy thousand half pints per year.

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[5]As noted earlier, firms can and do enter the market for the distribution of other firms' processed milk. Thus, entry barriers into distribution would be lower.

[6]Absent collusion, bidders will not know exactly which school districts they will ultimately serve when they bid on individual contracts. That is, they will not know the outcome of future contract lettings.

In summary, the cost of ingredients for a half pint of milk is on the order of about seven cents, packaging costs are about two cents, and delivery costs to serve a nearby school district are about one cent. Total delivered incremental costs are on the order of ten cents per half pint during the period analyzed. We expect these incremental costs to be independent of the scale of operations and similar across firms (after accounting for proximity). Fixed and other one-time costs will affect a dairy's decision whether to enter or exit the school milk business, whereas the incremental costs of supplying an additional half pint of milk or servicing another district are relevant for its pricing decisions.

The market characteristics described so far suggest competition among firms producing a homogeneous product with similar and constant incremental costs. Firms are likely to have good information about the costs of their competitors, since most cost changes affect all firms similarly. There are unlikely to be substantial informational advantages in the market. School districts would be willing to pay high prices for school milk, if they had no other choice. Competition is likely to be localized, because of the regulation of raw milk prices and because of relatively high transportation costs.

FACTORS FACILITATING COLLUSION

There are many features of Ohio's school milk markets that may affect the dairies' competitive interaction. Specifically, there are a number of characteristics that facilitate collusion.[7]

1. Firms compete only on price. Under the terms of the contract, the winning bidder supplies the product with specified characteristics (e.g., butter fat content or flavoring). A cartel need only coordinate submission and bid decisions, and not other characteristics of the product, which simplifies cartel operations.

2. The school districts' policy of publicly announcing bids and the identity of the bidders allows cartel members to detect "cheating" from cartel agreements. Undercutting and cheating on collusive arrangements would not go unnoticed, so a collusive arrangement is therefore more likely to be stable.

3. Most school districts held their auctions annually but at different times during a year, and they acted on their own.[8] The disorganized letting of contracts (as opposed to all contracts being let on a particular day, for

[7]These characteristics are prevalent in other markets. See, for example, Porter and Zona (1993).

[8]Some school districts occasionally band together in cooperatives and solicit bids for the group. However, cooperative arrangements historically have not prevented districts from soliciting bids individually.

example) allows cartel members to adjust bidding behavior during the bidding season to allocate market shares, and it provides an opportunity for nearly immediate retaliation for "bad cartel citizenship."

4. The predictability of the demand for school milk from year to year allows threats of future retaliation in response to deviations to be credible.

5. The fact that the markets themselves are easily defined according to school district boundaries permits allocations by assignment of territories.

6. The set of firms potentially submitting bids in a particular market is small and quite stable.

7. These firms use similar production processes and therefore face similar cost structures. The similarity of potential suppliers makes it more likely that a group of firms could agree on joint behavior.

8. The same dairies encounter one another in more than one market, and so competition may not be fierce.[9] Contact between competitors in multiple markets (school districts as well as wholesale accounts) makes collusive schemes that allocate markets more feasible.

9. The practice of obtaining competitors' price lists through retail customers (e.g., grocery stores) was common, if not universal. Advance notification of list price increases can lead to supracompetitive prices: The practice allows communication of intentions of competitors (Holt and Scheffman, 1987).

10. Dairies are frequently customers of one another. This facilitates direct communication and allows a pretext for meetings between competitors. The practice allows communication of pricing information (even for products that are not purchased) through full price lists. Holt and Scheffman (1988) condemn this practice as potentially facilitating collusion.

11. The many dairy trade associations in Ohio also allow a pretext for meetings of competitors. Most meet on a regular basis to discuss issues of mutual interest. These associations obviously understand the legal dangers since the minutes of these meetings often indicate that they begin by reading a statement warning members not to discuss prices.

According to the testimony of the Meyer and Coors representatives, these factors were of more than theoretical importance. Even if one ignores their testimony, a cartel among firms operating in the area is plausible and

[9]Bernheim and Whinston (1990) show that multimarket contact in a repeated market setting "relaxes the incentive constraints that limit the extent of collusion."

would be to the benefit of each of the participants. Since competition is localized, prices will fall to competitive levels only in areas where there is a sufficient number of local competitors. Distant competitors are disadvantaged by transportation costs and can discipline price increases to only a certain extent. The competitive significance of each supplier is directly related to its relative distance from the school district. Any elevation of price that is achieved through collusion could, in some circumstances, be defeated by the entry of new firms from outside the market. In the case of school milk, entry will not take the form of a new firm's setting up a processing plant; instead, it will be in the form of bids from firms whose plants are farther away. In this way, the transportation cost for distant noncartel entrants will constrain the ability of a cartel to raise prices, but if collusion is effective, then prices could be elevated by a significant amount. If local firms could coordinate their bidding behavior, then some profits could be earned without stimulating entry from distant suppliers. The reaction of any school district is unlikely to limit the ability of a cartel to raise price. As noted above, demand for school milk is inelastic, and school districts would continue to purchase milk even at elevated prices, to the detriment of the school districts and to the benefit of cartel members.

A scheme of respecting incumbencies is one way for a cartel to coordinate bidding behavior. Such a scheme would be attractive if cartel firms were near each other, as some are in this case. This mechanism avoids the cartel problem of allocating school districts of varying profitability (due to a location or level of service required) among the cartel members. Another way of coordinating bidding behavior would be the assignment of geographic territories to individual firms. Territorial assignment would be a more practical collusive mechanism when firms are geographically separated and some firm has a clear advantage in serving a particular district.

A MODEL OF COMPETITIVE BEHAVIOR

In a competitive market, firms in the school milk business face two interrelated decisions. First, should the firm submit a bid in a particular district? Second, if a bid is submitted, what should the bid level be? We address these decisions in turn in the subsections below. Here we describe a model of competitive bidding.

Porter and Zona (1999) estimated an econometric model of bidding behavior using a data set provided by the state of Ohio that contains information on school milk procurement for as many as 509 of the approximately 600 school districts in the state from 1980 through 1990, inclusive, with approximately sixty different bidders participating at some point in the sample. We created a control group composed of nondefendant firms that bid on Ohio school milk contracts. The data set contains information on the identity of the districts, their location and enrollment, and the timing of

TABLE 12-1
Characteristics of Ohio School Milk Data Set

Year	Number of School Districts or Cooperatives	Total Enrollment in School Districts	Number of Plants Operated by Submitting Dairies	Number of Dairies Submitting Bids	Average Price per Half Pint ($0.00)	Average FMO Price for Raw Milk
	(a)	(b)	(c)	(d)	(e)	(f)
1980	366	1,257,925	54	43	0.1282	0.0718
1981	398	1,379,619	50	44	0.1295	0.0769
1982	415	1,371,164	46	40	0.1295	0.0760
1983	436	1,415,281	48	40	0.1288	0.0764
1984	448	1,430,644	53	38	0.1313	0.0741
1985	463	1,460,697	48	35	0.1322	0.0708
1986	481	1,457,437	47	36	0.1304	0.0700
1987	494	1,566,591	46	33	0.1310	0.0701
1988	509	1,520,635	44	30	0.1338	0.0666
1989	491	1,564,869	43	26	0.1389	0.0708
1990	412	1,296,587	43	26	0.1575	0.0797

Notes: Dollars per hundredweight FMO (federal milk order) #33 Class 1 Fluid Milk; 186 half pints per hundredweight; prices quoted for July of each year.

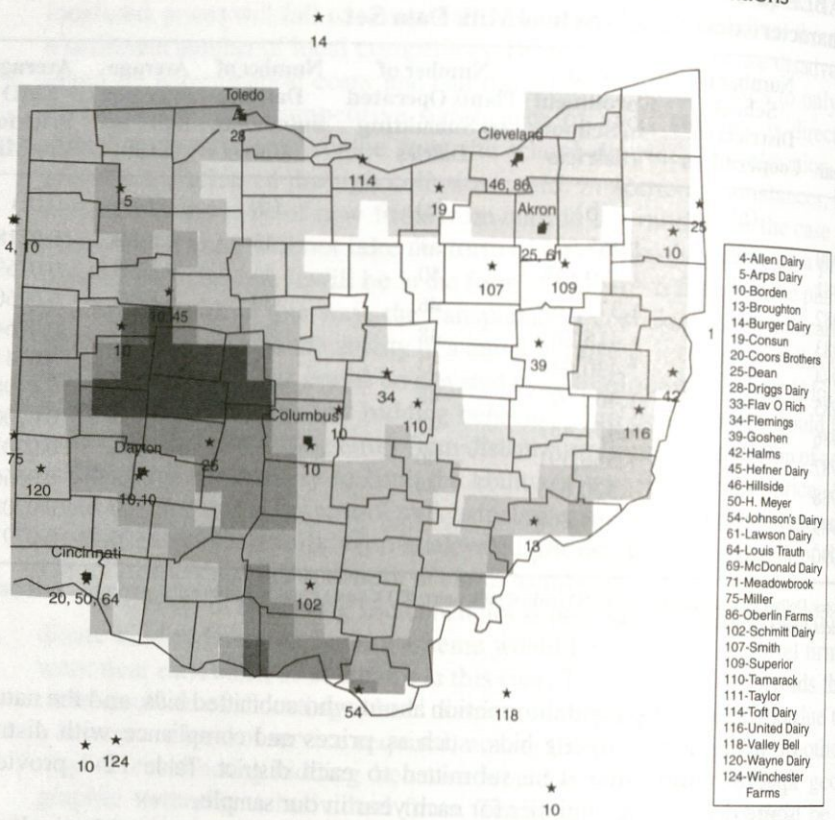
contract lettings; and information about who submitted bids, and the nature of winning and losing bids, such as prices and compliance with district specifications, that were submitted to each district. Table 12-1 provides some descriptive statistics for each year in our sample.

According to data obtained from the U.S. Department of Agriculture, a total of sixty-eight milk processing plants had sales in Ohio at some point during the sample period and potentially could have supplied school milk. Figure 12-1 displays the location and owners of the forty-six plants that supplied school milk in 1987. Superimposed on the plant location map in Figure 12-1 is an index of dairy concentration.[10] The darker the area, the more concentrated are the ownership and control of local school milk processing facilities. Figure 12-1 shows that the markets in the northeast section of Ohio are the least concentrated, and if they are competitive they should have the lowest prices, all else equal. Columbus and the southernmost tip of Ohio have markets where the supply of school milk is concentrated in the hands of relatively few producers. Over the period 1980–1990, the number of plants serving Ohio school districts fell from fifty-four to forty-three, and the number of firms fell from forty-three to twenty-six.

Table 12-2 shows the distribution of bidder distances in the Ohio data. The table also shows the distribution of potential supplier distances in the

[10]We measure concentration using the Herfindahl index. For market shares we use the fraction of plants within seventy-five miles of the region that are owned by each firm.

FIGURE 12-1 1987 Regional Supply Concentration and Plant Locations



Note: The concentration of an area is represented by its shading; white represents a completely unconcentrated area, while black represents an area serviced by a single supplier.

data. Approximately 85 percent of the firms supplying school milk in a given year do so from plants located less than seventy-five miles from the school district. Firms considering entry in order to supply milk to distant school districts appear to be disadvantaged by distance, even if they have a plant in operation.

The distribution of processing plants in the state and the apparent disadvantage of shipping long distances cause districts to receive a relatively small number of bids on school milk. For the districts in the data set, 45 percent received only one bid, 34 percent two bids, and 18 percent three bids. Even though there are a large number of potential bidders for any particular auction, very few actually bid. The mean number of bids is 1.8. The small number of bids submitted indicates that dairies may not have important private information. If bidders knew their own costs as well as the costs of other potential suppliers, then it seems plausible that bidding by only one or two dairies would be observed. The low-cost supplier would submit a bid just below the cost of the next-lowest-cost supplier, and the latter would

TABLE 12-2
Probability of Bidding and Winning Conditional on Distance from Plant to School District

Distance in Miles	Number of Districts	Probability of Bidding	Proportion of All Bids	Probability of Winning	Proportion of Winning Bids
	(a)	(b)	(c)	(d)	(e)
0–10	2115	19.5%	20.1%	13.6%	22.9%
10–20	3197	14.0	21.7	8.9	22.5
20–30	3840	7.6	14.2	4.9	15.0
30–40	4526	5.5	12.1	3.4	12.1
40–50	5637	2.3	6.3	0.9	4.2
50–60	6440	1.9	5.9	1.0	5.0
60–70	5314	1.4	3.7	0.5	2.0
70–80	6732	1.4	4.7	0.8	4.4
80–90	5200	1.0	2.5	0.6	2.5
90–100	4885	1.2	2.8	0.7	2.8
100–150	26079	0.5	6.1	0.3	6.6

Notes: Columns (b) and (d) report, for each distance category, the percentage of districts in which firms submitted a bid or the winning bid, respectively. Columns (c) and (e) total 100 percent and report the fraction of all bids or winning bids, respectively, in each distance category. Results are based on a total of 2053 submitted bids from control group firms out of 73,965 bid opportunities; 1260 of these were winning bids.

be indifferent between bidding at its own cost and not bidding. About 43 percent of all bids are submitted by the firms with the plants closest to the district, and 8 percent by the firms with the second-closest plant. Among winning bids, 49 percent are submitted by the firms with the closest plants, and 8 percent by those with the second-closest plant.

Bid Submission

In a competitive market a firm will submit a bid in a particular district whenever the probability of winning is relatively high and when the expected return covers both the costs of preparing the bid and the incremental costs of supplying the district. A model of bidding behavior should account for variables that reflect the potential bidder's absolute and relative advantage in serving a district. For example, variables that may be important in characterizing these advantages include whether or not the firm (1) has significant transportation costs to the particular district, as reflected by the distance from the district to the plant; (2) is a distributor or a processor of milk; (3) is the closest potential supplier (and so the most likely low-cost supplier for that district); (4) is the second closest, and hence likely the second-least costly potential provider; (5) is bidding on a large or small school district, as larger districts may require more time and energy to prepare a bid; and (6) can efficiently provide the specified milk under the terms

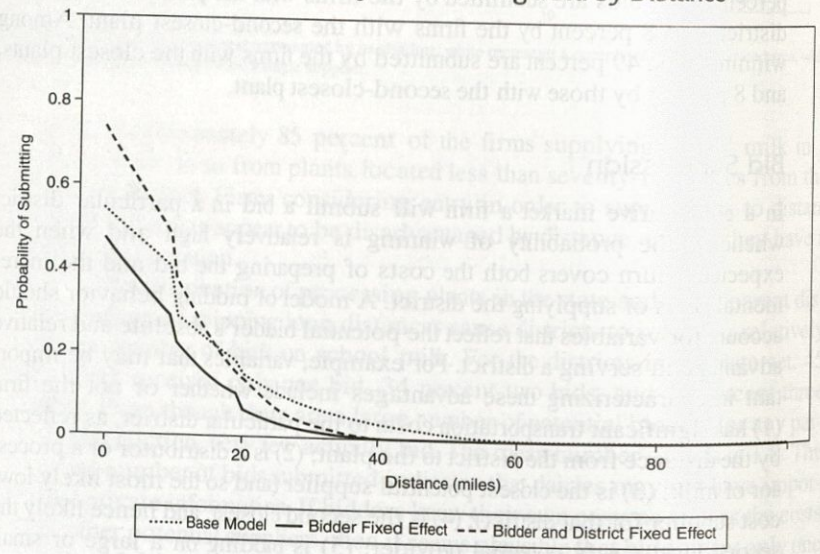
of the contract (whether or not coolers are required, or whether fixed price or indexed contracts are specified, for example).

From available bidding data, we estimated how these factors affect the decision whether to submit a bid by the control group of nondefendants. See Porter and Zona (1999) for more detail. The results from this estimation are then used as a benchmark for comparison with the behavior of the defendants.

The econometric results can be summarized as follows. Processors are more likely to submit bids than distributors, all else equal. This may reflect the fact that distributors tend to run a single school milk route, while processors tend to run several routes with school delivery. Firms, especially distributors, are more likely to submit a bid in one particular direction as opposed to all around their plant. This may reflect the effects of existing route structures. Firms are less likely to submit bids to school districts that are farther away from their plants than they are to closer districts. This probably reflects absolute cost differences. Districts that request coolers or straws receive fewer bids than districts that do not. The other specification items do not affect bidding behavior in a statistically significant way.

The likelihood of submitting a bid is a decreasing function of distance. Figure 12-2 displays the impact of distance on the probability of bidding for a hypothetical firm in the control group. To construct this figure we assume that the firm is the closest supplier to districts less than ten miles from its

FIGURE 12-2 Predicted Probability of Submitting a Bid by Distance



Note: Variables that are not related to distance are set to their mean value, except processor is set to one, closest is set to one at distances less than ten miles, and closer is set to one at distances between ten and twenty miles.

plant and the second-closest potential supplier at distances between ten and twenty miles. The three curves correspond to three different specifications. There are two steps in the predicted probability of bidding where the firm loses its locational advantage and becomes neither the closest nor the second-closest potential supplier. The probability of bidding by this hypothetical firm is above 50 percent at zero distance, but nearly zero beyond seventy-five miles.

Bid Level Contingent on Submission

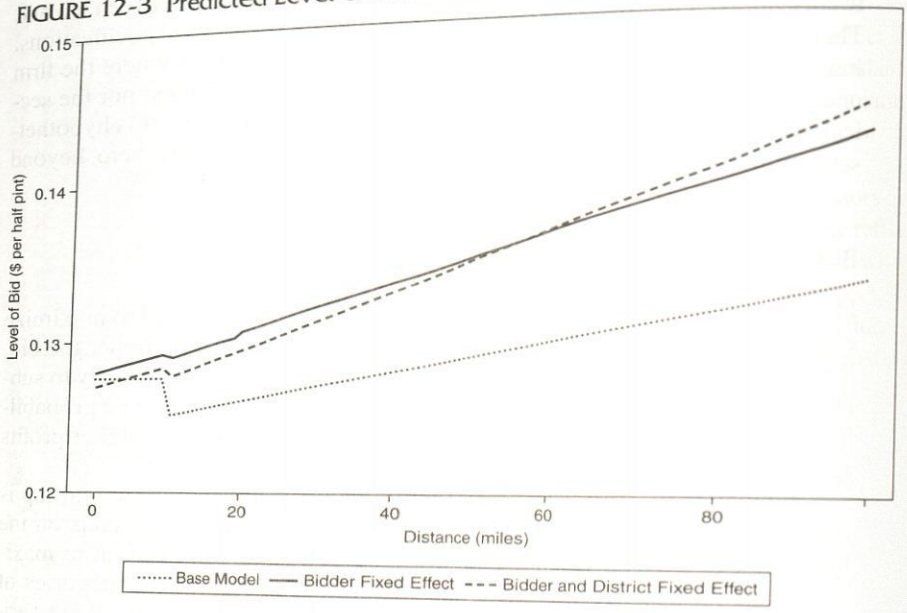
In competitive markets, a firm submitting a bid chooses its bid to maximize expected profit. A bid cannot be increased indefinitely; the higher the bid, the lower the likelihood of winning. To the extent that bids are costly to submit, it would not be profit maximizing to submit bids that have no probability of winning. A firm maximizing expected profit trades off higher profits against a lower probability of winning.[11]

Equivalently, bidders choose their markup over costs. The markup is affected by the probability of winning the auction, which depends on the likelihood of other firms submitting bids. The markup is chosen to maximize expected profit given the level of cost. There are two categories of variables that would tend to explain bidding behavior. First, there are variables that may contribute to cost, such as distance from the plant to the district; whether or not the bidder is a processor; whether or not coolers or other items are required or supplied; the number of required deliveries; and whether or not there is an escalator clause. Second, there are variables that reflect competitive characteristics of the market: the bidder's relative cost advantage and the number and costs of other suppliers. For example, if a bidder is the closest vendor, then that bidder can bid more than it would otherwise without decreasing the probability of winning. A second example is a variable that affects the probability that a firm submits a bid. Firms that are likely to submit bids on particular districts are those that have a high probability of winning and those expecting to earn relatively high profits in the event that they win the auction.

To analyze bid prices, we constructed a summary measure of each firm's bids for the various milk products, with 2 percent chocolate used as the base product. We measured the effects of the competitive factors described above on the bid levels of the control group of nondefendants. Figure 12-3 summarizes how control group bids vary with distance. We plot predicted bids for a hypothetical control group firm holding variables other than distance constant. The figure incorporates the effect of distance on the probability of submitting a bid and the resulting impact on the bid. Figure 12-3 presents the results for three different specifications of the

[11]See Wilson (1993), McAfee and McMillan (1987), or Milgrom and Weber (1982).

FIGURE 12-3 Predicted Level of Submitted Bids by Distance: Control Group



Note: Variables that are not related to distance are set to their mean value, except processor is set to one, closest is set to one at distances less than ten miles, and closer is set to one at distances between ten and twenty miles.

control group bidding model. A bid one hundred miles away would be between one and two cents higher than in a district adjacent to the plant, all else equal. Firms in the control group are unlikely to submit bids to districts at these distances from the plant, however. Firms closest to the district have some competitive advantage, but that advantage diminishes with distance.

Bidding by nondefendants is consistent with competitive bidding under standard models of spatial competition, where each firm may exercise local monopoly power. As described above, competition is localized, because of the regulation of raw milk prices and because of relatively high transportation costs.

BEHAVIOR OF DEFENDANTS

Comparison with Control Group Behavior

We now examine the bidding practices of the three dairies located in Cincinnati—Meyer, Coors, and Trauth—and compare them with the control group. We consider both the bid submission decision and the level of the bid contingent on submission.

Porter and Zona (1999) tested for differences between the estimated control group bid submission model and that estimated for each of the Cincinnati dairies. For each dairy, we reject the hypotheses that the defendants submitted bids according to the control group model at conventional significance levels under all the specifications considered. There are also significant differences in the statistical process generating the level of bids. That is, the bidding behavior of each of the Cincinnati dairies differs from the control group. Behavioral differences are not necessarily the result of anticompetitive behavior. We are interested in how the behavior of each of the defendants differs from the control group, given that they differ.

Comparison with a Collusive Strategy

We are faced with a standard problem in antitrust economics: distinguishing between competitive and collusive behavior.[12] Porter and Zona (1993) identified collusion in highway construction auctions by (1) focusing on bid levels rather than submission decisions, because conspirators apparently submitted complementary bids; (2) identifying differences in the determinants of cartel bids relative to that of other firms; and (3) observing that cartel bids seemed not to be cost based, except for the lowest cartel bid, in contrast to the bids submitted by other firms. Because these differences exist, we conclude that conspiracy with complementary bidding is more likely than not.

In a study of a nineteenth-century railway cartel, Porter (1983) proposed statistical tests to identify whether competition or collusion is more consistent with observed data based on pricing patterns over time. Some observed price fluctuations do not appear to be the result of demand shifts or changes in observable cost factors. Instead, the observed pattern of occasional price wars, following periods of unusually turbulent market shares, is unlikely to be observed under competition. Under a specific theory of conspiracy, such a pattern is possible. The existence of such a pattern informs an inference of collusion.

Our strategy for the problem at hand is similar. The nondefendant firms behave, on average, in a manner consistent with competition. We have concluded that the Cincinnati dairies behave in a statistically significantly different manner relative to the nondefendant firms. Is it likely that these differences are attributable to idiosyncratic effects of cost or competition? If not, are the differences attributable to independent factors, or are there suspicious patterns of correlation? We now address these two questions.

[12]Baker and Bresnahan (1992), Harrington (2008), and Porter (2005) discuss related methods of detecting the exercise of market power, or the presence of collusion.

There are many alternative methods of colluding in auction markets.[13] For example, conspirators could refrain from bidding against each other by allocating exclusive territories. Alternatively, they could submit several bids at inflated levels, where the number of bids may be intended to create the appearance of competition. In either event, the members of the ring know that competition has been limited in the affected markets. Any of these firms know that if they submit a bid they do not have to worry about being undercut by another ring member. Observed bids will differ from competitive bidding because the conspirators have coordinated their actions. The expected winning bid will be higher because conspirators have coordinated their actions, whether or not a conspirator wins the auction.

Since distance is an important factor in the control group model, we focus on that dimension. Moderate increases in shipping distance are associated with large declines in the probability of submitting a bid (Figure 12-2). Similar increases in distance are associated with increases in submitted bids in the control group (about 10 percent at seventy miles in Figure 12-3). We examine the deviations of defendant firms' bidding behavior from the control group predictions in this context.

Consider first the differences between predicted and actual bid submission behavior for each of the three Cincinnati dairies, at various distances. There are some notable patterns. First, all three dairies bid more frequently than the control group model predicts for districts within 30 miles of their plant. Second, Meyer is unusually likely to bid in districts 100 to 110 miles away, and Trauth in districts 60 to 80 miles away.

We also compare actual bids[14] with the control group prediction. The bids of Meyer and Trauth decrease relative to the control group prediction significantly with distance. In particular, their bids are significantly lower in the distance ranges where they were unusually likely to bid—Meyer at 100 to 110 miles, and Trauth at 60 to 80 miles. As further evidence, consider bid level regressions, comparable with the control group regressions, for the three Cincinnati dairies. For both Meyer and Trauth, which submitted distant bids, bid levels are a significantly decreasing function of distance. In contrast, the distance bids are significantly higher for the control group.

To focus on whether firms behave in a parallel fashion, we tested for statistical independence in the probability of bidding for the defendant firms using a standard pairwise procedure. Under the null hypothesis of independent action based on public information and the specifications of our bid submission model, knowledge of whether one particular firm bids should not help predict whether another firm also bids. Under an alternative hypothesis of either complementary bidding or territorial allocation, the

[13]Hendricks and Porter (1989) describe several collusive mechanisms, and why the detection of collusion is necessarily case specific. Klemperer (2008) explains why auction market competition policy should differ from other markets.

[14]By "actual bid," we are referring to the summary bid measure, rather than any element of the vector of bids that the firm may have submitted.

submission decisions are interrelated, and knowing how one cartel member behaves helps predict what the other does. In the case of complementary bidding, if one cartel member bids, then other ring members also bid. In this case the unexplained portion of the competitive bidding equation is positively correlated across cartel firms. In the case of territorial allocation, if a particular cartel member bids, then other cartel members will tend not to bid. Then the unexplained portion of the competitive bidding equation is negatively correlated across cartel members. The test for independence, or zero correlation, that we used has power against both alternatives. The results indicate that the unexplained portion of the Coors submission decision was positively correlated with the unexplained portion of the Meyer decision, and similarly for Coors and Trauth, and for Meyer and Trauth. All three correlations are significant at any standard level.

We perform a similar analysis for the level of the submitted bids. Under the null hypothesis of independent action based on public information and the maintained specification of the bid level equations, knowledge of what one particular firm bid does not help predict what another firm will bid. Under an alternative hypothesis of complementary bidding, knowing that one cartel member bid above the predicted level helps predict whether other cartel firms will bid above that level. If one cartel member bids high, then other ring members are also likely to bid high. The pairwise correlation coefficients are positive and significant for all three pairs.

Our results support the testimony by representatives of Meyer and Coors. The behavior of Coors, Meyer, and Trauth is consistent with a complementary bidding scheme in the area close to their plants, since more bids than expected are submitted at distances of less than thirty miles. Further, these bids tend to be relatively high. The correlation results for these three firms are also consistent with a complementary bidding scheme. There are statistically significant correlations in bid submissions by these firms, suggesting that if one of these firms bids, then the others also tend to bid (to a greater extent than their proximity, size, and other factors would predict). In addition, when these firms bid on the same districts in the same years, their bids tend to move together to a greater extent than their proximity, size, and other factors would predict.

It is difficult to craft a competitive story where bid levels decrease with distance, as they do for these firms. The behavior of the Cincinnati dairies is suspicious, even without a comparison with the behavior of nondefendant firms. We believe that the collective behavior of these three firms is best characterized as collusive.

The Defendants' Response

Not surprisingly, the defendant dairies disagreed with our interpretation of the evidence. They criticized our econometric approach on several grounds. For example, they noted that the list of explanatory variables in

our econometric model of bidding behavior was incomplete, in that they could point to a number of other factors that might also affect the decisions of whether to bid, and at what level. However, they did not provide a theoretical argument or any econometric evidence to indicate that the effect of omitting these variables would necessarily bias our tests in any particular direction. Instead, the force of their argument was that the model did not fit as well as one might like, and our conclusions therefore were suspect.

Second, they argued that the control group was not a cohesive group, because one could reject the hypothesis that they all bid according to exactly the same bidding model, and therefore a comparison of the defendants to the average behavior of the nondefendants is not an interesting exercise. However, Porter and Zona (1999) report that the bidding behavior of all but three of the fifteen nondefendant firms (those for which there are sufficient data to conduct the test) is not significantly different than the average behavior of the remainder. This contrasts with the defendants, all of whom have significantly different behavior.

Finally, the defendant dairies argued that econometric evidence alone cannot distinguish between an overt conspiracy and tacit collusion, whereby the dairies charged high local prices without ever communicating with each other.

EFFECT OF COLLUSION ON PRICES PAID

On the assumption that a conspiracy involving all the southwestern Ohio defendants was in force throughout the 1980s, what were the likely damages? Our methodology for estimating damages to the plaintiff school districts involves determining the percent markup in price attributable to collusion in various auctions.

Using regression techniques, Porter and Zona (1999) estimated the effect of variables that determine costs for the most efficient provider and other variables on the standardized price of the winning bid. The sample covers about four hundred districts, including those outside of the southwestern region. Annual dummy variables control for changes in the raw milk price, changes in uncertainties in the raw milk price over time, and changes in the costs of packaging year to year. We also control for district enrollment, the number of deliveries, and other characteristics of the school district. We include two location variables, to account for the effects of (1) the distance from the closest plant to the school district, as we expect price to be increasing with distance to the closest plant as shipping costs increase, and (2) the distance between the district and the second-closest plant. When the latter distance is large, all else equal, we expect the price paid by the school district to be higher since the closest firm can charge a higher price.

We also control for the effects of differing levels of competition in each of the markets. We measured competition in these markets using the number of equivalent firms defined by the inverse of the Herfindahl index.[15] We expect higher prices in more concentrated markets where fewer firms compete with one another.

If there is collusion in these markets, prices are on average above the competitive level. Therefore, we include in each regression an index of collusion based on the number of conspirators in this case who are within seventy-five miles of the school district in question.[16] We also include an interaction between the collusion index and the number of equivalent firms, since the effect of a restriction of competition will depend on the initial level of competition. We interact these indices of collusion with the annual dummy variables so as to measure, to the extent they exist, differences in the degree of collusion from year to year.

In our regression we predicted the winning bid using 2 percent chocolate milk as the base product. In general, the coefficients are of the anticipated signs and statistically significant. The number of firms in the market, as measured by the variables described above, indicates the significant effect of concentration on the price paid by the school districts.

The predicted increase in price caused by collusion in these auctions is measured as the difference between the predicted value when indices of collusion are included and the predicted value that is obtained when all indices of collusion are set to zero. The difference is the predicted percentage change in price resulting from collusion. The estimated effect of collusion is small in 1983–1984 and after 1989, consistent with the market participants' testimony that the cartel agreement broke down in those years.

The average effect of collusion on price is an increase of about 6.5 percent. This is consistent with our estimate of the average effect of distance on school milk bids. If, for example, two nearby firms conspired to serve a district adjacent to their plants and faced competition only from firms located at least fifty miles from that school district, then prices could be about one-half penny (or about 5 percent) higher than they would be otherwise. Districts that are farther from potential competitors face higher markups, and districts closer to the plants of competitive firms pay lower markups.

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[15]The Herfindahl index is based on the fraction of school milk processing plants within seventy-five miles of the district controlled by each processor. If there are ten owners of ten processing plants within seventy-five miles, then the Herfindahl is one-tenth, and the number of equivalent firms is ten. If there are ten dissimilar firms, the Herfindahl index will exceed one-tenth, and the number of equivalent firms will be less than ten.

[16]The index of collusion is the difference between the inverse of the Herfindahl index assuming competition and the inverse Herfindahl assuming collusion.

SUMMARY AND AFTERMATH

Our analysis exploits specific features of school milk markets, and we would not necessarily advocate using similar methods to study other auction markets. For example, an unusual feature of Ohio school milk auctions is that few bids are submitted, even relative to school milk auctions in other states. An important component of strategic decisions in this market is whether to submit a bid.

We also focus on the role of distance in bidding decisions. Processed milk is relatively expensive to ship, and competition is localized. We emphasize the fact that two of the three Cincinnati dairies tend to submit relatively low bids for distant school district contracts, and yet submit higher bids close to their plant. We document these patterns with a bidding model that ignores characteristics of potential rivals, except to the extent that we control for district specific fixed effects, in large part because we cannot be sure whether other firms were indeed rivals. In the case of the Cincinnati dairies, this omission should bias the results in their favor. Had they competed aggressively, bids for nearby districts should have been relatively low, as there were three local potential suppliers. Yet, prices in Cincinnati were relatively high, especially in comparison with the dairies' distant bids. This price pattern is consistent with local monopoly power, but local monopoly power is consistent only with collusion.

The detection of collusion in auction or other markets is necessarily case specific, since the details of a collusive scheme depend on a number of factors. The study of auction markets can nevertheless inform the study of collusion in other markets. Data are often available on the bids of all participants in an auction, and the auction rules define the set of strategic considerations. Under these circumstances, a detailed study of strategic behavior is feasible, and it may be possible to isolate behavior that is inconsistent with competition.

This case study describes some features of a conspiracy among a group of neighboring suppliers, when the conspirators are protected locally from competition by the transportation costs borne by distant suppliers, and when the conspirators compete on a relatively equal footing with other firms outside their local market. In this case, lower prices at more distant locations are consistent with a local conspiracy and inconsistent with competitive behavior.

The case brought by the state of Ohio against the Cincinnati dairies was settled in 1996 before it could go to trial. Earlier, the federal government lost a criminal conspiracy case in 1995 that centered on the testimony of the Meyer and Coors representatives. In the federal trial, the defense described this testimony as unreliable, on the grounds that it contradicted previous statements of innocence before a grand jury. The federal case did not rely on statistical or economic evidence. The state preferred to settle rather than to go to trial with the same direct evidence, which would be

subject to similar questioning. The economic evidence was intended to corroborate this testimony and to assess the amount of damages. It is very difficult to distinguish overt conspiracy from tacitly collusive behavior with economic evidence, which is typically not regarded as sufficient to establish liability.

In 1993, the U.S. Department of Justice (DOJ) clarified its Corporate Leniency Policy, under which the first cartel member to confess participation is awarded complete amnesty from prosecution (unless it was already the subject of an investigation, in which case amnesty is limited). All other participants are subject to harsh penalties. DOJ officials believe that this policy is now their most effective weapon in combating cartels (e.g., Hammond, 2001), one that induces a "race to the courthouse." Recent government cases have relied heavily on the testimony of participants in the conspiracies. The 1993 leniency policy did not shield informants from civil penalties, most notably from treble damages, but the 2004 Criminal Penalty Enhancement and Reform Act limits informants' penalties to actual damages (plus attorney fees) and increases the potential liability of other conspirators.

Rey (2003) and Spagnolo (2008) describe how leniency programs are implemented in the United States and Europe, and they discuss how leniency policies should be designed to fight collusion effectively. An effective policy would hasten the demise of existing conspiracies, as the costs of defecting from the agreement decrease, and the gains associated with continuing are limited. An effective policy would also prevent some new cartels from forming, if potential conspirators fear the potential legal consequences.

REFERENCES

Bajari, Patrick, and Lixin Ye. "Deciding between Competition and Collusion." *Review of Economics and Statistics* 85 (November 2003): 971–989.

Baker, Jonathan B., and Timothy F. Bresnahan. "Empirical Methods of Identifying and Measuring Market Power." *Antitrust Law Journal* 37 (1992): 3–16.

Baldwin, Laura, Robert Marshall, and Jean-Francois Richard. "Bidder Collusion at Forest Service Timber Auctions." *Journal of Political Economy* 105 (August 1997): 657–699.

Bernheim, B. Douglas, and Michael D. Whinston. "Multimarket Contact and Collusive Behavior." *RAND Journal of Economics* 21 (Spring 1990): 1–26.

Hammond, Scott. "Lessons Common to Detecting and Deterring Cartel Activity." In *Fighting Cartels—Why and How?* Goteborg: Swedish Competition Authority, 2001.

Harrington, Joseph E., Jr. "Detecting Cartels." In *Handbook of Antitrust Economics*, edited by Paolo Buccirossi, 213–258. Cambridge, Mass.: MIT Press, 2008.

Hendricks, Kenneth, and Robert H. Porter, "Collusion in Auctions." *Annales d'Economie et de Statistique* 15–16 (July–December 1989): 217–230.

Henriques, D., and D. Baquet. "Investigators Say Bid Rigging Is Common in Milk Industry." *New York Times*, May 23, 1993.

Hewitt, Cynthia, James McClave, and David Sibley. "Incumbency and Bidding Behavior in the Dallas–Ft. Worth School Milk Market." Unpublished manuscript, 1996.

Holt, Charles A., and David T. Scheffman. "Facilitating Practices: The Effects of Advance Notice and Best-Price Policies." *RAND Journal of Economics* 18 (Summer 1987): 187–197.

Holt, Charles A., and David T. Scheffman. "A Theory of Input Exchange Agreements." Mimeo, Federal Trade Commission, Bureau of Economics, 1988.

Klemperer, Paul. "Competition Policy in Auction and Bidding Markets." In *Handbook of Antitrust Economics*, edited by Paolo Buccirossi, 583–624. Cambridge, Mass.: MIT Press, 2008.

Lanzillotti, Robert F. "The Great School Milk Conspiracies of the 1980s." *Review of Industrial Organization* 11 (August 1996): 413–458.

Lee, In K. "Non-Cooperative Tacit Collusion, Complementary Bidding, and Incumbency Premium." *Review of Industrial Organization* 15 (September 1999): 115–134.

McAfee, R. Preston, and John McMillan. "Auctions and Bidding." *Journal of Economic Literature* 25 (June 1987): 699–738.

Milgrom, Paul R., and Robert J. Weber. "A Theory of Auctions and Competitive Bidding." *Econometrica* 50 (September 1982): 1089–1122.

Pesendorfer, Martin. "A Study of Collusion in First-Price Auctions." *Review of Economic Studies* 67 (July 2000): 381–411.

Porter, Robert H. "A Study of Cartel Stability: The Joint Executive Committee." *Bell Journal of Economics* 14 (Autumn 1983): 301–314.

Porter, Robert H. "Detecting Collusion." *Review of Industrial Organization* 26 (March 2005): 147–167.

Porter, Robert H., and J. Douglas Zona. "Detection of Bid Rigging in Procurement Auctions." *Journal of Political Economy* 101 (June 1993): 518–538.

Porter, Robert H., and J. Douglas Zona. "Ohio School Milk Markets: An Analysis of Bidding." *RAND Journal of Economics* 30 (Summer 1999): 263–288.

Rey, Patrick. "Toward a Theory of Competition Policy." In *Advances in Economics and Econometrics: Theory and Applications*, edited by M. Dewatripont, L. Hansen, and S. Turnovsky, 82–132. Cambridge, UK: Cambridge Press, 2003.

Spagnolo, Giancarlo. "Leniency and Whistleblowers in Antitrust." In *Handbook of Antitrust Economics*, edited by Paolo Buccirossi, 259–304. Cambridge, Mass.: MIT Press, 2008.

Wilson, Robert. "Strategic Analysis of Auctions." In *Handbook of Game Theory*, vol. 1, edited by Robert J. Aumann and Sergiu Hart, 227–279. Amsterdam: North-Holland, 1993.