CONSPIRACIES AND SECRET DISCOUNTS IN LABORATORY MARKETS

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Abstract

This paper uses laboratory methods to evaluate whether price-fixing conspiracies break down in the presence of opportunities to offer secret discounts. The primary treatment difference is whether or not buyer-specific discounts from the posted list price are permitted. In standard posted-offer markets, conspiring sellers are able to find and maintain near-monopoly prices. But when the possibility of offering secret discounts is introduced, sellers are unable to sustain collusive agreements, and transactions prices fall to near-competitive levels. Secret discounts, however, do not yield consistent competitive outcomes when sellers are provided *ex post* information about sales quantities.

1. Introduction

Economists often appear inconsistent in their attitudes toward collusion. On the one hand, there is a general agreement with Adam Smith that explicit communications among sellers in the same market almost inevitably result in an attempt to fix prices.[1] On the other hand, the problems of implementing, monitoring and maintaining an illegal agreement make many economists skeptical that the conspiracies will often have much of an impact on prices.[2]

Some limited empirical evidence on the effectiveness of collusion is available. Porter (1983), for example, studied a legal rail freight cartel that existed before the passage of the

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[1] Smith (1776, p. 144) however, does not seem to view meetings that produce conspiracies as inevitable, and he argues that government policy should do nothing to facilitate such assemblies.

[2] Some economists even doubt the effectiveness of conspiracies organized out of the shadow of illegality. For example, Milton Friedman (1974), predicted OPEC's price-fixing efforts would have only transitory effects.

Sherman Act, and concluded that although price wars were common, prices were raised from competitive to approximately Cournot levels under favorable conditions. However, the longstanding illegality of explicit price fixing imposes serious data limitations. Not only are conspiracies difficult to identify, but even when such agreements can be documented, actions that are unobservable to competitors (such as chiseling on a price agreement) are also generally unobservable to independent outsiders.[3] Without such evidence, it is difficult to evaluate the nature and success of price-fixing agreements, and the causes of breakdowns in pricing discipline.

The laboratory provides a good platform for the study of conspiracies, since it is possible to introduce controlled opportunities for explicit collusion, holding constant other key elements of the market structure that may affect the success of a conspiracy. Much of the relevant laboratory research has focused on the effects of trading institutions on the robustness of price-fixing agreements. Isaac and Plott (1981), for example, considered conspiracies in double auctions, i.e. markets where all bids, asks, and contracts are publicly displayed on a ticker tape. This institution, which is modeled after centralized stock exchanges, is well known to be quite competitive. Isaac and Plott found that sellers invariably tried to fix prices, but that agreements were always honored in the breach, and generally competitive outcomes prevailed. Isaac, Ramey and Williams (1984) allowed conspiracies in posted-offer markets, where sellers set prices independently, and then buyers make purchases from the sellers at the posted prices on a take-it-or-leave-it basis. In contrast to sellers in the double-auctions, posted-offer sellers consistently implemented successful conspiracies.[4]

The observation of successful conspiracies in laboratory posted-offer markets is important, because this institution is a good approximation of pricing in many retail and service markets. Nevertheless, many of the posted price markets of interest to industrial organization economists differ from the standard laboratory posted-offer implementation, in that sellers can offer private

[3] For a fascinating exception, see Porter and Zona (1993), who analyze data from a bid-rigging cartel discovered through telephone wire-taps used as part of a criminal investigation.

[4] Isaac and Walker (1985) also report that conspiracies are effective in sealed-bid auctions. A sealed-bid auction may be viewed as a special case of a posted-price institution where a single seller offers a single unit to a number of bidders.

discounts from the "list" prices. Discounting opportunities of this sort are typical, for example, in producer goods markets, and in markets for big-ticket consumer items like appliances and automobiles. The effectiveness of conspiracies in such markets is particularly important for antitrust policy, since many of the celebrated price-fixing cases involve producer goods.[5]

Still other institutional factors may counter any pro-competitive effects of secret discounting. In particular, the *ex post* reporting of aggregate seller sales information, such as that often published by trade associations may facilitate collusion, even when substantial discounting opportunities are available.[6] Clearly, the publication of sales information is unlikely to directly reveal discounting: Price concessions can often be hidden in reduced delivery and service fees, and sellers who defect from an illegal agreement will, of course, not report their defections. Nevertheless, large swings in sales volume may signal aggressive discounting, and may therefore temper such behavior (Stigler, 1964).

The effects of these kinds of institutional details on the success of conspiracies are of considerable antitrust policy relevance. While there is little disagreement that illegal price fixing should be punished where it is discovered, the policy issue arises in terms of optimal resource allocation. Given scarce investigative and litigation resources, antitrust agencies must concentrate on cases that are most likely to improve market performance.

This paper reports the results of ten laboratory markets that were conducted to examine the effects of explicit conspiracies on performance in markets with posted prices. In addition to a baseline posted-offer session conducted to confirm the competitive nature of our market structure without collusion, we report nine sessions where sellers were given the opportunity to conspire before posting prices. These nine sessions are evenly divided into three treatments: The first treatment used standard posted-offer trading rules following the seller price discussions, i.e. all trades must be made at the posted prices. In the second conspiracy treatment, sellers were

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[5] For example, possibly the most well known price-fixing cases in America involved the electrical equipment industry. The conspiracies extended from the 1920's until the 1950's, and grew to encompass virtually every aspect of electrical equipment sales. For an interesting account see Carlton and Perloff (1990) p. 216-219.

[6] The link between trade associations and conspiracy has been a matter of continuing concern to antitrust authorities. For example, in their review of DOJ horizontal price-fixing cases between 1963 and 1972, Hay and Kelley (1974) found that trade associations were present in almost all cases with fifteen or more conspirators.

given an opportunity to grant secret discounts from the list price. These discounts were private in that they could not be observed by other buyers and sellers. Comparison of results in these first two treatments confirm the importance of discount opportunities: Although stable conspiracies were implemented in each of the posted-offer markets, near-competitive transactions prices were observed in each of the markets where discounting was allowed. Secret discounts were also allowed in a third treatment, but sellers were provided with *ex post* information about one another's sales quantities before price discussions for the following period. This information seemed to facilitate cooperation in some of the sessions.

The remainder of this paper is organized as follows. The experiment design and procedures are described in section 2. Market results are reported in section 3, while conclusions and suggestions for further investigation are offered in a fourth section.

2. Experiment Design and Procedures

There is general agreement among economists that successful price-fixing conspiracies are more likely with small numbers of firms and a homogeneous product.[7] Since homogeneity and small numbers are dictated by our laboratory market software, we sought a market structure that would otherwise be fairly competitive. Consider the aggregate demand and supply arrays in figure 1, where buyers' reservation values and sellers' marginal costs are measured as deviations from P_c, the highest competitive price in the range of overlapping demand and supply. This market design consists of three buyers (B1, B2, B3) and three sellers (S1, S2, S3). Each unit is labeled by the subject's ID. Buyer B1, for example, has three units with values above, equal to, and below the competitive price, respectively. These value and cost steps represent maximum and minimum unit reservation prices, since sellers earn money by selling units at prices above cost, and buyers earn money by purchasing at prices below value. In this way the specified financial incentives induce the demand and supply structure. The instructions implemented the common procedure of not telling traders one another's values and/or costs. This procedure is inappropriate for direct tests of complete information theories, but we decided to use

[7] Hay and Kelley (1974) report that most price-fixing cases investigated by the Department of Justice involved 10 or fewer firms. They also report that conspiracies were more likely with relatively homogenous products.

a very incomplete information environment since one of the major cartel problems is that of finding and agreeing on prices that are profitable and equitable.

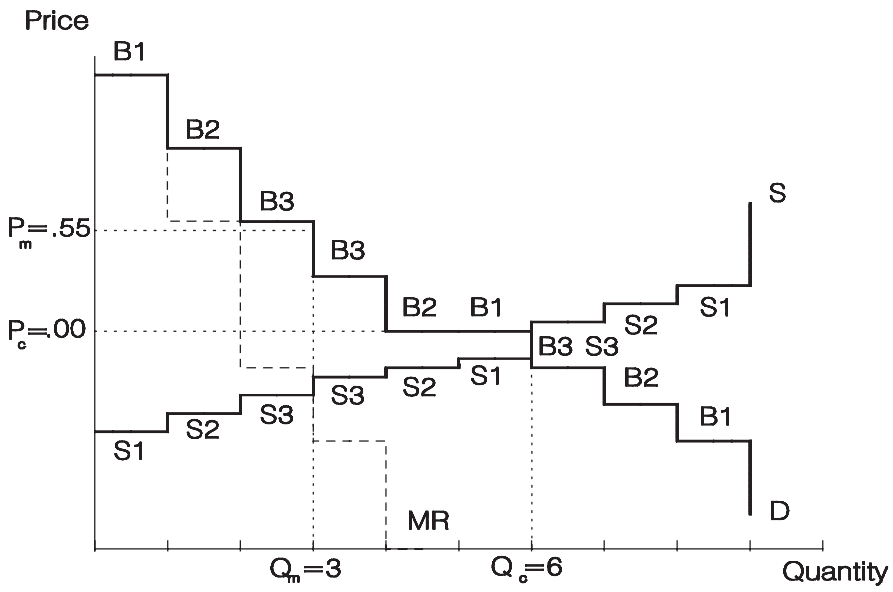

Figure 1. Supply and Demand Arrays.

Notice in figure 1 that each trader has two inframarginal units. In particular, each seller would produce 2 units in a competitive outcome, and each has a capacity to produce up to three units. The design is competitive in the sense that excess supply at prices just above the competitive level is as large as the capacity of any single seller.

Our market deviates from the typical laboratory procedure in that buyers are charged 5 cents each time they approach a seller. Shopping costs are a necessary feature of our discounting treatments, since trading time is limited in the laboratory. The 5-cent shopping fee keeps buyers' switches from causing extensive delays. Shopping costs also add an element of realism, since the process of approaching different sellers and eliciting price quotes is rarely costless. When we impose these costs in the lab, we get a more economically meaningful measure of shopping intensity than would be the case if shopping were costless. Notice that the nickel shopping cost does not alter the competitive price; all three buyers are willing to purchase two units from a seller who posts a (normalized) price of 0 since the surplus from the buyer's first unit far exceeds the shopping cost.

The dashed marginal revenue line (MR) in figure 1 intersects the industry supply function at a quantity of 3, and the joint-profit-maximizing price (P_m) is \$0.55, which is a nickel below the value step for B3 to allow for the shopping cost. A joint-profit-maximizing outcome requires each seller to produce a single (low-cost) unit, and this symmetry may facilitate stable collusion.[8] A small price cut from the monopoly level, however, will enable each seller to exhaust its capacity of 3 units. This large incentive to defect from any joint-profit-maximizing price serves to balance the design factors that may facilitate collusion: small numbers, product homogeneity, demand and supply stability, and the symmetric market shares at a joint monopoly outcome.

The effects of collusion-induced price increases can be evaluated in terms of market efficiency, which is measured by expressing the sum of buyers' and sellers' realized earnings as a percentage of the maximum possible aggregate surplus. The competitive outcome for the design in figure 1 achieves the maximum aggregate surplus of \$5.10, and the aggregate surplus in a joint-profit-maximizing outcome is \$4.20, for an efficiency of 82.4%.[9] Besides reducing efficiency, a joint monopoly outcome will increase the sellers' proportion of aggregate earnings. The most common measure of this latter tendency is the index of monopoly effectiveness, M, which is the increase in aggregate sellers' earnings over the their earnings in a competitive equilibrium, expressed as a percentage of the difference between the theoretical joint monopoly earnings and the seller earnings in a competitive equilibrium. The M value will be 100 for a perfect cartel and 0 in an efficient competitive outcome. Negative M values are also possible, and may be caused by either sub-competitive prices or inefficient production allocations.

As mentioned in the introduction, markets in the first treatment are conducted under standard posted-offer trading rules. Sellers independently post prices on a take-it-or-leave-it basis at the beginning of each market period. Then buyers are selected in a random order to shop, and the market period ends when all buyers have had a chance to make purchases. In the second, "list/discount" treatment, sellers post prices independently as before, but buyers may request

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[8] Isaac, Ramey, and Williams (1984) found that agreements were more stable if each seller was able to sell at least one unit at the selected price.

[9] In calculating the theoretical competitive and joint monopoly efficiencies, we assume that the three buyers each shop from a single seller, which reduces aggregate earnings by three times the shopping cost, i.e. by 15 cents. Shopping costs are similarly deducted from earnings when actual efficiencies are calculated for each market session.

discounts by sending a "DISCREQ" message. Sellers respond to the requests by typing in the original list price (no discount) or by typing in a lower, discount price. The number of keystrokes is the same in either case, so other buyers and sellers cannot directly observe such discounts. Moreover, all traders are visually isolated by foam board partitions that prevent them from seeing transactions prices, and prevent sellers from seeing sales quantities.[10] Thus, the discounts are made secretly and selectively (to some buyers but not necessarily to others). This secrecy is diminished in the third treatment, which is conducted exactly as the second, except that individual sales quantities are announced to the sellers at the end of each period, prior to their price discussions for the following period.

The major procedural problem with introducing a secret seller conspiracy was getting buyers out of the laboratory at the end of each period without arousing their suspicions. This was handled by taking the buyers to another room where they were randomly reassigned their roles as B1, B2 or B3 for each period. This random assignment was done by drawing colored marbles from a cup. When buyers returned to the laboratory several minutes later, they were seated at the computer that corresponded to their role for the next period.[11] The rotation had the additional advantage of equalizing buyer earnings, since B3 earns nothing at the joint-profit-maximizing price.[12]

After buyers left the room, sellers were read a message that allowed conspiracy, but barred physical threats, any post-session side payments, and the discussion of nonpublic information such as unit costs, sales quantities (if these were not announced), or discounts (if

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[10] To avoid paying unnecessary shopping costs, an "OUT OF STOCK" message appears below a seller's identifier on the buyers' screens when a seller has no remaining units in a period. This information is not provided to sellers.

[11] The rotation process took several minutes each period. In addition to drawing marbles, a monitor also had to verify earnings calculations, since the random role assignment procedure required that the buyers maintain their earnings records on paper.

[12] Actually, our software could have done the unit valuation rotations automatically, but the subjects had no way of knowing this. Buyers never seemed to realize the real reason for their trips to the other room. In fact when we asked one of the buyers afterwards whether there were any unusual or biased aspects to the procedures, he suggested that we rewrite the trading program to eliminate the necessity of trips to the other room.

permitted).[13] The restriction on physical threats and subsequent division is standard for this type of experiment.[14] The restriction on discussion of private information was intended to protect subjects from the stress of having to misrepresent their actions in the event they chose to defect from an agreement. During the discussion period, sellers slid their chairs back about 3 feet so that they could see each other, but the sides of the foam board dividers continued to obscure the individual sellers' computer monitors. The discussions varied considerably from one cohort of sellers to another, but they clearly understood the instruction as permitting collusive price fixing. One seller, for example, jokingly remarked that "We could go to jail for this." Discussions lasted until one of the experimenters signalled the return of the buyers, or about 3 minutes. The sellers then returned to their visually isolated computer screens to enter price and maximum quantity decisions for the period. Requiring that decisions be made in private adds an important element of realism, i.e. the temptation that arises once sellers leave the "smoky hotel room."

All markets consisted of 15 trading periods. The final period was not announced, and if asked, we did not tell participants the terminal period. Record sheets for buyers had plenty of room for extra information, and we always stopped well before the time period for which participants were recruited.

Procedures were standard in other respects. Each market session involved six subjects who were recruited from undergraduate classes at the University of Virginia. All subjects were experienced in the sense that they had participated in a previous posted-price session, with and without discounting, but with a different market supply and demand structure. Also, none of the

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[13] The message read: "While waiting for the buyers to return, we give you the opportunity to talk among yourselves about the market. You are free to discuss all aspects of the market, with three exceptions: (a) you may not discuss side payments or make physical threats, (b) you may not discuss quantitative information about your costs, or the maximum number of units you have available, and (c) you may not discuss any actions you took in the previous periods that was not directly observable by the other sellers. (Pricing decisions, you will recall, are public information. On the other hand, quantity postings, actual sales quantity and discounts, if any, are private). You may discuss any other aspect of the market. In particular, you may discuss what you think is appropriate action for the next period, but you may not discuss what you did for the previous period. After receiving the signal that the buyers are returning, please maintain strict silence. Also, if the sellers return to terminals to make price/quantity decisions, they may no longer communicate, even if the buyers have not returned."

[14] This restriction was used in all of the laboratory studies cited in the introduction. Physical punishments and post-session earnings divisions are neither observable nor enforceable, and would thus generate a substantial loss in experimental control. With the restriction, the conspiracy procedure implements a situation where cartel-members avoid explicit payments in order to reduce the chances of detection.

participants had participated in a previous conspiracy session. Subjects were paid $9.00 plus earnings, which averaged a little over $20 for a two-hour session. Finally, except for the manual recording of buyers' earnings, both the instructions and experimental environment were fully automated.[15]

3. Results

Outcomes are reviewed by treatment, starting with the three posted-offer conspiracies, CPO1-CPO3. Results of this first treatment are evaluated in light of a baseline session NPO, which was conducted under conditions identical to the other posted-offer sessions, except that conspiratorial opportunities were absent.[16] Results of the two list-discount treatments are considered subsequently, starting with the three sessions with collusion but no sales quantity reports, CD1-CD3, and concluding with the three list-discount conspiracies with sales quantity reports, CDQ1-CDQ3.

Posted Offer Conspiracies

The mean transactions price paths for the each of the posted offer sessions are shown as the thin lines in figure 2. For reference, dotted lines in the figure indicate the monopoly price P_m and the highest competitive price P_c. The posted-offer conspirators clearly maintained near-monopoly prices despite the strong individual incentives to chisel on prices high above marginal costs. Moreover, each of the three price sequences is quite distinct from the bolded average price path for the baseline session, NPO.

As suggested by the convergence of the control session to the competitive price prediction, the market was extremely efficient. Summary performance measures for the final five periods of this session (NPO) are listed just below the competitive predictions at the top of table

[15] The instructions for the posted-offer version are in Davis and Holt (1993, Appendix A4.2). The software that presents these instructions and controls market trading was written by Davis.

[16] In particular, the session consisted of 6 experienced participants. Also, buyers were charged 5 cents each time they approached a different seller, and they were taken from the room after each period.

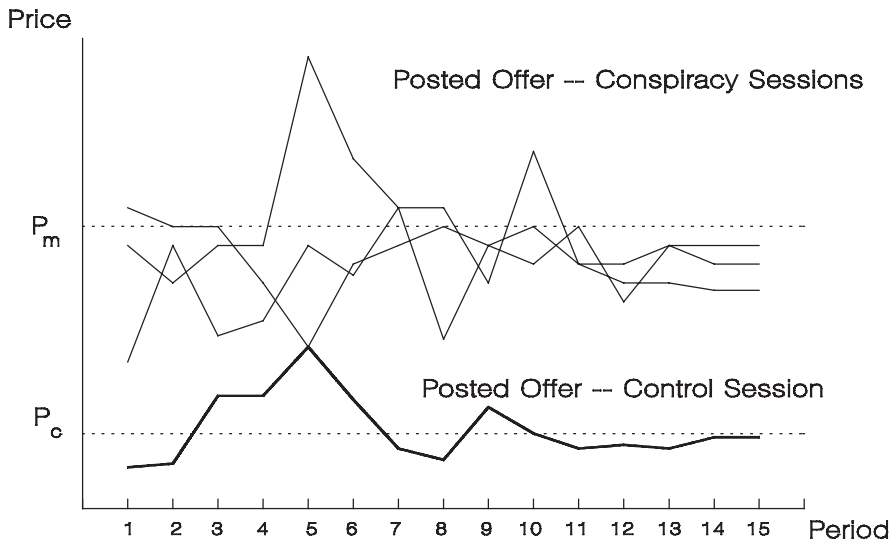

Figure 2. Mean Contract Prices: Posted Offer Sessions.

1.[17] Average transactions prices were 3 cents below the highest competitive price, and 98% of the possible gains from trade were extracted. The large negative monopoly effectiveness measure (-24) was a consequence of the below-competitive prices and inefficient allocations arising from the failure of seller S3 to sell a 2nd unit in two of the last five periods. Taken alone, the competitiveness of this session is only suggestive. However, it is very similar to results for a host of posted-offer markets conducted under very similar conditions.[18]

Viewed in light of this outcome, the uniform success of the posted-offer conspirators is remarkable. The implementation and maintenance of a conspiracy is not a trivial matter, particularly since sellers could not discuss the numbers of units sold in previous periods. Thus, sellers had to solve the problem of finding the optimal (or at least an acceptable) price in the absence of accurate information regarding aggregate demand. Moreover, the lack of quantity information created cartel maintenance problems, since each seller could unilaterally exhaust demand at any common price more than 30 cents above P_c. Absent some more or less

[17] As a crude means of controlling for the effects of price searching and convergence, we restrict our attention to data from the last 5 periods in tables 1 and 2. Inclusion of data from all periods in these tables generates qualitatively identical, but quantitatively smaller treatment differences.

[18] See, for example, Isaac, Ramey and Williams (1984) and Ketcham, Smith and Williams (1984).

Table 1. Mean Performance Measures, Last Five Periods of Posted-Offer Sessions.

(1) Session	(2) Price Deviation $P - P_c$	(3) Efficiency E	(4) Monopoly Effectiveness M	(5) Shopping Expenses
competitive	0	100	0	15
NPO	-3	98	-24	15
CPO1	48	69	16	15
CPO2	46	82	71	15
CPO3	40	80	44	15
monopoly	55	82.4	100	15

observable capacity allocation scheme, one or two sellers could be excluded from the market each period. This potential imbalance is compounded by a slight tendency for buyers to choose S1 when prices are identical.[19] This lever bias is like a slight locational advantage, such as a leading telephone listing.

Sellers addressed these allocation problems in different ways, and for this reason, it is instructive to consider a more detailed history of contracts for some selected markets. Consider the price sequence for session CPO1 in figure 3. Data for the 15 trading periods are separated by vertical bars. Within periods, price postings for sellers 1, 2 and 3 are represented, in respective order, by crosses (+). Contracts for single units are denoted by small dots (▪); multiple units sold at the same price show as an overlap of dots to the right of the price postings. Thus, for example, period 1 of session CPO1 is illustrated between the left-most pair of vertical

[19] If buyers showed no "lever bias" for low numbers and approached the sellers in random order, the sellers might find a simple agreement to post the monopoly price acceptable. Even though a given seller could be left out of the market in any single period, over the course of the session, earnings should be roughly equal, on average.

bars in figure 3. In this period, sellers S1 and S2 posted relatively high prices. Seller S3 subsequently sold all three of his available units, S2 sold a single unit, and S1 sold nothing.

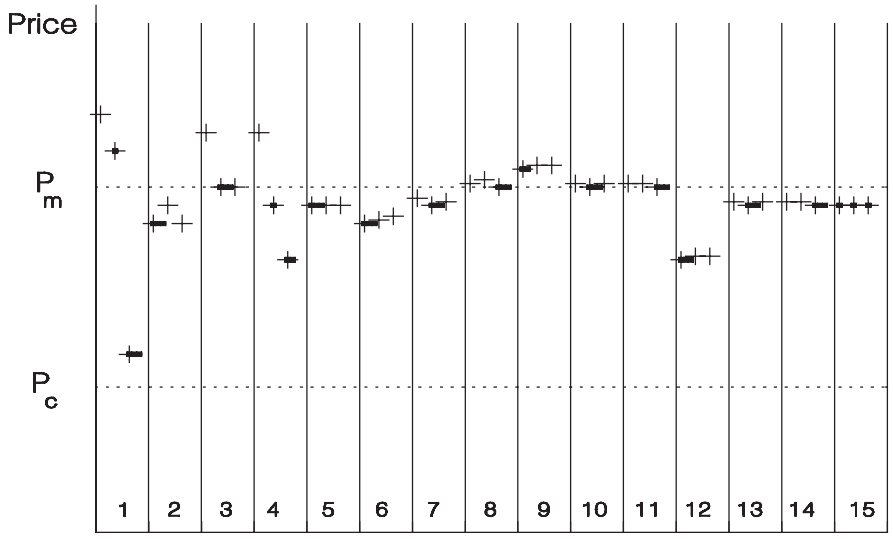

Figure 3. Price Sequence for Session CPO1. (Key: + price postings, ▪ contracts).

The sellers in session CPO1 adopted a price-rotation scheme. Starting in period 6, S1 offered the lowest price, with S2 and S3 posting prices one or two cents higher, as can be seen from the staggered position of the three "+" marks in the period 6 slot of figure 3. The low-price role was then passed to seller 2 in period 7, and to seller 3 in period 8. Sellers completed two more rotations in periods 9 through 14. The rotation is analogous to the celebrated "phases of the moon" bid rotation of the electrical equipment conspiracy. Rotation of the low price produces a stable, monitorable conspiracy, which allowed considerable freedom for price experimentation. Sellers tried gradually higher prices in periods 7, 8 and 9, and settled on the monopoly price in period 10. Except for a single attempt to examine the elasticity of demand period 12, prices remained near the monopoly level for the remainder of the session.[20]

Despite the ease of monitoring a price rotation scheme, it is extremely inefficient, since a single seller serves the entire market, as indicated by the row of contract dots on the cross for

[20] The sellers terminated the quantity rotation agreement in period 15, perhaps fearing that the session would soon end. They then agreed on a more efficient, but much less monitorable scheme of posting a common price, with quantity restricted to a single unit.

the lowest price in each period 6-14. With production concentrated in this way, two of the three lowest-cost units on the aggregate supply schedule remain untraded, and one high-cost extra-marginal unit is exchanged instead. For this reason, both aggregate efficiency and sellers' earnings remain quite low relative to those for an efficient monopolist, despite mean transactions prices very close to P_m. This point is made clear by comparing the monopoly predictions in the bottom row of table 1 with the summary measures for the last 5 trading periods of CPO1. The 48 cent average deviation from the competitive price in CPO1 is quite close to the 55 cent monopoly deviation. Nevertheless, only 69% of the maximum possible gains from trade were extracted in the last 5 periods of this session, compared with 82.4% that would be extracted by an efficient monopolist. The low monopoly-effectiveness measure in column 4 indicates that much of the efficiency loss was borne by the sellers, who obtained only 16% of the difference between the earnings of an efficient monopolist and the seller earnings at a competitive outcome.

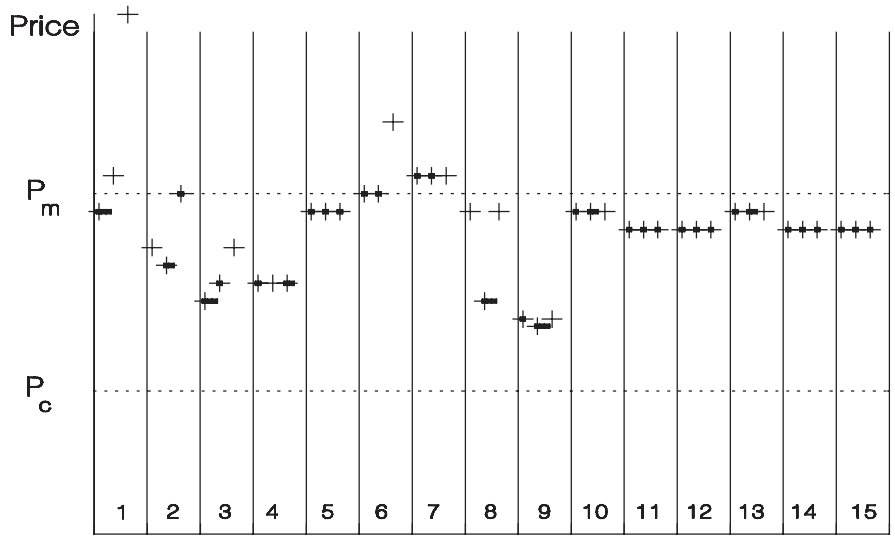

Figure 4. Price Sequence for Session CPO2. (Key: + price postings, ▪ contracts).

In sessions CPO2 and CPO3, sellers eventually adopted a quantity restriction scheme, which increased both efficiency and the problems of defection. Consider, for example, session CPO2, summarized in figure 4. After considerable discussion over several periods, the sellers agreed to restrict quantity offerings to a single unit in period 10, and to post a common price 5 cents below P_m. Sellers felt compelled to lower prices slightly in period 11 at the request of

seller 3, who was "unhappy" with the period 10 price (because seller 2 defected from the quantity-restriction arrangement). Seller 2 was savvy enough to realize that his defections changed the other sellers' perceptions of the aggregate demand curve. Thus, he cooperated in periods 11, 12, 14 and 15, when the price was maintained at 10 cents below P_m, but he again defected on the quantity division in period 13, when the sellers made a final attempt at a price increase.

Conspiracies and Private Discounts

In stark contrast to the stable conspiracies observed in the posted-offer sessions, the additional uncertainty created by allowing secret discounts generated dramatically lower

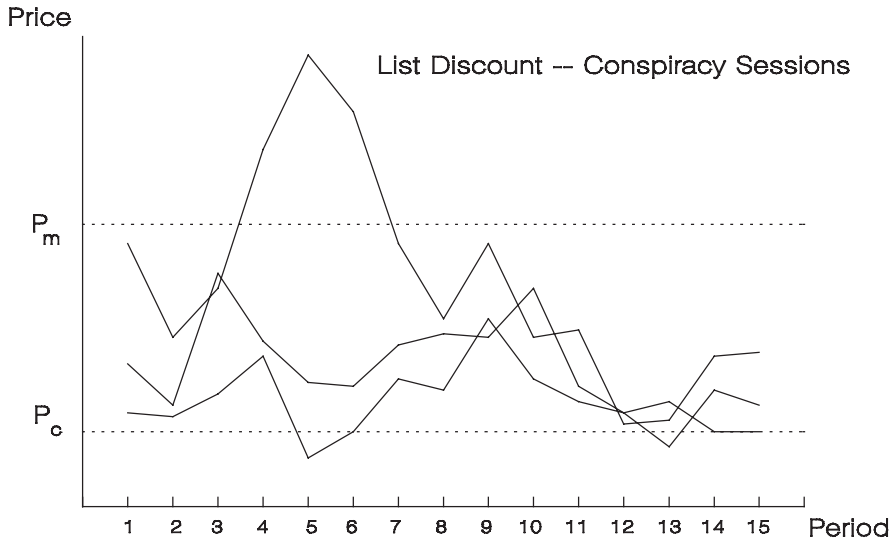

Figure 5. Mean Transactions Prices: CD Sessions.

prices, as is evident from the mean transactions price series in figure 5. Despite a wide diversity of mean prices in early periods, the cartels failed in each case, and prices collapsed toward the competitive level, as indicated by the cluster of lines close to the dotted P_c line on the right side of figure 5.

Some insight into the increased complexity of the cartel problem can be gained by inspecting market histories in more detail. Consider, for example, the sequence of contracts for session CD1, illustrated in figure 6. This figure is formatted as figures 3 and 4, but unlike these earlier contract histories, discounts cause the transactions price dots to stagger below posted price

crosses. Sellers quickly reached an agreement to post common list prices starting in period 3. Persistent discounting by all sellers created a lot of frustration, and seller S2 became angry and refused to continue discussions in periods 9-14. This resulted in a general decline in posted prices, along with nearly competitive transactions prices in later periods. Even the agreement to set a common list price in period 15 did not raise transactions prices appreciably. A similar competitive pattern was observed in session CD2, where the average transactions price was just 4 cents above P_c in the final 5 periods.[21]

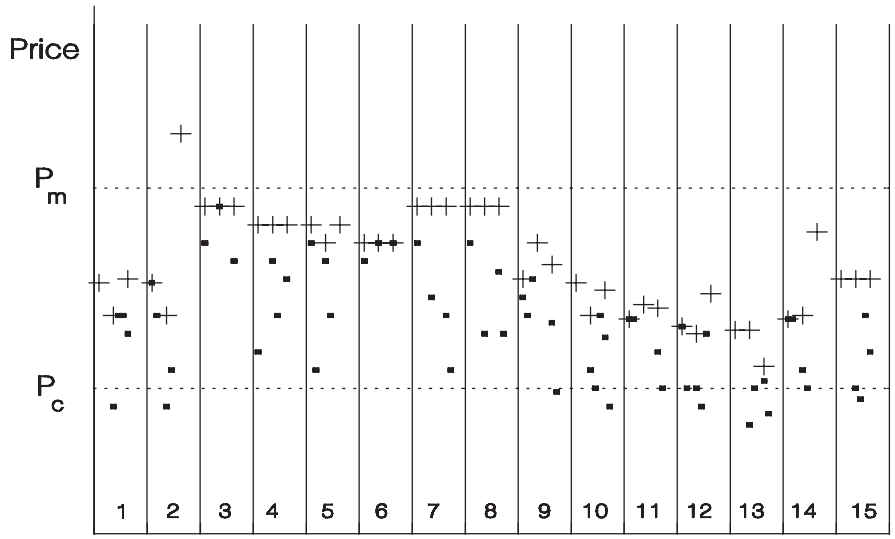

Figure 6. Price Sequence for Session CD1. (Key: + price postings, ▪ contracts).

Perhaps the most striking discounting occurs in CD3, shown in figure 7. This market generated high, stable and uniform list prices nearly a dollar above the competitive level throughout the session (and 50 cents above P_m). Despite the absence of any sales at the posted price after period 4, sellers felt justified in maintaining their extraordinarily high list prices on the grounds that the buyers were under-revealing, and that all would be lost if they weakened before the buyers.

[21] But notice that even with discounting these conspiracies are not innocuous from the buyer's perspective. Prior to the price collapse there is a sizable transfer of resources from buyers to sellers.

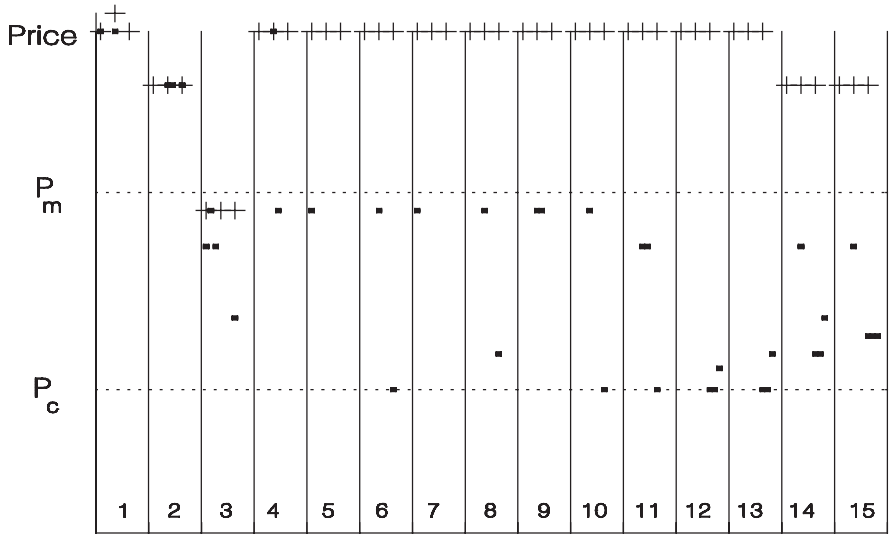

Figure 7. Price Sequence for Session CD3. (Key: + price postings, ▪ contracts).

The pattern of the discounted transactions prices, however, casts the sellers' representations of patient diligence in a somewhat different light. Although the sellers had initially agreed to offer no discounts from the common list price in period 2, the temptation was overwhelming. Sellers confronted this problem by agreeing to grant discounts to a price 5 cents below P_m in period 5. The consensus discount price was lowered by 10 cents in period 11, and the common list price was lowered by 20 cents in period 14. Although sellers 1 and 2 complied fully all aspects of the agreement, seller 3 complied only with the observable aspects, and offered deep discounts whenever selected.

Initially, seller S3's defections generated only occasional low contract prices, e.g., in periods 6 and 8. Buyers, discouraged by the extremely high list prices and generally poor discounts, were reluctant to pay even a nickel to approach a seller and request a discount in the middle periods, and for this reason it took them several periods to discover seller 3's attractive terms. But this deviant eventually dominated the market, servicing all buyers in periods 12 and 13, and selling 3 of the 4 units in the final two periods.[22] Notably, seller 3 offered

[22] The effect of seller S3's discounts is consistent with Adam Smith's (1776, p. 144) observation that "...In a free trade an effectual combination cannot be established but by the unanimous consent of every single trader, and it cannot last longer than every single trader continues of the same mind."

progressively less generous terms in the final periods, as he came to realize that the others were not granting such generous discounts.

The powerful effects of discounting opportunities are apparent from a comparison of mean performance measures for the list-discount conspiracy sessions, shown in the top-half of table 2, with comparable data for the posted-offer conspiracies in table 1. Over the last 5 periods, the mean deviation from P_c in each of the posted-offer markets is at least 25 cents larger than in CD3, the least competitive of the sessions with discounting. This minimum difference is large, nearly half of the 55 cent distance between P_m and P_c. Despite the limited number of observations, these differences allow rejection of the null hypothesis of no treatment effect at a 95% confidence level, using a nonparametric Mann-Whitney test.[23] In addition, comparison of monopoly effectiveness measures across treatments (in column 4 of each table) indicates that sellers in each posted-offer market earned more than the maximum earnings available in the competitive outcome, while the sellers in each market with discounting earned substantially less. Again, the null hypothesis of no difference (in average earnings) can be rejected at a 95% level using a Mann-Whitney test.

In contrast, the effects of the discounting treatment on aggregate efficiency are less clear. Although prices are lower with discounting and a much greater share of the surplus goes to buyers, overall efficiency increases only modestly over the posted-offer sessions. In fact, efficiency never approaches the competitive level and is even below the rate predicted for monopoly in one of the three sessions with discounting. Part of the efficiency loss in these sessions is accounted for by higher shopping expenses, as summarized in column 5 of the respective tables. Shopping costs, however, are not the whole story; efficiency losses are also generated by foregone sales of infra-marginal units, and by the tendency for high-cost units sold at discount to crowd out low-cost units of more cooperative rivals. In fact, the direct relationship between mean shopping expenses (column 5) and efficiency (column 3) suggests that shopping

[23] The intuition behind these results is immediate. There are $\binom{6}{3}=20$ possible ways that average prices for the 3 posted-offer and the 3 list-discount sessions could be ranked. Since the top three ranks are for the posted- offer sessions, the most extreme of these 20 outcomes was observed. Under the null hypothesis that discounting does not affect transactions prices, this would occur with probability 1/20 = .05.

Table 2. Mean Performance Measures, Last Five Periods of List/Discount Sessions.

(1) Session	(2) Price Deviation $P - P_c$	(3) Efficiency E	(4) Monopoly Effectiveness M	(5) Shopping Expenses
competitive	0	100	0	15
CD1	6	83	-48	26
CD2	4	86	-38	32
CD3	15	74	-58	18
CDQ1	38	85	70	20
CDQ2	41	77	34	17
CDQ3	7	81	-39	20
monopoly	55	82.4	100	15

tends to be socially beneficial in the CD sessions: The discounts elicited through more aggressive shopping appear to induce the sale of inframarginal units.[24]

Secret Discount and Public Sales Information

The immediate implication of the above results is that concerns regarding the profitability of price-fixing conspiracies in retail-type markets are attenuated to the extent that private discounts are possible. This conclusion is qualified by results of three sessions in a final treatment, where the secrecy of discounts is partially eliminated. Conditions for these sessions were identical to those in the list discount/conspiracy treatment, except that the numbers of units sold by each seller in the previous period were announced at the beginning of each seller discussion. These public announcements were intended to parallel the sales information that is often collected and disseminated by trade associations. The mean transactions price paths for

[24] The inverse relation between shopping expenses and price deviations in the CD sessions is also suggestive.

these CDQ sessions in figure 8 show that *ex post* quantity reports can facilitate collusion; near monopoly prices were observed in 2 of the 3 markets.

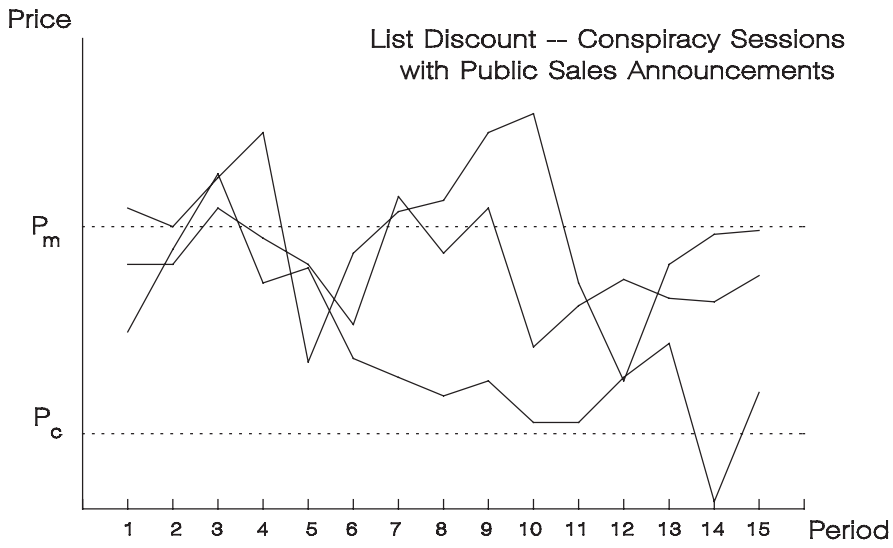

Figure 8. Mean Contract Prices: CDQ Sessions.

Given public quantity announcements, an efficient and fully monitorable conspiracy could be effected in the absence of transactions price data, if all sellers simply agreed to each offer a single unit at a common list price at or above the monopoly level. Since each seller is certain to sell a single unit in this scheme, nobody has an incentive to discount below P_m. Rather surprisingly (at least to us), none of the conspirators ever attempted a quantity-restriction scheme. Instead, they followed a series of much less monitorable price-discrimination schemes, and used the sales information as a rough measure of equity.

In session CDQ1, illustrated in figure 9, it became clear to the sellers by period 7 that each buyer could pay more for a first unit than for a second. Thus they agreed to post a common list price 45 cents above P_m, but to offer a discount of 10 cents on the first unit purchased by a single buyer, and 40 cents on the second. As is clear from the contract dots in the period 7 slot of the figure, both seller 1 and 2 defected from the discount agreement.

The common list price was lowered successively in periods 8, 10 and 11, along with adjustments in the two-part discount structure. As suggested by the more or less parallel transactions price-dot series, conspirators complied more closely with the agreed-upon discount

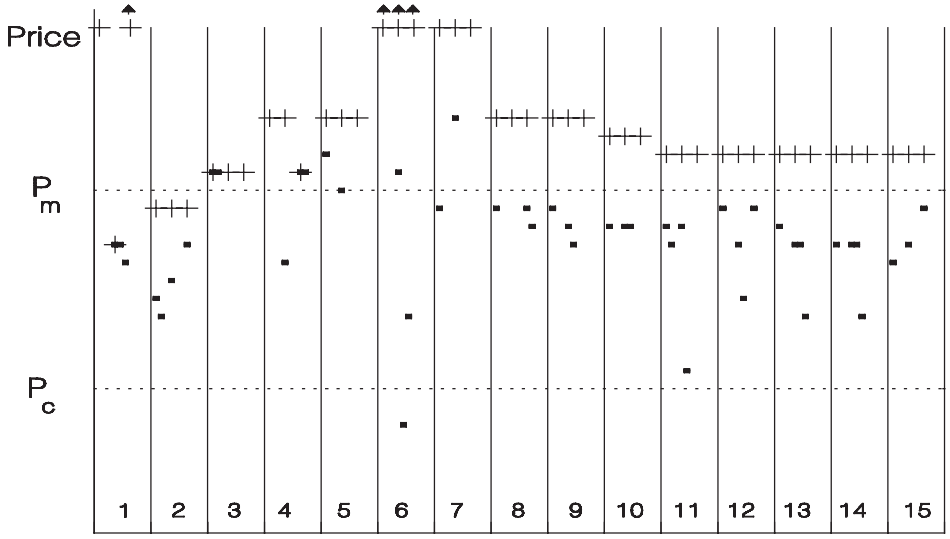

Figure 9. Price Sequence for Session CDQ1. (Key: + price postings, ▪ contracts).

structure in these subsequent periods. Deviations, however, were common, and there was at least one defection in periods 9, 11, 12, 13, 14 and 15. Nevertheless, the public sales announcements kept transactions prices from deteriorating altogether, since no seller felt comfortable selling more than two units in a period. Sellers in session CDQ2 used a simpler single-tiered discount arrangement and enjoyed even more success in maintaining high transactions prices than did the sellers in CDQ1.

Nevertheless, such collusion-with-discounting schemes can go awry, even with *ex post* sales information. This is evidenced by the sequence of contracts for session CDQ3 in figure 10. In this session the sellers managed to effect a common list price above P_m after period 7. Throughout the session, however, they agreed to offer discounts of unspecified magnitude. Seller 1, however, began making very generous discounts to ensure the sale of her first unit starting in period 6, and quickly developed a reputation among the buyers as a deep discounter, often selling three units. As a consequence, one of the other sellers was frequently not even approached by buyers in a period.

After seller 3 was left out of the market in periods 10 and 11, seller 1 started encouraging her compatriot to follow her strategy of giving a large discount to ensure the sale of a first unit. Also, to attract an initial sale, seller 3 was allowed by the others to post a lower list price in

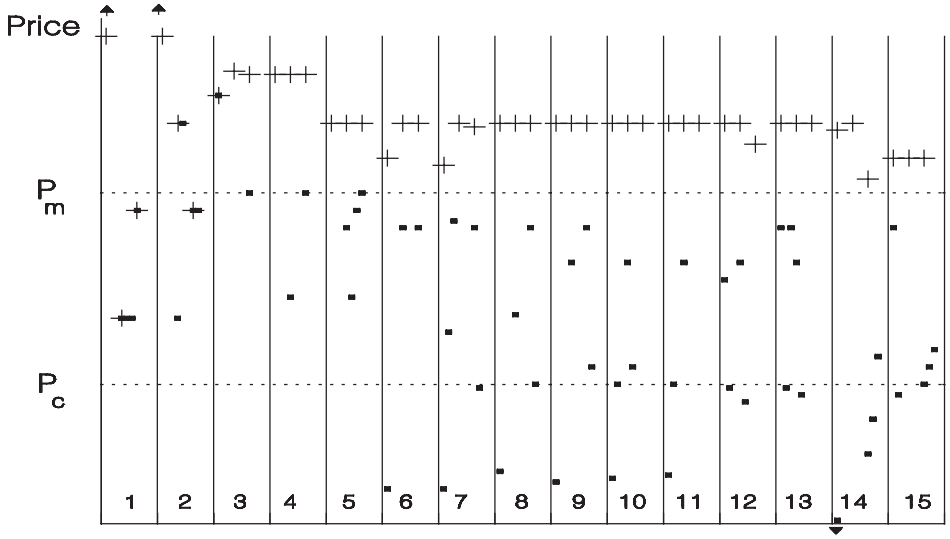

Figure 10. Price Sequence for Session CDQ3. (Key: + price postings, ▪ contracts).

period 12. This strategy failed, and seller 3 was again left out of the market in period 13. Seller 3, however, did manage to attract buyers when the others agreed to allow her to post a sub-cartel list price a second time, in period 14. Seller 3 responded by offering deep discounts. The consequent collapse of transactions prices was exacerbated by seller 1, who, out of apparent concern for about losing her reputation as a low price seller, not only shaded on the cartel list price but also sold her low-cost unit at only 5 cents above cost.

Transactions prices recovered to slightly above the competitive price in the final period of the session. Nevertheless, the summary measures at the bottom of table 2 indicate that session CDQ3 was far different from sessions CDQ1 and CDQ2, for which mean price deviations (38 and 41 cents) and M values (70 and 34) are very similar to comparable measures in the posted-offer conspiracies. The 7 cent price deviation and the M value of -39 for session CDQ3 are much more akin to the list-discount conspiracies summarized at the top of table 2.

4. Conclusions

When prices are posted on a take-it-or-leave it basis, financially motivated subjects who collude are able to discover and agree on a joint-profit-maximizing price, despite cost asymmetries and incomplete information about demand and supply conditions. The possibility

of secret discounts, however, creates monitoring and enforcement problems that can cause transactions prices to collapse to near-competitive levels.[25] The importance of secrecy is indicated by the substantial recovery of price-fixing arrangements when discounting is permitted but each seller's aggregate sales quantity is later revealed in a trade association report.[26] The reports used in the experiments were *ex post* and did not identify specific buyers and terms. Such reports would probably pass a rule-of-reason test for legality, in the absence of other factors like prior price-fixing convictions. The implication is that antitrust hostility to agreements to limit or coordinate discounts is well founded, and that trade association activities should receive careful scrutiny in markets where collusion is suspected.

The laboratory results strike ringing parallels with anecdotal evidence from antitrust cases. For example, a decline in market share will often cause a subject to defect from the cartel agreement, and the prevalence of secret price concessions generally causes subjects to reduce list prices. Even the widely discussed electrical equipment conspiracy was subject to frequent chiseling and price wars.[27] In fact, defection on these explicit arrangements was so pervasive that turbogenerator manufacturers were probably more successful at raising prices after the conspiracy ended, using various implicit tactics to coordinate price movements and limit discounts (Lean, Ogur, and Rogers, 1985).

In general, the subjects proposed and defected from agreements in a fairly resourceful manner. Given this resourcefulness and the severe limits that the software imposes on buyer/seller communications, the complete inability of sellers to implement an effective conspiracy is highly suggestive. This result is qualified, however, by the ability of some cartels to use public sales quantity reports to maintain price discipline, even in the presence of incentives

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[25] But we do not wish to conclude that secret discounts are sufficient to disrupt an explicit conspiracy. In some circumstances workable agreements may persist despite imperfect monitoring. In a duopoly, for example, the monitoring problem is reduced to one of determining whether defection occurred, since it always is obvious *who* defected.

[26] Clauser and Plott (1991) conclude that the continuous temptation to defect is the primary reason that conspiracies fail in double-auction markets that correspond to financial exchanges. Results of our CD sessions may be interpreted as extending this conclusion to a retail-type context with posted prices. However, results of the CDQ sessions suggest that the secrecy of opportunities to defect is also important in the posted-price context.

[27] "The Incredible Electrical Conspiracy," *Fortune*, April 1961.

to discount. The lesson from this research, then, is twofold: First, explicit conspiracies can generate sizable price effects in markets that parallel many important features commonly found in natural markets. Second, the success of these conspiracies may be sensitive to relatively subtle institutional alterations, such as the opportunity to offer discounts, or the dissemination of sales information. The anti-competitive effects of other institutional arrangements, such as the revelation of transactions prices via meet-or-release clauses or reductions in cost heterogeneity via standardized freight pricing, remain topics for future research.[28]

In closing, we wish to stress the usefulness of experimentation in the study of illegal activities like price-fixing. Econometric evaluation of market pricing behavior with naturally occurring data is often a challenge, but special problems of observability arise when the behavior under investigation is illegal. Sometimes it is possible to infer when an agreement was in effect and who defected (e.g., Porter, 1983), and comparison of experimental and econometric results could be beneficial. For example, Porter and Zona (1993) suggest that collusion in sealed-bid auctions can be detected by a low correlation between costs and losing bids. In the laboratory, it is not necessary to infer who is involved in bid rigging on a particular contract, and the effect of collusion on bid/cost correlations could be independently verified.

[28] Grether and Plott (1984) consider the effects of meet-or-release and other contractual provisions in the context of experiments with no opportunities for seller collusion. This paper was motivated by an FTC case, *In the Matter of Ethyl Corp.*, in which price fixing was suspected but not litigated.

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Appendix: Special Instructions for Buyers

In this experiment, we will randomly assign buyer identities and valuations. At the beginning of the experiment, buyers drew a permanent assignment letter A, B or C. Period identities for each buyer (B1, B2 or B3) will be determined prior to the start of each period. Moreover, since buyers will be seated at a different terminal each period, it is necessary for buyers to maintain an earnings record on paper.

1) Role Assignments.

Prior to the start of each period, buyers A, B and C will taken to a different room, and will be assigned the role of B1, B2 or B3 by drawing numbered balls from an urn.

2) Earnings Calculations

Earnings information will be recorded on the buyer decision sheets that appear in each buyer's folder. These sheets are formatted in a manner similar to your screen displays, with information for each trading period separated by double-lines into period decision blocks.

Buyer earnings records will be maintained as follows. Prior to each period, the buyers will enter the period number, along with his or her role assignment (B1, B2 or B3) under column 1 of the decision block for the period. A monitor will then check these entries, the buyers will replace the decision sheet in their folders, and return to the laboratory.

In the laboratory, buyers should copy unit values in column (3). After trading, buyers should also record transactions price and earnings information for all contracts completed in the period in columns (4) and (5). Each buyer should also record gross earnings, total shopping expenses and net earnings in the dotted matrix at the bottom of the decision block.

At the end of the period, buyers will once again leave the room and calculate cumulative earnings for the session. The monitor will verify the calculations, prior to determining role assignments for the subsequent period.