Supra-competitive Prices and Market Power in Posted-Offer Experiments

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Abstract

This paper reports the results of a posted-offer market experiment designed to examine the effects of static market power on prices, when other factors such as excess supply, the number of sellers, and dynamic incentives are held constant. Static market power results in a dramatic price increase in posted-offer triopolies with complete demand information. In duopolies, the effects of market power are not as obvious. Explanations for this difference are discussed.
I. Introduction

Despite a marked tendency for laboratory markets to converge to competitive price predictions, laboratory sellers are sometimes able to maintain prices above competitive levels.1 A variety of factors have been associated with supra-competitive prices in laboratory markets. Plott and Smith (1978) showed that the rules of the market institution are important: prices are higher when sellers choose prices simultaneously in a posted-offer (PO) auction than when buyers and sellers make bids and offers sequentially in an oral double auction (ODA). Smith (1965) attributed price deviations (in an ODA) during an adjustment phase to a relatively low excess supply at supra-competitive prices.2 Dolbear et al. (1968), Isaac and Reynolds (2001), Wellford (1990), Huck, Normann and Oechssler (2000b), and others report that a decrease in the number of sellers tends to increase price levels in several distinct trading institutions. Information conditions also appear to affect pricing. Dolbear et al. (1968) find that prices are more likely to exceed noncooperative levels when sellers are given complete cost and demand information, as compared with the case in which they must learn about market demand and supply conditions through experience. Huck, Normann and Oechssler (2000a) find more competitive pricing when sellers are given information about the strategic decisions of others and the profit consequences of these decisions.

From an antitrust perspective, the traditional approach to assessing the likelihood of supra-competitive prices is to calculate measures of concentration, and then to consider factors that

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1 See the survey in Holt (1995).

2 Davis and Williams (1991) similarly attribute supra-competitive prices in posted-offer experiments to insufficient excess supply at the competitive price.
‘facilitate’ collusion.³ Alternatively, antitrust analysis might proceed by evaluating changes in concentration and the effects of various ‘facilitating factors’ in the context of the incentive structure of the underlying market game.⁴ In particular, the concept of market power is a useful way to organize the effects of qualitatively different characteristics. Market power is generated when alteration of a particular structural or institutional condition provides an incentive for one or more firms to raise price above a common, competitive price level.⁵

The purpose of this paper is to provide a behavioral analysis of the relationship between pricing behavior and differing notions of market power, ceterus paribus. To do this, we conduct an experiment that consists of a parallel series of markets, with and without static market power, where the trading institution, excess supply, information conditions, the number of sellers, and dynamic market power incentives are held constant. We view this project as an important first step in evaluating a more fully analytical approach to assessing market power. Evaluating market power independent of changes in underlying conditions is important because alterations in underlying conditions can affect both the existence and recognition of both static and dynamic market power.⁶

³ This approach, attributable to Posner (1976) was a mainstay of the 1982 Horizontal Merger Guidelines issued by the Department of Justice (‘Guidelines’).

⁴ Later versions of the Guidelines issued 1992 and 1997, particularly the “Unilateral Effects” section, are more consistent with this approach.

⁵ A test for market power in this sense is based on the analysis of the profitability of a unilateral price increase from an initial position. This notion of market power is basically motivated by the test for market power identified in the Guidelines. A firm (or group of firms) are said to have market power if a small but significant price increase would be profitable.

⁶ As a general matter, market power may change with alterations in each of the factors mentioned above as being associated with supra-competitive pricing in laboratory markets. For example, while a horizontal merger certainly reduces the number of sellers in a market, it may simultaneously create incentives to raise prices above competitive
Notably, our primary focus is on static market power. This power can be inferred when one or more sellers can increase *current* profit with a unilateral price increase above a common competitive level. Static notions of market power, however, are not obviously the most important, because both naturally occurring markets and laboratory market games involve multiple market periods. In repeated games, relatively unprofitably noncooperative equilibria with low stage-game payoffs can serve as punishments that support high levels of collusion in "trigger-price" equilibria.\(^7\)

Indeed, the absence of static power may actually *increase* market power in a dynamic sense. This is because static market power typically raises noncooperative stage-game profits, thus damping incentives to cooperate: The harsh penalty of competitive pricing may more effectively enforce collusive outcomes than noncooperative outcomes involving supra-competitive prices. If this observation is valid, the antitrust implications are striking; markets that appear to be highly competitive, e.g. markets with large excess capacity, many sellers, etc., may in fact generate the least competitive price outcomes. With sufficiently low discount rates, dynamic market power is pervasive, and this motivated our decision to run parallel series of market, with and without static market power, but always with enough dynamic power to support perfect collusion in a trigger-

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\(^7\) These equilibria are analyzed in Friedman (1971) and Green and Porter (1984), for example.
price equilibrium.

Sections II and III contain discussions of the experimental design and procedures respectively. The price data is analyzed in section IV. The results indicate that static market power has a clear, even dramatic effect in triopoly markets, but the effect in duopoly markets is less clear. The final section contains a discussion of some possible explanations.

II. Separating Market Power Predictions

Figure 1 presents the four market structures used here. The market demand and supply functions in the four panels of this figure are determined by buyers’ values and sellers’ costs in the usual manner (e.g., Davis and Holt, 1993). All values and costs are measured in pennies as deviations from the competitive price, which is normalized to zero. Markets are conducted as posted-offer auctions, where sellers first choose prices and maximum quantity amounts simultaneously, and then buyers purchase at the posted prices. In the analysis that follows, buyers are presumed to be passive price-takers who purchase all earnings-enhancing units at the best available prices, and who divide their purchases equally between sellers with equally low prices.

Consider first the 2-seller design with no market power, labeled 2SNP in the upper left-hand part of Figure 1. Sellers’ units are indicated on the market supply curve by seller designations, S1 and S2, for sellers 1 and 2 respectively. Each seller has 1 unit with a cost of -35 and 1 unit with a cost of 0. Two units are demanded inelastically at all prices less than or equal to 60. The range of competitive prices is from -35 to 0. When demand is divided equally at the maximum competitive price of 0, each seller sells 1 unit and earns profit of 35. Obviously, neither seller has static market power at a common price of 0, since a unilateral price increase by either
would result in no sales and zero profits, and a price decrease would reduce earnings.

Static market power can be introduced by increasing demand so that the high-price seller in
the range of supra-competitive prices will not lose all sales. But to increase demand in the 2SNP
design would reduce excess supply, and as noted above, low excess supply itself may have an
upward influence on prices. Therefore, we increase demand and seller capacity together, in order
to maintain a constant level of excess supply. In our two-seller/power design, labeled 2SP in the
upper right panel of Figure 1, we doubled each seller's capacity and increased demand to six units
to maintain a constant excess capacity of two units. When demand is divided equally at the
(maximum) competitive price of zero, each seller earns 70 on the sale of the two low-cost units.
However, static market power exists, since a unilateral price increase would still result in the sale
of these two units, but at a much higher earnings level.

The noncooperative equilibrium in the 2SP design involves randomization over the range of
prices that constitute an "Edgeworth cycle". This randomization range is determined as follows. The
upper end of the Edgeworth cycle is a price of 60, where demand exceeds either seller's
capacity by two units, so either seller can earn a sure profit of 2[60 - (-35)] = 190. But the best
response to one seller's price of 60 is for the other to offer and sell four units at a price just below
60. Best responses to successively lower prices involve small price cuts, until price falls to 30,
since selling four units at a price below 30 is not as profitable as selling two units at a price of 60.
(Each seller always sells the two low-cost units, so profit comparisons are equivalent to revenue

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8 This equivalence of the Edgeworth cycle and the support of the mixed distribution is valid in the present context, but
not in general. See Holt and Solis-Soberon (1992) for a counterexample.

9 The analysis is based on the assumption that prices are continuous.
comparisons in this range, and $2 \times 60$ equals $4 \times 30$.)

Obviously, no pure-strategy equilibrium exists in this design, and noncooperative sellers would attempt to price in an unpredictable manner in order to avoid being slightly under-priced in the cycle. In equilibrium, sellers must be indifferent over all prices in the support of the mixed distribution, i.e., each price in this support must yield the security expected profit of 190 that results from a price of 60. Formally, let $G(p)$ denote the probability that the price $p$ posted by a seller $i$ is the highest price posted in the market for a period. Since sellers $i$ and $j$ have identical profit functions, we will consider a symmetric mixed equilibrium in which $G(p)$ is the distribution function for the common price distribution. If a price $p$ is the highest price, the seller will sell 2 units, and will earn $H(p) = 2[p + 35] = 2p + 70$. If $p$ turns out to be the lowest price, the seller two low-cost units and two high-cost units and earns $L(p) = 2[p + 35] + 2[p + 0] = 4p + 70$. Since $G(p)$ is the probability that $p$ is the higher price, the expected profit is: $G(p)H(p) + [1-G(p)]L(p)$. Since a seller must be indifferent between all prices over which randomization occurs, the function $G(p)$ must equate the expected profit at each price in [30,60] to the security profit at $p = 60$. The resulting equation yields:

$$G(p) = \frac{[4p - 120]}{2p}.$$  

As can be verified, $G(30) = 0$, $G(60) = 1$, and $G(40) = .5$. Therefore, the median of the common mixed distribution is 40, and the expected profit is 190.

The three-seller designs shown in the left and right panels at the bottom of Figure 1 are analyzed analogously. In the no-power design, 3SNP, each seller earns 35 on the sale of a single low-cost unit at the competitive price of 0. Since each seller's capacity of two units equals the
excess supply at supra-competitive prices, no market power exists; a unilateral increase from a common competitive price will result in no sales or profits. The 3-seller power design, 3SP, is obtained by doubling each seller’s capacity from two to four units and increasing demand from four to ten units in order to maintain the two units of excess supply at prices in range [0,60]. The symmetric mixed distribution is calculated as before. First note that each seller can be sure of selling two units at a price of 60, and the security profit is 155 (profits of 95 on the single low-cost unit and 60 on the high-cost unit). If one of the triopolists posts a price $p$ that turns out to be the highest price, this seller would sell two units and earn $H(p) = 2p + 35$. If the price is not the highest of the three prices, the seller sells four units and earns $L(p) = 4p + 35$. Again let $G(p)$ denote the probability of having the highest price, so the expected profit is $G(p)H(p) + [1 - G(p)]L(p)$, which is equated to the security level of 155 to yield the equation in (1). Since $G(30) = 0$ and $G(60) = 1$, sellers in the 3SP design randomize in the range [30,60], as was the case for the duopoly/power design. However, the median price falls from 40 to 34.\(^\text{10}\)

Consider now dynamic market power incentives. Although many outcomes may be supported via trigger strategies, it is expedient to focus on the conditions where the most profitable collusive outcome could be supported by the use of the noncooperative stage-game equilibrium as punishments for defection. Collusion can be supported as an equilibrium if the expected return from continuing to play the collusive outcome each period exceeds the expected return from unilaterally defecting in the subsequent period, and then earning noncooperative profits thereafter. The “N” row of Table 1 summarizes the expected profits from noncooperative play for each design.

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\(^\text{10}\) Calculation of the median price in the triopoly is a bit more involved than in the duopoly since $G(p)$, the probability that $p$ is the highest price, is now the probability that both of the other sellers price below $p$. If $F(p)$ denotes the common price distribution, $G(p) = F(p)^2$, and therefore, $F(p) = .5$ when $G(p) = .25$, or when $p$ is approximately 34.
summarized above. Maximal collusive profits, listed in “C” row of Table 11 present the per seller profits associated with evenly dividing demand at the limit price. In the 2SNP design, each seller can earn 95 by picking a price of 60 and limiting quantity to a single unit. The “D” row of Table 1 summarizes seller incentives to defect from the joint profit maximizing outcome. In the 2SNP design, for example, the defector could sell two units at a price just below 60, for a profit of about $120 + 35 = 155$. The profits for collusion and defection in the other treatments are calculated similarly. Notice in the table that for each treatment, $D > C > N$.

In a trigger-price equilibrium, defection is followed by noncooperative play forever. If $x$ represents the probability of continuation to the next period, the potential defector would earn $D$ in the period of a defection and would earn $N$ in all subsequent periods, for an expected profit of $D + Nx/(1-x)$. This expected profit for defection (and punishment) is less than the discounted profit from collusion, $C/(1-x)$, if $x > \left[D - C\right]/\left[D - N\right]$. This latter ratio, which will be called the Friedman coefficient, is calculated in the bottom row of Table 1.\textsuperscript{11} Setting the probability of continuation in excess of .5, induces dynamic market incentives in all designs. Notice also that the Friedman coefficient is the same for both paired power/no-power designs.

\section*{III. Procedures}

We conducted four markets in each of the four designs, for a total of sixteen posted-offer market sessions. Half of these sessions (2 sessions in each of the 4 treatment cells) were conducted at the University of Illinois (UI), and used the PLATO implementation of the posted offer.\textsuperscript{12} The

\textsuperscript{11} See Friedman (1971).

\textsuperscript{12} Sellers in a posted-price auction choose prices and maximum sale quantities simultaneously. After prices are
remaining eight markets were conducted at Virginia Commonwealth University (VCU), and used a networked-PC implementation of a posted-offer, written by Davis. All participants in the VCU markets were experienced in the sense that they had previously participated in a computerized posted-offer market, but a with different cohort of subjects and using a different market design.\footnote{No VCU participant was in more than one of the markets reported in this paper.} Participants in the UI markets were inexperienced. Buyers were simulated, and all sellers were undergraduate business students, who were paid a $3.00 appearance fee, plus their earnings from trades. Sellers earned money by selling units at prices above their costs. Earnings ranged between $7 and $55 per subject, inclusive of the appearance fee.

Identifiers for the sixteen markets listed in Table 2 are interpreted as follows: The number of sellers is indicated by 2S or 3S, the presence or absence of static market power is indicated by P or NP, and experience is indicated by an X. Finally, each identifier is concluded with a number 1-4 to distinguish sessions within treatment cells. Thus, for example, 2SNP1, shown in the upper left column of Table 2 refers to the first market conducted in the 2-seller/no power treatment.

With the following exceptions, laboratory procedures were standard for computerized posted-offer environments (Ketcham, Smith, and Williams, 1984). First, although each participant proceeded through interactive instructions presented at their own terminal, the instructions were also read aloud by the experimenter.\footnote{Our experience in other contexts suggests that reading instructions aloud facilitates learning, and it may also increase common knowledge regarding procedures.} Second, explicit information regarding demand limit prices, as

\footnotesize{displayed publicly, buyers are selected in a random sequence and are given the opportunity to purchase at the posted prices, up to the maximum sales quantities. Ketcham, Smith and Williams (1984) describe the PLATO posted-offer program in detail.}
well as the purchasing decision of the simulated buyers, was presented and read to participants after
the instructions.\textsuperscript{15} This information was presented to more closely approximate the information
assumptions underlying the static and dynamic games used to generate the equilibrium power
predictions.\textsuperscript{16} \textsuperscript{17} Third, rather than stop each experiment at a preset time for the entire session, or
after a given number of trading periods, we employed the following stopping rule: The experiment
proceeded uninterrupted for 15 periods. Prior to each period after period 15 a 6-sided die was
rolled, and the experiment was continued with a 1, 2, 3 or 4, and stopped otherwise. Running
uninterrupted for 15 periods gave us a standard data set in all experiments. The 2/3 probability of
continuation was high enough to avoid end-period effects, i.e., it exceeds the Friedman coefficients
shown in Table 1. As with demand information, the stopping rule was publicly announced in
advance.

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\textsuperscript{15} Following the instructions, participants were given a handout, and read the following message:

The buyers' side of the market in today's experiment is simulated.
There is a single buyer. This buyer will purchase \_ units at prices equal to or below \$\_\$, and will purchase
no units at any price above \$\_. If seller prices do not exceed \$\_, the buyer will make purchases first from the
seller posting the lowest price, then from the seller with the second lowest price, and so forth. If two sellers post
identical prices, then the buyer will use the throw of a die to choose which seller to approach first.

Once a seller has been selected, the buyer will purchase all units that can be afforded from that seller. If the
buyer finishes making purchases from one seller and still has more units available, then the buyer will switch to the
seller with the next lowest price, and so forth.

\textsuperscript{16} Participants were not explicitly told that all other sellers had identical costs, although they may have assumed this.

\textsuperscript{17} The rationing procedure implemented in the Simulated Buyer Announcement, does not divide demand when prices
are equal. Consequently, the competitive equilibrium price of zero is not a noncooperative equilibrium outcome, since
each seller has an incentive to reduce price slightly to ensure the sale of the seller's low-cost unit. A mixed strategy
equilibrium exists for both the 2 and 3 person games, and each is very close to the competitive equilibrium: The
median for the 2SNP design is .5 cents, while the median price for the 3SNP design is 2 cents. The mixing distributions
are calculated exactly as in the 2SP and 3SP designs, with security earnings equal to 35 (since either seller can ensure a
profit of approximately 35 by pricing slightly below 0. In either design, each seller earns competitive profits (35) on
average, and the calculations in Table 1 are unaffected. Details are available on request.
IV. Results

Before discussing specific results, we should discuss the way that the data are presented. First, we report posted prices rather than contract prices, because the static, mixed-strategy predictions derived in Section II pertain to posted prices. Second, we report price medians rather than means, since the median was calculated explicitly, and it places less weight on a few very low and very high contract price postings in the inexperienced trials.\footnote{Post-experiment comments by participants reveal that some of these aberrant price postings were keystroke errors.} Finally, we pool the data from the markets conducted at the two locations (with different experience levels and different computer PO implementations), since there is no statistically significant location effect.\footnote{Using the median of prices across periods 11-15 for each experiment as data points, a test of the null hypothesis of no experience effect generates a t-test statistic of 0.62. A test of the same hypothesis using the unit normalized version of the nonparametric Mann-Whitney test generates a test statistic of 0.74. Neither statistic allows rejection of the null hypothesis at significance levels even approaching conventional levels.}

The principle conclusions of our analysis are derived from the median price data presented in Table 2, and from a regression analysis reported below. Table 2 presents the medians of the posted prices for each of the sixteen markets for periods 11-15. When the four experiments in each treatment cell are pooled, the median prices for each period are plotted in Figure 2(a) for the 2SP and 2SNP treatments, and in Figure 2(b) for the 3SP and 3SNP treatments. In each figure, the competitive price is drawn as a dotted extension from the relevant no-power design, illustrated on the left side of the chart, while the lower and upper bounds of the static mixing distribution (deviations of 30 and 60), and the median of the static mixing distribution (deviations of 40 or 34) are drawn as dotted and dashed extensions, respectively, from the relevant market power design, shown in the right side of the chart. Observed median prices for the market-power design...
experiments are summarized in each figure by a heavy bolded line, while median prices for the no-power design experiments are summarized by the lighter line that connects a series of dots.

**Static Market Power**

Figure 2(b) clearly indicates that power dramatically affects performance in the 3-person experiments. The lower bound of the mixing distribution cleanly separates median contract prices, with prices approaching the limit price in the 3SP markets and approaching a level of 10-15 cents over the competitive prediction in the 3SNP markets. The median posted price path for the 2SP markets, shown in Figure 2(a), also exceeds the median posted price path for the 2SNP experiments each period after period 2. However, unlike the triopoly results, differences across power treatments are small in the duopolies, and the lower bound of the mixing distribution does not separate the power treatments nearly as well. These observations motivate our first conclusion.

**Conclusion1**: *Static market power affects median prices, particularly in the 3-person experiments.*

**Randomizing behavior**

Despite the clear effects of static market power, particularly in the 3-person designs, participants do not appear to randomize according to the static mixing distribution in either the 2-person or the 3-person markets. This can be seen in Figure 2(a), where, 10 of the 15 median prices were below the predicted level of 40 in the 2SP experiments, and in Figure 2(b), where median prices uniformly exceed the predicted level of 34 in the 3SP experiments.

Reexamination of median prices by market session in Table 2 provides further evidence of a lack of predicted randomization. Only 5 of the 20 median prices for periods 11-15 of the 2SP
markets are within 5¢ of the median consistent with mixing. Only one of 20 median prices for the 3SP experiments is within 6¢ of the 34-cent predicted median. These observations motivate our second conclusion.

**Conclusion 2:** Although the presence of static market power clearly affects pricing, participants generally do not randomize according to the static Nash predictions in these designs.

**Dynamic Market Power**

The exercise of dynamic market power would generate prices that exceed the equilibrium levels for each treatment. As Figures 2(a) and 2(b) suggest, three of the four treatment cells provide some evidence of dynamic market power. In both of the no-power treatments, median prices clearly exceed the near-competitive predictions, even in the latter periods: Median deviations are on the order of 25¢ for periods 11-15 of the 2SNP experiments, and 10¢ for periods 11-15 of the 3SNP experiments. Also, as shown in Figure 2(b), aggregate median prices for the last 5 periods of the 3-seller/power experiments range between 45 and 50 cents, clearly above the 34¢ deviation consistent with randomization. However, pooled median prices in the 2SP treatment, range between 21¢ and 38¢, somewhat below (and clearly not above) the 40¢ median in the static mixed equilibrium.

Examination of median posted prices by market provides some insight into differences in the nature of the deviations across treatments. With the exception of the 3-seller/power cell, where median prices are almost uniformly near the 60¢ limit price, outcomes within treatments vary widely, ranging from low to early competitive prices (e.g., 2SNPX4, 2SP1 and 3SNP1) to high and

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20 Recall, the competitive prediction is not a Nash equilibrium in either of the no-power designs, but a mixing equilibrium exists for each design that is very close to zero. See footnote 17.
near-collusive outcomes (e.g., 2SNPX3, 2SP2 (disregarding period 14) and 3SPX3). The mix of low and high prices within cells suggests the tacit conspiratorial behavior that might generally be expected in thin markets. This is our third conclusion.

**Conclusion 3:** Although participants infrequently adopt a profit maximizing conspiracy, there is some evidence of tacit collusion in each of the treatment cells, and median prices exceed the noncooperative prediction in 3 of the 4 cells.

**Market Power and the Number of Sellers**

The clean separation of price performance across the power treatments in the 3-seller markets shown in Figure 2(b) also applies to the individual markets, as may be seen by again referring to Table 2. In each of the 3SNP experiments, all median prices are at or below 30¢ (in fact 16 of the 20 prices are 15¢ or less) while median prices exceed 30¢ in each of the experiments in the 3SP design.

In contrast, in the 2-person experiments, not only is the aggregate difference in prices across power treatments smaller, but performance is much more heterogeneous. In the 2SNP markets both nearly competitive price postings (2SNPX4) and very high posted prices (2SNPX3) occur. Similarly, in the 2SP cell, both low median prices (2SP1) and high median prices (2SP2 and 2SPX4) are observed. It appears that, independent of static market power conditions in duopolies, sellers are occasionally able to conspire tacitly, and also occasionally price very competitively. Standard reasons (particularly the increased ease of punishment) may explain inverse relationship between cooperative opportunities and the number of sellers. The provision of demand information may also occasionally prompt more rivalry and thus more competitive prices. If the sellers assume
cost symmetry, they may start to view relative earnings as more important than total earnings.\textsuperscript{21}  

We summarize this discussion as a conjecture:

**Conjecture:** The capacity to both directly monitor and punish competitors in full information duopolies provides increased opportunities for tacit conspiracy, and increased rivalry; and therefore generates much more variable pricing performance.

The preceding conclusions are also cleanly summarized via regression analysis. Let $D_p$ represent a dummy variable for market power, taking on a value of 1 if the session induced static market power, and 0 otherwise; and let $D_2$ represent a number-of-sellers dummy, taking on a value of 1 if the experiment was conducted with 2 sellers. The specification in equation (2) is convenient in that it allows identification of dynamic and static market power in both the 2-person and 3-person designs.

\[
(2) \quad P_{med} - P_e = [B_3 + B_{3p}D_p](1-D_2) + [B_2 + B_{2p}D_p](D_2)
\]

The coefficients $B_2$ and $B_3$ measure tacit collusion in the absence of market power in the 2- and 3-person treatments respectively, while $B_{2p}$ and $B_{3p}$ capture the marginal effects of market power. Given static market power, $B_2 = B_3 = 0$, while $B_{2p} = 40$ and $B_{3p} = 34$. A variety of $B_2$ and $B_3$ coefficients are consistent with dynamic market power, with $B_2 = B_3 = 60$ and $B_{2p} = B_{3p} = 0$ in the Pareto-dominant collusive outcome.

Using 16 independent observations generated by calculating the median of posted prices for periods 11-15 for each experiment, an OLS regression generates equation 3.

\[
(3) \quad P_{med} - P_e = [14.75 + 34.75D_p][1-D_2] + [23.6 + 7.87D_p](D_2)
\]

\textsuperscript{21} See Holt (1995) for an expanded discussion of these effects.
\[
R^2 = .46, \quad F_{(3, 12)} = 5.34*,
\]
where t-test statistics (for the null of no difference from zero) are printed below coefficient estimates. A single asterisk by a test statistic indicates rejection of the null at a 95% confidence level, while a double asterisk indicates rejection of the null at a 99% level (direction not predicted).

Regression results provide statistical support for our three principle conclusions. First, while the positive signs on the \( B_{3p} \) and \( B_{2p} \) coefficients suggest that static market power generally increases prices, the large and statistically significant coefficient for the \( B_{3p} \) term indicates that static market power effects are important only in the 3-person markets. Second, the significance of the \( B_2 \) and \( B_3 \) coefficients suggests some exercise of dynamic market power, in the sense that prices are significantly different from zero, independent of the effects of static market power. Finally, third, note the insignificance \( B_{2p} \) in the 2 person design, and note that \( B_{3p} + B_3 = 49.5 \), far above 34. These observations suggest that, on average, individuals do not randomize according to the static mixing distribution.\(^{22}\)

V. Conclusion

Seller market power exists in a static sense when one or more sellers can profit from a unilateral increase in price above the competitive level (and therefore, when the competitive price is not a noncooperative equilibrium in the stage game). In laboratory experiments, a small number

\(^{22}\) A more formal test of the randomization hypothesis can be made by comparing the sum of squared errors for the above (unrestricted) regression with the sum of squared errors for the same regression, when all coefficients are restricted to values predicted under the static market power hypothesis. This comparison generates an \( F_{(3, 12)} = 7.31 \), which allows rejection of the randomization null at a 99% confidence level.
of sellers with market power are sometimes able to exercise it, especially in posted-offer markets. In the duopoly and triopoly posted-offer experiments reported here, market power is induced by having a relatively small (two-unit) excess supply at supra-competitive prices, to ensure that price increases do not result in large quantity reductions. The obvious question is whether the observed supra-competitive pricing is a result of market power as a theoretical construct, or whether it is an artifact of either small numbers or of small excess supply above the competitive price. This question is addressed by running control experiments in which market power is eliminated by simultaneously reducing demand and giving each seller a lower capacity that just equals excess supply at supra-competitive prices. Although there is no static market power in the control, the probabilistic termination rule admits the possibility of "collusive" outcomes, supported by trigger price strategies, in both the power and no-power designs.

In the no-power treatments, observed posted prices significantly exceeded static noncooperative levels, which indicates some degree of tacit collusion in both the duopoly and triopoly markets. But this supra-competitive pricing cannot be explained by the full exercise of dynamic market power, since prices were never close to the perfectly collusive level. The introduction of static market power is associated with higher posted prices, especially with three sellers. The posted prices in triopoly markets with power are even higher than the levels that result from the static noncooperative equilibrium exercise of this power, which again indicates some degree of tacit collusion in these repeated market games.

The results in the duopoly markets are more variable; some duopolies generate high prices
and others exhibit more rivalistic behavior.\textsuperscript{23} One would expect more disperse results with fewer participants, since individual differences have a larger effect in small markets. In addition, incentive effects may induce variability in 2-seller pricing decisions. With a single rival, it is possible to direct a punishment at that rival without sending a message to a third person, which may facilitate tacit collusion. On the other hand, duopolists may be more likely to become envious and vindictive, which may cause some duopolies to end up being very competitive. These opposing tendencies could produce varied results across duopoly experiments.

\textsuperscript{23} Similarly, Dolbear \textit{et al.}(1968) reported more variability in markets with 2 sellers than with 4 sellers.
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Plott, Charles R. and Vernon L. Smith, "An Experimental Examination of Two Exchange


Table 1. Calculation of Profits and the Friedman Coefficient, by Treatment

<table>
<thead>
<tr>
<th>Seller/ Power Treatment</th>
<th>2SNP</th>
<th>2SP</th>
<th>3SNP</th>
<th>3SP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noncooperative Profits ($N$):</td>
<td>35</td>
<td>190</td>
<td>35</td>
<td>155</td>
</tr>
<tr>
<td>Collusive Profits ($C$):</td>
<td>95</td>
<td>250</td>
<td>115</td>
<td>235</td>
</tr>
<tr>
<td>Unilateral Defection Profits ($D$):</td>
<td>155</td>
<td>310</td>
<td>155</td>
<td>275</td>
</tr>
<tr>
<td>Friedman Coefficient $\frac{D-C}{D-N}$</td>
<td>.5</td>
<td>.5</td>
<td>.33</td>
<td>.33</td>
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Table 2. Median Posted Prices for Periods 11-15.

<table>
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<tr>
<th>Period</th>
<th>2SNP1</th>
<th>2SNP2</th>
<th>2SNPX3</th>
<th>2SNPX4</th>
<th>2SP1</th>
<th>2SP2</th>
<th>2SPX3</th>
<th>2SPX4</th>
</tr>
</thead>
<tbody>
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<td>11</td>
<td>19</td>
<td>22</td>
<td>26</td>
<td>-1</td>
<td>17</td>
<td>52</td>
<td>35</td>
<td>40</td>
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<td>12</td>
<td>28</td>
<td>22</td>
<td>40</td>
<td>2</td>
<td>13</td>
<td>42</td>
<td>34</td>
<td>50</td>
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<tr>
<td>13</td>
<td>25</td>
<td>26</td>
<td>53</td>
<td>5</td>
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<tr>
<td>14</td>
<td>23</td>
<td>23</td>
<td>49</td>
<td>23</td>
<td>18</td>
<td>-11*</td>
<td>39</td>
<td>30</td>
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<tr>
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<td>20</td>
<td>15</td>
<td>49</td>
<td>8</td>
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<td>60</td>
<td>21</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Period</th>
<th>3SNP1</th>
<th>3SNP2</th>
<th>3SNPX3</th>
<th>3SNPX4</th>
<th>3SP1</th>
<th>3SP2</th>
<th>3SPX3</th>
<th>3SPX4</th>
</tr>
</thead>
<tbody>
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<td>15</td>
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<td>47</td>
<td>51</td>
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<td>11</td>
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<td>9</td>
<td>30</td>
<td>10</td>
<td>55</td>
<td>43</td>
<td>54</td>
<td>60</td>
</tr>
</tbody>
</table>

- One Participant commented that he errantly keyed in a price $1.00 below his intended price in this period. The median price for this period would have been 60 had the participant entered his intended price.
Figure 1. Supply and Demand Arrays
Figure 2a. Median Prices for the 2SNP (circle markers) and 2SP (bolded line) Treatments.

Figure 2b. Median Prices for the 3SNP (circle markers) and 3SP (bolded line) Treatments.