Chapter 17

THE EXERCISE OF MARKET POWER IN LABORATORY EXPERIMENTS

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1. Introduction

Many aspects of antitrust policy are influenced by the possibility that sellers in concentrated markets may have the power to raise prices above competitive levels. Of course, anyone can raise prices, so the issue is whether a change in structure, e.g., a merger, will allow one or more sellers to raise price profitably. A price increase by one seller diverts sales to others, so a firm is more likely to have market power when its competitors have limited capacity to expand their sales. Thus a merger that reduces competitors' capacity may create market power.

In laboratory experiments, any treatment that reassigns "units" of capacity from one seller to another may create or destroy market power, even if the aggregate supply curve is unchanged. For example, giving one seller a relatively large endowment of infra-marginal, low-cost units may make it less risky for this seller to raise price and forego the sale of high cost units. Thus it is not surprising that experiments with apparently similar supply and demand structures may yield different price outcomes. As discussed below, there are a number of other ways in which structural changes can affect the degree of power that sellers enjoy.

Market power can also be sensitive to the trading institution, and this is the context that power issues first arose in experimental economics. For example, the public posting of uniform prices in a posted offer auction eliminates the incentive to offer discounts on marginal units that arises in a double auction. In fact, Smith (1981) found that even monopolists are sometimes unable to maintain prices above competitive levels in double auctions, whereas supra-competitive prices are the norm in posted-offer monopolies. Similarly, Holt, Langan, and Villamil (1986) found that sellers in concentrated double auctions were sometimes able to raise prices, but that prices fell to competitive levels in about half of the sessions, despite the high concentration of seller capacity. Davis and Williams (1991) replicated the Holt, Langan, and Villamil results for double auctions, and then used the same market structure in a parallel series of posted-offer markets, where price increases above the competitive levels were strong and persistent.

Relatively high prices in posted-offer auctions are not surprising, since experimental economists have long noticed that prices in such markets tend to be above competitive levels, and will converge from above if they converge at all. One issue is whether

[†] This work was funded in part by the National Science Foundation (SBR 93-19842 and SBR 96-617784).

Handbook of Experimental Economics Results, Volume 1

DOI: 10.1016/S1574-0722(07)00017-0

this upward bias can be explained by standard game theory. Holt (1989) offered a game-theoretic definition of market power, i.e., that at least one seller has a unilateral incentive to raise price above a common competitive price. Thus the presence of market power means that the competitive equilibrium is not a Nash equilibrium. Ketcham, Smith, and Williams (1984) report data for a posted-offer experiment in which the Nash equilibrium price was identifiably above the competitive price, and prices were also above competitive levels. For most posted-offer experiments, however, the Nash predictions are difficult to calculate because of the complex supply and demand structures that are typically used. Nevertheless, some market power frequently exists, and in these cases, the Nash equilibrium typically involves randomization over some range of supra-competitive prices (Holt and Solis-Soberon, 1992). The first experiment that explicitly considered the behavior in markets with a mixed-strategy equilibrium were reported by Kruse et al. (1994). They found Edgeworth cycles at prices above competitive levels, up in the range of randomization, but subjects did not appear to be choosing prices randomly.

The posted offer experiments discussed to this point did not directly address the issue of whether supra-competitive prices are really due to market power, or whether other factors such as the number of sellers or the shapes of supply and demand drive the observed data patterns. This question led to investigations in which numbers effects and other factors are held constant, and market power is created or destroyed by reallocating capacity in a way that leaves the shapes of supply and demand unchanged (Davis and Holt, 1994). This work is discussed in detail in the next section. The final section surveys a number of contexts in which power issues have arisen in experimental investigations of other issues, e.g., the trading of pollution permits or the design of computerized auction markets

2. Market Power

We begin with a simple example that shows how market power can be created by capacity constraints, and how the mixed-strategy Nash equilibrium can be calculated in this case. Consider a market composed of two sellers and a single buyer. Each of the sellers has a capacity to produce two units at zero cost. The buyer will purchase three units at any price at or below a reservation price r. Thus the seller with the low price will sell both units of capacity, and the one with the high price will only sell one unit. Under these conditions, each seller would want to undercut the other's price, if it were known, until the other's price was so low that gains from selling two units as the low pricing seller no longer exceeded the profits from selling a single unit at price r. As is easily shown, there is no Nash equilibrium in pure strategies for this type of structure. Rather the equilibrium must involve mixing.

For any equilibrium in mixed strategies, sellers must be willing to choose price randomly, which can only be the case if the expected payoff is constant for all prices in the range of randomization. Thus, the first step in the analysis is to find the expected payoff function, and the second step is to equate expected payoffs to an appropriate constant.

In order to evaluate expected payoffs, let the common equilibrium distribution of prices be denoted by $F(p)$. Thus if one seller chooses a price of p, the probability that the other is below p is $F(p)$. Just as $F(p)$ is the probability that p is high, $1 - F(p)$ is the probability that a price p is low. Only 1 unit is sold with a high price and 2 units are sold with a low price, so the expected payoff is $pF(p) + 2p[1 - F(p)]$. (We ignore the possibility of ties, which occur with probability zero since the distributions are continuous.)

The second step in finding the mixed-strategy equilibrium is to equate this expected payoff to a constant. Since the high-priced seller will sell a single unit, the person considering making a very high price should raise it to the buyer reservation value r, which yields a payoff of r. The seller would be indifferent between this high price and any other if expected payoffs are equal to r, or if: $pF(p) + 2p[1 - F(p)] = r$. This equation is solved for the equilibrium price distribution: $F(p) = (2p - r)/p$, which equals zero when $p = r/2$. Thus the lowest price in the range of randomization, denoted $p_{\min}$, is half of the buyer reservation value in this example, and the range of randomization is from $r/2$ to r.

This simple example illustrates the steps that are typically involved in finding a mixed-strategy equilibrium: calculating the expected payoffs, equating them to a constant, and solving for the equilibrium price distribution. These calculations become more tedious very quickly as more sellers, more cost and demand steps, and asymmetries are introduced. Holt and Solis-Soberon (1992) contains a step-by-step guide to finding mixed-strategy Nash equilibria with more complicated step-function designs that result from the discrete units of capacity that are used in laboratory experiments.

Davis and Holt (1994) exploited these solution techniques to design an experiment that allowed the isolation of market power as motivation for price increases. Consider the asymmetric cost structure in Figure 1. The green supply function and the red demand function overlap on a range of competitive prices, the highest of which is indicated by a horizontal dotted line. In a no-power treatment, the price indicated by the dotted line is also a Nash equilibrium. To see this, consider the structure of supply for the no power design: Each of the five sellers, S1–S5, has a single low-cost unit, as shown on the lower-left step of the green supply function. In addition, sellers S1, S2, and S3 also have two high-cost units each, on the upper-right step. (Please ignore the italicized S1 and S2 indicators below upper step for now.) In total, no seller has more than three units out of the industry capacity of 11 units in the no-power design. Since the demand is only for 8 units at prices above the competitive level, any seller who raises price above a common competitive level will sell nothing. Hence such a unilateral price increase is unprofitable, and the highest competitive price is a Nash equilibrium.

Market power is created by reallocating seller S3's high-cost units to S1 and S2, as indicated by the parenthetical (S1) and (S2) notations below the high-cost step of supply in Figure 1. For the two large sellers, the aggregate capacity of their competitors has gone down by 1 unit, so a unilateral price increase to r will result in sales of 1 unit

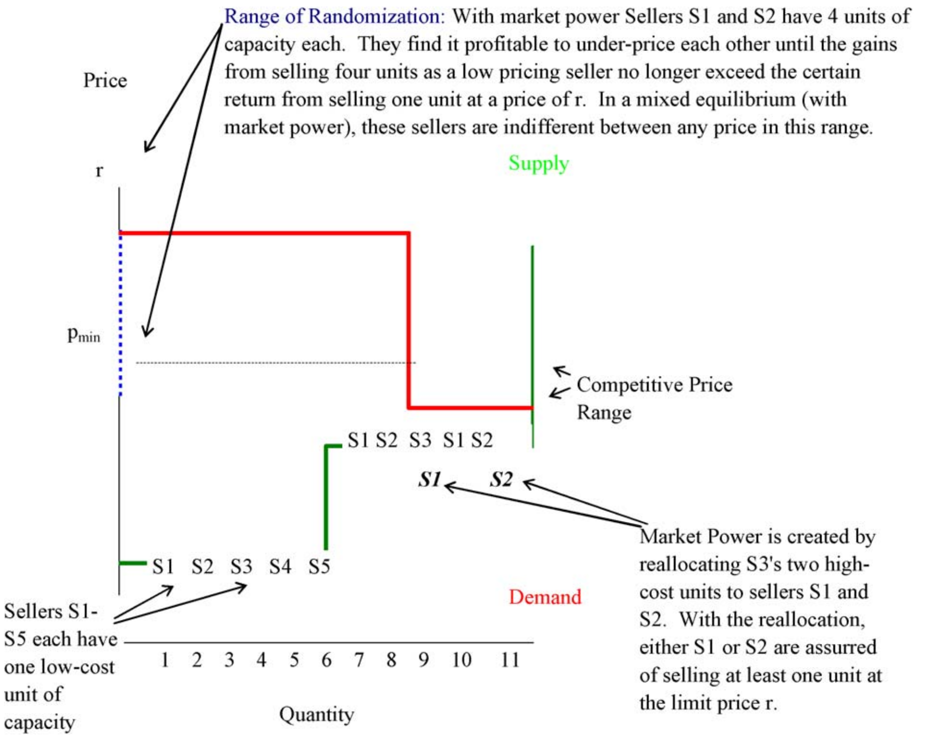

Figure 1.

instead of 0 units. The calculations are much more complicated for this design than for the example discussed above, but the same general approach can be used to show that the two large sellers will choose prices randomly on a range from $p_{\min}$ to r, as shown by the thick blue band on the vertical axis of Figure 1.

To summarize, the reallocation of seller S3's high-cost units to S1 and S2 gives them the unilateral incentive to raise price above the competitive level, which raises the Nash equilibrium prices up into the range of randomization. This allows an evaluation of the effects of creating market power, without changing the shapes of supply and demand. We conducted six posted-offer sessions with this setup. Three of these began with 30 periods of trading in the power design, followed by 30 periods in the no-power design. The treatment order was reversed in the other three sessions. The five subjects playing the seller roles were provided with complete information about demand and cost. The demand side was simulated by the experimenters (see Davis and Holt, 1994, for details).

Figure 2 shows the price sequences for a session that began with the power treatment. The prices of the two large sellers, S1 and S2, are colored as red and blue, respectively. The prices of the other three sellers are stars. Notice that the "red seller" is choosing the highest price of r for most of the first ten periods, which gradually brings the other

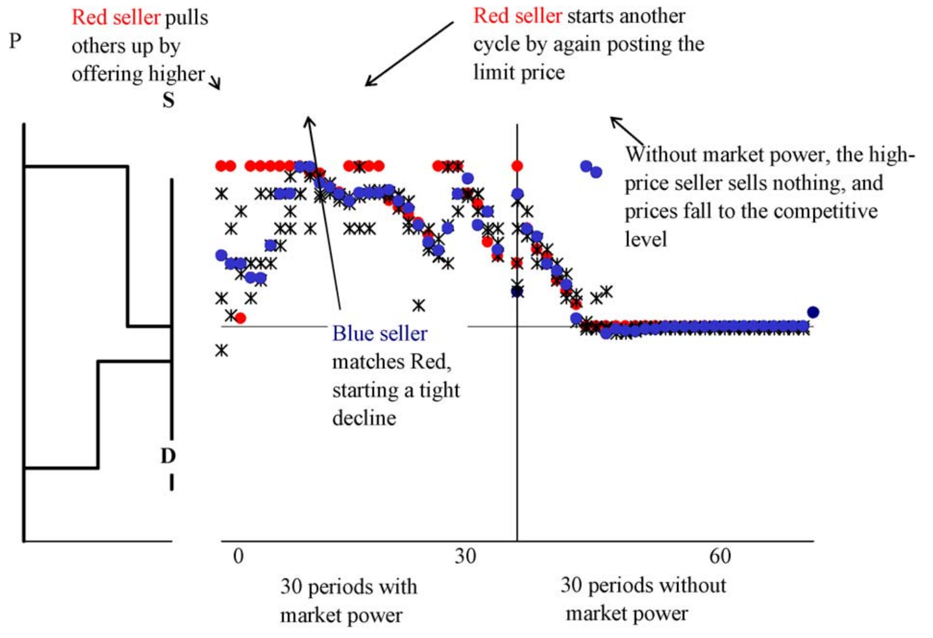

Figure 2.

sellers up. In period 10, the red seller undercuts the blue one, which starts a tight price decline for the next several periods, until red returns to choosing the highest price. This stops the price decline, but without an increase in others' prices, red becomes frustrated and drops price, which leads to a second tight decline. The price cycles continue, becoming a little more erratic, until period 30 where units are transferred from the two large sellers to seller S3, thereby destroying market power. Notice that prices start a steep decline after period 30, and there is no rebound after the blue seller briefly tries to signal with the highest price. With no power, this high-price gesture results in no sales for that seller, and an intense competition reigns throughout the rest of the session.

A similar pattern was observed in the other sessions that begin with the power treatment, shown by the blue dashed lines in Figure 3. The price average for these sessions, the bold blue line, rises and stays well above the theoretical prediction of the mixed equilibrium, as shown by the upper horizontal black line in the figure. (This line is the median of the price distributions for the large sellers, who make most of the sales.) Prices for these power/no-power sessions fall toward competitive levels when power is removed after period 30, as shown on the right side of the figure. A reversal of the order of treatments, with no power first, is shown by the red dashed lines for individual sessions and by the red bold line for the average across sessions. Note that there is some inertia, as prices do not always fall all the way to the competitive prediction in a no-power treatment that follows high prices in a power treatment.

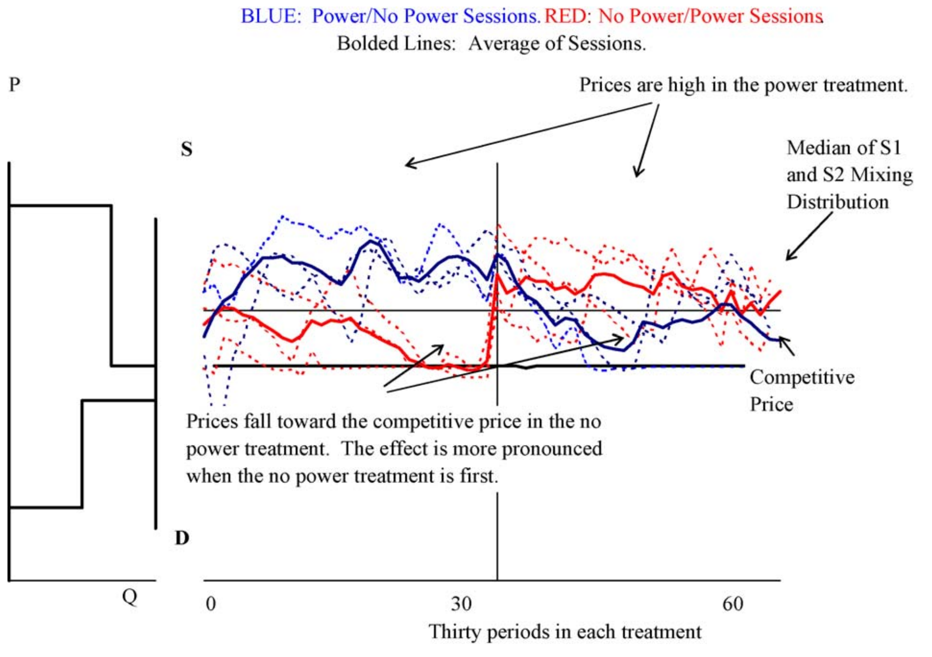

Figure 3.

Davis and Holt (1994) also ran six additional sessions in which a "merger" of the three small sellers was effected in the power design. Thus the treatments were: the pre-merger power design from before (five sellers with power) and the post-merger structure (three sellers with power). The interesting thing about the design is that the theoretical price distributions in the mixed equilibrium did not change, so the merger reduces the number of sellers without changing the extent of market power in a theoretical sense.[1] This pure-numbers effect did increase prices by a small, but statistically significant, amount; however the magnitude of this "pure numbers" effect was much smaller than the "market power" effect.

3. Applications of Market Power

Market power can have important implications in a wide variety of contexts where experimental analysis has played a role. For example, McCabe, Rassenti, and Smith (1993) consider the optimal design of computerized "call markets." The price is determined in these markets by letting buyers' submit bids and sellers' submit asks, which

[1] The merger, however, raises the Herfindahl index by about 450 points, just as the initial change from no-power to power raised the index by 450 points.

are then arrayed in supply and demand functions that are crossed to find the clearing price when the market is called. Overall these call markets tend to be quite efficient, almost on a par with standard double auctions. Nevertheless, some cost and/or valuation combinations may create market power that a trader could exercise by altering the bid or ask on a unit that is near the crossing, in order to make more money on an infra-marginal unit. For example, a buyer may lower a bid in the neighborhood of the anticipated crossing price in an attempt to lower the market price, and raise earnings on an infra-marginal unit for which a high bid has been submitted to ensure a purchase. McCabe, Rassenti, and Smith (1993) recognized the efficiency-reducing attempts of such possibilities, and suggested some trading rule variations to minimize the damage (such as keeping a closed bid/ask book).

A second instance where market power has arisen in the area of market design involves the construction of markets for pollution emission permits. In most instances where such markets have been introduced in the United States, market power has not been a concern, since the number of producers interested in buying and selling permits has been quite large. However, in some smaller countries, permit markets, if introduced, would be much thinner. Building on theoretical work by Misiolek and Elder (1989) and Hahn (1984), Godby (1997) shows that market power effects can cause sizable distortions in simple markets with structures that parallel those that would exist in some Canadian emissions permit markets, if established. The extent of the problem is a function not only of the relative size of the producers, but also the competitive conditions in producers' downstream markets, and on the initial distribution of permits. Based on his experiments, Godby (1997) suggests that careful attention to the market structure and to the way permits are distributed is warranted.

Market power also provides a fairly plausible explanation for "price-stickiness" observed in the U.S. economy (e.g., Rotemberg, 1982): Reynolds and Wilson (1997) provide a persuasive explanation for these counter-cyclical markups based on unilateral market power. Reynolds and Wilson show that unilateral market power can arise as a result of a demand shift, which may occur during a business cycle. In the design shown in Figure 1, for example, the power treatment produces high prices because the earnings from selling a single unit at the buyer's reservation value r are high enough to compensate for the lost sales of high cost units at the competitive price. However, a vertical upward shift in the demand curve raises the opportunity cost of foregoing the sale of marginal units, and, therefore, may eliminate market power. Thus, prices may not fall in recessionary times, because the demand reductions create some market power. An experiment reported by Wilson (1998) confirms that demand shifts of this type can introduce and remove market power.

We close by mentioning briefly one final application that again pertains directly to antitrust considerations. Recently, antitrust authorities have paid increased attention to synergies as a potential justification for mergers, if the efficiency gains are likely to be at least partially passed on to consumers in the form of lower prices. One possible standard would be to view more favorably proposed consolidations, if respondents can show that efficiency improvements in the recent past resulted in lower prices. An experiment by

Davis and Wilson (1998) shows that such a standard would be overly simplistic, because synergies and market power can be interrelated: For a given market structure, a synergy of a particular size can introduce market power where it did not previously exist, can take away market power that existed previously, or leave power conditions unchanged. The relationship between synergies and market power turns on whether the synergy affects the infra-marginal, low cost units, or higher cost marginal units. Results of the Davis and Wilson study suggest strongly that a policy that considers synergies as a justification for mergers must also consider carefully how the synergy will affect the combined firm's cost schedule.

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