Buyer Countervailing Power versus Monopoly Power: Evidence from Experimental Posted-Offer Markets

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Abstract

Although much research has been devoted to the impact of seller structure on market outcomes, considerably less is known about the influence of buyer structure. We examine the impact of buyer concentration on the pricing of a monopolist. Markets with both two and four buyers achieve prices well below the monopoly price, attaining even competitive levels — sometimes even lower. Moreover, markets with only two buyers show significantly lower prices than those with four buyers. We design an additional pair of treatments to pinpoint the source of this difference. We attribute the lower prices in the two-buyer treatment to the monopolist pricing more cautiously when there are fewer buyers in order to avoid costly losses in sales. Buyer concentration is thus an effective source of countervailing power: even an unregulated monopolist that faces no possible threat of entry may price competitively.

keywords: strategic buyer behavior, buyer concentration, monopoly, experimental economics

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1 Introduction

> "In the typical modern market of a few sellers, the active restraint is provided not by competitors but from the other side of the market by strong buyers... At the end of virtually every channel by which consumers' goods reach the public there is, in practice, a layer of powerful buyers." (Galbraith, 1952, pp.112, 126)
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> "I would expect bilateral oligopoly to be relatively monopolistic in operation... it simply is romantic to believe that a competitive solution will emerge, not merely in a few peculiar cases, but in the general run of industries where two small groups of firms deal with one another suddenly all the long-run advantages of monopolistic behavior have been lost sight of in a welter of irrational competitive moves." (Stigler, 1954, p.9)

Buyers are typically treated as passive price-takers in economic theory with sellers as the only strategic players. Yet in non-retail-trade industries, there is no theoretical or apparent reason why buyers should be any less influential in establishing the price than sellers. Since Bertrand's (1883) provocative finding that two firms competing in prices are sufficient to bring about the competitive outcome, the question of the competitiveness of a market as a function of seller concentration has been a hotly debated one.[1] In sharp contrast, the analogous topic concerning the impact of buyer concentration on market outcomes remains underexplored.

Galbraith (1952) introduced the notion that a small number of buyers can act as a countervailing force against the market power of a small number of sellers. His idea, however, was initially dismissed as far-fetched (see e.g. Stigler, 1954, and the above quotation) and received little attention in the four decades following the publication of his book on countervailing buyer power.[2] Recently, however, the importance of buyers has been recognized in theoretical bilateral oligopoly models (Snyder, 1996, Bjornerstedt and Stenneck, 2001, and Inderst and Wey, 2001), in industry studies of seller performance in the cable TV industry (Chipty and Snyder, 1999), wholesale pharmaceuticals (Ellison and Snyder, 2001), and the German automobile industry (Peters, 1998), and in experimental market studies with two sellers (Ruffle, 2000).

Furthermore, antitrust authorities recognize the potential role buyers may play in preventing collusion. The 1982 revisions to the Horizontal Merger Guidelines cite the "ability of sophisticated buyers to devise long-term contracts to break collusive agreements" as a measure to evaluate the

[1] See, for instance, Stiglitz (1987), Dufwenberg and Gneezy (2000), Huck et al. (2001).

[2] Exceptions include Lustgarten (1975) and Schumacher (1991) who construct measures of buyer structure for 4-digit SIC manufacturing industries and examine their impact on seller profitability and advertising intensity and Kling (1988) who shows that buyer concentration measures correlate negatively with price-cost margins in the U.S. trucking industry.

competitiveness of an industry. In practice, however, antitrust authorities lack clear guidelines regarding, for instance, the fewness of buyers required to influence price. The absence of clear empirically established criteria or theoretical benchmarks for buyers' influence may explain what may be interpreted as the courts' reluctance to approve mergers despite a seemingly concentrated buyer side of the market. For instance, in United States v. Country Lake Foods, Inc. (1990), the court refused to enjoin a merger where three large customers accounted for 90% of all purchases in the relevant product market. More recently, America's two largest pharmaceutical companies concurrently proposed to merge with the fourth and third largest firms in the industry. The justification put forth for these multi-billion dollar mergers was the claim that 80% of the estimated $306.9 million in fixed cost savings due to the elimination of redundancies would be passed onto large pharmaceutical buyers, mainly retail chains like Walmart and hospital triads, in the form of lower prices. Again, perhaps in the absence of well-established guidelines for the countervailing ability of large buyers, the courts (FTC v. Cardinal Health and FTC v. McKesson Corp.) blocked both mergers. In this paper we examine the ability of a small number of buyers to influence monopolist pricing and the means by which buyers are able to do so. We compare the pricing of a monopolist in a 30-round experimental market with two buyers to pricing in an identical market with four buyers. The buyers' individual and aggregate demand curves, the monopolist's marginal cost curve and the market structure (i.e. monopolist versus either two or four buyers) were all common knowledge in these experiments. The market institution we have chosen is the posted-offer market. In our posted-offer experiments, the monopolist selects a price and a quantity to make available for sale at that price. The price, but not the quantity, is posted (i.e., displayed) to all buyers. The buyers are then randomly ordered. Each buyer in turn proceeds to make privately the purchases that each desires at the posted price. Strategic buyer behavior in our posted-offer market is limited to rejecting profitable purchases, i.e. rejecting purchases at a price below the buyer's valuation. Buyers are unable to collude, to make a counter-offer or negotiate a better price.

We have selected these particular experimental design features to control for competing explanations of buyer countervailing power. For instance, the choice of a monopolist eliminates a more usual explanation for buyer power, namely seller competition for the business of the buyers (see

Snyder, 1998, and Ruffle, 2000). Similarly, by restricting the monopolist to posting a single price for all buyers, the posted-offer market eliminates more commonly cited sources of buyer market power in the popular press such as volume discounts, economies of distribution and bargaining. The private nature of buyers' purchasing (and withholding) decisions means that (even implicit) collusion is impossible in this market institution. A further reason for employing the posted-offer market is its highly structured nature, which permits sharper data analysis and hypothesis testing than in less structured, real-time negotiation institutions in which the dynamics may be less orderly and less quantifiable.[3]

Our results indeed show that markets with two buyers achieve significantly lower prices than those with four buyers. Given the above-mentioned controls built into our experimental design, there remain only two competing explanations for this result. Intuitively, fewer buyers may achieve lower prices because they feel more empowered when there are fewer of them. As a result, they withhold demand more aggressively. The monopolist succumbs by lowering his price in future periods. We refer to this possibility as the "buyer empowerment hypothesis". Alternatively, the mere threat of increased costly withholding when there are fewer buyers causes the monopolist to price more cautiously; we call this the "cautious monopolist hypothesis". The inclusion of an additional pair of treatments in which only the monopolist is uninformed about the number of buyers in the market enables us to identify the cautious monopolist hypothesis as the source of the lower prices observed in the two-buyer sessions.

We suggest that the results of these experiments highlight the countervailing role that buyer concentration may play in real-world markets. Even when changes in the number of buyers (either through mergers, entry or exit) may be discerned in real-world industries, concurrent unobservable changes (e.g., in demand conditions) are likely to follow, rendering attempts to disentangle the effect of buyer concentration difficult at best. Laboratory experiments have the ability to eliminate unobservables and to isolate cleanly the impact of buyer concentration. This experiment can be seen a first, focused attempt toward characterizing the effect of buyer concentration on market

[3] In another paper (Engle-Warnick and Ruffle, 2002), we exploit the structure of the posted-offer market and the independent nature of buyers' withholding decisions to infer individual buyer withholding strategies based on buyers' observed withholding decisions.

pricing. At the very least, our evidence points to the effectiveness of an implicit threat of buyer retaliation in achieving competitive prices, even against a monopoly. We have thus taken a first step toward accumulating evidence regarding why and how buyer concentration should be taken into account in competition policy. Further experimental research is called for along the lines of exploring the impact of other variables, one at a time, precisely in the manner that has been done with studies of seller concentration.[4]

Section 2 surveys the previous literature on monopoly experiments. We detail the experimental design and procedures for the two-buyer and four-buyer "informed" treatments in section 3. Section 4 presents the results of these treatments as well as the results for two additional "uninformed" two-buyer and four-buyer treatments. A discussion of buyer concentration as a third solution to the monopoly problem follows in section 5. Section 6 concludes.

2 Related Literature

For any finitely repeated game, the dominant strategy for posted-offer buyers is to make all profitable purchases in each period. Most posted-offer market experiments implement this solution by replacing human buyers with simulated buyers. These computerized buyers act according to the following algorithm: purchase from the lowest-price seller and continue to do so as long as the price is less than (or equal to) the buyer's valuation. Simulated buyers offer the advantage of reduced subject payments. More importantly, demand withholding can only confound the interpretation of the data when the theoretical model being tested focuses on strategic seller behavior.

Nonetheless exceptions to the replacement of human buyers with a myopic profit-maximizing computer algorithm do exist. Smith (1981) conducted a single posted-offer monopoly experiment in which not a single instance of demand withholding was observed and prices converged quickly to the monopoly price.

Subsequent monopoly experiments have focused on two distinct methods to restrain monopoly

[4] One such avenue for future research is the countervailing role of buyers in different market institutions. The structure and timing of the posted-offer institution are usually thought to characterize retail trade markets (see Ketcham et al., 1984). Indeed, we recognize that in real-world industries in which countervailing power exists, buyers are typically able to exert their influence through more direct means than withholding demand, by negotiating a better price, for instance.

power. One proposed solution to the monopoly problem is the contestable markets hypothesis (Baumol et al., 1982) according to which the threat of entry of a rival firm with the identical cost structure as the incumbent monopolist will force the monopolist to price at marginal cost. Experimental evidence supports this hypothesis. Both Coursey, Isaac and Smith (1984) and Brown-Kruse (1991) test the contestable markets hypothesis with a decreasing-cost, posted-offer monopolist and human buyers. Both find that prices approach or even converge to competitive levels. Coursey, Isaac, Luke and Smith (1984) duplicate the experimental design used in Coursey, Isaac and Smith with one addition, a sunk cost paid in each period by the monopolist and the rival firm in the case of entry. Prices were found to be above competitive levels, although still closer to the competitive price than the monopoly price.

A second solution involves the implementation of different regulatory mechanisms. Harrison and McKee (1985) test the Loeb-Magat mechanism (see Loeb and Magat, 1979) according to which the regulatory agency pays a subsidy to the monopolist in the amount of the consumer surplus generated at the monopolist's price. With these incentives, the monopolist's profit-maximizing solution corresponds to the competitive equilibrium. Harrison and McKee indeed find that this regulatory mechanism restrains monopoly power more effectively compared to an unregulated monopolist and even direct contestability. Besides the payment of a substantial subsidy payment, the Loeb-Magat mechanism also requires that the consumers' demand curve be known by the regulatory agency. To circumvent this informational requirement, Finsinger and Vogelsang (1981) devise a subsidy payment scheme that induces the monopolist to lower his price: their incentive scheme pays a subsidy to the monopolist in period t, $S_t = q_{t-1}(p_{t-1} - p_t), t = 1, 2, \ldots$ The values q_0 and p_0 indicate the pre-regulatory quantity and price. The recursive nature of this formula produces a subsidy in period $t+1$, $S_{t+1} = S_t + q_t(p_t - p_{t+1})$. Finsinger and Vogelsang show that this mechanism produces a monotonically decreasing price sequence that converges to the competitive price. However, the recursive incentive scheme has the property that if a firm errs by raising its price, it is penalized in all future periods.

Experimental tests of this mechanism by Cox and Isaac (1987) reveal that this unforgiving incentive structure typically leads to bankruptcy. They offer a modified version of the Finsinger-

Vogelsang mechanism, one in which the penalty for raising the price is temporary: all ten of their experiments converge quickly to competitive pricing. In this paper, we explore a possible third solution to the monopoly problem, namely, a concentrated buyer side of the market. If effective, buyer countervailing power may be an increasingly relevant solution to monopoly power in light of the worldwide trends away from industrial regulation (i.e., toward deregulation) and increased industrial concentration, resulting primarily from an ongoing horizontal merger wave (see, e.g., Pryor, 2001).

To test for the effectiveness of buyers against monopoly power, we design two treatments in which the monopolist faces either two or four buyers. Our hypothesis is that when the monopolist confronts a small number of buyers either the mere threat of lost sales due to buyer withholding will deter the monopolist from setting the monopoly price (to be referred to as the "cautious monopolist hypothesis"), or actual increased withholding when the buyers are fewer will force the monopolist to make price concessions in order to encourage the buyers to buy more ("buyer empowerment hypothesis'). Based on our results from an initial pair of two-buyer and four-buyer treatments in which the monopolist is informed of the exact number of buyers he faces, we design an additional pair of treatments in which he is uninformed of the number of buyers in the market. The results from our 2x2 experimental design allow us to distinguish between the cautious monopolist and buyer empowerment hypotheses.

3 Experimental Design and Procedures

3.1 Experimental Design

Upon arriving at the experiment, subjects were randomly assigned to the role of buyer or seller. To induce subjects to trade, they were given valuations or costs (in accordance with their role) for a number of units of production and explained that buyers earn the difference between their valuations and the price they pay on each unit they purchase, while the monopolist earns the difference between the price and his cost on each unit sold. The costs of unsold units are not subtracted from the monopolist's profits.

Figures 1a and 1b display the monopolist's marginal cost curve and the buyers' aggregate demand curve for the two-buyer and four-buyer treatments, respectively. The demand and cost curves remain static throughout the 30-round experiment. These curves as well as the individual buyers' demand curves were made common knowledge by providing each subject with a table of costs and values of all subjects and by reading aloud the contents of the table. The market structure in these two treatments was also common knowledge so that the monopolist (and the buyers) knew precisely how many (other) buyers were in the market. The results of these "informed" two-buyer and four-buyer treatments led us to design two additional treatments in which the monopolist was uninformed of the number of buyers in the market.[5]

[insert Figures 1a and 1b here]

We held constant across treatments all variables believed to be important to demand withholding and seller pricing, to the extent possible. In this regard, notice that both treatments share the same ten-unit, competitive price range. The midpoint of the competitive range has been normalized to zero, with all other prices, costs and valuations henceforth expressed as deviations from this competitive price. Moreover, both treatments share the identical monopoly price of 20 units of currency above the competitive price (+0.20).

In addition, individual buyer demand curves are identical for all buyers regardless of treatment. Specifically, every buyer possesses four units of demand, the first unit of which is valued at +0.35, the second and third units have values of +0.20 each, and the fourth unit has a value of +0.05.

The surplus division between buyers and the monopolist is also held fixed across treatments at 6:1 in favor of the monopolist: at the competitive price, each buyer earns +0.80 compared with +4.80 for the monopolist. Ruffle (2000) shows that the surplus inequality at the competitive equilibrium is one important determinant of the degree of buyer withholding and of duopolists' prices. Since individual buyers possess the same demand curve in these experiments, to hold constant the surplus division across treatments requires changing the monopolist's marginal cost curve.[6]

[5] We discuss this second set of "uninformed" treatments in Section 4.

[6] We chose this exact design as a particularly tough test of the impact of buyer concentration. An alternative

Each buyer, again independent of treatment or buyer identity, possesses market power. We adapt to the case of buyers the definition of seller market power applied by the 1984 Department of Justice horizontal merger guidelines. We define unilateral buyer market power as the ability of an individual buyer to deviate profitably from passive price taking.[7] Assuming the seller and all other buyers behave competitively, an individual buyer in our experiments may profit by unilaterally deviating: by withholding two of his four units of demand, the resulting demand curve intersects the monopolist's cost curve at the second-to-last step. At the resultant lower price, the withholding buyer earns more from his two remaining purchases than he does by making all four profitable purchases at the original competitive equilibrium price.[8]

Finally, in both treatments, the buyers face a monopolist. This eliminates possible seller concerns and uncertainty about the simultaneous price choice of additional sellers, thereby allowing us to concentrate on the impact of the buyers' decisions on monopolist pricing without the complication of competition between multiple sellers.

3.2 Experimental Procedures

All experimental sessions were computerized using software programmed in Visual Basic by Moty Fania. Multiple sessions were conducted simultaneously (for instance, five four-buyer sessions at a time or eight two-buyer sessions at a time) to preserve subject anonymity as much as possible.

Each round in the posted-offer market consists of the following sequence of events. The monopolist selects a price and chooses a quantity to make available for sale at that price. The monopolist's

design is to use the marginal cost and demand configurations from the four-buyer treatment for both the two-buyer and four-buyer treatments. That is, we could distribute evenly the 16 units of demand in the four-buyer treatment to two buyers. While this holds constant the market configurations across treatments, it changes two other measures: it reduces the surplus division from 6:1 in the four-buyer treatment to 3:1 in the two-buyer treatment. More significantly, buyers in this two-buyer treatment now possess twice as many units of demand (eight) compared to their counterparts in the four-buyer treatment. We were concerned that the relative abundance of units among buyers in the two-buyer treatment would reduce more than linearly their perceived cost of demand withholding. Thus, if higher levels of withholding (even as a fraction of their available units) and lower prices were indeed observed in the two-buyer treatment, the result could simply be an artifact of the experimental design rather than the reduced number of buyers. These shortcomings led us to choose the experimental design presented here.

[7] In Cournot quantity-choice experiments, Holt (1989) first implemented experimentally the notion of seller unilateral market power.

[8] The impact of demand withholding on this increasing-cost monopolist is still quite modest compared to a monopolist with a decreasing-cost schedule for which withholding would first hit him at his most profitable, lowest-cost units.

price (but not quantity) is displayed to all buyers. The buyers are randomly ordered. Each buyer in turn proceeds to purchase the number of units that he desires. Buyers' purchasing and withholding decisions are made privately so that buyers are unable to observe the number of purchases (and units withheld) of other buyers. In addition, buyers do not learn the number of units sold by the monopolist. These institutional details render it impossible for buyers to coordinate their responses to the monopolist. The period ends when the last buyer has had an opportunity to shop.

This sequence of events is repeated for 30 rounds. At the end of the experiment, subjects were paid a 15 NIS (New Israeli Shekel) showup payment in addition to their experimental earnings. Average seller earnings (including the showup payment) were 121 NIS compared to 67 NIS for the buyers. [9] Sessions lasted between one hour and one hour and thirty minutes.

All sessions were conducted at Ben-Gurion University. Seven two-buyer informed sessions were conducted along with eight four-buyer informed sessions. (Recall that the "informed" sessions indicate that the monopolist knew the precise number of buyers in the market.) All subjects were economics or business majors and had taken at least an introductory course in microeconomics. Participation was restricted to one session only per subject.

4 Results

4.1 Full Information (Informed) Treatments

We begin by addressing the following two questions: 1) Are a small number of buyers able to bring prices down below the monopoly level? 2) Are two buyers able to achieve lower prices than four buyers? The summary statistics presented in Table 1 and Figure 1 answer both questions in the affirmative.

[insert Table 1 here]

Result 1 *Buyers in both treatments achieve prices significantly below the monopoly price. Moreover, prices in the two-buyer treatment are substantially lower than prices in the four-buyer treatment.*

[9] At the time these experiments were conducted 4 NIS was equivalent to approximately $1 U.S.

The first noteworthy observation from these experiments is that buyers in these markets are able to obtain prices significantly below the monopoly price. As shown in Table 1, the mean posted price taken over all periods in all sessions in the two-buyer treatment is -0.07, two units below the lower bound of the competitive tunnel. This same statistic for the four-buyer treatment is 0.12, midway between the competitive and monopoly prices. However, this statistic is largely influenced by the high prices of the early rounds: Figure 2 shows that prices in both treatments converge to the competitive price range.

[insert Figure 2 here]

Figure 2 also reveals the price gap between the two treatments in the early and intermediate periods. Comparing the price distributions of the two treatments on a period-by-period basis, the results of Mann-Whitney non-parametric tests indicate that we can reject the null hypothesis that the two price distributions come from the same underlying population distribution at the 95% confidence level in periods 4, 7, 9, 12, 13, 14 and 16, and at the 90% confidence level in periods 2, 3, 8, 11, 15, 17, 18, 19, 20, 21 and 29.

The question remains why are prices in the two-buyer treatment substantially lower? Result 2 suggests that buyer behavior cannot account for the difference.

Result 2 *Demand withholding per buyer, per period is identical in the two-buyer and four-buyer treatments.*

Thus, the observed difference in prices between the two treatments obtains despite the fact that the number of units withheld per buyer, per period was, surprisingly nearly identical in the two treatments (0.793 in the two-buyer treatment versus 0.766, t-test of means=.412, p=.68, df=1218). Alternatively, the number of sales lost to demand withholding per buyer per period was, again, nearly identical in the two treatments (0.695 versus 0.698, t-test of means=.055, p=.96, df=408).[10]

The observed disparity in buyers' as well as sellers' profits as a function of the treatment follows naturally from the first two results. Lower prices and identical withholding levels explain why

[10] The number of sales lost to withholding and the number of units withheld are closely related measures, but need not be identical in every period. A difference arises when a buyer withholds a unit of demand and a subsequent buyer in the same period purchases this unit so that the seller does not lose any sales to withholding.

individual buyers in the two-buyer treatment earned more than those in the four-buyer treatment, while sellers' profits are greater in the four-buyer treatment.

To provide some measure of just how ineffective our posted-offer monopolists are against a small number of buyers, we calculate the index of monopoly effectiveness, M, given by:

$$M = (\pi_A - \pi_C)/(\pi_M - \pi_C),$$

where π_A is actual profit, π_C is competitive profit, and π_M is monopoly profit.

This measure makes possible a comparison of results across experiments with different design parameters by normalizing the monopolist's actual profit by the difference between the theoretical monopoly and competitive profits. For example, a value of $M = 1$ ($M = 0$) would indicate that the monopoly achieves monopoly (competitive) profits. Based on final period profits, Holt (1995, p. 381) computes this index for six different posted-offer monopoly experiments with different cost structures (decreasing or increasing), buyer types (human or simulated) and regulatory mechanisms. He finds that the index varies from 0.44 (simulated buyers, decreasing costs and a cost-based regulatory mechanism (Harrison, McKee and Rutstrom, 1989)) to 1.0 (human buyers and increasing costs (Smith, 1981)). Like Smith (1981), our experimental design also involves human buyers and increasing marginal costs. However, our index of monopoly effectiveness also based on final period profits lies well below the above-reported range. We find $M = -1.88$ in the two-buyer treatment and $M = 0.005$ in the four-buyer treatment. That is to say, the competitive or even slightly below competitive prices along with some residual withholding lead to profits at or below competitive levels in both our posted-offer monopoly treatments.

4.2 Uninformed Treatments

The finding that buyer behavior as measured by the number of units withheld per buyer was identical in the two treatments suggests that the lower prices observed in the two-buyer treatment cannot be explained by the buyer empowerment hypothesis. There remain two possible explanations. First, although the quantity of demand withholding does not differ in the two treatments, it may nonetheless be the case that buyer withholding is qualitatively different in the two treatments.

For instance, perhaps the buyers in the two-buyer sessions condition their decisions to withhold on different variables (or different levels of those variables) than those in the four-buyer sessions, and these variables are more effective in bringing prices down. Engle-Warnick and Ruffle (2002) explore further this hypothesis: based on buyers' observed withholding decisions, we characterize individual buyer behavior with repeated-game, withholding strategies.

By comparing buyers' inferred withholding strategies across the two treatments we are able to determine if, in fact, there exists a qualitative difference in withholding behavior between the two-buyer and four-buyer sessions.

A second possible explanation for the lower prices achieved in the two-buyer sessions despite no difference in the quantity of demand withheld in the two treatments is that to avoid intense withholding the monopolist prices more cautiously when confronted with only two buyers than when faced with four.

To explore this cautious monopolist hypothesis, we conducted a second pair of two-buyer and four-buyer "uninformed" treatments with identical marginal cost and demand parameters to those employed in the "informed" treatments. The sole difference between the two pairs of treatments is that in the uninformed treatments, the monopolist only was not told how many buyers were in the market; instead, he was told (in both the two-buyer and four-buyer uninformed treatments) that he faced "a small number of buyers, but more than one". Buyers, on the other hand, knew precisely how many other buyers were present along with them in the market. Since the monopolist only is uninformed, the logic underlying the cautious pricing hypothesis is removed, while that underlying the buyer empowerment hypothesis remains intact.

If the cautious pricing hypothesis is correct, then the observed price gap between the two informed treatments should disappear in the uninformed treatments. Result 3 reports this to be the case in the early and intermediate periods.

Result 3 *Prices in the two-buyer, uninformed and four-buyer uninformed sessions both start out above the competitive price range and gradually fall within the competitive range. Prices in these two treatments are very similar from the beginning of the experiments through the middle rounds. However, in the middle rounds, prices begin to diverge significantly. Prices in the four-*

buyer sessions remain within the competitive price range, whereas prices in the two-buyer sessions continue to fall below the competitive equilibrium.

Figure 3 shows that the median prices are very similar through period 14. However, beginning in period 15 prices start to diverge: the median price settles in the competitive range in the 4B treatment, whereas the median price in the 2B treatment falls below the equilibrium price, and continues falling throughout the duration. The results of period-by-period Mann-Whitney tests show that we cannot reject the null hypothesis that the two price distributions are the same at the 5% level in any of the first 16 periods. (We can reject the null at the 10% level in periods 11, 15, and 16.) However, the price divergence that begins in period 15 becomes significant at the 5% level in period 17 and increases in significance throughout the remainder of the experiments.

[insert Figure 3 here]

That initial and intermediate prices are indistinguishable in the 2B and 4B uninformed treatments lends support to the cautious pricing hypothesis, namely, observed price differences in the informed treatments can at least be partially explained by the monopolist pricing more cautiously against two buyers than against four.[11] In an effort to determine the price divergence between the two treatments beginning in the middle rounds, we turn to withholding behavior in these two treatments.

Result 4 *The overall aggregate quantities of demand withholding and sales lost to demand withholding are identical in the uninformed two-buyer and four-buyer treatments. Furthermore, the distributions over time of these withholding measures are not significantly different for the vast majority of rounds of play. Only in the late rounds do marginally significant differences between the two treatments appear.*

[11] It is worth noting that the disappearance of the early price gap between the two uninformed treatments allows us to reject a design-related explanation for the observed price gap in the informed treatments: in order to maintain a constant monopolist-to-buyer profit ratio, the monopolist's costs have been set considerably lower in the two-buyer treatment than in the four-buyer treatment. One might argue that, psychologically, this design feature offers the monopolist in the two-buyer treatment a "comfort zone" below the competitive price that doesn't exist in the four-buyer treatment. The finding that the price gap in the uninformed treatments disappears, even though the demand and cost configurations were common knowledge in all treatments, allows us to reject this explanation. We thank Charlie Holt and Todd Kaplan for raising this issue.

The number of units of demand withheld per buyer, per period is 0.821 in the 2B, uninformed treatment compared to 0.824 units in the 4B, uninformed treatment (Wilcoxon-Mann-Whitney z=-0.167, p-value=.87 where a buyer's average withholding over the entire session is treated as an independent observation). Similarly, the number of sales lost to demand withholding per buyer, per period is 0.744 units in the 2B treatment compared to 0.774 in the 4B treatment (exact p-value from Wilcoxon-Mann-Whitney nonparametric test=0.35).[12]

Moreover, an examination of the distribution of demand withholding over the 30 periods by treatment reveals strong similarities between the treatments. Figure 4 plots the average per period sales lost to withholding for the uninformed two-buyer (2B) and four-buyer (4B) treatments. Sales lost to withholding start out at low levels in both treatments (0.2 units on average). Withholding quickly intensifies and remains at relatively high levels beyond round 20 when, in both treatments, withholding begins to decay. Results from the Mann-Whitney test reveal that only in period 22 are the distributions of average sales lost to withholding significantly different at the 5% level. (In periods 21, 23, 25 and 27, the difference is significant at the 10% level.)[13] Thus, the marginally significant differences in withholding between the two uninformed treatments that appears in the late periods cannot explain the price gap between these two treatments that emerges already in period 17.[14]

[insert Figure 4 here]

Taken together, Results 3 and 4 support the cautious pricing hypothesis. That is to say, the observed difference in initial pricing in the informed treatments is due to the monopolist pricing more tentatively when confronted with only two buyers. When the number of buyers is unknown to the monopolist, Result 3 shows that the initial price differential disappears. Had buyers in the

[12] Even if we ignore the lack of independence between periods and treat each buyer's withholding decision in each period as an observation, a t-test of means reveals no significant difference in either the number of units withheld per buyer, per period (t-stat=0.043, p-value=0.96, df=1798) or the number of sales lost to withholding per buyer, per period (t-stat=0.384, p=.70, df=448).

[13] Because buyers' withholding decisions are independent of one another, we are able to increase the sample sizes and therefore the statistical power of these Mann-Whitney tests by treating the observed number of units withheld by each buyer as an independent observation and comparing these distributions across treatments. Doing so leads to the identical qualitative results reported above.

[14] See Engle-Warnick and Ruffle (2002) for differences in the inferred withholding strategies of buyers across these two treatments as a possible explanation for the observed price divergence in the middle rounds.

2B treatment withheld less than those in the 4B treatment, for instance, the monopolist's initial pricing behavior could perhaps be explained, in part, by a response to the observed withholding behavior in the two treatments. This confound however is not present in our data. The finding that the quantitative withholding behavior is identical in the two treatments (Result 4) therefore strengthens our conclusion that the lower pricing in the two-buyer informed treatment follows simply from the monopolist's more cautious reaction to two buyers.

To gain additional insights into the similarities and differences between the experimental treatments, we estimated a dynamic panel model. We report the results here, with the caveat that our sample size is small in terms of both the number of monopolists and the number of rounds of play in each experiment. It is well known that least squares coefficient estimates are seriously biased in this setting. So, we report results from the one-step estimator of Anderson and Hsiao (1980), which uses differences of lagged variables as instruments for the endogenous variable.

The regression model is:

$$y_{it} = B_1 y_{it-1} + B_2 x_{it-1} + B_3 d + n_i + v_{it},$$

where y_{it} and y_{it-1} represent the price that monopolist i sets at time t and $t-1$ respectively; x_{it-1} represents the number of sales lost to withholding at time $t-1$; d is a dummy variable that will represent four-buyer sessions in one specification and full information in another; ni is a time invariant individual effect, and vit is seller i's error at time t. The model is first differenced, removing the individual effect, and first, second, and third lags of the first differences of x as well as second and third lags of the first differences of y_{it} are used as instruments for y_{it-1}. (The results were robust to many different choices of instruments.) The dummy variable is added after differencing, thus if significant it represents a difference in pricing trends, not levels. This yields the following specification:

$$Dy_{it} = B_1 Dy_{it-1} + B_2 Dx_{it-1} + B_3 d + Dv_{it}.$$

Our small sample size restricts the number of feasible specifications. For example, in comparing behavior between the two-buyer and four-buyer sessions, we are attempting to distinguish two sets

of observations, each containing only 15 different individuals. The limited availability of instruments also restricts the number of specifications: we require at least as many instruments as regressors, and have at our disposal only lagged values of the regressors. Therefore we investigate only two particular regression specifications. For the regressions we used the dynamic panel data module in PcGive Professional (Hendry and Doornik, 2001).

Table 2 reports the coefficient estimates, their standard errors, t-stats and p-values for the first regression specification, in which the dummy variable represents 4-buyer sessions.

[insert Table 2 here]

A Wald test finds both the regressors on lagged price and units lost to withholding significant at better than the 1% level, and on the four-buyer dummy variable at the 6.6% level. The Sargan tests accepts the lack of serial correlation in the errors, and AR(1) and AR(2) specification tests are passed as well. The fit of the regression appears to be good: residual sum of squared errors is 306.09 and the total sum of squared errors is 299.7.

The second regression, in which the dummy variable represents full information, passes the same tests of specification with the results displayed in Table 3 below.

[insert Table 3 here]

We interpret the positive but small coefficient on the lagged dependent variable in both regressions as rather small inertia in the pricing decision from period to period. The negative and significant sign on the previous period's lost sales to withholding indicates that the monopolists were influenced by the buyers' demand withholding decisions in a logical manner: an increase in sales lost to withholding on average results in a lower price in the next period. The results in Table 2 show that there is a small but significant difference between pricing in the two-buyer and four-buyer sessions. Since the dummy variable is added after differencing, the four-buyer dummy result is interpreted as evidence that the trend in pricing from period t to $t-1$ is more positive in the four-buyer sessions than in the two-buyer sessions, everything else in the model held constant. Table 3 reveals no corresponding significant difference between the informational treatments.

These regressions are consistent with the nonparametric tests we presented earlier, and shed a ray of light on the pricing decisions of the monopolists. Not only are the price levels higher in the four-buyer session than the two-buyer ones, but the trend in price setting is more positive in the four-buyer sessions as well.

5 Discussion

Contestability and regulation are two well-known solutions to the monopoly problem. Both have received much attention in the theoretical literature (see Baumol, 1982, and Laffont and Tirole, 1993, for surveys) and considerable support from laboratory experiments (see Section 2). This paper provides strong experimental support for a third solution to the monopoly problem, first introduced by Galbraith (1952). A concentrated buyer side of the market has been shown here to eliminate monopoly power. Two recent trends attest to the growing relative relevance of this solution.

First, beginning with the Reagan-Thatcher era, industry regulation has steadily fallen out of favor as a tool to limit market power. Rather, deregulation has been the worldwide trend. Since the late 1970s, the airlines, railway, trucking, intercity bus, telecommunications, cable TV, public utilities, petroleum, brokerage and banking industries have all undergone deregulation in the U.S. and, in some instances, worldwide as well.[15] Second, fueled primarily by an ongoing horizontal merger wave, industrial concentration has increased over the past two decades and is expected to continue to increase over at least the decade to come (Pryor, 2001). According to our results, rising industrial concentration needn't necessarily be a cause for concern: one must probe on an industry-by-industry basis whether a rise in concentration constitutes an increase in the original or the countervailing market power.

In these posted-offer market experiments, the competitive and below competitive prices achieved by the buyers have however come at the expense of reduced market efficiency. Through demand withholding (the only strategic action at the disposal of posted-offer buyers), buyers are able to

[15] Winston (1993) offers an overview of the U.S. economic deregulation experience.

force prices down. Similar price levels in more symmetric market institutions such as the double-auction or pit market, the bilateral negotiation institution (Cason et al., 2002) or the multilateral negotiation institution (Thomas and Wilson, 2002) needn't compromise efficiency. The possibility of repeated price negotiations in these market institutions can generate lower prices. It remains to be seen whether such prices can indeed be obtained in these institutions. On the one hand, buyers' enlarged strategy space associated with these market mechanisms favors lower prices compared to the posted-offer market. On the other hand, the ease with which posted-offer buyers can commit to not buying in a given period and the costliness of this action to the posted-offer monopolist encourages him to slash his price in the next period. In real-time double auction or pit markets, for instance, patience or, at best, a modest price reduction may be the monopolist's response to a buyer's refusal to accept his ask price.

Regardless, this paper complements existing research that finds bargaining strength to be a possible source of countervailing power (Snyder, 1998, and Ellison and Snyder, 2001): Our results suggest that the mere presence of a small number of buyers and the threat they pose to sellers may be sufficient to bring about prices significantly below the monopoly price.

6 Conclusion

We have designed a series of experiments to examine the impact of buyer concentration on seller pricing. On the one hand, we have presented buyers with an onerous task: buyers face an increasing-cost monopolist, are unable to collude or even signal their actions to others and are limited to accepting or rejecting posted prices. On the other hand, in an effort to induce at least some buyers to reject profitable purchases, we designed our experiments to include a substantial surplus inequality between the monopolist and individual buyers at the monopolist and the competitive prices. Indeed, we observe substantial variation among buyers in their withholding patterns. However, in the aggregate, buyers withhold demand to the same extent in the two-buyer and four-buyer treatments.

Notwithstanding, we find that two buyers achieve significantly lower prices than four buyers. By manipulating the monopolist's information, we are able to identify the source of the price gap.

When the monopolist (but not the buyers) is uninformed about the number of buyers in the market, the price gap between the two-buyer and four-buyer treatments disappears. As a result, we are able to attribute lower pricing in the informed two-buyer treatment to the monopolist's cautious or conservative pricing for fear of provoking costly withholding. Put differently, the monopolist appears to place a higher subjective probability on buyers who withhold demand above a given price threshold in the informed two-buyer treatment than the informed four-buyer one. Therefore, to avoid triggering this price threshold in the two-buyer sessions, he offers a lower price. This observation provides the basis for a behavioral theory of buyer countervailing power as well as a motivation for exploring the actual strategies employed by buyers in this environment.

More generally, our results establish that even an unregulated monopolist that faces no possible threat of entry may price competitively. This finding contributes to our understanding of solutions to the problem of monopoly, particularly at a time when regulation has fallen out of favor as a remedy to market power and measures of industrial concentration are on the rise. Similar to the contestable markets hypothesis, a particular market structure is required for buyer countervailing power to be effective; the required market structure cannot be chosen or imposed. In this sense, just as the theory of contestable markets was intended as a theoretical ideal (Baumol, 1982, p. 3), we propose buyer concentration as an analogous extension of the domain of competitive pricing.

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Posted-Offer Market Results by Treatment

Treatment	Mean Posted Price	Mean Efficiency	No. of Sales Lost per Buyer-period	No. of Units Withheld per Buyer-period	Mean Buyer Profit per Period	Mean Monopolist Profit per Period
Two-buyer	-0.07	0.764	0.695	0.793	0.840	3.21
Four-buyer	0.12	0.755	0.698	0.766	0.475	4.14

Table 1: Summary Statistics for the Two-Buyer and Four-Buyer Treatments

Dependent Variable: y_{it}- y_{it-1}

Variable	Description	Coefficient	Std.Error	t-stat	p-value
Dy_{it-1}	Price	.0213	.0071	3.03	.003
Dx_{it-1}	Units Withheld	-.0042	.0016	-2.63	.009
d	4-Buyer Dummy	.0032	.0017	1.84	.066
Constant		-.0054	.0016	-3.39	.001

Table 2: Dynamic Panel Regression Estimate with Four-Buyer Session Dummy

Dependent Variable: y_{it}- y_{it-1}

Variable	Description	Coefficient	Std.Error	t-stat	p-value
Dy_{it-1}	Price	.0213	.0071	3.02	.003
Dx_{it-1}	Units Withheld	-.0042	.0016	-2.63	.009
d	Full-Info. Dummy	.0025	.0018	1.43	.153
Constant		-.0025	.0011	-2.34	.020

Table 3: Dynamic Panel Regression Estimates with Information Dummy

Demand and Cost Configurations for the Two-Buyer and Four-Buyer Treatments

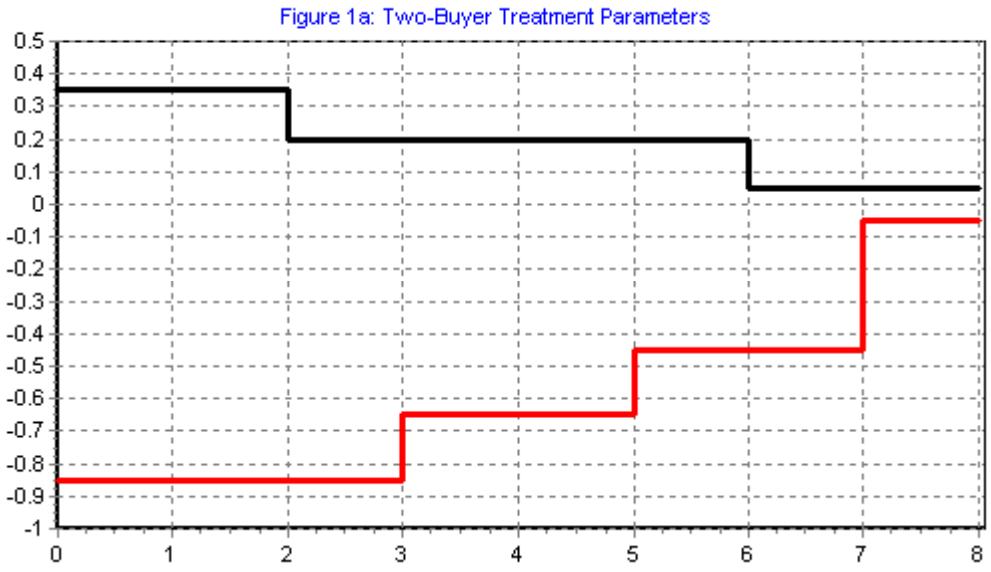

Figure 1a: The monopolist's marginal cost and the buyers' demand curve in the two-buyer treatment. All costs and valuations are expressed as deviations from the midpoint of the competitive price range.

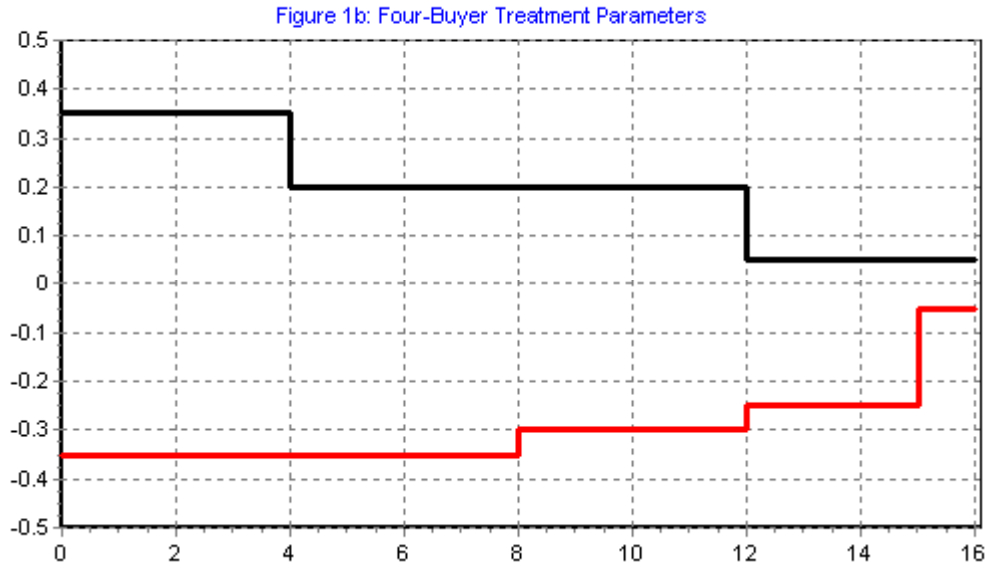

Figure 1b: The monopolist's marginal cost and the buyers' demand curve in the four-buyer treatment.

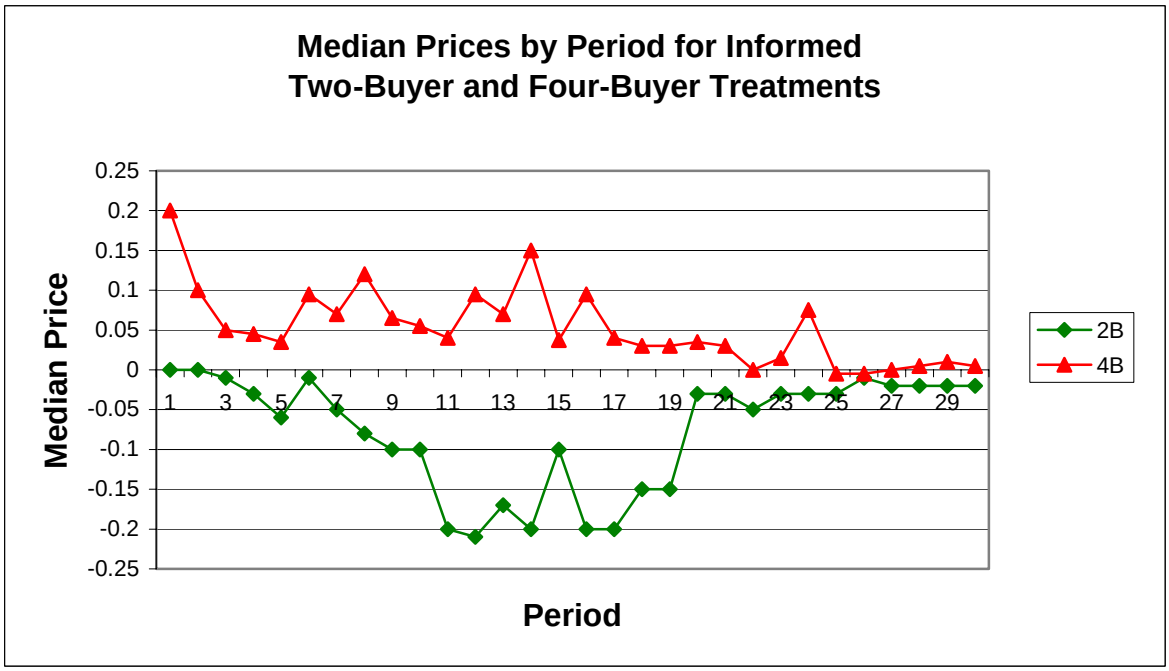

Figure 2: Median price series for the two treatments in which the monopolist knew whether he faced two buyers (2B) or four buyers (4B).

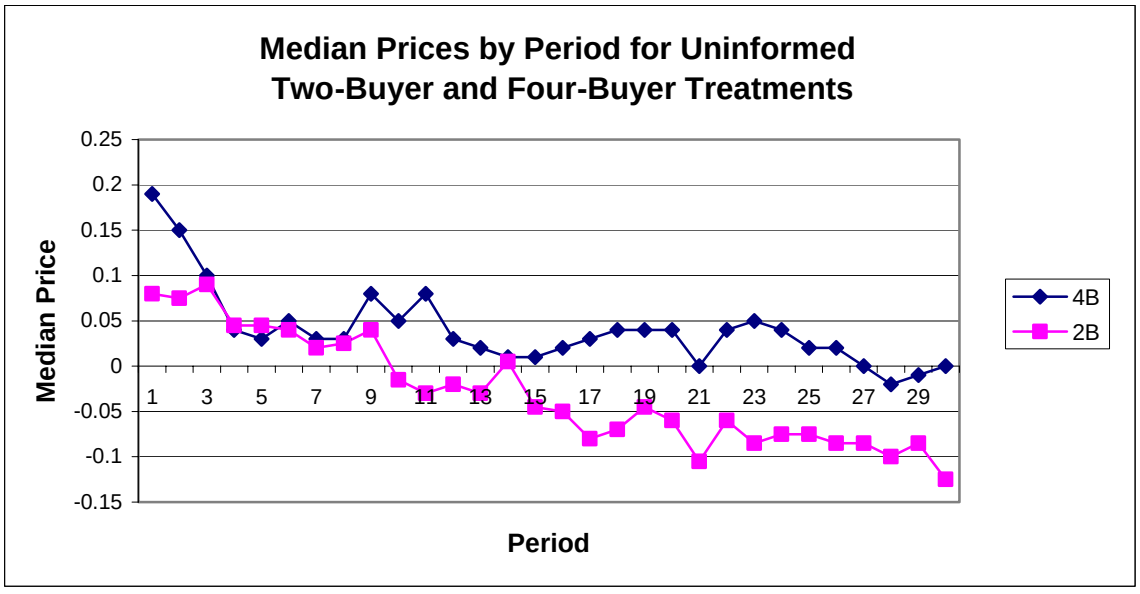

Figure 3: Median price series for the two-buyer (2B) and four-buyer (4B) treatments in which the monopolist did not know how many buyers he faced.

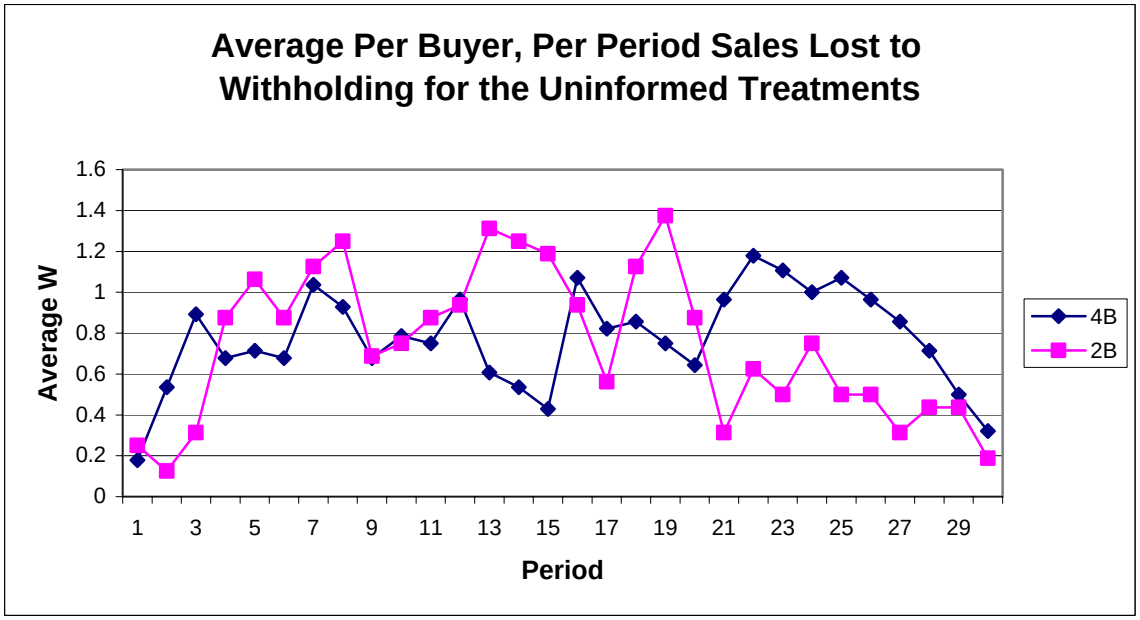

Figure 4: Times series plots for the per buyer, per period sales lost to demand withholding averaged over all of the sessions in each of the two uninformed treatments in which the monopolist did not know how many buyers he faced.