Fixed Cost Magnitude, Fixed Cost Reporting Format, and Competitive Pricing Decisions: Some Experimental Evidence*

STEVE BUCHHEIT, *Texas Tech University*

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Abstract

Although neoclassical economic theory predicts that fixed cost magnitude and fixed cost reporting format will not influence short-term pricing decisions, these factors systematically affected pricing decisions in a duopoly experiment. Increasing fixed cost magnitude (a pure sunk cost in this study) across experimental conditions caused participants to first lower, then raise competitive prices. Consistent with the psychological phenomenon of loss aversion, this change in pricing behavior reduced the frequency of reported losses. This study further reveals that the accounting format for reporting fixed costs influenced pricing behavior. Specifically, participants receiving *capacity costing* feedback reports established increasingly lower selling prices relative to the prices established by participants receiving *contribution margin* feedback reports. Given that a very simple cosmetic reporting manipulation produced increasingly significant competitive pricing differences in a market setting, this study provides evidence that functional fixation is not necessarily eliminated by market forces.

Key Words: Cost-based pricing; Functional fixation; Loss aversion; Sunk cost.

Detailed Abstract

This study investigates two related aspects of the association between fixed costs and competitive pricing behavior. First, does the format in which fixed costs are reported in accounting records affect competitive pricing decisions? Second, does the financial amount (i.e., magnitude) of fixed costs influence competitive pricing behavior? These issues are investigated in a Bertrand-Edgeworth market with no pure strategy equilibrium. The market consists of two price-setting rivals who produce at constant marginal cost up to a capacity constraint. In Bertrand-Edgeworth duopolies, the low-priced seller typically (1) uses all available production capacity, but (2) sells at a relatively low unit margin. In contrast, the high-priced seller typically (1) has unused production capacity, but (2) sells at a relatively high unit margin.

Regarding the first research question, much accounting research examines whether individuals fixate on accounting or whether they can "see through" alternative reporting formats. In general, past research results suggest that "functional fixation" can occur in individual settings (e.g., the format of

accounting information can affect pricing decisions), but not in market settings. The absence of a pure-strategy equilibrium in a Bertrand-Edgeworth market setting potentially allows cost reporting format to affect pricing behavior, as it has been shown to do in individual settings, because a wide range of competitive pricing behavior is "rational" when no pure-strategy equilibrium exists. Loosely speaking, the market in this study can be thought of as one in which no "correct price" exists.

Unlike prior market studies, this study offers evidence that the functional fixation observed in individual settings can continue at the market level. Specifically, research participants who received *capacity costing* feedback reports established increasingly lower competitive prices relative to participants who received *contribution margin* feedback reports. From an information economics perspective, both report formats contained identical information in this study; however, competitive pricing results and participant survey responses support the hypothesis that, relative to *contribution margin* reports, *capacity costing* reports encourage a "low price, high volume" pricing strategy. This simple cosmetic reporting manipulation produced pricing differences that increased (rather than being driven away) over 30 repeated rounds of market competition.

Regarding the second research question, both accounting and economic research examines the influence of fixed costs on pricing decisions. A long-running controversy regarding this issue can be summarized as follows. On one hand, survey evidence shows that firms use full cost information, which includes fixed and sunk costs, to set prices. On the other hand, incorporating any sunk costs into a pricing decision violates economists' prescription for profit maximization: set marginal revenue equal to marginal cost. This controversy is complex and multidimensional, largely because it includes issues related to the influence that fixed *resources* and fixed *costs* have on pricing decisions.

By using an experimental economics approach, the current study holds fixed resources (and other confounding factors) constant in order to investigate the possibility that fixed costs, which are always sunk costs in this study, can influence competitive pricing decisions. Intuitively, increasing fixed cost magnitude can change a profit into a loss; therefore, the psychological concept of *loss aversion* suggests that fixed cost magnitude may influence short-term pricing decisions. However, the Bertrand-Edgeworth setting allows testing of a more subtle relationship. Specifically, this study posits that *loss aversion* will cause research participants to first lower, then raise competitive prices as fixed cost magnitude increases across experimental conditions because participants can reduce the frequency of reported losses through an inflection in competitive pricing levels.

Contrary to marginal pricing theory, results from this study indicate that fixed cost magnitude significantly influences competitive pricing behavior. As relatively low fixed cost levels increased across experimental conditions, competitive prices decreased. Results suggest that participants sacrificed high profit margins in order to reduce the frequency of reported losses. However, as fixed costs increased to a level at which price reductions no longer mitigated the frequency of reported losses, participants reversed their price-cutting behavior and raised prices. This U-shaped pattern of prices is robust over later rounds of the experiment.

1. Introduction

This study investigates two related aspects of the association between fixed costs and competitive pricing behavior. First, does the format in which fixed costs are reported in accounting records affect competitive pricing decisions? Second, does the financial amount (i.e., magnitude) of fixed costs influence competitive pricing behavior? New light is shed on these issues by exploring them in a competitive environment with no pure strategy equilibrium. Specifically, these issues are investigated in a Bertrand-Edgeworth market setting. The market consists of two price-setting rivals who produce at constant marginal cost up to a capacity constraint. In Bertrand-Edgeworth duopolies, the low-priced seller typically (1) uses all available production capacity, but (2) sells at a relatively low unit margin. In contrast, the high-priced seller typically (1) has unused production capacity, but (2) sells at a relatively high unit margin. I discuss the importance that the experimental setting has on each research question below.

Both managerial and financial accounting research examine whether individuals fixate on accounting or whether they can "see through" alternative reporting formats (Luft and Shields 2001). Recent research in financial accounting provides evidence that even experienced financial statement users' pricing decisions are subject to "functional fixation" in individual settings (Hopkins 1996, Hirst and Hopkins 1998, Hopkins, Houston, and Peters 2000). Similarly, experimental research in managerial accounting has extensively studied how cost system format (e.g., absorption vs. variable costing) affects pricing decisions. Evidence from individual decision-making settings suggests that systematically higher price offers occur under absorption costing relative to variable costing (see Sprinkle 2003 for a review). In contrast, Kachelmeier (1996) and Waller, Shapiro, and Sevcik (1999) find that accounting format change does not affect pricing outcomes in experimental market settings.

This paper tests the hypothesis that accounting report format can influence competitive pricing decisions in a certain type of market setting. Specifically, the absence of a pure-strategy equilibrium in a Bertrand-Edgeworth market setting potentially allows cost reporting format to affect pricing behavior, as it has been shown to do in individual settings, because a wide range of competitive pricing behavior is "rational" when no pure-strategy equilibrium exists (Kruse, Rassenti, Reynolds, and Smith 1994). Loosely speaking, the market in this study can be thought of as one in which no “correct price” exists. To the extent that this type of setting is more like naturally occurring markets relative to the market settings examined by Waller et al. (1999) and Kachelmeier (1996), this study offers evidence that the functional fixation observed in individual settings may continue at the market level (see Libby, Bloomfield, and Nelson 2002; 789).

This study also investigates a second and related issue: does the magnitude of fixed costs influence competitive pricing behavior? Investigating this question speaks to the long-running controversy regarding the influence that fixed costs have on pricing decisions (see Hall and Hitch 1939 and Lucas 1999). The controversy can be summarized as follows. On one hand, survey evidence shows that firms use full cost information, which includes fixed and sunk costs, to set prices (Govindarajan and Anthony 1983; Drury, Braund, Osborne, and Tayles 1993; Shim and Sudit 1995). On the other hand, incorporating any sunk costs into a pricing decision violates economists’ prescription for profit maximization: set marginal revenue equal to marginal cost. This controversy is complex and multidimensional, largely because it includes issues related to the influence that fixed *resources* and fixed *costs* have on pricing decisions.[1]

Experimental markets can hold fixed resources (and other confounding factors) constant in order to investigate the possibility that fixed costs, which are always sunk costs in this study, can influence competitive pricing decisions. By systematically manipulating fixed cost magnitude, this study investigates whether sunk costs influence competitive pricing decisions (consistent with the empirical use of cost-based pricing) or whether sunk costs have no influence on competitive pricing decisions (consistent with marginal pricing theory). Specifically, this study focuses on the possibility that, because increasing fixed cost magnitude can change a profit into a loss, fixed cost magnitude can influence short-term pricing decisions (Tversky and Kahneman 1991).

Like this study, Kachelmeier (1996) manipulates sunk costs in a market setting and his manipulation caused sellers to experience both reported gains and losses. He finds that sunk costs do not influence competitive pricing outcomes. However, relative to the current Bertrand-Edgeworth setting, the market discipline in Kachelmeier’s double-auction market is extremely forceful, potentially overwhelming any systematic effect that sunk costs might have on competitive prices.[2]

Contrary to marginal pricing theory, results from this study indicate that fixed cost magnitude significantly influences competitive pricing behavior. As relatively low fixed cost levels increased across experimental conditions, competitive prices decreased. Results suggest that participants sacrificed high profit margins in order to reduce the frequency of reported losses. However, as fixed costs increased to a level at which price reductions no longer mitigated the frequency of reported losses, participants reversed their price-cutting behavior and raised prices.

Regarding the cost reporting manipulation, I report findings contrary to Kachelmeier (1996) and Waller et al. (1999). My cosmetic reporting manipulation has a marginally significant effect on pricing outcomes over the entire experiment (30 rounds); however, this effect becomes *more* significant during later rounds of the study (after participants experience repeated accounting feedback). To my knowledge, this study offers the first evidence that a cosmetic accounting format change can cause sustainable pricing differences (i.e., increasingly significant through 30 rounds) in a competitive, compensated market setting.

The remainder of this paper is organized as follows. The next section presents the experimental setting. The following section sets forth the motivation and hypotheses. Section 4 presents experimental results, and the final section summarizes contributions and limitations.

2. Experiment

Basic Incentive

Because all fixed costs are sunk in this experiment, the basic incentive is to maximize profit margin (revenue minus variable cost). Relatively high prices yield high unit margins, but risk low sales volume. Relatively low prices decrease unit margins, but increase the chance of high sales volume. Price determination is the only decision variable.

Participants and Task

One hundred and forty-four volunteer student participants were recruited from graduate business courses. On average, participants had 6.6 years of work experience. Participants received profit-maximizing incentives in a duopolistic competition that was a modified version of the Bertrand-Edgeworth price-setting competition used in Kruse et al. (1994).

Participants assumed the role of a "widget seller," where widgets were a homogenous, perishable good.[3] Each widget seller had the fixed capacity to produce 40 widgets per round. Sellers incurred a fixed rent cost every round and a variable cost of $5 for every widget sold. The potential market demand was 100 widgets per round. The buyer side of the market consisted of 100 computer-simulated buyers, each potentially willing to purchase one widget per round. The 100 buyers each had different reservation prices ranging from a high of $500 to a low of $5, with buyer reservation prices in $5 increments. Buyers were ordered in six possible queues, with the specific buyer order randomly determined at the start of each market period.[4]

The seller who established the highest price could sell widgets to all residual buyers in the queue (i.e. buyers who remained in the queue after the low-priced seller sold all 40 of her widgets). If high-valued buyers appeared early in the demand queue, these buyers would purchase a widget from the low-priced seller. This situation created a relatively *unfavorable* outcome for the high-priced seller because that seller's low-priced opponent would have sold to "the good customers" (i.e., buyers with relatively high reservation prices). In contrast, high-valued buyers appearing late in the queue presented a relatively *favorable* situation for the high-priced seller because any residual buyers would have a high reservation price for widgets. Figure 1 illustrates how the randomly determined buyer order can affect the high-priced seller.

Insert Figure 1 about here

A question-and-answer period followed the experimental instructions. During this time, the experiment administrator clarified any aspect of the game that was unclear to participants.[5] The compensated portion of the study followed the question-and-answer session. Each compensated round of the game had the following structure. First, competitors selected their widget prices. Second, a die was rolled to determine demand realization (i.e., the six possible buyer queues). Next, the administrator entered prices and realized demand into a computer. Finally, the computer produced a feedback report for participants. Figure 2 provides example reports for each type of cost reporting format used in this study.

Insert Figure 2 about here

Experimental Administration and Manipulations

Participants were randomly assigned to one of twelve cells in a 6×2 between-subjects design that manipulated fixed cost magnitude (six levels) and cost reporting format (*contribution margin* format or *capacity costing* format). The experiment was administered in 36 separate sessions, each containing four participants. Although each pricing competition occurred between only two participants, each experimental session contained a group of four participants. Because each session had its own random demand, testing a group of four participants permits the direct comparison of the cost reporting manipulation. As such, each experimental session simultaneously tested two pricing competitions - one competition between participants who each received a *contribution margin* report and one competition between participants who each received a *capacity costing* report.[6] Thus, the 36 sessions enabled six bilateral negotiation pairs per cell.

The six fixed cost magnitudes ($1,000 increments) ranged from a low fixed cost of $2,000 to a high fixed cost of $7,000. Fixed resources had constant capacity constraints (40 units for all participants), constant cost (within each session), and lasted only one period. Although unknown to participants in advance, all experimental sessions lasted 30 rounds.[7] As such, 24 subjects experienced fixed costs of $2,000 during each round of a 30-round experiment, 24 experienced fixed costs of $3,000 during each round of a 30-round experiment, etc. On average, participants earned US $19.35 during the 90-minute experiment, with individual payments ranging from US $8 to US $35.[8]

3. Hypotheses

The Influence of Fixed Cost Magnitude

By contrasting economic theory with psychological theory, I make two directional predictions regarding the influence that sunk costs (i.e., fixed cost magnitude) will have on pricing decisions. Specifically, extant economic theory predicts that sunk costs *will not* influence short-term pricing behavior while psychological theory suggests that sunk costs *may* systematically influence short-term pricing behavior. As discussed below, loss aversion suggests that as fixed cost magnitude increases, experimental prices will first fall and then rise. Theory from each discipline is discussed in turn.

It is well known that Bertrand-Edgeworth settings generally have no pure strategy equilibrium (Allen and Hellwig 1993). Likely for this reason, there are numerous equilibrium and disequilibrium models that attempt to explain seller-pricing behavior and, as such, "accurate" price predictions are controversial.[9] While a precise mixed-strategy equilibrium is computationally intractable in the current setting[10], an offsetting advantage is that a wide range of pricing behavior is "rational". Based on the parameters of this study, the range of rational prices includes all prices from $145 to $245.[11] In equilibrium, firms are predicted to "mix strategies" by selecting prices from this range in accordance with an equilibrium-derived probability distribution. Knowing the precise equilibrium is unnecessary given this study's directional research hypotheses; however, it is necessary that sunk costs have no predicted influence on competitive pricing decisions (consistent with marginal pricing theory). This is a feature that, as far as I am aware, all models attempting to explain Bertrand-Edgeworth pricing behavior share.[12]

Although extant economic theory predicts that sunk costs will not affect competitive pricing decisions, the psychological theory of *loss aversion* (Tversky and Kahneman's 1991) provides a foundation for fixed cost magnitude to systematically influence pricing behavior in a Bertrand-Edgeworth environment. The basic argument is that changes to fixed cost magnitude change the reported frequency of profit and loss. Consistent with loss aversion, decision makers may change their prices in order to reduce the frequency of reported losses.[13]

An example based on the parameters of this study and the economic rational range of prices, [$145, $245] (see footnote 11), illustrates why increasing fixed cost magnitude may encourage decision makers to reduce prices in order to reduce the frequency of reported losses. Specifically, imagine a relatively low price competition (LOWPRICE) where firms set prices of $145 and $146 and a relatively high price competition (HIGHPRICE) where firms set prices of $244 and $245. Because HIGHPRICE is closer to the duopoly price, total expected profit is $2,352 higher in HIGHPRICE compared to LOWPRICE. However, the division of total profits is more imbalanced (in favor of the low-priced competitor) in HIGHPRICE relative to LOWPRICE. As illustrated below, this imbalance potentially admits a role for fixed cost magnitude to influence competitive pricing levels.

If fixed costs are $2,000 per period (the lowest level of fixed cost magnitude in this study), then it is not possible for either firm to incur a reported loss in HIGHPRICE or LOWPRICE. However, if fixed cost magnitude increases to $3,000, then the firm charging $245 (e.g. the high-priced firm) in HIGHPRICE incurs a $120 reported loss *with certainty*. In contrast, it remains impossible for either firm to incur a reported loss in LOWPRICE.

Loss aversion predicts that decision makers wish to avoid reference-dependent losses (Tversky and Kahneman 1991). That is, decision makers find losses of amount *$X* more aversive than gains of amount *$X* are attractive. Fixed cost magnitude monotonically affects reported breakeven points, a natural reference point for business decision makers to use when establishing a reference point for gains and losses (Burgsthaler and Dichev 1997, Hayn 1995). Critically, changing fixed cost magnitude does not affect the economic incentives in the preceding example – regardless of fixed cost magnitude, total expected profit is $2,352 higher in HIGHPRICE compared to LOWPRICE. Although the economic incentives are not affected by an increase in fixed cost magnitude, loss aversion suggests that a price reducing strategy becomes *more likely* once fixed costs are high enough to turn reported gains into losses. The following research hypothesis, stated in alternative form, presents this possibility:

> HYPOTHESIS 1(a): *Ceteris paribus, in capacity constrained duopoly settings, as relatively low levels of fixed costs are increased, sellers will establish relatively low prices in an effort to reduce the frequency of reported losses.*

Interestingly, the preceding hypothesis contradicts the standard cost-based pricing practice of applying a constant markup to the accounting cost base (Garrison and Noreen 2003). When fixed costs increase, reported costs increase; therefore, selling prices should *increase* according to the standard cost-based pricing formula. Thus, the cost-based pricing formula provides a basic rationale for why increasing fixed cost magnitude may increase competitive prices. Simply put, decision makers may need to raise prices to “cover costs” when fixed cost magnitude increases.

To illustrate using the previous example, assume that fixed costs are now $5,000 per period. In both HIGHPRICE and LOWPRICE, the high-priced firms (firms charging $245 and $146, respectively) incur a reported loss with certainty while the low-priced firms earn a reported profit with certainty.

However, if fixed cost magnitude increases to $6,000, then neither firm in LOWPRICE can earn a reported profit. That is, neither firm in LOWPRICE is charging a price sufficient to cover costs. In contrast, the firm charging $244 (i.e., the low-priced firm) in HIGHPRICE earns a reported profit.

As this example shows, increasing competitive prices can reduce the frequency of reported losses if fixed cost magnitude is relatively high. As in Hypothesis 1(a), the economic incentive is unaffected by fixed cost magnitude (total expected profit is $2,352 higher in HIGHPRICE compared to LOWPRICE); however, the contention is that a price increasing strategy is *more likely* to occur if fixed costs are relatively high because sellers can reduce the frequency of reported losses by establishing relatively high competitive prices. Consequently, the following research hypothesis is stated in the alternative form:

> HYPOTHESIS 1(b): *Ceteris paribus, in capacity constrained duopoly settings, as fixed costs are increased to relatively high levels, sellers will establish higher prices in an effort to reduce the frequency of reported losses.*

In total Hypothesis 1 predicts that prices will first fall and then rise in response to increasing fixed cost magnitude. However, no prediction is offered as to when the inflection point will occur.[14] Rather, the parameters for fixed cost magnitude were selected such that decreasing *and* increasing relative prices might be observed. Specifically, the lowest level of fixed cost magnitude ($2,000) presents a small risk for either price-setting competitor to incur a reported loss during any experimental round (i.e., "covering" $2,000 worth of fixed costs is easy). In contrast, the highest level of fixed cost magnitude ($7,000) ensures that at least one price-setting competitor will incur a reported loss during each experimental round (i.e., both sellers cannot “cover” their fixed costs).

The Influence of Fixed Cost Reporting Format

The second issue investigated is whether *accounting reporting format* affects the relationship between fixed costs and competitive pricing. As noted previously, prior studies support the proposition that higher *reported* unit costs lead to higher price offers in individual settings; however, no sustainable (i.e., beyond one period) effect of cost-based pricing has been found in an interactive market setting (Waller et al. 1999). Although Waller et al. (1999) find that market discipline eliminates reporting format’s effect on price determination, they suggest that future research investigate the effects of alternative accounting systems on disequilibrium behavior.[15]

The cost reporting manipulations are: (1) a standard contribution margin format (which separates fixed and variable costs) and (2) a capacity costing format (which includes a proportionate amount of fixed costs into each output unit).[16] Although Radhakrishnan and Srinidhi (1997) argue that capacity costing can improve pricing decisions, Buchheit (2003) presents evidence that capacity costing reports can reduce profitability because of the explicit "unused capacity cost" signal inherent to this reporting format. Specifically, Buchheit finds that decision makers who receive capacity costing reports in a growth setting curtail capacity resource investment in an effort to minimize unused capacity costs. In a non-market individual decision setting, the cost savings from capacity reduction were more than offset by the opportunity costs from forgone sales such that capacity costing reports reduced the profitability of decision makers who received these reports relative to decision makers who received traditional accounting reports.

In the current study, capacity costing reports emphasize the opportunity cost associated with low sales volume (i.e. unused capacity costs). Consequently, capacity reporting may augment the desire to select a low-price, high-volume pricing strategy. Figure 2 illustrates the potential of capacity cost reporting to provoke price-reducing behavior. Intuitively, price competition requires sellers to trade-off selling more at a lower margin versus selling less at a higher margin. If a decision maker receives a capacity cost feedback report, an explicit unused capacity signal appears during any period in which the decision maker does not fully employ capacity resources. All else being equal, decision makers can reduce this non-value added cost (i.e., unused capacity cost) by reducing next-period prices; therefore, capacity costing reports may encourage sellers to select a "high volume - low margin" strategy because the explicit unused capacity signal increases the decision-weight placed on that option (Buchheit 2003, Maines and McDaniel 2000). In contrast, the contribution margin format does not provide a feedback signal related to unused resource costs, so contribution margin reports do not specifically encourage a high volume or high price strategy.[17] The second hypothesis, stated in the alternative form, predicts how this difference could impact pricing patterns in the current setting:

> HYPOTHESIS 2: *Ceteris paribus, in capacity constrained duopoly settings, capacity costing reports will lead to lower competitive prices relative to contribution margin reports.*

4. Results

Insert Figure 3 about here

Fixed Cost Magnitude

Figure 3 shows the average prices set by participants at each fixed cost level. Consistent with Hypothesis 1(a), as fixed cost levels increased from a relatively low level, average prices decreased. Average prices in the $2,000 through $5,000 fixed cost groups were $232, $222, $207, and $202, respectively. Figure 4 illustrates the average prices established by each of these groups over the 30 rounds of the experiment.

Insert Figure 4 about here

Evidence that fixed cost magnitude influenced loss-averse pricing behavior comes from multiple sources. A seven-point Likert scale (1 = "dramatic influence" and 7 = "no influence") asked participants whether or not fixed costs influenced their pricing decisions. Participants with $5,000 fixed costs felt that fixed costs influenced their pricing decisions more than participants with $2,000 fixed costs (2.1 vs. 4.1; $t = 5.21$; $p < .01$, two-tailed).[18] A second question asked participants whether they felt pressure to reduce prices when actual sales volume was less than the 40-unit maximum sales volume (1 = “much pressure” and 7 = “little pressure”). Participants in the $5,000 fixed cost group felt more pressure to lower prices after selling less than the maximum sales volume relative to participants in the $2,000 fixed cost group (2.2 vs. 3.7; $t = 4.38$; $p < .01$, two-tailed).

Finally, a comparison of the actual reported loss frequencies to the loss frequencies that would have occurred without price reductions suggests that participants successfully avoided losses by reducing prices. In the $2,000 through $5,000 fixed cost groups, the actual frequency of experimental rounds where a reported loss was sustained was 9.4%, 12.6%, 14.2%, and 36.0%, respectively. Using the $2,000 group's relatively high prices as a benchmark, the percentage of reported losses that the $2,000 fixed cost group would have incurred if their fixed costs were $3,000 (15.3%), $4,000 (29.3%), or $5,000 (40.0%) suggests that price reductions successfully mitigated the frequency of *reported* losses, even though the fixed components of such losses are irrelevant from an economic perspective.

Although averages prices were negatively associated with fixed cost levels when fixed costs were increased from a relatively low level, the opposite was true when fixed costs were increased to a relatively high level (consistent with Hypothesis 1(b)). Average prices in the $5,000 through $7,000 fixed cost groups were $202, $218, and $226, respectively.[19] Figure 5 illustrates the average prices established by each group over the 30 rounds of the experiment.

Insert Figure 5 about here

Although post-experimental responses indicate that fixed costs influenced pricing decisions, there was no relative response difference among participants in the high fixed cost groups. Participants responded to a seven-point scale (1 = "dramatic influence") that asked if fixed costs influenced their pricing decisions. The average responses were 2.1, 2.4, and 2.5 for the $5,000, $6,000, and $7,000 fixed cost groups, respectively ($F = .34$; $p > .71$). When asked whether or not they felt pressure to reduce prices when actual sales volume was less than the 40-unit maximum sales volume, no significant difference was observed among the highest three fixed cost groups. Using another seven-point scale (1 = "much pressure"), the average responses were 2.2, 2.6, and 2.6 for the $5,000, $6,000, and $7,000 fixed cost groups, respectively ($F = .90$; $p > .41$).

In contrast, comparing actual reported loss frequencies to the loss frequencies that would have occurred without price increases suggests that participants successfully avoided losses by increasing prices. Specifically, the $5,000 fixed cost group's (relatively low) prices were used as a proxy for the loss frequencies that would have occurred without the price increases observed in the $6,000 and $7,000 fixed cost conditions. In the $5,000 through $7,000 fixed cost groups, the actual frequency of reported losses was 36.0%, 49.8%, and 56.1%, respectively. Using the $5,000 group's prices as a benchmark, the frequency of losses that the $5,000 fixed cost group would have incurred if their fixed costs were $6,000 (57.6%) or $7,000 (70.1%) suggests that price increases successfully reduced the frequency of reported losses.

Insert Table 1 about here

Consistent with both Hypothesis 1(a) and 1(b), the repeated measures ANOVA presented in Table 1 reveals significant associations between fixed cost magnitude and pricing decisions ($F = 5.47$, $p < .01$).[20] This result is robust over the final 20 (10) experimental rounds ($F = 4.91$, $p < .01$ and $F = 4.44$, $p < .01$, respectively). A significant polynomial contrast ($F = 4.68$, $p < .01$) shows that a quadratic model best fits the fixed cost magnitude variable, thus accounting for the inflection predicted in the contrast between Hypothesis 1(a) and 1(b).[21]

Fixed Cost Reporting

Hypothesis 2 investigates whether *capacity costing* reports will lead to lower competitive prices relative to *contribution margin* reports. Average prices in the *capacity costing* condition and the *contribution margin* condition were $215 and $221, respectively (see Figure 6). Results from Table 1 indicate that this difference is only marginally significant ($t = 1.57$, $p = .06$, one-tailed); however, this result is significant during later rounds of the experiment. Over the final 20 (10) experimental rounds, it appears that repeated exposure to the reporting feedback (i.e., “learning” from the feedback reports) caused increasingly significant differences between reporting conditions ($t = 1.75$, $p = .04$ and $t = 2.14$, $p = .02$, one-tailed, respectively).

Insert Figure 6 about here

Post-experimental responses support the assertion that the reporting manipulation led to pricing differences. Before and after the compensated experimental rounds, participants were asked the lowest price they would feel comfortable charging for one widget (i.e., their reservation price). Results indicate no difference in reservation price before the experiment; averages for the *capacity costing* and *contribution margin* report groups were $179.10 and $184.15, respectively ($t = 0.41$, $p = .68$). However, after repeated exposure to the reporting manipulation, participants viewing the *capacity costing* report had lower reservation prices than participants viewing the *contribution margin* report ($162.54 vs. $175.85; $t = 2.11$; $p = .02$, one-tailed).

When asked whether or not they felt pressure to reduce prices when actual sales volume was less than the 40-unit maximum sales volume, participants viewing *capacity costing* reports felt marginally more pressure to lower prices relative to participants viewing *contribution margin* reports (2.5 vs. 3.0; $t = 1.39$; $p = .08$, one-tailed). Finally, there was no difference between participants viewing *capacity costing* and *contribution margin* reports with respect to the perceived influence that fixed costs had on pricing decisions (2.6 vs. 2.9; $t = 0.76$; $p = .22$, one-tailed).

Additional analysis of the fixed cost reporting manipulation suggests that the difference between the *capacity costing* condition and the *contribution margin* condition is caused by the relative magnitude, not the frequency, of the unused capacity signal. Specifically, the magnitude of unused capacity cost is large when prices are relatively high because high prices imply low sales volume and low sales volume implies a relatively large amount of unused capacity. Figure 7 illustrates that the average price difference between the *capacity costing* and *contribution margin* conditions is rather pronounced in the fixed cost conditions that resulted in relatively high prices, but this difference is minimal in the fixed cost conditions that resulted in relatively low prices.

Insert Figure 7 about here

By construction, there is a linear relationship between unused capacity cost and the fixed cost manipulation because higher fixed costs imply larger amounts of unused capacity cost. However, the observed relationship is convex as evidenced by a significant quadratic polynomial contrast (F = 5.84, p < .02). In other words, if the average amount of unused capacity cost is scaled by fixed cost magnitude, a U-shaped pattern similar to Figure 3 shows that the magnitude of the reporting manipulation (i.e., the relative amount of unused capacity cost) was less severe when prices were low. In contrast, the frequency of positive unused capacity cost signals did not vary by fixed cost condition (F = 0.21, p = .95). As such, the price difference between the *capacity costing* condition and the *contribution margin* condition appears to be driven by the magnitude, not the frequency, of the unused capacity signal.

Supplementary Analysis: Price Adjustment Over Time

Downward price movements (see Figures 4, 5, and 6) raise the issue of whether the experimental manipulations (1) permanently affect pricing behavior or (2) merely affect the rate at which all research participants reach a common price. In other words, would research participants have reached some common equilibrium if more experimental rounds were conducted? Kruse et al. (1994, 355) report similar downward price movements over a comparable number of rounds; however, their 60-round study was sufficiently long for prices to flatten. The authors conclude that prices *do not* reach equilibrium. Practical considerations (i.e., participant time constraints) prevented the current study from being doubled in length.

Given that pricing decisions do not reach an equilibrium state in this study, one could argue that obtained results are not inconsistent with economic theory. For example, extant Nash equilibrium models predict that fixed cost magnitude (and cost reporting format) will not affect (1) the range or (2) the probability distribution of prices over which sellers "mix-strategies" *in equilibrium*. Although results from this study demonstrate that fixed costs can have both robust and systematic effects on competitive prices, these affects may be a differential adjustment to equilibrium rather than a permanent pricing difference.[22] Regardless, this differential adjustment appears to be economically important because significant pricing differences last for a relatively long duration (i.e., 30 pricing rounds).

5. Summary

This study reports results from an experiment investigating how fixed cost magnitude and fixed cost reporting format affect competitive pricing behavior in a capacity constrained, duopolistic setting. I find evidence that fixed cost reporting format increasingly influences competitive prices. After repeated exposure to accounting feedback, participants receiving *capacity costing* feedback reports established lower selling prices relative to the prices established by participants receiving *contribution margin* feedback reports. I also find evidence that fixed cost magnitude, which is a sunk cost in this study, affects short-term pricing behavior in a manner consistent with loss aversion. As fixed cost magnitude increased from relatively low to relatively high levels, experimental participants first lowered then raised competitive prices. Although this finding is inconsistent with marginal pricing theory, experimental evidence suggests that research participants successfully reduced the frequency of reported losses through this inflection in competitive prices.

Of course, this study includes a number of features that may limit its generalizability to natural settings. The experimental setting was designed to isolate potential effects that fixed cost magnitude and cost reporting format have on short-term pricing decisions. Thus, the fixed costs were single-period and unavoidable. Findings do not necessarily extend to longer horizons with alternative uses of existing capacity and with avoidable fixed costs. Further, results from single-product duopoly competition between capacity constrained sellers may not generalize to richer, multi-firm settings. Although experimental research has found that results in Betrand-Edgeworth settings are fairly robust to factors such as the number of sellers (Kruse et al. 1994, Davis, Holt, and Villamil 1996) and the level of available capacity (Kruse et al. 1994), such factors were not investigated in this study.

Future research could test the robustness of the current study's results by considering soft capacity constraints (such as those observed in the software industry), imprecise cost estimates, alternative supply rationing rules, and alternative volume vs. margin tradeoffs.[23] Another possible area for future investigation is the effect of market power (Holt 1989). As the ratio of capacity resource capability to total market demand increases, sellers' market power decreases. The opposite is true as this ratio decreases. In a series of two and three seller experiments with computer simulated buyers, Davis et al. (1996) find that prices are positively associated with market power. One reasonable expectation is that the strength of the results found in this study would also be positively associated with market power.

Future research could also investigate why the results observed in this Bertrand-Edgeworth setting have not occurred in other markets (such as double-auction settings). This type of investigation might focus on institutional differences between markets and how such differences affect competitive behavior. Specifically, the interaction (i.e., relative weight) of loss aversion versus profit maximization, the evolution of strategic pricing (Engle-Warnick and Slonim 2003), and the anticipation of competitor actions versus optimal responses given anticipations (King and Schwartz 2000) are all interesting avenues for further study. Although loss aversion (Hypothesis 1) and signal-weighting (Hypothesis 2) appear to offer reasonable explanations for much of the competitive pricing behavior observed in this study, other psychological forces are certainly at work in this relatively complex environment.

Notwithstanding these limitations, this study offers some novel evidence in two heavily-researched, important areas. First, this study offers evidence that psychological considerations such as loss aversion can cause decision makers to violate marginal pricing rules. Second, this study suggests that functional fixation associated with cosmetic accounting changes will not always be driven away by market forces. In this study, a very simple cosmetic reporting manipulation produced systematically different competitive prices and this difference increased (rather than being driven away) over 30 repeated rounds of market competition.

Endnotes

1. See Balakrishnan and Sivaramakrishnan (2002) for a critical overview of research that attempts to explain the fixed cost / pricing issue by jointly considering fixed resources and fixed costs.

2. Van Boening and Wilcox (1996; 462) label the double-auction "the most competitive institution we know of" and discuss the double-auction market's uniform pricing tendency. Specifically, although double-auctions *allow* trading at different prices, they usually *result* in steadily declining price dispersion as experimental trading periods pass. Among other factors, the double-auctions' forceful market discipline may be due to (1) a narrow range of "rational" prices and (2) exogenously assigned seller redemption values. In contrast, Bertrand-Edgeworth markets typically (1) have a wide range of rational prices and (2) do not assign seller redemption values. These factors help distinguish Kachelmeier's (1996) double auction market from the current Bertrand-Edgeworth market.

3. Factors such as changing inventory levels can cause short-term information differences, rather than cosmetic format differences, between the reporting formats used in this study. By not allowing storable inventory, this potential confound is eliminated.

4. The six possible buyer orders were graphically shown to participants and randomly determined by a die roll. Qualitative features of each demand order were discussed with research participants during a question and answer period that occurred before the compensated portion of the experiment. Figure 1 illustrates the extreme buyer orders (i.e., those most and least favorable to sellers).

5. Post-experimental evidence suggests that participants clearly understood the task. Specifically, participants were asked to rate their understanding of the opposing incentives inherent to the experiment on the following scale (4) immediate, clear understanding (3) very clear understanding, but not immediate, (2) not a very clear understanding, (1) confused throughout the experiment. The average (minimum) response was 3.85 (3).

6. Besides creating *ceteris paribus* conditions for the cost reporting manipulation, the four-subject design offered two other benefits. First, it reduced the possibility of price collusion between competitors because participants only knew their competitor was "one of the other three participants in the room." Second, the four-subject design allowed for inter-gender pairing when necessary. Teger (1980) finds women systematically less competitive than men in experimental settings; however, no gender-based competitive effects were found in this study.

7. Not announcing experimental duration has been used in other studies to control for end-of-game effects (e.g., Kruse 1993, 635). However, determining the number of rounds via a randomizing device is likely a better way to accomplish this objective because this technique permits an objective, quantifiable end-game expectation.

8. The choice in this study was to vary monetary stipends in an effort to create reasonably consistent expected compensation in each fixed cost magnitude cell. However, varying monetary incentives introduces the possibility that compensation function differences, rather than the fixed cost magnitude manipulation, caused observed performance differences via an endowment effect or an incentive effect. Two actions were taken to address this possibility. First, compensation functions were varied *within* the lowest three fixed cost groups by giving either (1) no endowment and a relatively high conversion rate or (2) an endowment and a relatively low conversion rate. (Endowments were consistently given in the highest fixed cost groups to avoid the possibility of a total loss during the experiment.) Compensation function ("endowment" vs. "no endowment") was then included as a covariate in a repeated-measures ANOVA identical to Table 1 ($n = 72$ participants; i.e., the three lowest fixed cost groups) revealing no effect for compensation function ($F = .02$, $p = .90$). Second, OLS regressions were run using current period price as the dependent variable. Explanatory variables included endowment, conversion rate, fixed cost magnitude, and squared fixed cost magnitude (to account for the U-shaped prediction shown in Figure 3). Results, available from the author, reveal that participants' endowment and exchange rates (1)

have minimal effects on price and (2) are statistically insignificant. However, coefficients corresponding to fixed cost magnitude and its square are consistent with Table 1.

9. Kruse et al. (1994) find that each of the four competing pricing theories they investigate (competitive equilibrium, tacit collusion, mixed strategy Nash equilibrium, and Edgeworth cycle theory) help explain some aspects of pricing behavior in a Bertrand-Edgeworth setting; however, no single theory is completely consistent with observed data.

10. Dasgupta and Maskin (1986) show that all Bertrand-Edgeworth settings with capacity constrained sellers have a Nash equilibrium in mixed strategies and Holt and Solis-Soberon (1992) show how to compute mixed-strategy equilibria for complicated step-function structures (such as the 10-price PLATO posted-offer program). However, Holt and Solis-Soberon note that such calculations become progressively more complex as more steps are introduced. In the current study, 100 prices (i.e., "steps") must be analyzed (see footnote 11). As such, 2^{100} strategies must be evaluated for each of the six demand functions in order to implement the solution technique. Putting this computation into perspective, Breiter and Carlin (1997) limit their calculation of accurately predicting the entire NCAA tournament (2^{63} possibilities) to the regional tournaments (2^{15} possibilities) because they claim evaluating 2^{15} strategies took eight hours on a Sparc20 workstation.

11. Although other theories suggest wider "rational" ranges, the [$145, $245] interval is based on Edgeworth cycle theory and the mixed strategy Nash equilibrium. Edgeworth cycle theory predicts, roughly, that a firm will play a myopic best response to its opponent's previous-round price. In this study, the best response to price *p* between $146 and $245 is *p - $1*. In contrast, the best response to a previous price of $145 is *p* = $245. Intuitively, a "high-margin, low-volume" pricing strategy is optimal when the opponent's price is below $146. Holt and Solis Soberon (1992) show that the support of the mixed-strategy Nash equilibrium lies on the Edgeworth price cycle; therefore, even without

calculating the mixed-strategy equilibrium, we know that prices below $145 or above $245 are never chosen in equilibrium.

12. Sunk costs obviously do not affect pricing predictions based on (1) supply and demand curve intersection (e.g., competitive equilibrium) and (2) myopic best response (e.g., Edgeworth cycle theory). Determining the Nash equilibrium via the standard single-shot game makes sunk costs irrelevant because fixed costs are a scaling factor that disappears when solving the mixed-strategy equilibrium program. I am unaware of any model that includes a fixed-cost-induced price shift in a Bertrand-Edgeworth setting. Because empirical evidence on the descriptive validity of theories can help theorists revise models to incorporate empirical findings that are not consistent with the model's predictions (Smith 1994), results from this study may help inform future modeling modifications.

13. *Loss aversion* admits a role for sunk costs if fixed cost magnitude changes the decision frame for outcomes. In contrast, under constant absolute risk aversion (CARA preferences), *risk aversion* is invariant to fixed amounts that are added or subtracted to each outcome. To illustrate, consider two separate choices between two outcomes. First, consider a choice between $6 for sure and a lottery with an equal chance to win $15 or $0. Now consider a second choice where a $5 fixed cost is subtracted from all possible outcomes; therefore, the choices are $1 for sure and a lottery with an equal chance to win $10 or lose $5. Under *risk aversion*, the choice should not change due to the subtraction of a constant. However, under *loss aversion*, the $1 for sure payment would be selected more frequently than the $6 for sure payment because of the potential loss in the second choice.

14. Predicting the inflection point between "price decrease" and "price increase" (Hypothesis 1(a) and 1(b), respectively) is computationally intractable because doing so requires knowledge of loss probabilities that research participants mentally assign to (potentially) every possible price combination. In addition, it may well be necessary to know each participant's loss averting time horizon (e.g., do participants

attempt to avert single period or multi-period losses?) and each participant's relative weight on loss aversion vs. profit maximization.

15. Although stable equilibria (e.g. Nash mixed-strategy equilibrium) can theoretically be specified in the current setting, experimental results are consistent with disequilibrium pricing behavior. Like other Bertrand-Edgeworth experimental studies (e.g., Kruse et al. 1994), the current study exhibits average price declines throughout 30 rounds – a phenomenon inconsistent with equilibrium behavior. Implications of disequilibrium behavior are discussed in the next section.

16. Capacity costing is a partial (not full) fixed cost assignment method. To illustrate, assume a company pays $100 to rent a machine capable of manufacturing 100 units; however, only 70 units are produced. The entire $100 is assigned to the 70 units under full absorption costing (with potential estimation error shown through variances). However, capacity costing assigns a constant $1 to each unit yielding product cost of $70 and $30 of "unused capacity cost" (a period expense). McNair and Vangermeersch (1996) argue that capacity costing reports assist long-term decision making; however, current research has not considered capacity costing's influence on cost-based pricing decisions.

17. Investigating full absorption costing offers an interesting avenue for future research. Absorption costing attempts to assign all capacity costs to output units (with estimation error shown through volume variance). However, the feedback signal provided by the volume variance is dependent on budgeted (or normal) output levels, so the variance signal provided under absorption costing is not unambiguously favorable or unfavorable.

18. Reported manipulation checks were added after the $3,000 and $4,000 experimental sessions were completed. I thank Lisa Gaynor for suggestions regarding manipulation checks.

19. The average price from the ex-post inflection point (the $5,000 fixed cost level) has information consistent with sellers changing from a price-reducing strategy to a price-increasing strategy in an effort to reduce reported loss frequencies. Specifically, the ex-post average price in the $5,000 fixed cost group was $202; however, the lowest common price at which mutual profits could occur in the $6,000 fixed cost group is $209. (In the case of common prices, buyer demand was divided equally between sellers.) As such, using the "lowest common loss avoiding price" as a benchmark, price reduction was no longer a loss-averting strategy when fixed cost magnitude increased from $5,000 to $6,000.

20. Because no reporting manipulation occurred on the first experimental round, Table 1 reports results from rounds 2 through 30. Including round 1 in the analysis does not affect the conclusion that fixed cost magnitude affects pricing decisions ($F = 5.28$, $p < .01$).

21. The prices analyzed in Table 1 are not independent given that participants engaged in duopolistic competition. Independent observations are obtained by considering the pricing behavior of each pair of competitors (n = 72 pairs). Unfortunately, the appropriate dependent variable is debatable when pairs are investigated. For example, each pair's *average price per round*, each pair's *lowest price per round*, and the *average transaction price per round* are all possible dependent variables with intuitive appeal. An analysis identical to Table 1 was conducted using each of these three pricing metrics as the dependent variable. In all cases, results are robust and consistent with the individual results presented in Table 1. Specifically, there is a significant association between fixed cost magnitude and each pricing metric, regardless of the time period investigated (over all rounds, the final 20 rounds, and the final 10 rounds). In addition, the relationship between fixed cost reporting format and each pricing metric is robust. Specifically, the association between fixed cost reporting format and pricing metrics is not significant over the entire experiment, but becomes increasingly significant during later rounds of the experiment.

22. Although competitive prices show no signs of reaching equilibrium, research participants do show signs of adaptive learning. Following the choice of a price that was lower (higher) than their opponent's price, participants tended to increase (decrease) their prices in the next round. Such behavior is consistent with Selten and Buchta's (1994) "direction learning" theory which states that, although decision makers may not be able to explicitly calculate a best response strategy, they may know the *direction* of their best response.

23. Given that profits are maximized at the collusive price of $255, an intuitive expectation is that, *after extracting fixed cost magnitude differences*, average profit in each fixed cost group will map into average prices. Reproducing Figure 3 with average profit (rather than average price) yields a less severe U-shape because the increased sales volume associated with lower prices largely offsets the lost unit margins. Pairwise comparisons between fixed cost magnitude groups yield either insignificant or marginally significant profit differences. For example, the most significant profit difference is between the relatively high-priced $7,000 group versus the relatively low-priced $5,000 group. *After extracting the fixed cost magnitude differences* the $7,000 group's average profit is marginally greater than the $5,000 group's average profit (t = 1.84, p = .07, two-tailed).

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TABLE 1

Posted Selling Price Analysis

Dependent Variable: Posted Selling Price

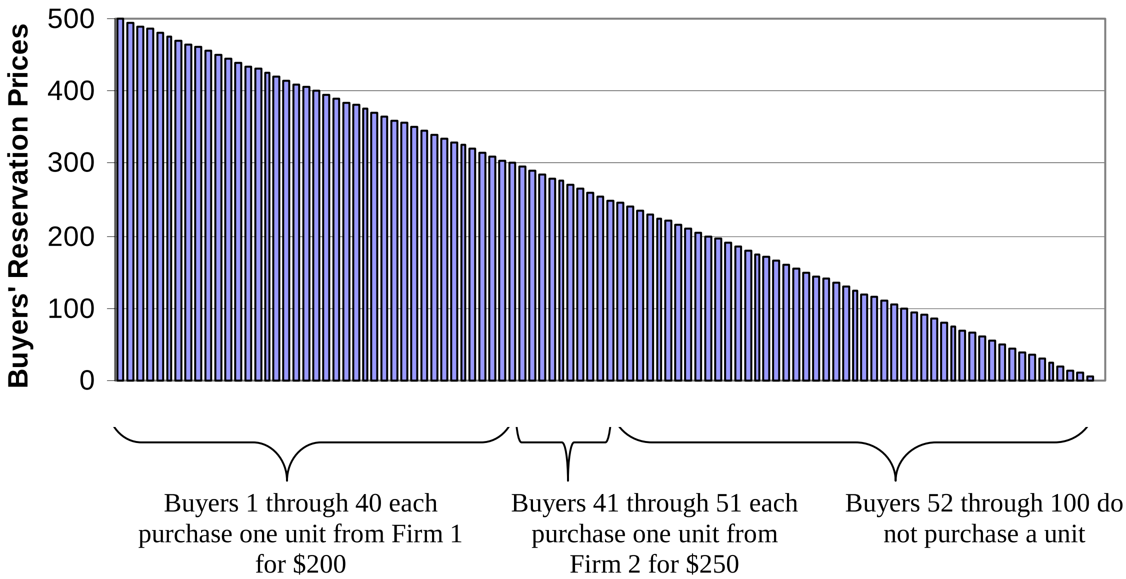
Source of Variation	*SS*	*DF*	*MS*	*F*	*p-value*
Between-Subjects Effects	*(2,994,972.1)*	*(143)*			
Reporting Format: Capacity Costing or Contribution Margin	*44,011.6*	*1*	*44,011.6*	*2.46*	*0.12*
Fixed Cost Magnitude: 2,000 through 7,000 (in '000 increments)	*489,590.4*	*5*	*97,918.1*	*5.47*	*<0.01*
Reporting Format × Fixed Cost Magnitude	*54,674.4*	*5*	*10,934.9*	*0.61*	*0.69*
Covariate: Experimental Session	*61,344.4*	*1*	*61,344.4*	*3.43*	*0.07*
Error: Subjects	*2,345,351.3*	*131*	*17,903.4*		
Within-Subjects Effects	*(7,341,782.6)*	*(4,032)*			
Experimental Round	*55,567.0*	*28*	*1,984.5*	*1.09*	*0.34*
Experimental Round × Reporting Format	*55,745.5*	*28*	*1,990.9*	*1.10*	*0.33*
Experimental Round × Fixed Cost Magnitude	*263,102.6*	*140*	*1,879.3*	*1.03*	*0.38*
Experimental Round × Covariate	*54,151.5*	*28*	*1,934.0*	*1.06*	*0.38*
Experimental Round × Reporting Format × Fixed Cost Magnitude	*242,513.3*	*140*	*1,732.2*	*0.95*	*0.64*
Error: Experimental Round × Subjects	*6,670,702.6*	*3,668*	*1,818.6*		
Total	*10,336,754.7*	*4,175*			

Descriptive Statistics	*Average Price*	*Standard Deviation*
Reporting Format		
Capacity Costing	*214.5*	*26.3*
Contribution Margin	*221.0*	*26.9*
Fixed Cost Magnitude		
$2,000 Fixed Costs	*232.3*	*27.0*
$3,000 Fixed Costs	*221.6*	*31.5*
$4,000 Fixed Costs	*206.5*	*22.1*
$5,000 Fixed Costs	*202.2*	*19.6*
$6,000 Fixed Costs	*218.1*	*27.2*
$7,000 Fixed Costs	*225.9*	*20.2*

Figure 1 How buyer-rationing rules affect sales

Assumed Prices: Firm 1 = $ 200, Firm 2 = $ 250

Value Queue: The *least favorable* rationing rule for the high-priced seller.



Inverse Value Queue: The *most favorable* rationing rule for the high-priced seller.

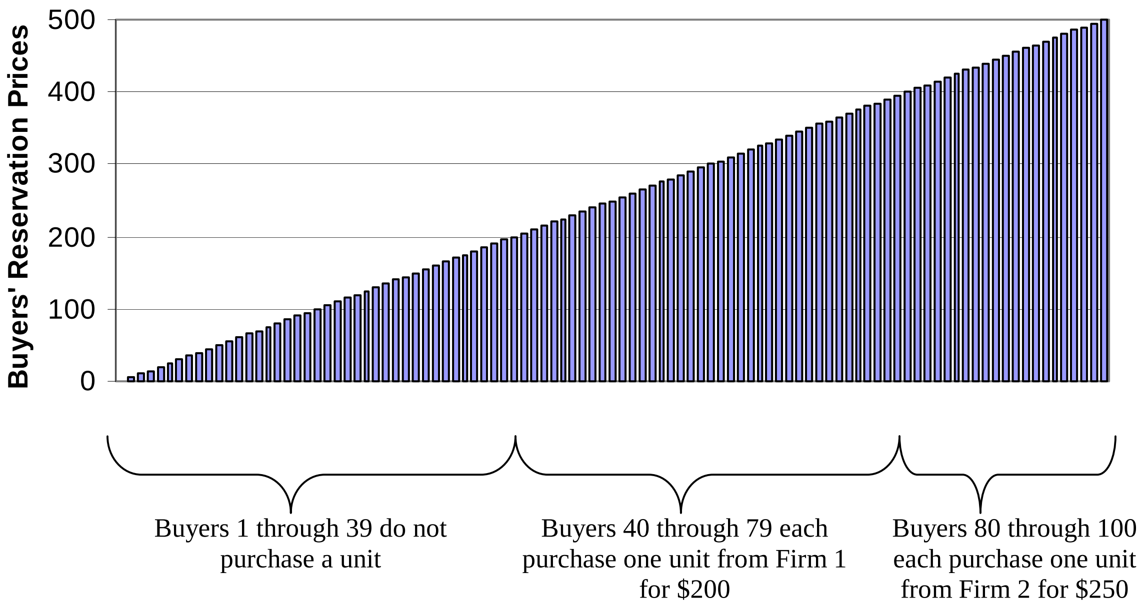


Figure 2 Sample feedback reports received by research participants

Contribution Margin Report:

Player 1		**Day #30 Performance Report**	
Total Revenue:	**$ 4,800**	Your Sales Price:	**$ 150**
Total Variable Costs:	**160**	Units Sold:	**32**
Contribution Margin:	**$ 4,640**	Unit Variable Costs:	**$ 5**
***less* Total Fixed Costs:**	**$ 5,000**	Your cumulative Profit is:	**$ 100,135**
Profit:	**$ (360)**	Your Opponent's sales price was:	**$ 145**
My Next Sales Price Is:	**$ _______**		

Capacity Cost Report:

Player B		**Day #30 Performance Report**	
Total Revenue:	**$ 4,800**	Your Sales Price:	**$ 150**
Total Unit Costs:	**4,160**	Units Sold:	**32**
Gross Margin:	**$ 640**	Unit Costs at Full Capacity:	**$ 130**
***less* Unused Capacity Cost:**	**$ 1,000**	Your cumulative Profit is:	**$ 100,135**
Profit:	**$ (360)**	Your Opponent's sales price was:	**$ 145**
My Next Sales Price Is:	**$ _______**		

Figure 3 Average prices by fixed cost magnitude

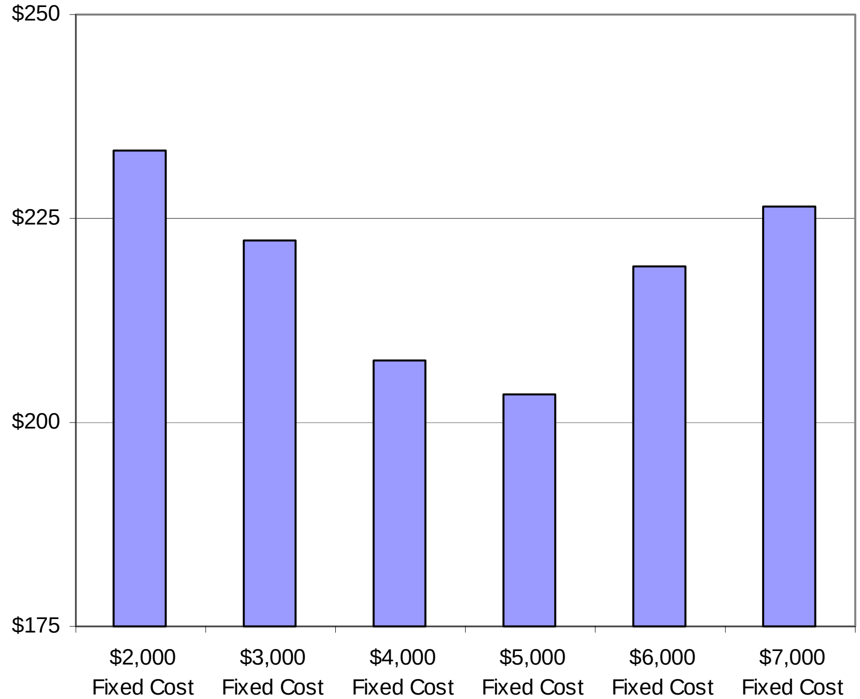


Figure 4 Average price trend: lowest four fixed cost groups (5-round average prices shown)

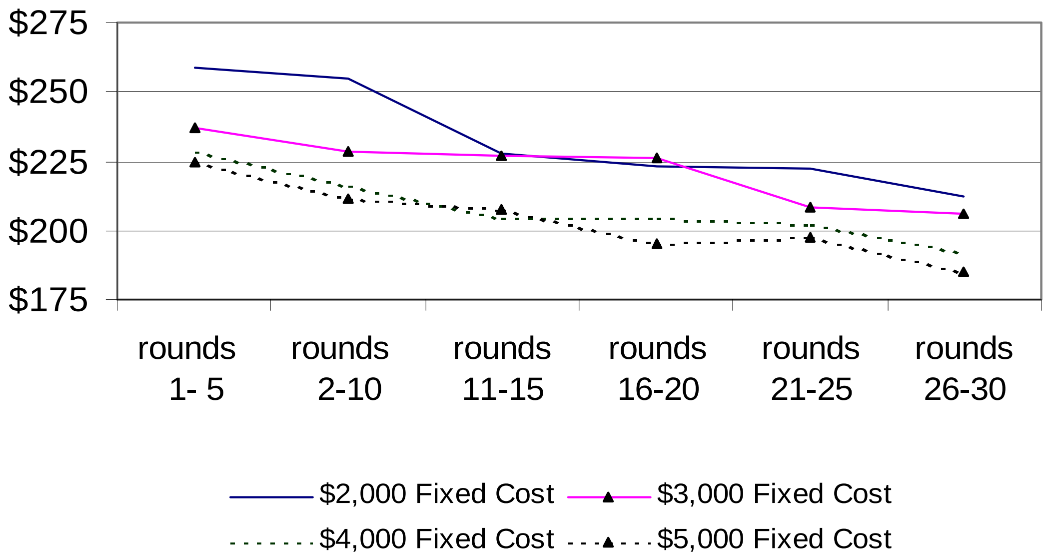


Figure 5 Average price trend: highest three fixed cost groups (5-round average prices shown)

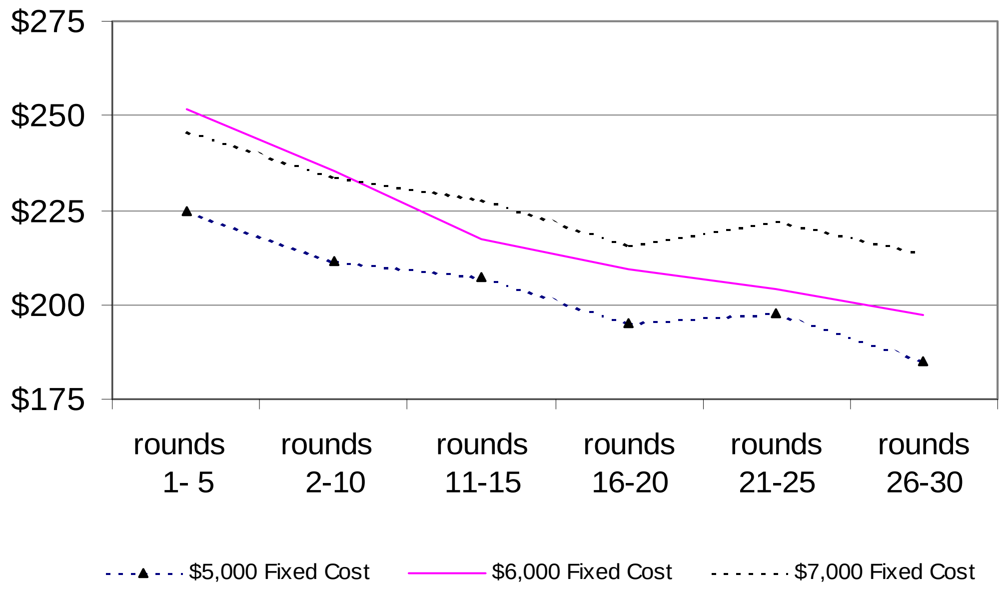


Figure 6 Average price trend: cost reporting groups (5-round average prices shown)

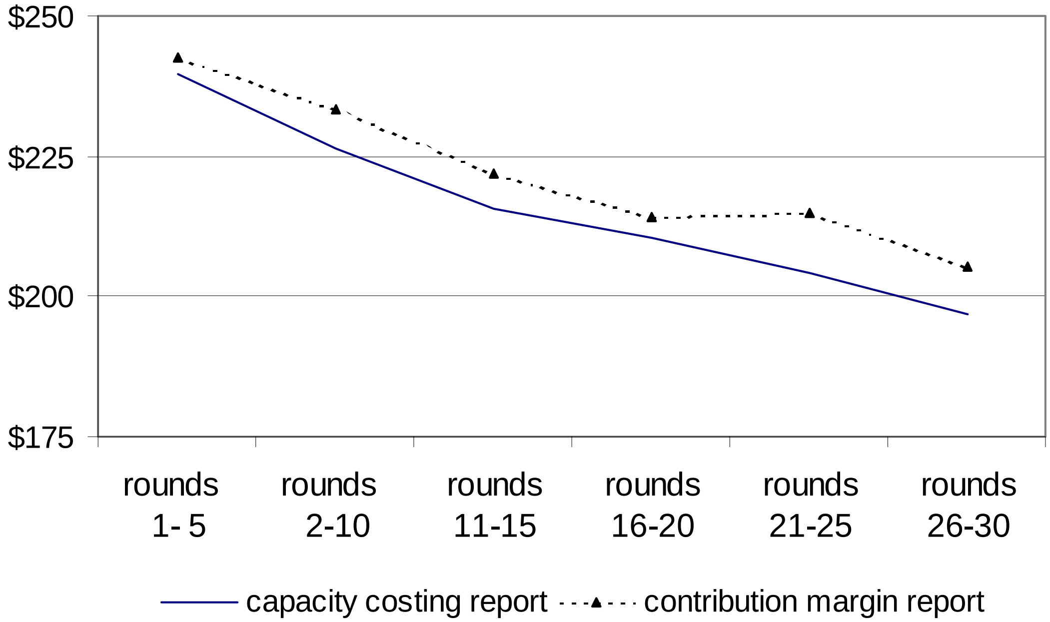


Figure 7 Average prices by fixed cost magnitude and fixed cost reporting