Asymmetric Cost Pass-Through in Multi-Unit Procurement Auctions: an Experimental Approach

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Abstract

Output prices tend to respond more quickly to increases in input prices than to decreases in input prices. While standard economic theory would not predict this pattern, it is found in many market settings. In a laboratory experiment, we find asymmetric pass-through of cost shocks in discriminatory (pay-as-bid) procurement auctions when participants lack information about those shocks. In order to maximize revenue, bidders “pad” their bids close to the expected clearing price for units with costs below that price, but they do not bid below cost on higher cost units. Therefore, if costs are higher than expected, the clearing price will rise and if costs are lower than expected, the clearing price will remain high. To isolate the effect of information, we also look at “industry-wide” cost shocks where the cost of a common input changes uniformly for all bidders, and find no evidence of asymmetric pricing. We also show that asymmetric pricing does not occur in uniform price auctions. Discriminatory auctions may be worse than uniform at “tracking” shifts in underlying costs, leading to price asymmetries and production inefficiencies.

Keywords: Asymmetric Pass-through, Rockets and Feathers Pricing, Procurement Auctions, Experimental Economics

JEL Codes: D44, D820

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1 Introduction

In a classic examination of the UK gasoline market, Bacon (1991) noted an interesting empirical regularity between retail and gasoline prices and the corresponding wholesale cost: retail prices tended to rise “like a rocket” when the wholesale cost increased, but they fell “like a feather” when the wholesale cost decreased. In particular, the speeds of adjustment for a 1-pence change in the wholesale cost differed by about a week for cost increases versus decreases. This asymmetric adjustment of retail prices to wholesale or input costs has been found in a wide variety of settings from gasoline and groceries to emissions permits and interest rates.\(^1\)

While it is relatively straightforward to identify an asymmetric pass-through pattern in price and cost data, it often difficult to isolate the causes of the patterns we observe. In addition, it seems likely that the drivers of the phenomenon differ across market settings. Common explanations include menu-cost frictions, inventory capacity constraints, consumer search limitations, and short-run tacit collusion.\(^2\)

This paper examines a new explanation for asymmetric pass-through in the context of multi-unit procurement auctions where one buyer purchases a good from one or more sellers. With the development of electronic platforms, these types of auctions are being used more and more frequently by businesses as a way to minimize the cost of obtaining supplies, work, and other supply chain management services.\(^3\) Another prominent uses of multi-

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\(^1\) Asymmetric pass-through has been demonstrated in markets for gasoline (Borenstein et al., 1997; Galleotti et al., 2003; Al-Gudhea et al., 2007; Grasso and Manera, 2007; Lewis, 2009), supermarket products (Levy et al., 2006; Muller and Ray, 2007), interest rates (Enders and Granger, 1998; Neumark and Sharpe, 1992; Thompson, 2006), carbon dioxide emission permits (Zachmann and von Hirschhausen, 2008), and various goods in the USA’s CPI and PPI baskets (Peltzman, 2000). Peltzman (2000) uses large samples of over 200 diverse consumer and producer products and finds asymmetric pricing in more than two of every three markets examined.

\(^2\) If there are menu cost frictions, altering the retail price is costly and it may be profit-maximizing to keep the price constant when input cost falls, especially if that cost is likely to rise later (Madsen and Yang, 1998; Peltzman, 2000; Bhaskar, 2002; Ray et al., 2006). If building additional inventory capacity is time intensive, then supply can remain restricted even if the input cost falls, until the new capacity is completed (Borenstein and Shephard, 2002). If consumers’ opportunity costs of searching for the best price are relatively high, then firms can exploit the fact that consumers will not explore options very much by keeping the price high (Lewis, 2011; Lewis and Marvel, 2011, Tappata, 2009, and Yang and Ye, 2008).

\(^3\) CAPS Research conducted a study of electronic reverse auctions through interviewing firm and supplier
unit procurement auctions is in wholesale electricity markets, where there is some evidence of asymmetric pass-through of emissions permit prices (Zachmann and von Hirschhausen, 2008).

Asymmetric pricing may arise in a repeated auction setting as a result of the pricing rules and bidding behavior, independent of the explanations above. Discriminatory (pay-as-bid) formats are used in many e-procurement auctions, for wholesale electricity markets in the United Kingdom, and reserve power markets in Germany and Italy (Rivero, 2011). Since discriminatory auctions are pay-as-bid, there are strong incentives to bid above marginal cost, especially for low cost units. Bidders must decide how much to “pad” their bids based on their expectations about other firms’ costs and the auction clearing price. In this setting, a pricing asymmetry arises from the fact that bidders will not bid below their marginal cost, even if that cost is above the expected clearing price. Therefore, if costs are higher than expected, the clearing price will rise. But if costs are lower than expected, the clearing price will remain high because bidders are padding their bids to maximize revenue. Aggregate marginal costs may be higher or lower than in expectation in markets where firms have imperfect information about other firms’ costs and production processes.

In this analysis, we use a laboratory experiment to test for asymmetric pass-through of private cost shocks in discriminatory auctions where participants have imperfect information about a component of other participants’ cost. To isolate the effect of information, we compare the outcome of these private shocks to industry-wide cost shocks where the cost of a common input changes uniformly for all bidders. As a comparison, we look at the effects of the two types of cost shocks on equilibrium prices in another auction format commonly used in practice: uniform price.4 In uniform price auctions, there is little incentive to pad bids on low cost units, since those units are likely to be infra-marginal, and therefore not

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4In uniform price procurement auctions, the lowest bids are accepted to meet demand and producers receive the same price for all accepted units. Typically, the highest accepted bid, or the lowest rejected bid is used as the market price.
affect revenue received. When the market environment is highly competitive and bidders are essentially price takers, there is little incentive to pad at all. As a result, in competitive markets, uniform price auctions would not lead to asymmetric pricing of any type of cost shift.

Consistent with our predictions, we find evidence of asymmetric pricing in discriminatory auctions for “private” cost shifts but not for “industry-wide” cost shifts. In addition, we find no evidence of asymmetric pricing for uniform price auctions. The incentive for infra-marginal bid-padding in discriminatory auctions may make them less flexible than uniform price auctions at tracking cost shifts, especially if bidders do not have full information about the nature of those cost shocks.

This finding speaks to the ongoing comparison of sealed-bid uniform price and discriminatory auctions. Whether one of these auction formats is superior to the other remains controversial. There is no clear theoretical ranking between the two in terms of prices or efficiency (Ausubel & Cramton, 2002; Back & Zender, 1993; Bikhchandani & Huang, 1989; Binmore & Swierzbinkski, 2000). Therefore, it is largely an empirical question as to which auction format will be preferred under which circumstances. There has been some discussion that, in practice, it is easier for bidders to tacitly collude in uniform price auctions than discriminatory. Fabra (2003) shows that uniform auctions are more prone to collusion particularly in repeated settings because infra-marginal bids are payoff irrelevant and can be used to facilitate collusion near the margin. In fact, when the UK switched from the uniform auction format to discriminatory for wholesale electricity, the regulatory authorities cited higher average prices in uniform auctions as the reason (Fabra, 2003). However, there is also evidence consistent with our findings that discriminatory auctions may be worse than uniform price auctions at “tracking” underlying cost shifts leading to allocative inefficiencies (Burtraw et al., 2011) particularly when bidders have asymmetric information (Abbink et al., 2003).

Our results suggest that it is important to understand how markets adjust to cost
shocks especially if they lead to unexpected welfare allocations. The same intuition that
we present for a single buyer procurement auction could apply to a market setting with
multiple buyers. For example, if vendors post prices for multiple units and have private and
increasing marginal cost of production, they may try to extract surplus by pricing at the
expected market equilibrium price for all of their units. Similar to discriminatory auctions,
shocks to private costs in markets with multiple buyers could lead to asymmetric pass-
through, if vendors do not know how the shocks effect the competitive clearing price. If
firms quickly pass on cost increases but are much slower in transmitting cost decreases, it
allows them to capture more surplus than an equilibrium model would predict when prices
fall. The welfare impacts of this kind of pricing could be significant in markets where input
prices change frequently, leading to many instances of these short run asymmetries.

In the next section we describe our experimental procedures. In section 3 we describe
the conceptual framework for our conjectures on the pass-through of private and industry-
wide cost shocks in discriminatory and uniform multi-unit procurement auctions. In section
4 we present our results and in section 5 we conclude.

2 Procedures

There were 6 participants per experimental session recruited from the undergraduate pop-
ulation at the University of Virginia. Participants acted as producers with the capacity to
produce up to 8 units of an indivisible, identical product in each of 12 periods. The total
supply capacity for the experiment was $6 \times 8 = 48$ units each period and the quantity de-
manded by the buyer was fixed at 32 units. Each period, producers could sell units of the
good at auction, submitting up to 8 bids. The bids were ranked from low to high and the
units with the lowest 32 bids were accepted each period. In uniform price auctions, partic-
ipants received the lowest rejected bid for each accepted unit. In discriminatory auctions,
participants received their unit bid for each accepted unit. If the bid for a particular unit
was accepted, participants earned the difference between the price and the production costs. The production cost for each unit had two components: a private cost and an industry-wide cost. The private costs for each unit were randomly generated in each period and differed among participants and sessions in the experiment. The industry-wide cost was the same experimental dollar amount for each unit for all producers in a period.

A moderator read the experimental instructions out loud at the start of each session, outlining the experimental software, cost parameters, how to bid, and the auction rules for determining earnings and profits. The context of the experiment was quite general: producers bidding at auction to produce a product. This framing simplified the task for participants and left little room for outside biases to affect bidding.

In every period of the experiment, individuals’ private costs were drawn from a uniform distribution of $5 −$10 experimental dollars in $0.25 increments. These different cost draws determined the magnitude and direction of the private cost shocks and varied across treatments. In positive (negative) cost shock periods, the competitive clearing price was higher (lower) than the expected competitive clearing price. The competitive, or Walrasian price, is the price at the intersection of the aggregate marginal cost curve (summed over all bidders) and the demand curve. In other words, if every bidder bid exactly his cost (private + industry-wide) for every unit, the marginal clearing price in the auction would be the Walrasian price.

There were three experimental treatments of the industry-wide cost: a baseline treatment, a positive cost shock treatment, and a negative cost shock treatment. In the baseline treatment, the industry-wide cost was invariant at $6 experimental dollars per unit for all 12 periods of the experiment. In the positive cost shock treatment, the industry-wide cost was $6 experimental dollars for periods 1–6 and $9 experimental dollars for periods 7–12. Likewise, in negative cost shock treatments, the industry-wide cost was $6 experimental dollars for periods 1–6 and $3 experimental dollars for periods 7–12. Bids for each unit were chosen from a drop down menu with values between $8 and $25 experimental dollars in $0.25
increments.

We ran 6 sessions for each industry-wide cost treatment for each auction format (uniform and discriminatory). Each subject participated in only one experimental session. There were a total of 36 experimental sessions that involved 216 individuals. Participants earned an average of about $22 for a session lasting around an hour. They received $6 for showing up in addition to earnings from selling units for prices above their costs. The experiments took place at Veconlab, the experimental economics laboratory at the University of Virginia.

3 Conceptual Framework

3.1 Discriminatory Auctions

In discriminatory auctions, bidders would earn the most revenue if they bid the marginal clearing price for all units with costs below the marginal clearing price. For higher cost units, they could bid at or above cost. In practice, bidders cannot perfectly predict the marginal clearing price. With each unit, bidders in discriminatory auctions are trading off the expected revenue with the probability of being accepted. In less competitive environments with few units or very little excess supply, bidders can exercise market power and earn revenues above the competitive marginal price. However, in the limit, as the number of bidders increases, the marginal clearing price converges to the competitive Walrasian price.\footnote{Despite the complexities of equilibria in finite player multi-unit auctions, Swinkels (1999) shows that, in the limit, as the number of bidders increases they essentially become price takers at a price that converges to the competitive equilibrium price.}

Our laboratory environment was designed to be relatively competitive. Private costs are changing each period, making it difficult to know which bids will be marginal. In addition, demand is just 2/3 of supply capacity, making it difficult to exercise market power. Because of these conditions, we expect marginal clearing prices to be at or slightly above the Walrasian price. While there are no closed form solutions for optimal bidding in multi-unit discriminatory auctions, bidders optimizing revenue would bid close to the expected
Walrasian clearing price for units with costs below that price.\(^6\) If bidders were to use this strategy, we would expect to see asymmetric pass-through of private cost shocks.

In the top half Figure 1, we have an illustration of the outcomes of positive private cost shocks (left) and negative private cost shocks (right). The solid black line represents the cumulative marginal cost curve and the solid gray line represents bidders’ supply curve. There is a vertical line at 32 units representing the inelastic demand. The marginal clearing price is the intersection of the bidders’ supply curve and demand. The expected Walrasian price for the baseline treatment in the experiment is $14.3. In the left side of the figure, private cost shocks have pushed the aggregate marginal cost curve up, so that the actual Walrasian price is $15.3, above the expected Walrasian price. All bidders bid $14.3 for all units with cost less than $14.3 and cost for all units with cost above $14.3 (solid gray line). The result is a marginal clearing price of $15.3. The average and marginal prices paid by the buyer reflect the level of the actual Walrasian price, i.e. full pass through of positive private cost shocks.

In the right side of the top half of Figure 1, private cost shocks have pushed the aggregate marginal cost curve down so that the actual Walrasian price is $13.3. Again, all bidders bid $14.3 for all units with cost less than $14.3 and cost for all units with cost above $14.3 (solid gray line). The result is a marginal clearing price of $14.3. Here the average and marginal prices paid by the buyer will be higher than the Walrasian price, and the negative cost shock is not passed through.

In the bottom half of Figure 1 there is an illustration of the outcomes of positive (left) and negative (right) industry-wide cost shocks. We would not expect to see asymmetric pass-through of industry-wide cost shocks. In this picture there are no private shocks so that the expected Walrasian price and the Walrasian price are are equal. In the bottom left, there is a positive industry-wide cost shock such that the Walrasian price increases from $14.3 to $15.3. All bidders bid $15.3 for all units with cost less than $15.3 and cost for all units with

\(^6\)Bids for the lowest cost units might be slightly lower since revenue losses are highest for those units if bidders bid too high to be accepted.
cost above $15.3. The result is a marginal clearing price of $15.3, full pass-through of the $1 price increase.

The bottom right of Figure 1 illustrates a negative industry-wide cost shock where the Walrasian price decreases from $14.3 to $13.3. All bidders bid $13.3 for all units with cost less than $13.3 and cost for all units with cost above $13.3. The result is a marginal clearing price of $13.3, full pass-through of the $1 price drop. To conclude, if this is a close approximation of players’ strategies, we would expect to see asymmetric pass-through of private cost shocks but not industry-wide cost shocks in discriminatory auctions.

In addition, the failure to pass-through negative private cost shocks may lead to production inefficiencies. The most efficient outcome is one where the units purchased are being produced at the lowest production cost to meet demand. If the auction clears at a price that is higher than the competitive (Walrasian) equilibrium price, bids on higher cost units may be accepted over those on lower cost units, leading to production inefficiencies. Therefore, we would expect lower efficiency following negative private cost shocks than following positive private cost shocks, but we would not expect industry-wide cost shocks to affect production efficiency.

### 3.2 Uniform Price Auctions

In uniform price auctions, there is no incentive to pad the bid on the lowest cost unit and there is some incentive to pad bids higher cost units, particularly if there is a good chance of their being marginal. Bidders trade off the probability of being the price determining bid with higher profits on all units accepted. Similar to discriminatory auctions, as the number of bidders increases, the auction price will approach the competitive (Walrasian) price and bidders become price takers. In our relatively competitive laboratory environment, players could maximize surplus by bidding cost (or a little above on the margin) for each unit.

If all players bid their marginal cost for each unit, we would expect full pass-through
Private Cost Shock

Positive
expected price = 14.3
Walrasian price = 15.3

Negative
expected price = 14.3
Walrasian price = 13.3

Full pass-through of positive shock
Negative shock not passed-through

Industry-Wide Cost Shock

Positive
Walrasian price = 15.3

Negative
Walrasian price = 13.3

Full pass-through of positive shock
Full pass-through of negative shock

Figure 1: Discriminatory Auction: All bidders bid the expected Walrasian price for units with costs below the expected Walrasian price and bid cost for all units with costs above the expected Walrasian price. There is asymmetric pass-through of private cost shocks but not industry-wide cost shocks
of all types of cost shocks. The marginal cost curve and the supply curve would equivalent and the clearing price would always be equal to the Walrasian price (i.e. full pass-through). With bidders bidding their cost for each unit we would not expect any type of cost shock to affect production efficiency.

4 Results

We begin our analysis with a general comparison of the performance of the uniform versus discriminatory auctions in terms of procurement payments and efficiency (lowest cost units are accepted). Then, we look at the individual bid data to see if we find evidence that bidders are using the conjectured strategies. We end our analysis by testing our hypotheses regarding the pass-through of private and industry-wide cost shocks in uniform and discriminatory auctions.

4.1 Procurement Payments and Efficiency

Two important performance measures for multi-unit procurement auctions are: 1) How much it costs the buyers to meet demand (average price paid) and 2) Allocative efficiency, where maximum efficiency is achieved by minimizing production costs to meet demand. Figure 2 offers a comparison of these performance measures between uniform and discriminatory auctions. In order to create a common metric across treatments, we normalize the price measures by subtracting the Walrasian price. Likewise, to assess efficiency, we normalize the cost of meeting demand by subtracting the minimum cost of meeting demand.

The left side of Figure 2 displays the normalized price measure, where each point represents the deviation from the Walrasian price in each period averaged over the 18 experimental sessions for each auction type. Because of the normalization, any point above zero represents a price above the Walrasian price and any point below zero represents a price below the Wal-

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7 This strategy is an equilibrium if all bidders act as price takers, an assumption that is appropriate as the number of bidders in an auction increase (Noussair, 1995).
Figure 2: Normalized Prices and Costs Averaged Over Sessions

The right side of Figure 2 offers a comparison of the allocative efficiency between the auction types. Here the y-axis indicates normalized cost. Again, each point on the graph is the normalized cost averaged over the 18 sessions of that auction type. Here, zero represents maximum efficiency and positive values represent deviations from minimum cost. Examining the graphical evidence, it appears that on average the discriminatory auction is less efficient than the uniform price auction. This is consistent with the hypothesis that discriminatory auctions are worse at tracking underlying private cost shocks (particularly negative shocks), leading to production inefficiencies.
4.2 Individual Bidding Strategies

We based our hypotheses on the idea that bidders are following certain strategies. For discriminatory auctions, we conjectured that bidders would bid the expected expected Walrasian price for all units with costs below the expected Walrasian price and cost for all units with costs above the Walrasian price. For uniform price auctions, we conjectured that bidders would bid their cost for each unit. There are no closed form solutions for optimal bidding in these auctions, but our conjectured strategies are equilibria in the limit if the buyer demands a fixed proportion of supply and the number of bidders goes to infinity. Therefore, bidders may use these strategies in a competitive enough environment. Since our environments have a finite number of bidders, bids can affect the probability of acceptance. However, bidders know little about how others costs are changing each round, so it is difficult to assess the probability of acceptance. We will now look at individual bid data to assess the extent to which these are valid benchmarks.

Discriminatory

Figure 3 depicts the evolution of bidding strategies over experimental periods with discriminatory auctions. We display data from our baseline treatment for ease of exposition. The y-axis is average unit bid and the x-axis is unit cost (these are drawn in $0.25 increments). The dashed line represents our conjectured strategy and is flat at the expected Walrasian price (14.3) for unit cost < 14.3 and then takes a 45 degree angle for all unit costs above 14.3. It is clear that in early periods, bidding strategies appear quite different from what we propose. However, as subjects refine their strategies over time, the bids begin to converge on the dashed line. By period 9, bidders appear to be following the strategy relatively closely. Table 1 displays the summary statistics for the accepted bids over experimental periods in discriminatory auctions. The mean accepted bid approaches the expected Walrasian price in the later periods. Also notable is that bid variance drops dramatically in later periods as bidders hone their strategies.
Figure 3: Average Unit Bid vs. Unit Cost: Discriminatory

Table 1: Summary Statistics: Accepted Bids Discriminatory

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Uniform

Figure 4 displays the evolution of bidding strategies over experimental periods for uniform price auctions. This figure is analogous to Figure 3 for discriminatory auctions: we use data from baseline treatments, we graph average bid against unit cost for each period, and the gray line represents our conjectured strategy for uniform price auctions (bid = cost). While there is some noise, it does appear that in general bidders are bidding at cost. There looks to be less adjustment in bidding over time relative to the discriminatory auctions. Table 2 displays the summary statistics for the accepted bids by experimental period. The mean and variance of the bids are relatively constant over the 12 periods. Perhaps the incentives in uniform price auctions are more transparent to bidders than in discriminatory auctions, allowing them to hone in on a strategy sooner.

<table>
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4.3 Pass-through of Cost Shocks

We hypothesized that we would find asymmetric pass-through of private cost shocks for discriminatory auctions but not for uniform price auctions. Figure 4.3 provides graphical evidence of this claim. The y-axis is the average price paid for accepted units. For discrim-
Figure 4: Average Unit Bid vs. Unit Cost: Discriminatory
inatory auctions, this is the average accepted bid and for uniform price auctions it is the average uniform price. The x-axis is the Walrasian, or competitive equilibrium price. The 45 degree line represents points where the average price is equal to the Walrasian price. The three sets of points are data from the negative, baseline, and positive cost shock treatments. We use data from the last 4 periods in the auction to allow time for bidders to refine their strategy. Each vertical line represents the expected Walrasian price for the treatment. If there was full pass-through of all private cost shocks, we would expect to see average price follow the 45 degree line. The uniform price auction data on the right appear to roughly follow this pattern. If there were asymmetric pass-through of private cost shocks average prices would be above the 45 degree line to the left of the expected Walrasian price and on the 45 degree line to the right of the expected Walrasian price. It is clear that in the discriminatory data on the left, prices are above the 45 degree line to the left of the expected Walrasian price, and they are closer to the 45 degree line to the right of the expected Walrasian price.

We also hypothesized that we would not find asymmetric pass-through of industry-wide cost shocks for either of the auction formats. Figure 4.3 compares the pass-through rates following the industry-wide cost shocks. To ease the comparison across treatments,
we normalize the price by subtracting the Walrasian price so that a zeros represents the competitive equilibrium price. The price for discriminatory auctions is the average accepted bid and for uniform auctions, it is the uniform price. We plot the mean of the normalized price measure with 95% confidence intervals for the auction immediately following the cost shock (period 7) and for the last half of the experiment. There appears to be overlap in the distribution of the normalized prices across the three treatments for both auction formats, suggesting symmetric pass-through of industry-wide cost shocks.

We now use regression analysis to test these claims more rigorously. We are interested in whether there is an asymmetry in the adjustment from positive and negative cost shocks within an auction type. We are also interested in how negative and positive cost shocks of both kinds affect discriminatory and uniform price auctions differently. In order to isolate these effects, we interact the cost shock indicators with auction type. Since we have 2 auction formats (uni and dis), 2 types of industry-wide cost shock (pos iw, neg iw), and 2 types of private shocks (pos pri, neg pri), there are a total of 8 treatment indicators. We regress the normalized outcome variables on the 8 treatment indicators, period fixed effects, and session fixed effects. Each coefficient can be interpreted as the mean deviation from the competitive price (or minimum cost) for each treatment type after controlling for session and period fixed effects. We estimate models (1) and (2) using data from periods 5-12, giving participants a chance to learn about the auction format and hone their strategies. Session is indicated by, $s$, and period is indicated by $t$.

\[
\text{Average Price-Walrasian Price}_{st} = \beta_1 \cdot 1(\text{uni pos iw})_{st} + \beta_2 \cdot 1(\text{uni neg iw})_{st} + \beta_3 \cdot 1(\text{uni pos pri})_{st} + \\
\beta_4 \cdot 1(\text{uni neg pri})_{st} + \beta_5 \cdot 1(\text{dis pos iw})_{st} + \beta_6 \cdot 1(\text{dis neg iw})_{st} + \\
\beta_7 \cdot 1(\text{dis pos pri})_{st} + \beta_{10} \cdot 1(\text{dis neg pri})_{st} + \text{FE}_s + \text{FE}_t + \epsilon_{st} \quad (1)
\]
Figure 6: Comparison of Average Price - Walrasian Price For Industry-Wide Cost Shock Treatments and Baseline Treatment. Standard errors are clustered at the experimental session
\[
\text{Cost-Minimum Cost}_{st} = \beta_1 \cdot 1(\text{uni pos iw})_{st} + \beta_2 \cdot 1(\text{uni neg iw})_{st} + \beta_3 \cdot 1(\text{uni pos pri})_{st} + \\
\beta_4 \cdot 1(\text{uni neg pri})_{st} + \beta_5 \cdot 1(\text{dis pos iw})_{st} + \beta_6 \cdot 1(\text{dis neg iw})_{st} + \\
\beta_7 \cdot 1(\text{dis pos iw})_{st} + \beta_{10} \cdot 1(\text{dis neg pri})_{st} + FE_s + FE_t + \varepsilon_{st}
\] (2)

The results from these two estimations are shown in Table 3. In general, the point estimates for both average price and efficiency are positive, indicating that prices are at or slightly above Walrasian prices and that there are some positive production inefficiencies. In general, the coefficients on negative cost shocks are higher (more positive) than the coefficients on positive cost shocks. This means that prices and costs are higher relative to the competitive equilibrium with negative cost shocks than with positive cost shocks, which is consistent with the hypothesis of asymmetric pass-through.

To see which of these differences are significant, we use F-tests to test the restriction that a positive cost shock coefficient is equal to a negative cost shock coefficient. The results are shown in Table 4. The first set of results tests these restrictions for the average price model (left) and the second set tests these restrictions for the cost model (right). As hypothesized, in the price model, the difference between the coefficients on private positive cost shocks and private negative costs is highly significant for discriminatory auctions. None of the other positive and negative cost shock comparisons are significantly different at the 5% or even 10% level.

At the bottom of Table 4, we test the hypothesis that the asymmetry of pass-through is the same for both auction types. These results are also consistent with our hypotheses. The asymmetry in pass-through rate is higher for discriminatory auctions than for uniform auctions for private cost shocks but not for industry-wide cost shocks.

Interestingly, there are several asymmetries in auction efficiency. Uniform price auctions are less efficient following negative private cost shocks than positive private cost shocks. In addition discriminatory auctions are less efficient following negative industry-wide cost
shocks than positive industry-wide cost shocks. However when we test for the difference in the degree of asymmetry between the two auction formats, the difference is not statistically significant at the 5% level for either private or industry-wide cost shocks.

Table 3: Estimation of Treatment Effects

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Average Price-Walrasian Price</th>
<th>Cost-Minimum Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>uniform positive industry-wide</td>
<td>0.157</td>
<td>1.103</td>
</tr>
<tr>
<td></td>
<td>(0.296)</td>
<td>(1.026)</td>
</tr>
<tr>
<td>uniform negative industry-wide</td>
<td>0.104</td>
<td>2.814*</td>
</tr>
<tr>
<td></td>
<td>(0.322)</td>
<td>(1.112)</td>
</tr>
<tr>
<td>uniform positive private</td>
<td>0.226*</td>
<td>3.149***</td>
</tr>
<tr>
<td></td>
<td>(0.0865)</td>
<td>(0.862)</td>
</tr>
<tr>
<td>uniform negative private</td>
<td>0.331***</td>
<td>4.772***</td>
</tr>
<tr>
<td></td>
<td>(0.0544)</td>
<td>(0.537)</td>
</tr>
<tr>
<td>discriminatory positive industry-wide</td>
<td>0.0693</td>
<td>-1.647</td>
</tr>
<tr>
<td></td>
<td>(0.116)</td>
<td>(1.215)</td>
</tr>
<tr>
<td>discriminatory negative industry-wide</td>
<td>0.249</td>
<td>5.990</td>
</tr>
<tr>
<td></td>
<td>(0.152)</td>
<td>(3.108)</td>
</tr>
<tr>
<td>discriminatory positive private</td>
<td>0.142</td>
<td>4.222***</td>
</tr>
<tr>
<td></td>
<td>(0.0780)</td>
<td>(1.127)</td>
</tr>
<tr>
<td>discriminatory negative private</td>
<td>0.483***</td>
<td>5.137***</td>
</tr>
<tr>
<td></td>
<td>(0.0496)</td>
<td>(0.577)</td>
</tr>
</tbody>
</table>

Observations: 288

Standard errors are clustered at the experimental session. * p < 0.05, ** p < 0.01, *** p < 0.001
Table 4: F-Test Results

<table>
<thead>
<tr>
<th>Issue</th>
<th>Average Price</th>
<th>Production Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F stat</td>
<td>p value</td>
</tr>
<tr>
<td>Asymmetric Effect of Private Shocks: Uniform</td>
<td>$β₃ = β₄$</td>
<td>1.32</td>
</tr>
<tr>
<td>Asymmetric Effect of Private Shocks: Discriminatory</td>
<td>$β₅ = β₆$</td>
<td>34.42</td>
</tr>
<tr>
<td>Asymmetric Effect of Industry Wide Shocks: Uniform</td>
<td>$β₁ = β₂$</td>
<td>0.02</td>
</tr>
<tr>
<td>Asymmetric Effect of Industry Wide Shocks: Discriminatory</td>
<td>$β₅ = β₆$</td>
<td>1.39</td>
</tr>
<tr>
<td>Difference in pass-through rates between formats: private</td>
<td>$β₄ − β₃ = β₅ − β₇$</td>
<td>4.65</td>
</tr>
<tr>
<td>Difference in pass-through rates between formats: industry-wide</td>
<td>$β₂ − β₁ = β₆ − β₅$</td>
<td>0.26</td>
</tr>
</tbody>
</table>

5 Conclusion

Asymmetric pricing is observed in many markets. It can be problematic because it may lead to unexpected shifts in welfare if firms capture more surplus than an equilibrium model would predict when prices fall. Common explanations of asymmetric pricing include menu-cost frictions, inventory capacity constraints, consumer search limitations, and short-run tacit collusion. In this study, we find evidence for a new explanation for asymmetric pass-through in multi-unit discriminatory (pay-as-bid) procurement auctions.

In order to maximize their revenue in pay-as-bid auctions, we hypothesized that competitive bidders would bid close to the expected Walrasian (competitive) price for units with costs below that price, and cost or a little above on units with costs above that price. If firms have perfect information about other firms’ costs, bidders will respond to cost shocks and the clearing price will track the change in Walrasian price. However, if firms have imperfect information about other firms’ costs and production processes, there will be asymmetric pass-through of cost shocks. If costs are higher than expected, the clearing price will rise above the Walrasian price. But if costs are lower than expected, the clearing price will remain close to the Walrasian price because bidders are padding their bids to maximize revenue.

We used a laboratory experiment to test our hypotheses. To isolate the effect of
information on the symmetry of pass-through we had shocks to two components of costs: 1) private (only known to the individual bidder) and 2) industry-wide (a common input known to all bidders). To isolate the effect of the auction format on the symmetry of pass-through, we compared the outcomes from discriminatory auctions to the other commonly used multi-unit auction format, uniform price. We find evidence that bidders behavior in discriminatory auctions can be approximated by our conjectured strategy. Further, in line with our hypotheses, our results show asymmetric pass-through of “private” cost shocks but not “industry-wide” cost shocks discriminatory auctions and no asymmetric pass-through in uniform auctions.

Our results contribute to the debate about the relative merits of using uniform versus discriminatory price auctions. It may be the case that uniform price auctions facilitate higher prices on average. However, there may be costs in terms of unexpected welfare shifts of moving to discriminatory auctions, particularly in markets with input prices that fluctuate frequently or where there is a lot of private information.

In addition, our results enrich our understanding of how market equilibria are reached. While it is relatively straightforward to identify an asymmetric pass-through pattern in price and cost data, it often difficult to isolate its cause. The mechanism we describe for asymmetric pass-through of private cost shocks in discriminatory auctions may cause asymmetric pass-through of private cost shocks in other market settings as well. If vendors set prices for multiple units and have private and increasing marginal cost of production, they may try to extract surplus by pricing at the expected equilibrium price. If private cost shocks change the equilibrium price in unanticipated ways, asymmetric pricing and significant welfare shifts could result.
Sources Cited


