Pre-study plan: Cost signals and collusion

Tom-Reiel Heggedal* Espen R. Moen† Christian Riis‡

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Research question

Are list prices as cost signals effective collusion instruments?

We develop a model where sellers in a market signal their costs. After observing the signals, one buyer choose which seller to approach, and gives that buyer a take-it or leave it offer.

Our experiment is designed to test the model's predictions.

Theoretical framework

We analyze a market with two sellers and one buyer. The game has the following stages:

1. With probability s the sellers establish a cartel.
2. Each seller draw independently their type, H or L, where q is the probability of high type. A high type has production cost c_H, the low type has production cost c_L. Type is private information.
3. Sellers simultaneously and independently make announcements, h or l. A cartel always announces h, h
4. The buyer observes announcements, chooses a seller, and offers either p_H or p_L for one unit
5. The transaction goes through if accepted by the seller.

We focus on parameter combinations supporting an equilibrium with the following characteristics:

1. Without any information (empty signals), the buyer offers price p_L
2. With $s = 0$ (no collusion) the unique equilibrium is separating
3. With $s = 1$, point 1 implies that the buyer offers p_L
4. There exists positive values of s, at which the buyer offers p_H, conditional on signals h, h.

*Department of Economics and CESAR, BI Norwegian Business School.
†Department of Economics and CESAR, BI Norwegian Business School.
‡Department of Economics, BI Norwegian Business School.

Beliefs of the buyers are key in our model. For a low s, buyers may believe that collusion is probably not going on and choose p_H with signals $\{h, h\}$. If s is high, buyers may believe that sellers probably collude and consequently offer p_L.

In equilibrium, if the buyer observes signals $\{h, h\}$, he chooses a seller at random and offers

$$\begin{aligned} p_H \text{ if } s &\in \left[0, \frac{1-\Delta}{\Delta}\right] \\ p_L \text{ if } s &\in \left[\frac{1-\Delta}{\Delta}, 1\right], \end{aligned}$$

where $\Delta \equiv \frac{p_H - p_L}{v - p_L} < 1$. We say collusion is effective if $s \in \left[0, \frac{1-\Delta}{\Delta}\right]$.

The following summarizes the main predictions of the model:

- **Model prediction 1**. If collusion does not take place, a pooling equilibrium fails if

$$p_L - c_L > \frac{1}{2}\left(p_H - c_L\right),$$

  and sellers play according to the separating equilibrium. If $p_L - c_L < \frac{1}{2}\left(p_H - c_L\right)$, low type sellers have an inventive to deviate from the separating equilibrium.

- **Model prediction 2**. If both sellers signal h, then then the buyer offers p_H to a random seller if $s \in \left[0, \frac{1-\Delta}{\Delta}\right]$ while the buyer offers p_L to a random seller if $s \in \left[\frac{1-\Delta}{\Delta}, 1\right]$.

Experiment

Design

The experiment is designed to test the main predictions of the model. To do so we have four treatments that vary with respect to the probability the sellers establish a cartel s. Based on model prediction 1, we predict that sellers signal their true type when allowed to choose signal, and that this behavior is invariant to s. Further, based model prediction 2, we predict that buyers' offer conditional on observing two high signals depends on whether s is above or below the separation cut-off $\frac{1-\Delta}{\Delta}$.

Implementation

It is straight forward to implement a parameterized version of the market game (as given by the five stages above) in the lab. Our treatment variable is s, and we use the following parameters: $q = 0.5$; $p_H = 80$; $p_L = 50$; $c_H = 55$; $c_L = 10$; $v = 100$. With these parameters we have $p_L - c_L > \frac{1}{2}\left(p_H - c_L\right)$, and the pooling equilibrium does not exits. Further, the cut-off $\frac{1-\Delta}{\Delta} = 0.667$, and, hence, collusion is effective when $s < 0.667$.

Our main treatment measures are the signals chosen by sellers (conditional on types) and the price offers from the buyers (conditional on signals). In particular, let $\theta \in \{0, 1\}$ denote the true signal of a seller, taking value 0 if the signal is not true and 1 if the signal is true. Further, let $p|_{h,h}$ denote the price offer from a buyer receiving two high signals. We also measure sellers' profits, and whether buyers makes an offer to the seller with the lowest signal. The following table gives an overview of the four treatments and equilibrium predictions:

	$T_1(s=0)$	$T_2(s=0.25)$	$T_3(s=0.5)$	$T_4(s=0.75)$
$\theta =$	1	1	1	1
$p\vert_{h,h} =$	p_H	p_H	p_H	p_L

We use blocks of 9 subjects. Subjects stay within blocks, and unique subjects are used in all treatments. In our analysis we regard average behavior within blocks as independent observations. A session may include several blocks.[1] Subjects play 30 games. Prior to the first game subjects randomly draw roles so that there are 3 buyers and 6 sellers in each block. These roles are fixed for all games. Before each game, subjects in a block are randomly matched into markets consisting of 1 buyer and 2 sellers.

In the experiment, price offers and payoffs are denominated in experimental currency units (ECU). The exchange rate is set to equalize expected payoffs between treatments. At the conclusion of the session subjects are paid privately based on accumulated payoffs in ECU from all games played.

A high cost seller that accepts to sell when offered the low price incurs a loss of 5 ECU. As an insurance against negative payoffs, all subjects are allocated 150 ECU before play starts.

The experiment is implemented by zTree (Fischbacher, 2007) and subject management is handled through ORSEE (Greiner 2015).

Pilot

A pilot study with two matching blocks for $T_1(s=0)$ and one matching block for $T_2(s=0.25)$ was carried out. The predicted pattern of behavior is qualitatively present in the pilot data.

Treatment measure	Observations	Mean	Std.dev
$\theta_{s=0}$	360	0.775	0.418
$\theta_{s=0.25}$	138	0.949	0.220
$p_{s=0}\vert_{h,h}$	114	70.5	14.0
$p_{s=0.25}\vert_{h,h}$	99	69.1	14.5

We observe that a large fraction of sellers signal their true cost, in accordance with theory. Note that θ's are, of course, conditional on that sellers have a signal-choice to make (i.e., when there is no cartel). Further, the price offered conditional on observing two high signals is approximately 70. That is, 71 percent of buyers offered the high price in this situation. The observed treatment effects are $\theta_{s=0} - \theta_{s=0.25} = -0.174$ and $p_{s=0}|_{h,h} - p_{s=0.25}|_{h,h} = 1.4$, with only the first difference significant using parametric tests. The second treatment difference is small and non-significant.

Turning to power tests, we pool observations from our pilot as we only have three independent observations. The prediction from theory in T_4 is $p_{s=0.75}|_{h,h} = 0.50$, however, observed price offers in the pilot are on average 10 price points off from the predicted level. Conjecturing a similar price point deviation in T_4, the difference between average behavior in the pilot and the conjecture from T_4 is 9.2. Based on this effect and the variance in the pilot, we calculate the sample size needed to reach a power of 95 percent or better, given a 5 percent significance level and a Wilcoxon rank sum test (one sided).[2] The power-threshold required is reached with 5 independent matching blocks per treatment.

[1] A session consists of a set of subjects present in the lab at the same day and time.
[2] This estimate was obtained using the method described in Bellmare et al. (2016).

References

Bellemare, C., Bissonnette, L. & Kröger, S. (2016). Simulating power of economic experiments: the powerBBK package. *J Econ Sci Assoc* 2, 157–168.

Fischbacher, U. (2007): z-Tree Zurich Toolbox for Ready-made Economic Experiments. *Experimental Economics* 10(2):171-178.

Greiner, B. (2015): Subject pool recruitment procedures: organizing experiments with ORSEE. *Journal of the Economic Science Association* 1(1): 114-125.