Price Ceilings as Focal Points? An Experimental Test*

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Abstract

In this experiment, we analyze whether price ceilings can have a collusive effect in laboratory markets. Our main interest is the focal-point hypothesis saying that a price ceiling may facilitate tacit collusion and lead to higher prices because it resolves a coordination problem inherent to collusion. Our results reject the focal-point hypothesis. Markets with price ceilings have lower prices than market with unconstrained pricing. The static Nash equilibrium predicts the data accurately.

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1 Introduction

Price ceilings are a common instrument of competition policy. They have been used at least since ancient Greek times and are known from today's markets as diverse as food, rents, fees for physicians, interest rates and electricity spot market prices.

The prevalence of price ceilings and the temptation for policy makers to impose them is easily explained. One can go as far back as Roman Emperor Diocletian (*The Edict on Prices*, 301 A.D.)

> *"In response to the needs of mankind itself, we have decided that maximum prices of articles for sale must be established. We have not set down fixed prices since many provinces occasionally enjoy the fortune of welcome low prices. [E]very person shall take note that the liberty to exceed them [maximum prices] has ended, but that the blessing of low prices has in no way been impaired."*

In short, this policy prevents prices from getting higher than the ceiling but does not harm competition possibly pushing them below the ceiling. To be precise, only non-binding price ceilings (that is, those above the competitive equilibrium price) have this property. Binding price ceilings can lower welfare.[1]

Industrial economists have challenged the conclusion that price ceilings cannot weaken competition with the theory of focal points (Scherer and Ross, 1990). The Folk Theorem (see for example Tirole, 1988) predicts that infinitely many prices can occur as outcomes of collusive equilibria in infinitely repeated games if the discount factor is sufficiently high. This suggests a coordination problem when firms attempt to collude. Here, a price ceiling may serve as a focal point on which firms coordinate. If that is the case, price ceilings would facilitate tacit collusion and lead to higher prices—contradicting the logic captured in the above quote.

Given that the focal point counter argument itself has become rather widespread[2], it has received surprisingly little attention in the literature. First of all, there is no formal model strengthening it. Secondly,

[1]Binding price ceilings have the negative effect of reducing supply since they are set below the market clearing price. Such negative effects were observed during the California electricity crisis where ceilings prices on the spot market worsened the shortage of electricity. See Rassenti, Smith and Wilson, (2001).

[2]For example, the European Commission recently made use of it in the EMI/Time Warner and Sony/BMD merger cases.

there is a remarkable absence of evidence from field markets. A recent exception is Knittel and Stango (2003).

Knittel and Stango (2003) investigate interest rates of U.S. credit cards in the 1980s. In this market, various price ceilings were effective. Most states (81% in 1979) imposed a ceiling of 18% interest rate, 11% had a ceiling below that level, 3% were above the 18% level, and 6% had no ceiling at all. It is precisely this heterogeneity of price ceilings that makes the analysis of this market promising. Indeed, Knittel and Stango (2003) find that interest rates in markets with a 18% ceiling were on average higher than interest rates in markets with a higher ceiling. The lowest interest rates were observed in markets with a ceiling lower than 18%. This suggests the following conclusions which the authors underpin with a number of sophisticated econometric regressions. Ceilings lower than 18% are binding whereas those of 18% and above are not. Since the relative incentive to deviate from a collusive interest rate increases with the interest rate, markets with a ceiling higher than 18% are less often collusive than those with a ceiling of 18%. Since, in addition, markets with the 18% ceiling have higher interest rate than markets with no ceilings, this is convincing evidence that the focal point story is empirically relevant.

In this paper, we analyze whether price ceilings can have a similar collusive effect in laboratory markets. Our main interest is the focal point hypothesis. In the laboratory, we can control whether a price ceiling is non-binding (by setting it above the equilibrium prediction) and we can impose different ceilings in our design. Our paper builds on two previous experimental papers. Issac and Plott (1981) analyze double auction markets with price controls (both price ceilings and floors). They clearly reject the focal point hypothesis. By contrast, their data suggest that non-binding price ceilings actually lower prices, consistent with the traditionally expected effect. Prices often failed to converge to the competitive equilibrium, leaving a "buffer" between the price ceiling and actual prices which prevented full convergence. Coursey and Smith (1983) analyze price ceilings with posted-offer markets. They obtain qualitatively the same results as Issac and Plott (1981). Markets converge to the competitive equilibrium and price ceilings as focal point do not play a role. A maximum price may lower average prices as prices cannot converge from above any more but markets still converge to a price below the ceiling.

Despite this experimental evidence against the focal-point hypothesis, we believe that further experimental research is warranted. Firstly, the results by Isaac and Plott (1981) are hardly surprising because of the well known strong tendency of double auction markets to converge to the competitive equilibrium. Here, non-binding price ceilings cannot be expected to have an effect. Coursey and Smith's (1983) posted-offer markets appear to present stronger evidence against the focal point hypothesis. Posted-offer market often have prices above the competitive equilibrium so a price ceiling may reduce average prices. However, in their design the incentive to collude are extremely small. The highest price ceiling they study is only \$0.05 above the competitive equilibrium (\$5.25) and as a result each seller would increase his or her profit by only \$0.05 or \$0.1. The total profit would increase by less than 10% compared to the equilibrium profit. Deviating from collusion by lowering the price by \$0.01, in contrast yields additional profits of at least \$0.13.[3] Furthermore, due to the random sequencing of buyers, the competitive equilibrium is not a Nash-equilibrium.[4] In the Nash-equilibrium of their design, prices above the price ceiling are played with positive probability, such that it is possible that the price ceiling in Coursey and Smith is indeed binding with respect to the Nash-equilibrium prices. This could explain why a price ceiling that is non-binding (with respect to the competitive equilibrium) still leads to lower prices.

Our design, in contrast, establishes the upper end of the competitive price range as unique Nash-equilibrium and provides substantial incentives to collude at the price ceilings, as profit would increase by about 40%. We therefore believe it is better suited to test the hypothesis.

[3]Unfortunately, details of the design of Coursey and Smith (1983) are not reported, but it appears, that at least one buyer would actually *lose* from colluding because of a forgone commission fee that is not compensated by the price increase.

[4]Given that the number of sellers is four, Nash-equilibrium (understood as Nash-equilibria in a game between the sellers, assuming that buyers maximize their payoffs and randomize between sellers who post the same price) is arguable more appropriate than competitive equilibrium as solution concept in this framework. The lack of detail in Coursey and Smith (it is not evident how the individual sellers' cost schedules look like) makes it impossible to calculate Nash-equilibria. Standard distributions of cost schedules (such that no seller sells more than two units in the competitive equilibrium), however, imply that there is no pure strategy Nash-equilibrium. Mixed strategy Nash-equilibria involve positive probability on prices above the competitive equilibrium.

Unit	Marginal Cost
1	0.50
2	0.90
3	1.30
4	1.70
5	2.10
6	2.50

Table 1: Marginal Production Costs for the Sellers

2 Theory and Experimental Design

We implement posted-offer markets with four symmetric sellers and simulated buyers. Sellers decide simultaneously about prices and they are automatically committed to sell the maximal quantity such that marginal costs do not exceed the price, given sufficient demand. Automated buyers are rationed efficiently, that is they buy in order of decreasing willingness to pay and from sellers in order of increasing price. In case several sellers charge equal prices, buyers split their demand equally and units sold are not restricted to integers.[5]

The marginal costs for the sellers are given in Table 1. There were 24 simulated buyers who could buy one unit each. Their willingness to pay is given in Table 2. The seller were restricted to state prices that were multiples of 0.01 and costs were incurred only for units that were actually sold.

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The competitive price range is easily seen to be $p^* \in [1.70, 1.80]$ and the competitive equilibrium quantity is $q^* = 16$ with each seller selling 4 units. At the upper end of the competitive price range sellers make a

[5]Posted-offer markets are often plagued by a multiplicity of Nash-equilibria. Moreover, these are often derived assuming that buyers split their demand equally between sellers with identical prices (see, e.g. Davis and Holt, 1993), which even rational human buyers have no reason to do (and the experimental software would usually not even allow them to do so). Abolishing this assumption in general destroys all pure strategy Nash-equilibria. By employing computerized buyers who follow the above assumption, we elimate this problem which simplifies the calculation of expected profits, and eliminates any randomness.

# Buyers	WTP
4	3.60
4	3.00
4	2.40
4	1.80
4	1.20
4	0.90

Table 2: Willingness to Pay of the Simulated Buyers and Number of Buyers with the Respective Willingness to Pay (WTP)

profit $\Pi^* = 4 * 1.80 - (0.50 + 0.90 + 1.30 + 1.70) = 2.80$.

The price of 1.80, the upper end of the competitive price range, is also the *unique* Nash-equilibrium of the price setting game between sellers. To see this note first that all prices below 1.80 are strictly dominated by 1.80. Let seller 1 choose a price of 1.80. Market demand at this price is 16 units. Even if the other sellers all choose prices below 1.80, seller 1 can still sell four units since in that case the total supply by the other sellers supply is at most 12 units. Since he could not profitably sell more than four units at any lower price, deviating below 1.80 always leads to a lower profit. Now assume all sellers charge 1.80. If seller 1 deviates to any price $p > 1.80$, seller 1 sells nothing.[6] The reason is that market demand at this price is $D(p) \leq 12$ and the other sellers supply 12 units. Hence all sellers choosing $p = 1.80$ is a Nash-equilibrium.

To establish uniqueness of the Nash-equilibrium, recall that no bidder would choose a strictly dominated price of $p < 1.80$ in a Nash-equilibrium. Then consider the case that $n \in \{1, 2, 3, 4\}$ sellers choose $p^{\max} > 1.80$ and the remaining seller(s) choose prices $1.80 \leq p < p^{\max}$. Since total market demand $D(p^{\max}) \leq 12$ and each seller charging a price below $p^{\max}$ supplies at least 4 units and demand is split equally between sellers who choose the same price, the demand for the sellers at the maximal price is at

[6] While this argument holds for our market with simulated buyers and efficient rationing, it would not hold for a posted-offer market with random sequencing of buyers since a seller might find a buyer with high willingness to pay even after the first 12 units have been sold. In particular, by deviating to $p = 2.40$, a seller would almost for sure be able to sell at least one unit.

most $(12 - 4(4 - n))/n = 4(n - 1)/n \leq 3$. If the highest-price sellers sell nothing (which is always, but not exclusively, the case if $n = 1$) any highest-price firm could profit by deviating to $p = 1.80$, which yields a guaranteed profit of $\Pi = 2.80$. Otherwise, let each of the highest-price firms sell d. In that case, by deviating to $p^{\max} - 0.01$ a highest-price seller would lose only $0.01d$, but, since it could now capture the whole demand previously shared by the highest-price sellers and since it always has excess supply of at least one unit (at cost of at most 1.70), it would increase its sales by at least $\min\{d, 1\}$ and hence its profits by at least $(p^{\max} - 1.70)\min\{d, 1\} > 0.1\min\{d, 1\} > 0.01d$, since $d \leq 3$. Hence it always pays to deviate for the highest-price sellers, so no other configuration of prices can be a Nash-equilibrium.

The collusive outcome is all sellers choosing a price of $p^c = 3.00$, each seller selling 2 units.[7] The profits are $\Pi^c = 2 * 3.00 - (0.50 + 0.90) = 4.60$. The gains from colluding are thus $\Pi^c - \Pi^* = 1.80$ or about 64% of Nash-equilibrium profits. By undercutting slightly to $p^u = 2.99$, a seller can sell six units and make a profit of $\Pi^u = 6 * 2.99 - (0.50 + 0.90 + 1.30 + 1.70 + 2.10 + 2.50) = 8.94$ hence the incentive to undercut is $\Pi^u - \Pi^c = 5.34$, or about 116% of collusive profits. Hence both the gains from collusion as well as the incentives to undercut are substantial. Note furthermore, that if only one seller deviates to p^u, the profit of the remaining sellers drops to $\frac{2}{3}(3.00 - 0.50) = 1.67$ and if two undercut, it drops to 0.

Colluding at $p = 2.40$ is only slightly less profitable, yielding a profit of $\Pi = 3*2.40-(0.50+0.90+1.30) = 4.50$, and hence gains from collusion of about 61%. Moreover, it is much less risky. The profit from undercutting to $p = 2.39$ is $\Pi = 5 * 2.39 - (0.50 + 0.90 + 1.30 + 1.70 + 2.10) = 5.45$, implying incentives to undercut of about 21% of collusive profits. Profits in case one seller undercuts are $\frac{7}{3}2.40 - (0.50 + 0.90 + \frac{1}{3}1.30) = 3.77$ and in case two sellers undercut of $2.40 - 0.50 = 1.90$. Hence three sellers alone can increase their profits from colluding, no matter what the last seller does.

In any case, while there are substantial incentives to collude (profits could be increased by about 2/3), sellers face a coordination problem. Not only are there two reasonable prices at which firms could collude, incentives to deviate are substantial which makes attempts to collude risky. In particular, a lone firm setting the highest price never makes a profit.[8] This coordination problem might be solved in the presence

[7] It is obvious that the collusive outcome has to be at a price where demand drops. Since the profits on the third unit in case sellers charge 2.40 is $2.40 - 1.30 = 1.10 < 2 * 0.60$, it pays to raise the price to 3.00 and sell only two units each.

[8] In the experiment, they sometimes do, if sellers choose dominated prices < 1.70 reducing their supply below 4 units.

Treatment	Ceiling Periods 1-30	Ceiling Periods 31-60
LowNo	Low (2.20)	None
NoLow	None	Low (2.20)
HighLow	High (2.80)	Low (2.20)

Table 3: Overview of the Price Ceilings in the Three Experimental Treatments

of a price ceiling, since it present a focal point for coordination. Furthermore, it reduces the incentives to undercut relative to the collusive profits, which should increase stability of a collusive agreement.

We study the effect of price ceilings in three treatments. Each treatment runs over 60 periods and is split into two halves. In our two main treatments LowNo and NoLow, we implemented a low price ceiling $p^l = 2.20$ either in the first 30 periods (LowNo) or in the second 30 periods (NoLow). In the third treatment HighLow we started with a high price ceiling $p^h = 2.80$, which was lowered to $p^l = 2.20$ in the second half. See Table 3 for an overview.

Collusion at $p^l = 2.20$ would yield profits $\Pi^l = 3 * 2.20 - (0.50 + 0.90 + 1.30) = 3.90$ and hence gains from collusion of $\Pi^l - \Pi^* = 1.10$ or about 39% Undercutting to $p = 2.19$ yields a profit of $\Pi = 5 * 2.19 - (0.50 + 0.90 + 1.30 + 1.70 + 2.10) = 4.45$, implying incentives to undercut of about 14% of collusive profits. Hence the incentives to deviate from the collusive agreement at p^l are slightly lower than for collusion at $p = 2.40$ and dramatically lower than for collusion at $p = 3.00$.

Collusion at $p^h = 2.80$ would yield profits $\Pi^l = 2 * 2.80 - (0.50 + 0.90) = 4.20$ and hence gains from collusion of $\Pi^h - \Pi^* = 1.40$ or 50%. Undercutting to $p = 2.79$ yields a profit of $\Pi = 6 * 2.79 - (0.50 + 0.90 + 1.30 + 1.70 + 2.10 + 2.50) = 7.74$, implying incentives to undercut of about 84% of collusive profits. Thus the incentives to deviate from the collusive agreement at p^h are lower than for collusion at $p = 3.00$. The profits are, however, lower than for collusion at $p = 2.40$. Hence while the high price ceiling could also solve the coordination problem by providing a focal point, the coordination problem is not solved completely, because, opposed to collusion at the low ceiling, it is not maximizing joint profits among the admissable prices. Furthermore, it should be less robust since the incentives to deviate are substantially higher than at the low price ceiling.

Written instructions were identical in all treatments and are reprinted in the appendix. Subjects were informed at the beginning of the experiment that there would be a change in the market rules in the second half of the experiment without being informed about the nature of this change. In case a price ceiling was introduced, changed or abolished, subjects were informed about this by a message on the computer screen.

For our main treatments LowNo and NoLow we ran two sessions with 12 subjects each. Since fixed groups of four subjects interacted for the whole experiment, this implies six statistically independent observations per treatment. For the third treatment HighLow we conducted one session with 12 subjects or 3 independent observations.

The experimental software was developed and the experiments were run using zTree (Fischbacher, 1999). The experiments were run at the experimental laboratory at Royal Holloway, University of London in January and February 2005. The subjects were Royal Holloway students (90% undergraduates) of various disciplines (28% economics, 15% management, 57% others, including mathematics, media arts, history, etc.).

The experiments (including reading of the instructions and payment) took between 75 and 90 minutes. Subjects were paid in cash at the end of the experiment at a rate of 20 points = 1£ plus a £4 flat fee. Average payoffs (including the flat fee) were £11.46 in LowNo and £11.87 both in NoLow and HighLow. For comparison, Nash-equilibrium profits are £12.40, whereas if subjects collude at $p = 2.40$ if there is no ceiling and at p^l if there is a low ceiling, profits would have been £16.60. Hence subjects achieve profits substantially below collusive profits and even below Nash-equilibrium profits.

3 Results

Figure 1 and Table 4 show the results of our main treatments LowNo and NoLow. Prices are generally higher without price ceilings in both treatments. Prices [with] *without* the ceiling appear to be higher particularly in LowNo when a ceiling in phase 1 was released in phase 2. This pattern confirms the findings by Coursey and Smith (1983).

The *differences between* session averages reported in Table 4 are statistically significant (where each of our six groups of four firms counts as one observation and data from all periods is used). In LowNo,

	treatment LowNo			treatment NoLow		
		all periods	second half		all periods	second half
phase 1	Low Ceiling	1.789 (0.184)	1.782 (0.150)	No Ceiling	1.922 (0.313)	1.833 (0.101)
phase 2	No Ceiling	2.013 (0.599)	1.914 (0.636)	Low Ceiling	1.833 (0.093)	1.819 (0.071)

Table 4: Summary Statistics of prices, standard deviations in parentheses

phase 2 prices are significantly higher (two-sided Wilcoxon, $p = 0.027$) whereas in NoLow phase 1 prices are higher (two-sided Wilcoxon, $p = 0.027$). We can also compare across treatments. In phase 1, prices in NoLow are higher than those in LowNo (two-sided Mann-Whitney, $p = 0.016$) and in phase 2 it is the other way round (two-sided Mann-Whitney, $p = 0.024$). These differences are not significant any more if we only take data from periods 16-30 and 46-60 into account. Finally, we do not observe an order effect. That is, phase 1 prices in NoLow are not different from phase 2 prices LowNo, and phase 2 prices in NoLow are not different from phase 1 prices LowNo.

Result 1. Price ceilings cause lower prices. Average prices without a ceiling are significantly higher at the 5% level both within treatments and across treatments if data from all periods is taken into account.

The second feature of the data as shown in figure 1 and Table 4 is that the Nash equilibrium prediction of 1.80 works remarkable well. Prices converge towards 1.80 in both phases of both treatments. When a price ceiling is imposed, average prices are extremely well organized by the Nash prediction. After some five to ten periods, average prices are only marginally below or above 1.80. Without a ceiling, prices are "close" to 1.80 only in the final periods of the relevant phase. To statistically validate this claim, we compute 95% confidence intervals around the means reported in Table 4. The intervals are based on White (1980) robust standard errors which account for possible dependence across time and groups.[9] We find that the 95% confidence intervals include the Nash prediction of 1.80 in all cases listed in Table 4 except phase 2 of treatment LowNo when data from all periods is taken into account.

[9]Conservative non-parametric tests do not allow to test for a ...

The histogram in figure 2 shows the frequency of choices with and without price ceiling. It is based on data from periods 16-30 and 46-60 from both treatments. It reveals that the bracket including the Nash prediction (1.75 - 1.85) contains by far the most choices (58% and 70% respectively). Moreover, when we ignore the somewhat arbitrary brackets and look at individual prices, it turns out that 1.80 is the most frequent choice both with a price ceiling (17%) and without (18%). Moreover, the Nash price is also the median of the distribution with and without price ceiling.

Result 2. The Nash equilibrium predicts average prices well. Average prices are not statistically different from the Nash prediction in both phases of all treatments. The Nash prediction is also the mode and median of the distribution of prices both with and without a price ceiling.

We finally report on the alleged focal-point effects of the price ceilings. From results 1 and 2 and figure 1, it is clear that the price ceiling of 2.20 does not predict average prices well. The histogram in figure 2 shows that the 2.20 bracket is of minor importance at best. We find that the price of 2.20 was set only 9 times (or less than 1%) when the ceiling was effective (where the total number of price observations is 1140). We conclude

Result 3. The price ceiling does not play any role in firms' price-setting behavior. There are virtually no attempts to establish 2.20 as a collusive price. The price ceiling plays no role as a price choice.

We finally report on another treatment, HighLow. The rationale for this treatment was that collusion under the high ceiling may be too difficult to sustain because incentives to deviate are relatively higher. Collusion should be more likely in the second phase. However, see table 5, we do not observe much collusion here. The Nash equilibrium prediction works well again and the ceilings have no apparent impact on behavior.

		treatment HighLow	
		all periods	Periods 16-30, 46-60
phase 1	High Ceiling	1.87 (0.21)	1.82 (0.06)
phase 2	Low Ceiling	1.81 (0.05)	1.80 (0.03)

Table 5: Summary statistics of prices, standard deviations in parentheses

Result 4. The price ceiling does not have any influence on firms' price-setting behavior in treatment HighLow.

4 Discussion

Why does the focal point hypothesis fail so spectacularly? It seems that subjects simply take the price ceiling as given. They leave a "buffer" between the ceiling and their choices rather than trying to collude on the highest price possible. Note also the difference in behavior in the early periods of the second phase. Whereas in LowNo subjects jauntily set very high prices (higher than the price that would maximize joint profits, 3.00), in NoLow subjects are not even close to the maximum *admissable* price.

Perhaps the most surprising aspect of our data is the convergence to Nash equilibrium. Posted-offer markets do not always converge and if they do then usually to the competitive equilibrium (Plott, 1989). Here, however, we observe convergence to the Nash equilibrium in all treatments and all sessions. The only group that does not converge but manages to collude for a while is in treatment LowNo. Interestingly, this group colludes in the phase without a price ceiling at $p = 2.40$, after having converges remarkably quickly to the Nash-equilibrium in the first phase. We see the following possible reasons for this surprisingly robust convergence

- As opposed to the majority of posted-offer markets, our design implies a unique Nash-equilibrium which coincides with the upper end of the competitive price range.

- Sellers were restricted to setting prices but their quantity choice was automated. This prevented a collusive high-price low-quantity strategy, which might have made collusion comparatively difficult because it required exact coordination on a price.

- The fact that buyers were simulated eliminated non-maximizing behavior of the buyers. This in turn ensures that sellers obtain their equilibrium profits if they set equilibrium prices, which facilitates convergence. Put differently, in our experiment only the sellers needed to converge, while in posted-offer markets with human buyers, the behavior of both sellers and buyers has to converge.

5 Conclusions

In this paper, we have reported on experiments designed to test the focal point hypothesis of price ceilings. This hypothesis argues that price ceilings may have the counter-intuitive effect of raising prices rather than lowering them. The logic is that price ceilings serve as a coordination device. Because the price ceiling is a focal point, firms will find it easier to collude than without the ceiling.

In our experimental data, we do not find such an effect at all. Prices are initially lower with a ceiling than without one, and later in the experiment they do not differ significantly. The maximum admissable price is virtually never chosen. Further, we find strong evidence that the Nash equilibrium price predicts the data very well.

Our results are consistent with previous findings by Issac and Plott (1981) who analyze double auction markets with price controls and Coursey and Smith (1983) who do the same for posted-offer markets. Our results strengthen these earlier results, because we provide substantially higher potential gains from collusion and ensure that the price ceiling is not binding with respect to Nash-equilibrium prices. Our results are in contrast to the field-data study by Knittel and Stango (2003) who find a focal point effect of price ceilings.

Dufwenberg, Gneezy and Nagel (2002) find that price floors may actually lower prices. They analyse simple duopoly experiments with perfect Bertrand competition. They find that, without the floor, subjects' choices are somehow bound away from marginal cost pricing whereas with the price floor substantially above marginal cost is often chosen. As a result average prices are higher without the floor. Their findings are not predicted by the Nash equilibrium or the quantal response equilibrium refinement.

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Figure 1

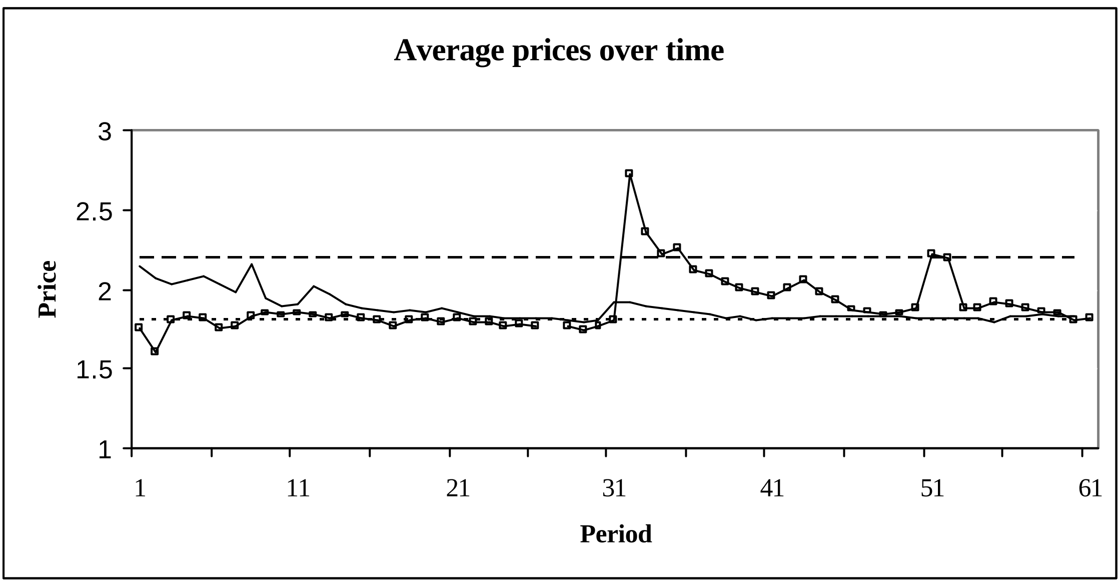
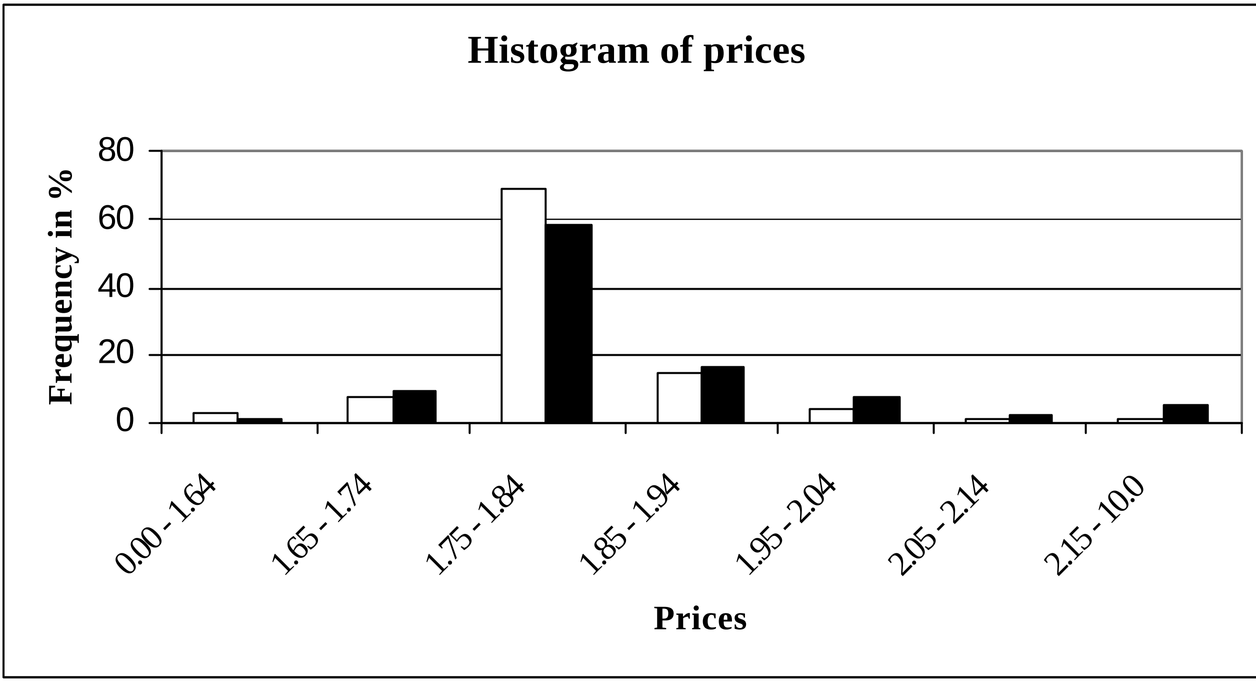

Average prices over time
Price
3
2.5
2
1.5
1
1
11
21
31
41
51
61
Period

Figure 2



Note: data from periods 16-30. Solid boxes: no ceiling, empty boxes: ceiling 2.2

Instructions

This is an experiment on market decision-making. Take the time to read carefully the instructions. A good understanding of the instructions and well thought out decisions during the experiment can earn you a considerable amount of money.

In this experiment, you will be one of four sellers in a market. You will have to decide at which price you are going to sell a fictitious commodity. There will be 2 times 30 periods of trade. After the first 30 periods, we will change the market conditions. We will inform you in detail about theses changes after the first 30 periods are over.

During the 60 periods the other three sellers in the market are represented by the same subjects. That is, though there are 12 participants in the room, the same four sellers will serve the market for the entire course of the experiment. The other 8 participants will serve other markets.

The trade of the commodity determines your payoff in "Points". After the experiment, your payment in Pound Sterling will be computed and you will be paid immediately in cash. You will get £1 for every 20 Points you earned. In addition, you receive a payment of £4 independently of the points you earned.

In what follows, we will explain to you how sales in the market will be done and how your earnings are computed. After you have read the instructions, you will have the opportunity to ask questions. Before we start with the actual experiment, we will ask you a few questions in order to review these instructions and ensure everybody has fully understood them. Then we will begin the first trading period.

How sales are done:

In every period, you and the other three sellers in the market choose a price at which you wish to sell units of the commodity. While you may sell more than one unit, you can post only one price. That is, you cannot sell different units at different prices. Prices may have two decimal points.

Each seller can produce and sell up to six units in every period. You have to pay production costs for each unit you sell. The production costs for each unit you may sell are as follows:

Unit	Costs in Points
1	0.50
2	0.90
3	1.30
4	1.70
5	2.10
6	2.50

What the table says is that, for the first unit you may sell, you have costs of 0.50 Points. If you sell a second unit, this second unit costs you 0.90 Points, and so on for units 3 to 6. For example, if you sell two units, your total costs are 0.50 + 0.90 = 1.40. You do not incur any costs for units, which you do not sell. Note that all four sellers in the market have the same costs of production. (In fact, everybody in the room is reading the same instructions.)

The number of units of the commodity you offer will automatically be chosen by the computer in a way that ensures that you do not make losses. At most, you will sell the quantity that can be produced at costs below or equal to your chosen price. For example, if you post a price of 1.43, you will not sell more than 3 units. That is, the computer programme ensures that you will never sell any units at a price below production costs. Note that this is the maximum quantity you may sell. The actual quantity you will sell will depend on the demand and on the prices that you and the other sellers choose.

How purchases are done:

No buyers participate in this experiment. Instead, buyers are simulated by the computer. Each simulated buyer can buy exactly one unit. Each buyer has a certain (maximum) willingness to pay for the unit. This willingness to pay is simply the highest price at which the simulated buyer will purchase the commodity. These maximum prices buyers are willing to pay and the according number of buyers who have this willingness to pay are as follows:

willingness to pay	number of buyers with this willingness to pay
3.60	4
3.00	4
2.40	4
1.80	4
1.20	4
0.90	4

From the table you see that there are 24 buyers in total. 4 buyers are willing to pay up to 3.60 Points for their unit, 4 more buyers are willing to pay up to 3.00 Points for a unit, and similarly 4 buyers are willing to pay 2.40, 1.80, 1.20 and 0.90 respectively. Note that, given these values, no unit will be purchased from sellers who set a price higher than 3.60.

After you and the other sellers have chosen the prices, the simulated buyers make purchases according to the following rules:

1. Buyers purchase in decreasing order of their willingness to pay. That is, the first four buyers who purchase are those who pay up to 3.60 for their unit. Then come the buyers who pay up to 3.00, and so on.
2. Buyers start to purchase from the seller with the lowest price, then buyers purchase from the seller with the next lowest price, and so on.
3. Buyers purchase their unit only if the price of that unit does not exceed their willingness to pay. As long as a price posted by you or another seller does not exceed this maximum price, the buyer will buy.
4. If two or more sellers post the same price, the buyers who want to buy at this price will split their demand equally between these sellers.
   For example, assume that there are two sellers who charge a price of 2.89 (implying a total demand of 8 units at this price). Suppose further that the other two sellers charged lower prices such that these two sellers already sold 7 units. Then the two sellers charging a price of 2.89 face a demand of 1 unit jointly together, and our rule number four would imply that both sell half a unit. Each of them would incur costs for only half a unit, (0.50/2 = 0.25). This is why we allow the commodity to be divisible.

Earnings and feedback:

Your earnings are as follows. For every unit you sell, you earn the difference between your price and production costs for that unit. Total earnings in every period are the sum of earnings for all units sold. The computer will calculate the earnings for all units sold and also total earnings.

At the end of each period, you will see a screen informing you about the following:

- The prices charged by the other sellers in the market.
- The total quantity supplied by other sellers at prices lower than your price.
- The total demand at your price.
- The number of units you sold.
- Your total costs for the units you sold.
- Your resulting profit.

As an aside, the prices of the other sellers are given in decreasing order. Therefore you cannot identify other sellers by the position of their price in the feedback screen.

Summary of instructions:

- Sellers:
    - Sellers can produce and sell up to 6 units. All sellers have the same costs of production.
    - Sellers earn the difference between the price and their unit costs.
    - By posting a price, sellers decide to sell any number of (up to six) units at this price as long as production costs do not exceed the price.

- Buyers:
    - Buyers are simulated by the computer.
    - Each buyer can buy one unit.
    - Buyers buy as long as the price does not exceed their willingness to pay.
    - Buyers shop in order of decreasing willingness to pay.
    - Buyers start purchasing from the cheapest seller.

- The experiment is divided into a series of 2×30 trading periods. You and the same other three sellers will serve one market for the whole 60 periods.

Please answer the following questions before we start with the experiment

To begin with, note that the prices that occur in this example have been randomly generated. They are not meant as examples of "good" or "bad" choices. They only serve to illustrate how the market works.

Do not worry if you have difficulties with finding the answers. The computations you are asked to do here will be done by the computer during the experiment. With the following questions, we just want to make sure that you have complete understanding of how the market works. We will explain the solutions later on.

In our example, the four sellers charge the following prices:

Seller 1: 2.77
Seller 2: 0.94
Seller 3: 3.98
Seller 4: 1.33

1.) From which seller would the buyers purchase first, second, third and fourth? Please write down the answer in column A. (Hint: Recall that buyers start with the sellers with the cheapest price and then move on to the sellers with higher prices.)

	A	**B**	**C**	**D**	**E**
Buyers buy …	… from seller number	price of this seller	number of units offered by seller	number of units demanded	by buyers with willingness to pay
first					
second					
third					
fourth					

2.) Now, please add the prices the sellers post in column B. (E.g., Seller 2: 0.94)

3.) How many units would the individual sellers offer at the prices given in the example? Please write them down in column C. (Hint: Recall that the quantity that a seller offers is the maximum quantity that can be produced at costs below or equal to the price. Use the table with the cost data to find the answer.)

4.a) How many units would buyers buy from the individual sellers? Write down the answer in column D.
4.b) In column E, please write down the willingness to pay of the buyers who would buy from the respective seller. (Hint: Buyers with the highest willingness to pay start purchasing. Buyers keep purchasing until their willingness to pay is not lower than the price. Use the table with the willingness to pay data to find the answer.)

Here are the correct answers to the questions in the questionnaire.

	A	B	C	D	E
Buyers buy …	… from seller number	price of this seller	number of units offered by seller	number of units demanded	by buyers with willingness to pay
first	2	0.94	2	2	2 buyers with 3.60
second	4	1.33	3	3	2 buyers with 3.60 1 buyer with 3.00
third	1	2.77	6	3	3 buyers with 3.00
fourth	3	3.98	6	0	0 buyers

Let us finally illustrate with an example how the profits are determined in the markets.

Have a look at seller 1 and let us summarise the information from the table:

- Seller 1's price is 2.77, so he will offer 6 units.
- At this price, 8 units would be demanded by the buyers (4 buyers with a willingness to pay of 3.60 plus 4 with a willingness to pay of 3.00).
- Buyers have already bought 5 units from sellers with lower prices, so only 3 buyers demand a unit from seller 1.
- These three buyers have a willingness to pay of 3.00, so they are actually willing to pay seller 1's price of 2.77.

We can conclude that:

- Seller 1 has revenues of 3*2.77 = 8.31.
- Seller 1 incurs costs for these three units of 0.5+0.9+1.3 = 2.70.
- Seller 1 will earn a profit of 8.31 – 2.70 = 5.61.