Location Experiments: Preliminary Results

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Abstract

This paper lays out an agenda for location experiments. Preliminary results are obtained from classroom experiments.[1]

1 Introduction

To date, there has not been much experimental analysis of location theory. Benson & Feinberg (1988) is an early paper. Amoz Kats has produced a list of suggested location models to test. First, there are the location-only games where prices are fixed. On a unit line, there can be any number of firms. There exist theoretical equilibria for all number of firms except three. I plan to run preliminary experiments with groups of two and three in December. It would be interesting to see if any pattern develops in the three-firm case.

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†Transcription of version of January 16, 1996.

[1]This is my second "Third-year paper," which proposed several ideas for experimental research. The first idea (location experiments), led to the successful funding of research for my second dissertation, "Experiments in Location Games" through an NSF doctoral dissertation enhancement grant. Another idea is an extension of Gode and Sunder's (1993) oral double auction with zero-intelligence agents, which is not a part of my second dissertation, but is on my future research list.

It is important to keep in mind that there are also cooperative outcomes. In Brown-Kruse, Cronshaw, & Schenk (1993), a simple location-only (price fixed) game is used to test both competitive and cooperative outcomes with two firms. Experimental results yielded outcomes that closely resembled both theoretical outcomes. First, with anonymous pairings negating any possibility of coordination, the competitive outcome resulted. And in another treatment, with the possibility of nonbinding communication, the cooperative outcome was observed.

Another possibility of an interesting experiment would be to conduct this model with sequential moves. This could be one-shot, testing the location strategy, or it can be continuing, allowing the firms to first enter sequentially, then moving around. Two- and three- firm cases might be interesting here.

All of these experiments can be carried out easily in discrete multiple periods in the classroom setting. Continuous time requires computer assistance.

2 Preliminary Results of Preliminary Experiment

Location only, simultaneous, multiperiod, 2-, 3-, and 4-firm groups, run on November 30, 1995, by Tony Dziepak

2.1 Design

Price fixed, choose location along a linear market space of length 100. Players must choose integer from 0 to 100 indicating location choice. Players move simultaneously, and run multiple periods. Groups of two, three, or four players. Simulated consumers are uniformly distributed along space, with 100 buyers total. Each buyer will walk to the nearest seller to purchase one unit per period. Goods are identical in price and quality among sellers.

2.2 Procedure

The classroom used was an undergraduate game theory class at Virginia Tech. There were 10 students. We intended to run two pairs and two triples, but after three periods, we combined the two pairs into a group of four (see results). Groups were matched anonymously, but subjects knew if they were in a group of two, three, or four. Instructions and a sample record sheet are included in appendix 1. The instruction sheets were coded in letters only so that no numbers influenced their ordering.

Subjects wrote their location choice on their record sheet. The monitor collected the sheets and the location choices were recorded, and the profits were calculated. When the sheets were returned, the subjects learned the location choices of the other player(s) in their group, their (own) profit for the period, and their cumulative earnings. We ran a total of 8 periods.

2.3 Results

All players in the two-firm groups played 50 for the first three periods. This is the theoretically predicted outcome. This was expected because this was a game theory class. To make things more interesting, we decided to combine the two groups of two into one group of four.

In the three-firm case, so far there is no apparent pattern. The raw data is given in Table 1. I will plot these later.

One four-firm group was run for the last five periods. The results are given in Table 2. It appears that the four players were trying to reach the theoretically predicted outcome of (25, 25, 75, 75). Problems resulted when players decided to alternate between the first and third quartiles. There was a coordination problem Players may have wanted to pair up at the quartiles, but the last two rounds resulted in three and one. Some players may have picked an intermediate location in anticipation of this. The equilibrium might have been achieved with more rounds.

According to the exit interviews, one triplet subject indicated that he was

Table 1: Three-Player Group Results.

Period	x_1	x_2	x_3	q_1	q_2	q_3	p_1	p_2	p_3
Group 1									
1	67	66	35	33.5	16	50.5	33.5	16	50.5
2	65	50	45	42.5	10	47.5	76	26	98
3	55	20	40	52.5	30	17.5	128.5	56	115.5
4	60	65	68	62.5	4	33.5	191	60	149
5	50	33	48	51	40.5	8.5	242	100.5	157.5
6	60	39	69	15	49.5	35.5	257	150	193
7	35	42	70	38.5	17.5	44	295.5	167.5	237
8	37	30	70	20	33.5	46.5	315.5	201	283.5
Group 2									
1	33	51	70	42	18.5	39.5	42	18.5	39.5
2	70	75	75	72.5	13.75	13.75	114.5	32.25	53.25
3	70	49	50	40	49.5	10.5	154.5	81.75	63.75
4	70	47	33	41.5	18.5	40	196	100.25	103.75
5	70	32	33	48.5	32.5	19	244.5	132.75	122.75
6	70	29	51	39.5	40	20.5	284	172.75	143.25
7	60	31	28	54.5	16	29.5	338.5	188.75	172.75
8	60	71	71	65.5	17.25	17.25	404	206	190

not deviating from a position for most of the periods, in an effort to signal his ”claim” on that spot. His idea was that others should learn that this is his location, and that they should avoid this location. He also stated that he deviated from that spot in order to ”gain more,” obviously an end-game strategy.

From the exit interviews, it is obvious that a continuous game would be very insightful.

Table 2: Four-Player Group Results.

Period	x_1	x_2	x_3	x_4	q_1	q_2	q_3	q_4
1	50	48	75	50	6.75	49	37.5	6.75
2	50	40	25	20	55	12.5	10	22.5
3	50	80	75	30	22.5	22.5	15	40
4	20	20	75	35	13.75	13.75	45	27.5
5	20	78	75	60	40	23.5	9	27.5
Total sales					138	121.25	116.5	124.25

2.4 Discussion

While the spreadsheet did work as planned to assist in the calculation of sales between periods, it was apparent that the layout of the program could be improved to facilitate quicker calculation and recording of data.

In the three- and four-firm groups, the procedure of recording the other seller's location was not consistent. That is, the two columns labeled "other seller's location" may have been scrambled. Players may have concluded from this that the same other players' locations were consistently kept in the same column throughout the periods, but this was not the case. Thus the players may have thought that other players were jumping around more than they actually did.

This scrambling of columns was most prevalent in the four-firm case, and may have contributed to the flip-flopping.

2.5 Conclusion

I think it would be beneficial to run these experiments using computer assistance. This would greatly facilitate the quick calculation and tabulation of results between periods. From the preliminary results, my intuition is that players want to reach the equilibrium if they could. Thus the 2-, 4- and 5-firm cases should be straightforward in terms of motivation, regardless of the information environment. The only thing that will change with the information design (allowing nonbinding communication, precommitted observation, etc., will be the speed at which the players arrive at that equilibrium.

More interesting might be the cases where the number of players are greater than 5. Here, multiple equilibria exist. Will some equilibria configurations be more prevalent than others, and will this depend on the design? Maybe some formations will never be reached in practice.

The three-firm case needs to be examined further; with more periods and with different treatments of learning.

It would be interesting to try this basic location model with different treatments of time periods. This was done with simultaneous moves in discrete time periods. It would be interesting to try one session of continuous time, or sequential play. Sequential play is examined more closely in the next section.

2.6 Sequential entry

Prescott & Visscher (1977) Shows sequential entry of firms with foresight: in three firms, the outcomes are different depending on if the game is winner-take-all, or if the players each collect their earnings. Kats recently spoke (Nov 95) about a modification of the rules of the game, which results in equivalent outcomes regardless of winner-take-all, or keep what you earn. It involved a requirement that players could not locate at the same point in space, and allowing the players to opt out of the experiment.

In experimental economics, I wonder if the participants are playing with a winner-take-all mentality. The idea of these modifications may have important implications for experimental design; especially in location games.

Here's what needs to be done with sequential moves: first, a multiperiod game, sequential version of the location games, in linear and circular space. Also, one-shot games with both treatments of location rules.

2.7 Continuous Time

With computer assistance, one could envision a video-game-like environment, lasting an average of five minutes. The two sellers would each be positioned in front of a monitor, which instantly displays the current location and earnings rate of both sellers.

There could be many treatments of location changes. In one treatment, sellers could instantly change locations by typing the mile-post number on the keyboard and hitting enter. The location would instantly move, and be observable to both sellers.

Another treatment might be that changes in location is slow, so that once the new position is entered, the firm can only move, say, one mile per second. This adds some precommitment in changes in product positioning, and this may give the other firm an indication of the direction in which its rival is headed.

Suppose that sellers could change their position by the application of costly force, like a spaceship changing velocity by firing rockets? The idea is that changing location is costly, and to initiate the velocity, the seller must apply force (investment cost). The move is somewhat committed because it requires equal and opposite force to decelerate the firm into the new location. Furthermore, more force applied will move the firm to the new position quicker.

This could be done in velocity instead of acceleration. In this case, the cost of the change is proportional to the distance moved and the speed of change.

Another idea is that the rival observes the proposed repositioning of its rival in advance. The repositioning precommitment could be observed by both sellers as an open dot, moving slowly at one mile per second, and then when the open dot reaches its new location, the actual change in location occurs instantly.

The results can be analyzed for dynamic patterns that might develop, which may reflect dynamics observed in the real world.

I have no idea if any of these experimental settings could be easily conducted. It would require a computer program that could instantly display location and profits as they happen. I can envision the development of software that could conduct all sorts of these simultaneous games. They could play very much like a video game.

I think a few discrete periods forces the sellers to play a pure strategy although mixed strategies is the equilibrium theoretical outcome. I think that a greater number of periods (at least 30), a sequential game, or a continuous time setup, as described above, may reveal some observation of mixed strategy behavior.

2.8 Mixed Strategy

It is difficult to observe mixed strategies. If a player has to choose a location in a period, you don't know if he is playing pure or mixed strategies. Perhaps he wants to choose location A with probability .5 and location B with probability .5. So the player randomizes, but this is not observed. Suppose players are allowed to explicitly select a mixed strategy; i.e. they write down .5(A)+.5(b). Then the experimenter can randomize for them. The experimenter can thus observe true strategy better.

2.9 Extension 2: including buyer behavior

Another idea is to test buyer behavior in the face of search costs. This paper measures firm behavior (using human subjects), assuming that consumer behavior is optimal. In this simple model, there is no reason to expect that buyers would act any differently.

However, when reservation prices are introduced in a multiperiod game, I think there might be some countertheoretical behavior. In addition, my first paper deals with location theory with consumers that have incomplete information about prices that the firms charge. It involves incurring solicitation costs in the form of canvassing the shops. It is possible that search behavior in the real world is different from the theoretical solution.

2.10 Procedures

I think that these location theory experiments are a bit more complex than the usual experiments; for example, simple ultimatum games. Perhaps it would be good if I could first be involved with a simpler experiment as a warmup, and to gain some experience. Perhaps I could do some other simple location experiments, like the ones described on the Kats mimeo, in section 2, above.

2.11 Price and location

In a two-firm game where players can choose both price and location, the theoretical outcome is that firms should locate at approximately 0.27 and 0.73, and play mixed strategies in prices. A design consideration might be how to interpret mixed strategy behavior of subjects. To really observe mixed strategies, I think a good experiment would have either many periods (more than ten), or be run in continuous time.

Other extensions: quadratic transportation cost, unit circle market space.

3 Comments on and ideas for extensions of Gode & Sunder (1993)

3.1 Summary

An attempt to determine how much of the ODA efficiency is attributable to the discipline of the institution vs. attributable to the rationality of the human traders. Runs a 3-factor, 5-treatment design. Factors: 1) machine traders that bid and offer randomly from the interval [0, 200], 2) machine traders that bid and offer randomly from the same interval subject to budget constraints (reservation prices and costs), and human subjects that attempt to maximize profit subject to the same budget constraints.

Treatments: 5 budget constraints with different characteristics. Six buyers and sellers

Comments: Poor direction of human subjects: No publication of demand and supply schedules, instructions, making experiment difficult to replicate.

3.2 Results

The zero-intelligence traders showed less convergence toward the equilibrium price than the human subjects, but there was some slight convergence. However, the ODA was able to achieve a high-level of allocative efficiency.

This paper contrasts the low variance of the ZI-C with the ZI-U. It is unfair to characterize the difference in the variance as resulting from the market discipline. This is from the discipline of the budget constraints.

This paper might have implications for markets that involve agents that are not profit-motivated, such as publicly-provided goods.

Interesting extensions would be to compare the efficiency of ZI traders in an ODA institution with other trading institutions, such as bilateral bargaining, posted-price, etc.

3.3 Extension 1. Run same experiments with replacement

As follows: Six buyers and six sellers begin the market with the given demand and supply schedules. Other buyers and sellers are used to replace the original buyers and sellers when a transaction occurs. The entering buyer and seller are given the same reservation price and cost of the exiting buyer and seller so that the demand and supply curves remain constant. The replacement traders observe all transactions as they occur.

In this way, one can separate the inherent price conversion of ZI traders from the convergence associated with learning. In this setup, there will be no intraperiod convergence of ZI-C traders (in contrast of the God and Sunder (1993) result). The interesting result will be how much less convergence there is in the human traders. I predict that the humans will converge much slower. The convergence in this model will be 100 percent attributable to learning by the humans of prices. The market discipline of forcing the latter period trades into narrower range of viable prices is removed.

Another result that would be marvelous is if the human traders converge to the average price, rather than the equilibrium price. Indeed, any significant difference from the equilibrium price toward the average price would tend to support the theory that market discipline is important to guide the traders to the equilibrium.

This could have important implications for institutional design: continuous trading vs. batch(?) trading. In batch trading the market sells out, where the last units can only be traded by the marginal traders, at a price that must necessarily be at or very near the equilibrium price. However, in continuous trading, the market never sells out, so that the impact of these marginal players on ”anchoring” the price at the equilibrium never occurs. There are constantly new buyers and sellers entering.

Sample instructions for an ODA with replacement is included in appendix 4.

3.4 Extension 2: Bilateral ”averaging of revelation” institution

Factors: profit-motivated humans, ZI-C traders, ZI-U traders. The ZI-U traders will be identical to the ZI-U results in the ODA.

ZI-C procedure: The buyers and sellers are randomly matched. The buyers give a random bid from 0 to their reservation price, while sellers randomize from their cost to 200. Two possible treatments of zero-intelligence, neutral negotiation: 1) The proposed trading price is the average of the two bids. Trade will occur if this proposed trading price is within the budget constraints of both parties. 2) Trade will occur only if the bid and offer overlaps, and the trade price will be the average of the two prices.

Treatment of human subjects (this is not freelance bargaining): 1) humans are randomly matched by computer (six pairs simultaneously). Simultaneously, buyer gives bid and seller gives offer. Again, use two possible treatments of contract price as above for the ZI traders.

Three possible treatments of budget information: 1) Players know their own budget constraint only, 2) Players know their own constraint, plus are revealed their partner's actual budget constraint after offer had been made, 3) Players are revealed their partner's budget constraint upon being matched, before the offer is made (possible fairness implications).

This brings me to the concept of a bilateral ultimatum or dictator game: Both sides propose a split, actual split is the average of the two proposed splits. In bilateral ultimatum, both sides are allowed to reject, in asymmetric ultimatum, one side may reject, in bilateral dictator, neither side may reject.

So in this repeated game, one or both sides might be given the option of rejecting even if the proposed trade price lies within both budget constraints.

Five possible restrictions of offers: 1) Offers are unrestricted, 2) offers are restricted to the player's budget constraint, 3) offers are restricted to some interval [0, 200], 4) 2 and 3 combined, and 5) offers are restricted to be within the budget constraints of both players.

Procedures: 1) Run ZI simulations and human experiments with the bilateral "averaging of revelation" institution. 2) Add negotiation algorithms to machine traders. 3) Add learning/feedback mechanisms to machine traders. 4) Extend Gode and Sunder (1993) to include simple bid/offer strategy and/or learning/feedback mechanisms to machine traders. 5) Run ZI simulations and human experiments with the posted offer/bid institutions; first with ZI traders, then add simple bid/offer strategy and/or learning/feedback.

Appendix

Market Experiment Instructions:

1. Kats 1.1, 1.2, and 1.3: Price fixed, 2/3/4 players choose location along a unit line; discrete, multiple periods, simultaneous move. 8 persons: 2 triplets and 1 pair. 10 persons: 2 triplets and 2 pairs. 11 persons: 3 triplets and 2 pairs. Code sheet: p:A2; q:C2 or F2; r:D3; s:B2; t:C1 or F1; u:A1; v:F3; w:B3; x:D2; y:B1; z:D1.

A spreadsheet will automatically calculate sales and cumulative earnings when we enter in the location choices after each period of play.

Instructions: This is an experiment in economic decision making. If you make good decisions, you could make a considerable amount of money that will be paid to you in cash at the end of the session.

In this experiment, you are one of two or three sellers of a fictitious product in a market. You will not be told with whom you are matched, but you will know whether you are in a group of two or three. Throughout the experiment you will be grouped with the same seller or sellers. You both will have the opportunity to sell your product to a group of 100 simulated customers. These customers are located along a road that is 100 blocks long, with one customer per block.

You and the other seller(s) will each be asked to choose a location on this road. Depending on the location of your firm, some customers will be closer to your store while others will be closer to the other seller's store(s). Each customer will purchase one unit of product from the nearest seller. If two or more sellers choose the same location, the customers who solicit that location will be divided equally between the sellers at that location.

As you probably have noticed, there are more than two or three people in the classroom; there are several pairs and triples of sellers. Each group serves a different set of customers, a different market. You and the other seller(s) in your market will choose a location each period. Either you may choose a different location the next period, or may repeat a previous location choice.

There will be several business periods in this experiment. In this preliminary experiment, we will try to run up to eight periods, time permitting. At the beginning of each period, you and the other seller(s) in your market will be asked to write your chosen location on the record sheet for that period and turn the sheet over once you are done. This location must be a whole number from 0 to 100. A monitor will collect the record sheet from everyone. Then the buyers choose from which seller to purchase. After the customers are finished buying, the number of units you sold and your earnings are recorded on your sheet, and it is returned to you.

When your record sheet is returned to you, the next period begins. You are again asked to choose a location for the period and so on, until the end of the experiment. At the end of the experiment, you will be paid at the rate of one cent per unit sold. Validity of the experimental procedure requires that you do not talk with other subjects. Also, please remember your seller code so that you get the same sheet back each time.

Any questions?

Table 3: Sample record sheet.

You are seller code ______. You are on a group of ______ sellers.						
Period	Your location	Other seller's location	Other seller's location	Other seller's location	Your sales this period	Your cumulative earnings
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						

2. Regular ODA (modified from Eckel copy 1989)

This is an experiment in the economics of market decision making. The instructions are simple, and if you follow them carefully and make good decisions you will earn a considerable amount of money. In this experiment we are going to simulate a market in which some of you will be buyers and some of you will be sellers in a sequence of market trading periods. Before the experiment you will be given a sheet, labeled buyer or seller, which describes the value to you of any decisions you might make. You are not to reveal this information to anyone; it is your own private information.

Specific Instructions to Buyers: During each trading period you are free to purchase from any seller or sellers up to two units. For the first unit that you buy during the trading period you will receive the amount listed in row (1) marked "First Unit Redemption Value." If you buy a second unit you will receive the additional amount listed in row (5) marked "Second Unit Redemption Value." The profits from each purchase are computed by taking the difference between the redemption value and purchase price of the unit bought. Under no conditions may you buy a unit for a price which exceeds the redemption value. In addition to this profit you will receive a \$0.15 commission for each purchase. Then your earnings are as follows: Earnings = redemption value - purchase price + commission. Your total profits and commissions for a trading period are computed by adding up the profits and commissions on sales made during the trading period. Suppose for example that you buy 2 units and that your redemption value for the first unit is \$20 and for the second unit is \$18. If you pay \$15 for the first unit and \$16 for the second unit, your earnings are:

Earnings from 1st unit = 20 - 15 + 0.15 = 5.15; Earnings from 2nd unit = 18 - 16 + 0.15 = 2.15; Total earnings = 5.15 + 2.15 = 7.30.

The blanks on the record sheet will help you record your profits. The purchase price of the first unit you buy during the first period should be recorded on row (2) at the time of purchase. At the end of the period record the profits on this purchase as directed in rows (3) and (4). Record the total of profits and commissions on the last row of the page. Subsequent trading periods should be recorded similarly.

Specific Instructions to Sellers: During each trading period you are free to sell to any buyer or buyers up to two (2) units. The first unit that you sell during a trading period you obtain at a cost of the amount listed on the attached sheet in row (2) marked "Cost of First Unit." If you sell a second unit you will incur the cost listed in row (6) marked "Cost of Second Unit." The profits from each sale are computed by taking the difference between the price at which you sold the unit and the cost of that unit. Under no condition may you sell a unit at a price below the cost of the unit. In addition to this profit you will receive a \$0.15 commission for each sale. Then your earnings are as follows:

Earnings = sale price of unit - cost of unit + commission.

Your total profits and commissions for a trading period are computed by adding up the profit and commissions on sales made during the trading period. Suppose for example that your cost of the first unit is 14$andyourcostofthesecondunitis$16. If you sell the first unit at 20$andthesecondunitat$19, your earnings are:

Earnings from 1st unit = 20 - 14 + 0.15 = 6.15; Earnings from 2nd unit = 19 - 16 + 0.15 = 3.15; Total earnings = 6.15 + 3.15 = 9.30.

The blanks on the record sheet will help you record your profits. The sale price of the first unit you sell during the first trading period should be recorded on row (1) at the time of sale. At the end of the period record the profits on this sale as directed in rows (3) and (4). Record the total of profits and commissions on the last row on the page. Subsequent periods should be recorded similarly.

Market Organization: The market for this commodity is organized as follows. We open the market for a trading period (a trading "day"). The period will last for 5 to 10 minutes; you will be told before each trading period exactly how long it will last. Any buyer (seller) is free at any time during the period to raise his/her hand and make a verbal bid (offer) to buy (sell) one unit of the commodity at a specified price. The bid (offer) must be higher (lower) than the outstanding bid (offer), should one exist. The verbal message to the Auctioneer shall follow this form: "Buyer (seller) # bids (offers) \$." Any seller (buyer) is free at any time to accept the bid (offer) of any buyer (seller) by yelling out loud in the following form: seller (buyer) # accepts. If a bid (offer) is accepted a binding contract has been closed for a single unit and the buyer and seller will record the contract price to be included in their earnings. Any tied acceptances will be resolved by a random choice of buyer or seller by the Auctioneer. There are likely to be many bids and offers that are not accepted, but you are free to keep trying, and as a buyer or a seller you are free to make as much profit as you can. Any questions?

3. ODA with replacement (One unit per agent, no commission, modified from the 2. ODA, above)

This is an experiment in the economics of market decision making. The instructions are simple, and if you follow them carefully and make good decisions you may earn a considerable amount of money. In this experiment we are going to simulate a market in which some of you will be buyers and some of you will be sellers in a continuous trading period. Before the experiment you will be given a sheet, labeled buyer or seller, which describes the value to you of any decisions you might make. You are not to reveal this information to anyone; it is your own private information.

Specific Instructions to Buyers: After you are allowed to enter the market, you are free to purchase one unit of the good from any seller. If you buy a unit, you will receive the amount listed in row (1) marked "Redemption Value." Your profit is computed by taking the difference between the redemption value and purchase price of the unit bought. Under no conditions may you buy a unit for a price which exceeds the redemption value. Your earnings are as follows: If you buy a unit, earnings = redemption value - purchase price. If you do not buy a unit, earnings = 0. Suppose for example that your redemption value is 7.50.$Ifyoubuyaunitat$9.00, your earnings are:

9.00 - 7.50 = 1.50.

The blanks on the record sheet will help you record your profit. The purchase price of the unit you buy should be recorded on row (2) at the time of purchase. At the end of the session, record your profit on this purchase as directed in rows (3) and (4).

Specific Instructions to Sellers: After you are allowed to enter the market, you are free to sell one unit to any buyer. The unit that you sell you obtain at a cost of the amount listed on the attached sheet in row (2) marked "Cost of Unit." Your profit is computed by taking the difference between the price at which you sold the unit and the cost of that unit. Under no condition may you sell a unit at a price below the cost of the unit. Your earnings are as follows:

If you sold your unit, earnings = sale price of unit - cost of unit. If you did not sell your unit, earnings = 0.

Suppose for example that your cost of the unit is $14. If you sell the unit at $20, your earnings are:

$20 - 14 = 6.00$.

The blanks on the record sheet will help you record your profits. The sale price of the unit you sell should be recorded on row (1) at the time of sale. At the end of the session, record the profits on this sale as directed in rows (3) and (4).

Market Organization: The market for this commodity is organized as follows. At all times, there will be six buyers and six sellers in the market. We begin the session with the first six buyers and sellers. When a transaction occurs, the buyer and seller who bought and sold the unit will be finished. They will be replaced by another buyer and seller, and the session will then continue. Any buyer (seller) that has been allowed to enter the market is free to raise his/her hand and make a verbal bid (offer) to buy (sell) one unit of the commodity at a specified price. The bid (offer) must be higher (lower) than the outstanding bid (offer), should one exist. The verbal message to the auctioneer shall follow this form: "Buyer (seller) # bids (offers) $." Any seller (buyer) that has been allowed to enter the market is free accept the bid (offer) of any buyer (seller) by yelling out loud in the following form: seller (buyer) # accepts. If a bid (offer) is accepted a binding contract has been closed for a single unit and the buyer and seller will record the contract price to be included in their earnings. Any tied acceptances will be resolved by a random choice of buyer or seller by the auctioneer. There are likely to be many bids and offers that are not accepted, but you are free to keep trying, and as a buyer or a seller you are free to make as much profit as you can. After you have made a purchase/sale, you are to remain silent until the end of the session, which should last about 20 to 30 minutes, depending upon the number of participants. The session will continue until we run out of replacements. You must remain silent until you have been allowed to enter the market. Any questions?

Simulation Algorithms:

4. ODA with replacement, zero-intelligence traders: This program should be easy to write because ZI traders with replacement is just like agents trading multiple units one at a time, so you don't have to worry about removing and replacing agents. Six buyers, six sellers, sellers costs are 2,3,4,5,6,7, buyer's values are 14,12,10,8,6,4. Sellers and buyers randomize subject to the interval [0,15], and the budget constraints.

Algorithm, written in quasi-code: 0. Set initial (bid, offer) at (0, 16). 1. Randomization (coin flip) between a buyer's bid and seller's offer. 2. Randomization (die toss) of the agent number (integer) (1 - 6). 3. Randomization of the bid/offer value (integer) (1 - 15). 4. If bid/offer is within budget constraint, then goto 5, else goto 1. 5. If bid/offer is higher/lower than outstanding bid/offer, then goto 6, else goto 1. 6. Post bid/offer; i.e. replace old bid/offer with new bid/offer as selected in 3. 7. If bid - offer ? 0 then goto 8, else goto 1. 8. Print transaction price, buyer #, and seller #. 9. Repeat 29 more times: goto 0.

At present, I am not fresh with any computer language, so I will not attempt to write this in computer language and run it until I can find someone who is interested in assisting me. Any help would be appreciated. I think I will later try to run this in spreadsheet form. Of course, it is easy to predict the result from this simulation, but I would like to run it because this will be the baseline for future simulations with low-intelligence traders. Once I get the initial program running, I hope to modify it to include some simple learning/feedback mechanisms.

References:

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Benson, Bruce L.; Feinberg, Robert M.; An Experimental Investigation of Equilibria Impacts of Information; Southern Economic Journal; 54(3), January 1988, pages 546-61. Price setting in experimental spatial (or differentiated product) duopoly markets was examined in order to (1) empirically evaluate published arguments that theoretical models of spatial competition should assume a Hotelling-Smithies type conjectural variation (sellers assume rival prices are fixed), and that the Loschian conjecture (sellers assume that rivals match price changes) should be applied only when collusion occurs; and (2) determine whether the type of information available to sellers regarding their rivals' actions impacts pricing behavior. The experimental markets provide some evidence against the first arguments and further, but somewhat weaker, support for the second.

Brown-Kruse, Jamie; Cronshaw, Mark B.; Schenk, David J.; Co; Co; Co; Theory and Experiments on Spatial Competition; Economic Inquiry; 31(1), January 1993, 139-65. The authors present theoretical and experimental results on spatial competition between two firms. Firms choose locations simultaneously along a line representing a linear market. Identical consumers with nonincreasing demand functions are uniformly distributed along this line. The authors solve for symmetric equilibrium payoffs in an infinitely repeated game for the case of linear demand and an arbitrary discount factor. The set of equilibria found includes both competitive and collusive payoffs. In laboratory experiments in which the final period was unknown to the players in advance, the authors observed both competitive and collusive outcomes. Nonbinding communication led to collusion.

Catherine Eckel (1989) ODA instructions, mimeo.

Enelow, James M.; Hinich, Melvin J., eds.; Advances in the spatial theory of voting; Cambridge; New York and Melbourne: Cambridge University Press, 1990, pages xi, 240. JF1001 A26 1990 & JF1001 E53 1984. Eight papers provide an overview of the developments in the spatial theory of voting during the last twenty years. Papers focus on multiparty competition, entry, and entry deterrence in spatial models of elections; "heresthetic" and rhetoric in the spatial model; spatial strategies when candidates have policy preferences; a decade of experimental research on spatial models of elections and committees; candidate uncertainty and electoral equilibria; the theory of predictive mappings; multicandidate spatial competition; and the setter model. Enelow and Hinich are at the University of Texas, Austin.

Amoz Kats (1995) Suggestions for Experiments in Spatial Oligopolies, mimeo;

Mason, Charles F.; Phillips, Owen R.; Nowell, Clifford; U WY; U WY; Weber State U; Duopoly Behavior in Asymmetric Markets: An Experimental Evaluation; Review of Economics and Statistics; 74(4), November 1992, 662-70. Experimental duopolies are analyzed to answer two questions: Are asymmetric duopolies less likely to collude than symmetric duopolies? Is the time it takes to reach an equilibrium affected by asymmetry? In a repeated game where output is the choice , the authors have data for nineteen (respectively, twenty-one) subject pairs where both agents are low-cost (respectively, high-cost) and twenty-five subject pairs where one agent is high-cost and one is low-cost. Subjects make choices for at least thirty-five periods. Results indicate that asymmetric markets are less cooperative and take longer to reach equilibrium than symmetric markets.

McKelvey, Richard D.; Ordeshook, Peter C.; Division of the Humanities and Social Sciences, CalTech; Division of the Humanities and Social Sciences, CalTech; A Decade of Experimental Research on Spatial Models of Elections and

Committees; Caltech Social Science Working Paper: 657, October 1987, pages 34; also in Enelow, James M.; Hinich, Melvin J., eds. Advances in the spatial theory of voting. Cambridge; New York and Melbourne: Cambridge University Press, 1990, pages 99-144. The Euclidean representation of political issues and alternative outcomes, and the associated representation of preferences as quasi-concave utility functions is by now a staple of formal models of committees and elections. This theoretical development, moreover, is accompanied by a considerable body of experimental research. We can view that research in two ways: as a test of the basic propositions about equilibria in specific institutional settings, and as an attempt to gain insights into those aspects of political processes that are poorly understood or imperfectly modeled, such as the robustness of theoretical results with respect to procedural details and bargaining environments. This essay reviews that research so that we can gain some sense of its overall import. AV: Copies available from: Division of Humanities and Social Sciences, 228-77, California Institute of Technology, Pasadena, CA 91125

Prescott, Edward C.; Michael Visscher (1977) Sequential Location among Firms with Foresight, Bell Journal of Economics 8: 378-93.

Selten, Reinhard, ed.; Game equilibrium models III. Strategic bargaining; With contributions by W. Albers et al. New York; Berlin; London and Tokyo: Springer, 1991, pages viii, 282. H61 T55 v.2. Ten papers, in the third of a four-volume set of essays from a year-long research project at the Center for Interdisciplinary Research (ZiF) of the University of Bielefeld, examine game equilibrium models of bargaining. Contributions focus on a noncooperative approach to the Nash bargaining problem; a two-person repeated bargaining game with long-term contracts; three approaches to bargaining in nontransferable utility games; folk theorems for the proposal-making model; a noncooperative model of bargaining in simple spatial games; demand commitment bargaining–the case of Apex games; prominence, competition, learning, and the generation of offers in computer-aided experimental spatial games; a bargaining game with incomplete information; wage bargaining as a strategic game; and a game equilibrium model of thin markets. Contributors are Wulf Albers, Elaine Bennett, Eric van Damme, Werner Guth, Hans Haller, James D. Laing, Akira Okada, Myrna Wooders, and the editor. Selten is at the Institut fur Gesellschaft- und Wirtschaftswissenschaften of the University of Bonn.

Williams, Kenneth C., MiSt, Candidate Convergence and Information Costs in Spatial Elections: An Experimental Analysis; and Herzberg, Roberta; Wilson, Rick, IN U; Rice U, Costly Agendas and Spatial Voting Games: Theory and Experiments on Agenda Access Costs; both in Palfrey, Thomas R., ed. Laboratory research in political economy. Ann Arbor: University of Michigan Press, 1991, 113-35, 169-99; JA73 E87 1993. Ten papers examine the formal approach to studying political processes and political behavior through the use of laboratory methods. Contributions focus on a comparative analysis of direct democracy, two-candidate elections, and three-candidate elections in an experimental environment; political competition in a model of economic growth; the explanation and prediction of presidential elections; candidate convergence and information costs in spatial elections; a stochastic game model of committee bargaining; costly agendas and spatial voting games; sincere versus strategic voting behavior in small groups; testing game-theoretic models of free riding; costly communication; and communication in a commons–cooperation without external enforcement. Palfrey is Professor of Economics and Political Science at CalTech.

- - - - -; Spatial Elections with Endorsements and Uninformed Voters: Some Laboratory Experiments; Public-Choice; 80(1-2), July 1994, pages 1-8. This paper presents a laboratory experiment designed to examine voting behavior, within a spatial election framework, when subjects are only endowed with endorsement information. In the experiment, subjects are assigned ideal points on a single-issue dimension. With the aid of an endorsement, their task is to vote for the candidate whose position is closer to them. The results show that under these conditions, subjects are in fact playing a lottery, where the odds of being correct is a function of spatial location. The study points out that researchers should be aware of an 'information bias' in models that use this particular information source.