

Competitive Equilibrium and Classroom Pit Markets for the Early 21st Century

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Abstract

Small efforts to display the relevance of economic concepts early on in a student's education can serve to prevent the "economics is not very useful" attitude from setting in. This paper extends the work of Holt (1996) to describe a pit-market experiment used to illustrate the concept of competitive equilibrium. In addition to detailed instructions as to how to set up and conduct a pit-market experiment, features of the data are discussed and many accompanying materials, including software for the display of the data, are provided.

keywords: competitive equilibrium, pit market, classroom experiment, experimental economics

*I thank Rachel Croson for valuable comments. The materials discussed in this paper are available for download at the author's website: <http://econ.bgu.ac.il/facultym/bradley/pitmarket.zip>.

1 Introduction

1.1 Motivation

Economic concepts are taught at such a level of abstraction that the student views these concepts as irrelevant to understanding real-world phenomena. Small efforts to display the relevance of economic concepts at the earliest stages of a student's training can prove invaluable to his outlook on the discipline. The aim of this article is to offer instructors a tool to convince students of the salience and relevance of one of economics most central and empirically robust concepts, that of competitive equilibrium.

In this paper, I provide a detailed description of a market experiment used to display the power of the competitive equilibrium outcome. My own experience suggests that conducting this experiment early on in an economics student's education, soon after teaching the concept of competitive equilibrium in introductory microeconomics, for example, goes a long way in preventing the "economics is not very useful or relevant" attitude from setting in.

1.2 Experiments in the Classroom

The use of experiments in the classroom continues to expand beyond dedicated courses in experimental economics. An increasing number of non-experimentalists are expressing interest in conducting experiments in elementary classes to demonstrate fundamental economic concepts. To serve this end, Bergstrom and Miller (2000) have written a textbook designed to illustrate elementary economics principles through experiments. Andrew Schotter (1997) provides an intermediate microeconomics textbook that emphasizes the use of classroom experiments. Greg Delemeester and Jurgen Brauer have compiled an extensive, annotated list of 122 classroom, hand-run experiments accessible online: <http://www.marietta.edu/delemeeg/games/>. In a regular column, entitled "Classroom Games" that appeared in the *Journal of Economic Perspectives* from 1996 through 1999, Charles Holt and co-authors elaborated various classroom experiments

designed to teach elementary as well as more advanced economic concepts. In one such column, Holt (1996) details a pit-market experiment designed to display the concept of competitive equilibrium. Based on its effectiveness in teaching the competitive equilibrium solution, Holt endorses the pit market trading exercise as his “clear first choice if [he] were limited to a single lecture in a microeconomics course at any level.”

This article builds upon the work of Holt (1996). One aim of this article is to provide sufficient detail concerning all stages of the experiment (including the pre-experiment preparations, useful hints for conducting the experiment, post-experiment questions for discussion and theoretical and empirical homework exercises), so that even someone who has never conducted an experiment may feel confident in doing so. A second aim of this paper is to bring these experiments in line with the computer technology of the early 21st century. In this vain, two pieces of software have been made available for download. The first is an Excel spreadsheet in which the transactions may be entered and the profits automatically calculated. For instructors wishing to conduct these experiments repeatedly or on large groups, this spreadsheet is particularly time-saving. The second is software developed to display the transactions from an experimental session and the supply and demand parameters employed in the session.

In the next section, suggestions for experimental designs are offered. Section 3 lays out the experimental procedure as well as the supplies and manpower needed to conduct pit-market experiments. Section 4 offers ideas for a classroom discussion and homework exercises. Two, more advanced topics concerning features of the data from pit-market experiments, and competitive market experiments more generally, are also discussed. Section 5 concludes.

2 Experimental Design

You will want to construct the supply and demand curves ahead of time. Unless you know precisely how many students will show up for the experiment, you should prepare a number of designs in advance to accommodate different numbers of subjects. As long

as you avoid designs with extreme earnings inequalities at the competitive equilibrium, prices and quantities are likely to converge to the competitive outcome. Smith (1962, pp. 119-120) first showed that convergence is inhibited in designs with a perfectly elastic curve.

[insert Table 1 here]

Table 1 offers suggestions for designs in which the number of trading pairs varies from 8 to 15. In all of these designs, the aggregate supply and demand curves produce a two-unit vertical overlap. In other words, there exists a two-unit competitive price range with a unique competitive quantity. One may prefer a design with a unique competitive price prediction. This may be achieved either through a unique crossing point of the supply and demand curves or a horizontal overlap. The problem with these alternatives is that the traders who earn zero profit on the purchase or sale of their unit at the competitive price are not incentivized and will often not trade this unit, thereby inhibiting convergence to the competitive quantity, possibly the competitive price. Some researchers mistakenly believe they are circumventing this problem by employing a design with a horizontal overlap and paying subjects a commission on each unit they trade. However, the payment of a commission increases the maximum price each buyer is willing to pay for a unit by the amount of the commission and decreases the minimum price at which each seller is willing to sell his unit of production. In other words, the payment of a trading commission shifts upward (downward) the aggregate demand (supply) curve by the amount of the commission, thereby reestablishing the vertical overlap (of length twice the amount of the commission).

You can use a deck of playing cards, designating the black cards as the sellers' costs and the red cards as the buyers' valuations, as suggested by Holt (1996). Having your own cards made will, however, give you increased flexibility in your choice of design; specifically, you won't be limited to assigning valuations and costs in the range of 1 to 10. At the very least, you should laminate your deck of playing cards to prevent students from bending or otherwise making the cards distinguishable from one another. I would

nonetheless suggest getting your own set of cards professionally made at a printing shop. Buy two different colors of cardboard paper. The file “cards.doc” in the “Forms” directory of the downloadable file offers a template from which the cards may be printed onto the colored paper. After printing the cards with the desired numbers on them, have the paper cut into cards of identical size. Laminate the finished cards.

3 Experimental Procedure

3.1 Supplies and Manpower

There are a few preparations required before entering the classroom to conduct a pit-market experiment. All of the required forms are available for download at my website (<http://econ.bgu.ac.il/facultym/bradley/pitmarket.zip>). The following supplies are needed to conduct these experiments: instructions (included), personal record sheet (included), transactions sheets (included), notebook computer (not included!), Excel spreadsheet (included), cost and valuation cards (template included), stickers, stopwatch, a classroom with portable chairs and tables to create an open space in the middle, blackboard and chalk or whiteboard and marker, envelopes in which to enclose the subject payments (optional).

To conduct these experiments on a group of 16-30 students you will need at least two, and up to four, helpers, depending on the volume of transactions at the competitive equilibrium. In the absence of research assistants you may ask for volunteers from the class. An odd number of students automatically makes available one student as an assistant.

Two persons are required to record the transactions at two transaction booths. One person stands at the blackboard. In addition to keeping track and announcing periodically the time remaining in each period, this person collects the transaction sheets from the booth operators, writes each transaction price on the board as he receives it and passes the sheet onto the helpers seated at the computer. One (usually the instructor) or

ideally two people are seated in front of a notebook computer. One person dictates the details of each transaction as it arrives to the person seated in front of the computer who types in the details in the Excel spreadsheet. (To preview the layout of the spreadsheet, see Table 2, discussed in section 4.2.2.)

3.2 Procedures

Before the students arrive for the experiment, create a large open space in the middle of the classroom. Set up two transaction desks at the front of the room, near the board. Set up a third, nearby table to install the notebook computer.

When the students arrive divide them into an equal number of buyers and sellers. Since friends typically sit beside one another, dividing the class in half once the students are seated prevents friends from trading with friends. Pass out the instructions sheet along with the personal record sheet to each participant. Unless you and all of your helpers know all of the participants' names, you will want to assign each participant an identity number. While the students are reading the instructions, distribute stickers of one color, say blue, to the buyers. On the sticker is written the buyer's identity number, beginning with 101 through 115 (prepared ahead of time), depending on the number of pairs. Similarly, sellers receive stickers of a different color, say purple, with their identity numbers from 201 through 215 (depending on the number of pairs) written on the sticker. Ask students to place their stickers on their chest so that their identity numbers are visible. After students have read the instructions, the experimenter reads them aloud and answers any questions. The profit calculations, the fact that the seller does not incur the cost of his unit if he does not sell it, and the fact that students are free to negotiate with whomever they like from the opposite side of the market (identifiable by the color of the sticker) are all points worth emphasizing.

When you are ready to begin the first period, two helpers distribute the cost and valuation cards to the students. After everyone has received a card, the timekeeper announces the beginning of the first period. At this point, students enter the "pit" and

begin negotiating with one another.¹ When a buyer and a seller agree upon a price, they are to come to one of the transaction desks, turn in their respective cards face down and report their agreed upon price to the transaction booth operator. It is a good idea if the booth operator repeats the transaction price aloud so that both parties to the transaction hear this price. This avoids any confusion or misunderstanding between the two parties about the agreed upon price. Both parties return to their seats and fill in their personal record sheets while the booth operator records the price, the transacting parties' cards and identity numbers on the transactions sheet. After filling in the details of the transaction, the booth operator hands the transaction sheet to the person standing at the board who writes the price under the appropriate period number. The sheet is then passed onto the person (usually the instructor) seated in front of the computer who enters the transaction in the Excel spreadsheet.² After typing in the transaction, cross it out on the transaction sheet.

With the fast-paced, simultaneous negotiations that characterize trading in the pit market, three minutes more than suffice for a period, even for large groups of students. (Double-auction experiments can require up to five-minute periods.) The timekeeper watches the clock and announces that one minute has elapsed, one minute remains, and thirty seconds remain. At the end of the period, ask those subjects who did not trade to turn in their cards. Before proceeding to the next period, separate and count the cost and valuation cards to ensure that all subjects indeed returned their cards.

To avoid misunderstandings, you will want to decide and make clear to all students until what point a transaction will be accepted. My own rule is that after the period has ended, no further negotiations are permitted. However, those transactions that have

¹Rachel Croson has reminded me that in cultures more reserved and less gregarious than that of Israel, students may initially require a little verbal prompting to encourage them to negotiate with one another. She also suggests counting down the seconds to the start of the period to build up students' anticipation.

²If you are short on helpers, you may wish to have transacting parties report directly to the computer where the transaction details are entered. The transactions booths, however, make the recording of transactions far less chaotic and provide a hard copy of all transactions.

been negotiated but not yet recorded (due to a lineup at one of the transaction booths) are valid.

3.3 A Few Pointers

If a subject trades a unit at a negative profit, before beginning the next period, it is advisable either to inform the student aloud that his profit from the trade is negative or to ask to speak with him and inform him privately. It is important to catch errors: more often than not one of the helpers has recorded the student's cost or valuation incorrectly so that the student's actual profit is positive.

You may choose to disallow collusive discussions among students between or during periods, as Holt (1996) suggests. With a larger group of say 24 or more students, my experience indicates that attempts at collusion break down quickly, often within the same period in which they were begun. Thus, the advantage of permitting collusion is that failed attempts at collusion facilitate your subsequent task of convincing students of the robustness of the competitive solution. However, in smaller groups, particularly if the participants know and trust one another, collusion can be successful. Ruffle (2001) reports a highly successful case of seller price collusion in a pit market with nine pairs of classmates who knew one another well.

After having observed convergence to the competitive equilibrium, you may wish to try a different treatment. The possibilities are limited only by time and your imagination. For instance, you can impose a price ceiling or a price floor. You can alter the balance of the number of buyers and sellers. By changing the relevant distributions of cards, you may vary the shape (elasticity) of the supply or demand curve, or shift either or both the supply and demand curves. Changes or shifts in supply and demand curves may be announced or unannounced. If announced, you can motivate the shift of a curve by explaining that it is the result of the introduction of a tax or subsidy or a change in technology or consumers' tastes.

A word of caution: the larger the change in the competitive price between back-to-

back treatments, the more periods you should allow for convergence *ceteris paribus*. It is common to observe anchoring effects in these markets according to which one side of the market is able to resist, through tenacious negotiations, sudden and substantial price fluctuations. Instead convergence to the competitive equilibrium is gradual, taking place over several, perhaps many, periods. Section 4.2.1 discusses the relevance of negotiating strength in these markets more generally.

4 Discussion

4.1 Classroom Discussion and Exercises

Whether you choose to conduct these pit-market experiments before or after introducing supply and demand is a matter of taste. I prefer to conduct them immediately following the lecture on competitive equilibrium in an introductory microeconomics course.³ I usually begin by showing students the results of the experiment in the form of a transactions graph, like those displayed in Figures 2 and 3, to be discussed below. I also write down as two separate rows the buyers' valuations cards and sellers' costs used in the experiment. I then ask students to explain why prices converged to the particular observed outcome.⁴ Expect to hear answers such as: the average of all valuations and costs, an equitable price at which buyers' and sellers' earnings are equated, and the price at which total profits are maximized.⁵ Write each answer on the board and then have students vote on which answer they believe to be the correct one. Even if a student offers the correct answer, the competitive equilibrium price, this answer never receives the most votes, even in advanced undergraduate classes!

³Alternatively, Wells (1991) who discusses a double-auction experiment suggests conducting the experiment before the formal presentation of supply and demand.

⁴Holt (1996, p. 198) recommends this same method to initiate discussion as well as an approach using questions that lead students to the concept of the competitive equilibrium.

⁵Of course, for a symmetric supply and demand parameterization, none of these answers is incorrect. However, none of them *explains why* prices converge to the competitive range. For this reason you may choose to employ a slightly asymmetric design.

Your task now is to demonstrate the logic underlying competitive market forces and convergence to the competitive equilibrium. The realization that competitive forces moved prices toward the competitive price captures students' attention. You may wish to take advantage of their attentiveness to demonstrate other elementary economics concepts. Along these lines, many theoretical and empirical exercises are available in the "Forms" directory in the file available for download at my website. Many of these questions may be adapted for classroom discussion. The topics of utility, consumer and producer surplus, demand and supply elasticity and monopoly pricing may be introduced or reviewed after revealing to students the supply and demand parameters from the experiment in which they participated. For the empirical exercises, distribute the raw data (in the form of Table 2) from the experiment in which the students participated, or post it on the course website. Students may be asked to compute the variance and standard deviation of transaction prices by period and subsequently taught that decreased price variance accompanies convergence to the competitive outcome.

4.2 Features of the Data from Pit-Market Experiments

4.2.1 Negotiating Abilities and Slow Price, but not Quantity, Convergence

Dozens of studies have confirmed the robustness of convergence to the competitive equilibrium under a variety of conditions. Davis and Holt (1993) provide a thorough survey. Nonetheless the price dynamics of every experiment are unique and it does very infrequently happen that a session does not converge, even after numerous periods. Prices can appear "stuck" in a range outside the competitive equilibrium.⁶ Shocks to the supply and demand schedules typically "loosen" prices so that they converge to the new equilibrium. More frequent than no convergence is slow convergence. Sometimes 10 or more periods are required before prices enter the competitive range due to the negotiating ability of one side of the market, usually the buyers.

⁶This is more common, although still very infrequent, in classroom experiments in which subjects are not paid and therefore, profit maximization, a necessary condition for convergence, may be imperfect.

The experiment displayed in Figure 2 provides an interesting example of exceptionally slow price, but not quantity, convergence.⁷ This session consists of 10 pairs of traders. The supply and demand curves for this session appear in Figure 1. The competitive price range is between 36 and 38, with a competitive quantity of six units.

[insert Figure 1 here]

[insert Figure 2 here]

In period 1, prices exhibit typically high variance. In periods 2-5, buyers bring prices down below the competitive range: 34 is the modal transaction price in each of these periods. That notwithstanding, the competitive quantity of six units is traded from period 5 onward suggesting relatively high price variance; that is, in every period from period 5 onward two transactions occur at a price of 37 to permit the two marginal sellers with costs of 36 to trade their units at a positive profit.⁸

That the remainder of the transaction prices persist at a price below the competitive range (despite the two publicly observable transactions at 37 each period) attests to the buyers' negotiating strength in this session. In fact, it is only in the final period that the median price reaches 36, the lower bound of the competitive range. By the average price measure, this session still hasn't converged by period 11, falling short by a mere 0.16 units.

Figure 3 provides an additional example of relatively strong buyers. The data come from an experiment involving the parameters in Table 1 with 10 pairs of traders.⁹ The competitive price range for this session is 31 to 33, with a competitive quantity of eight units.

⁷This is the tax (on the sellers) treatment from session *tax10s11* of Ruffle (2001).

⁸In period 8, only one trade occurred at 37; one seller settled for a profit of zero and sold his unit at a price of 36.

⁹These are the first seven periods of the baseline (pre-subsidy) treatment from session *sud10s2* reported in Ruffle (2001).

All but one of the six transaction prices are well below the competitive range in period 1. However, prices progressively rise from one period to the next, while the price variance generally declines. Six periods are required before the average price converges, from below, to the competitive range.

[insert Figure 3 here]

The next subsection investigates the specific transactions of this session in more detail.

4.2.2 Order of Transactions

Time permitting, a common feature of the data you may very well choose to demonstrate (in more advanced classes) and one your students will remember concerns the order of transactions within a period. Holt (1996) points out that “the most profitable trades often occur first. After the high-value buyers and low-cost sellers are out of the picture, the final haggling is typically among those with a smaller potential surplus and those who will find it impossible to trade at all” (p. 199).

Indeed the data in Table 2 and Figure 2 (from the session discussed at the end of the previous subsection) illustrate an elegant example of this regularity. Table 2 provides a record of all transactions between periods 3 and 7 inclusive. Each row indicates the details of the transaction. The rows are arranged according to the order in which the transactions took place. In each row appears the transaction price, the seller’s i.d. number (201 to 210) who sold the unit along with his cost, followed by the buyer’s i.d. (101 to 110) who purchased the unit along with his valuation. The seller’s profit (price minus cost) and the buyer’s profit (valuation minus price) are displayed in the next two columns. Finally, the average and median prices as well as the price variance of all transactions in a period are displayed.

[insert Table 2 here]

Precisely as Holt suggests, the highlighted trades in periods 3 and 4 of Table 2 show that the early trades in these periods occur between the highest-value buyers and the lowest-cost sellers. To understand this phenomenon, let us return to the transactions of the first two periods in Figure 2. Transaction prices in periods 1 and 2 reveal extremely high price variance (38.4 and 22.86, respectively). Furthermore, the quantity traded fluctuates from 6 to 9 units. (Recall that the competitive quantity is 8.) These price and especially quantity volatilities render traders nervous about being unable to trade their units. Those with the largest potential surplus have the most to lose. As a result, these anxious traders quickly find one another and compromise on a price.

With prices and quantities showing considerably more stability in period 4, this phenomenon weakens beginning in period 5: the first two trades are no longer between the highest-value and lowest-cost traders. In period 4 most transaction prices fall within the competitive range and already by period 3, 7 or 8 units trade in every subsequent period. Thus, the highest-value and lowest-cost traders' risk of not trading is considerably reduced, thereby allowing them to be more patient in closing transactions.

Even more interesting are the traders involved in the two last trades in period 7 (highlighted in Table 2). The four marginal traders find the precise price, 32, that allows each of them to trade at a profit. Each of the four traders earns 1 unit of profit on his transaction.

One often-heard critique of economics experiments is that the monetary incentives are insufficient to motivate subjects to exert themselves to solve the decision task. On the contrary, the minimal profit earned on the two last trades shows just how highly incentivized subjects can be: all four of them continued to negotiate to earn one unit of profit (a meager 12 U.S. cents in this particular paid experiment). Even if you do not observe the last trades among the marginal traders, your data will reveal small realized profits on transactions in which the marginal traders are involved: this is a prerequisite to convergence to the competitive quantity. The point to be made is that this pursuit of profit maximization aids in convergence to the competitive equilibrium and lends it its sway.

5 Concluding Remarks

The centrality of the notion of competitive equilibrium to microeconomics cannot be overstated. Its underlying logic involving the concepts of excess supply and demand, competitive market forces and profit maximization reflects basic economic thinking. A classroom experiment to demonstrate the relevance of competitive equilibrium can move it from the realm of the abstract to the realistic in the student's mind. This paper describes an experiment designed to accomplish just that. By providing detailed instructions at all stages of the experiment, my aim is to guide the instructor through all stages of the experiment. With this in mind, many accompanying materials have been made available in a downloadable file. Among these materials are two pieces of user-friendly software, one to help record the transactions during the experiment, the other to display the transaction prices series in the form of a graph. May our students think more like economists!

References

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Distributions of Costs and Valuations

Cards		Number of pairs of sellers and buyers							
Sellers' Costs	Buyers' Valuations	8	9	10	11	12	13	14	15
11	53	1	2	2	2	2	2	2	2
16	48	1	1	1	2	2	2	3	3
21	43	1	1	1	1	2	3	3	3
26	38	1	1	2	2	2	2	2	3
31	33	2	2	2	2	2	2	2	2
36	28	2	2	2	2	2	2	2	2

Table 1: Suggestions for experimental designs. The first two columns under the heading "Cards" indicate the values of the cards to use for the sellers' costs and buyers' valuations. The entries indicate the number of cards to include in the deck for each specified value when the number of subject pairs (between 8 and 15) is as shown.

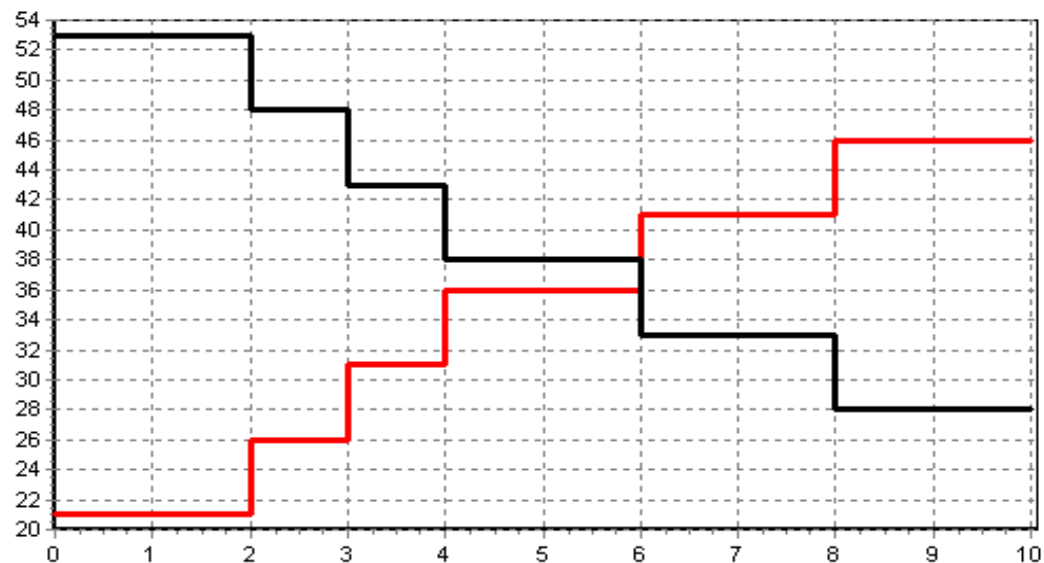


Figure 1: The induced supply and demand curves for the experiment reported in Figure 2.

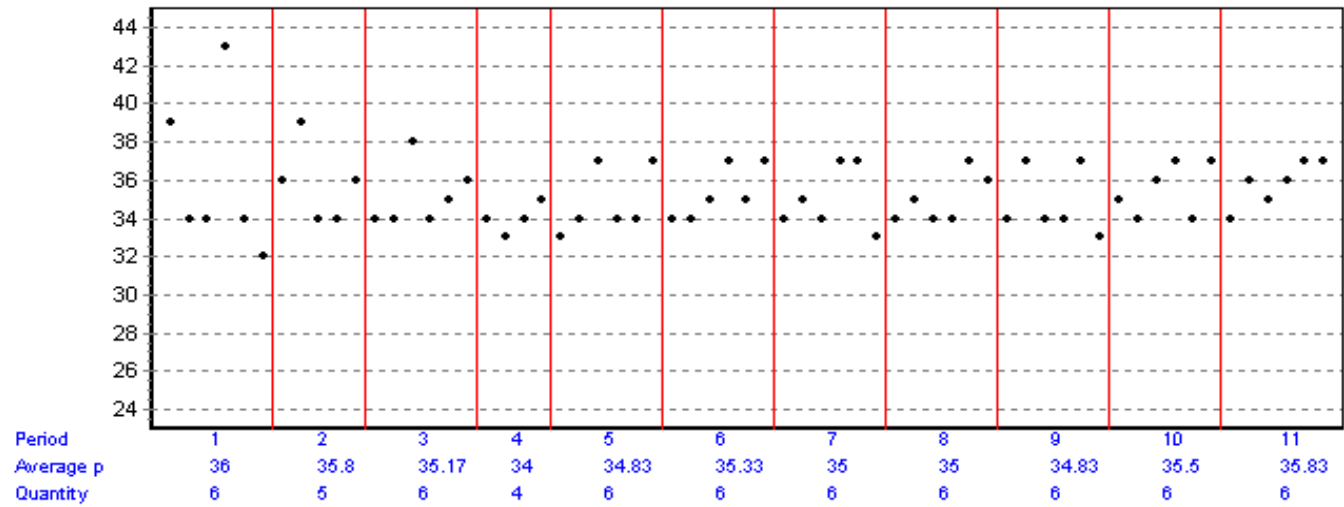


Figure 2: The exceptionally slow price, but not quantity, convergence of this session attests to the negotiating strength of the buyers. (The competitive price range is 36-38 and the competitive quantity is 6 units.)

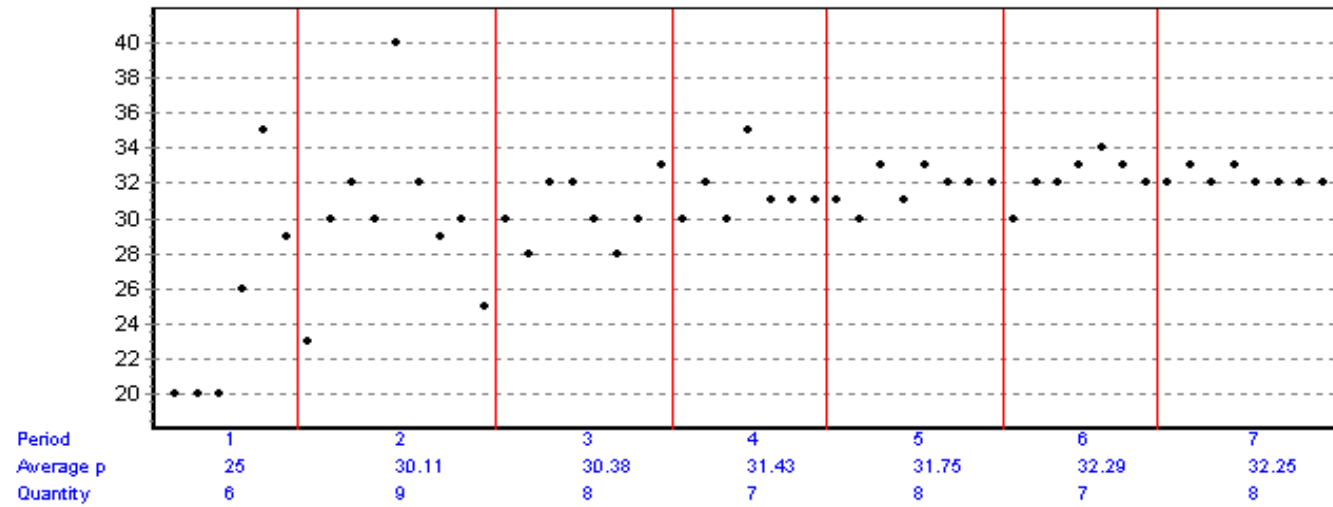


Figure 3: A session with very high initial price and quantity variance. By period 7, the session has converged tightly to the competitive price range of 31-33 and the competitive quantity of 8.

Period	Transaction	Price	seller i.d.	cost	buyer i.d.	valuation	seller profit	buyer profit	average price	median price	variance
3	1	30	206	11	108	53	19	23	30.38	30.00	3.41
3	2	28	205	11	110	53	17	25			
3	3	32	208	21	109	38	11	6			
3	4	32	207	31	104	43	1	11			
3	5	30	209	26	107	33	4	3			
3	6	28	210	26	105	38	2	10			
3	7	30	202	16	106	48	14	18			
3	8	33	204	31	103	33	2	0			
4	1	30	201	11	103	53	19	23	31.43	31.00	2.95
4	2	32	207	11	107	53	21	21			
4	3	30	205	21	108	38	9	8			
4	4	35	203	31	109	48	4	13			
4	5	31	202	26	106	43	5	12			
4	6	31	206	16	104	38	15	7			
4	7	31	204	26	110	33	5	2			
4	8										
5	1	31	210	11	104	53	20	22	31.75	32.00	1.07
5	2	30	208	16	107	38	14	8			
5	3	33	203	26	110	53	7	20			
5	4	31	206	11	109	43	20	12			
5	5	33	201	26	103	48	7	15			
5	6	32	204	21	102	33	11	1			
5	7	32	205	31	105	38	1	6			
5	8	32	209	31	101	33	1	1			
6	1	30	209	11	105	53	19	23	32.29	32.00	1.57
6	2	32	202	26	107	53	6	21			
6	3	32	210	21	109	43	11	11			
6	4	33	207	11	103	38	22	5			
6	5	34	206	16	110	48	18	14			
6	6	33	205	26	102	38	7	5			
6	7	32	203	31	108	33	1	1			
6	8										
7	1	32	203	21	103	53	11	21	32.25	32.00	0.21
7	2	33	210	26	107	38	7	5			
7	3	32	206	26	105	48	6	16			
7	4	33	207	11	106	53	22	20			
7	5	32	208	11	101	43	21	11			
7	6	32	202	16	104	38	16	6			
7	7	32	201	31	110	33	1	1			
7	8	32	204	31	109	33	1	1			

Table 2: A record of all transactions from periods 3 to 7 of a session with a competitive quantity of 8 and a competitive price range of 31-33. High quantity and price variance in periods 1 and 2 lead to opening trades between the highest-value buyers and lowest-cost sellers in periods 3 and 4. With the subsequent stabilization and convergence of prices and quantities, the last trades in period 7 occur between the two pairs of marginal traders.