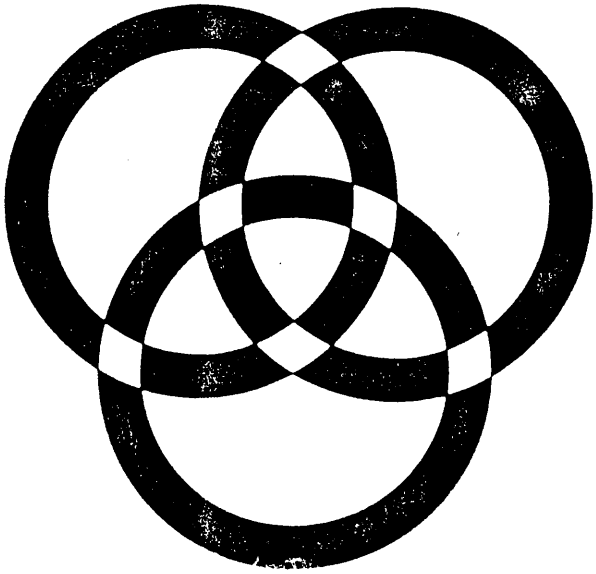

INVESTIGATING OLIGOPOLIES WITHIN THE LABORATORY

Dan Alger

BUREAU OF ECONOMICS
FEDERAL TRADE COMMISSION

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by Dan Alger

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TABLE OF CONTENTS

Chapter I

BUILDING AN EMPIRICAL FOUNDATION WITHIN THE LABORATORY

Good antitrust enforcement policy requires predictions concerning oligopolistic behavior within the markets involved. Yet, economics offers precious little, or actually too much, for help in predicting behavior within these oligopolies. We are offered too many plausible theoretical models that are all said to describe oligopolistic behavior, and some of these models suggest widely different policy prescriptions from the others. The well-known cause of this situation is the lack of reliable data that would allow us to separate the good performers from the bad performers among these models. As far as I am aware, any empirical conclusion concerning oligopolies has an associated group of reputable economists that find the conclusion unconvincing. The empirical foundation of oligopoly theory is so weak that in almost 150 years of studying oligopoly markets not one model has been rejected by the economics profession because its predictions were inconsistent with observed behavior in actual oligopoly markets. We want to strengthen this empirical foundation.

In this study we examine market behavior within some oligopolies constructed within the laboratory, markets constructed so we may test the relative success or failure of the models economists have used to justify their antitrust policy prescriptions. We shall determine if any of these general models do, in fact, predict behavior reasonably well for the special cases offered by our laboratory markets. Our ultimate claim will be that if any model performs poorly for these relatively simple and well-understood markets, then we should not give the reasons that generate this model's predictions much credence when applying the model to the more complex and less well-known markets actually encountered in antitrust enforcement.

Our data appears to be consistent with the earlier laboratory data for the same type of market, but as we will see, it suggests completely different findings concerning equilibrium

behavior. Earlier experimental studies tended to show near-competitive prices, prices declining as the number of sellers increases, and prices rising with the subjects' level of experience. If we were to consider the market periods in our data that correspond to those market periods analyzed in these earlier studies, we would see similar results. Nevertheless, a change made in our markets, allowing them to continue operating for many more market periods than in the previous studies, seems to change our ultimate findings significantly. We found it often took an extremely long time to reach an equilibrium, and that disequilibrium behavior appeared much different from the eventual equilibrium behavior. In equilibrium our markets tend to show near-monopolistic prices, no change in price with the different number of sellers we used, and no change in price with changes in the subjects' level of experience.

Laboratory Markets Can Help Build an Empirical Foundation Necessary for Good Antitrust Enforcement

It seems the primary reason for the weak empirical foundation of oligopoly theory is that the typical econometric study must work under some tremendous limitations. Probably the most important limitation is missing or inaccurate data. This is the rule rather than the exception when studying naturally occurring markets. Almost always there are no data for some important variables. In a naturally occurring market, the values of many structural parameters are unobservable, even while information on them is necessary to calculate the theoretical prediction. Common examples are a buyer's preferences or several components of a sellers' costs. The size of different subjective elements of preferences or costs (*e.g.* some information costs or any premiums for risk) are almost never available, yet they are often essential for evaluating a market's performance. As evidence of the difficulty of assessing costs in a litigation context, consider the common occurrence of antitrust cases where neither side can even establish whether observed prices were above or below any reasonable measure of cost. And, in addition to the usual reasons for missing or inaccurate data and the errors in measurement common

to all sciences, data in economics often comes from a participant in the market who has an incentive to misrepresent these data. To get some feeling for the potential impact of this misrepresentation, consider the difficulty in determining actual transactions prices in a market with *sub rosa* discounting.

A second limitation of the typical econometric study is that the market parameters of the relevant naturally occurring markets are not those actually desired for the analysis. Most importantly, not having the appropriate market parameters increases the difficulty of making the ideal comparison, that is, a comparison between two identical markets except for a change in a single treatment variable. The analyst is forced to make strong statistical assumptions just to be able to reach any conclusions. Powerful statistical techniques, with the strong statistical assumptions that accompany them, are often utilized just to sort out the interactions of the many structural variables the analyst would like to have held constant in the first place. Also, without any control over the values taken on by the market parameters, the analyst is often faced with data where variables only take on a very limited range of values, a limitation which also increases the demands on the statistical analysis.

Another common limitation is that for the particular topic under study there is only one relevant data set from naturally occurring markets. This often seems to short circuit the ideal sequence of generating a hypothesis, testing it against some data, modifying the hypothesis, testing it against some new data, and so on. All too often the new, modified hypotheses are tested using the same data set as the earlier tests, a procedure which corrupts any of the statistical conclusions.

Now consider how these difficulties can be eased if data can be generated within a controlled, laboratory setting. We create a laboratory market by giving real cash value to "paper" assets and providing rules for gaining these assets. The values attached to these paper assets determine the values taken on by different market parameters. Since we control the cash awards, we have a procedure that allows us to induce the characteristics we desire onto our subjects. If we want the subject to prefer outcome A to outcome B, we can award him five

dollars if *A* occurs but only one dollar if *B* occurs. As long as the subject prefers five dollars to one, we can be relatively assured he prefers *A* to *B*.[1] With the proper reward structure, we can create one subject with preferences identical to those of a firm with some particular cost structure, or another subject with preferences identical to those of some particular buyer.

With our control over the market parameters, problems of missing or inaccurate data concerning our market parameters are usually of minimal concern. And, as data on the choices made by the different market participants are easy to keep track of in the laboratory, we don't expect problems of missing or inaccurate data of any type.

Having control over the market parameters gives the experimenter the opportunity to analyze just those markets desired for the crucial test. This control allows him to make statistical tests that are clean and simple, unlike those typically employed in the usual econometric study. To determine the effect of a particular structural variable, an experimenter can directly compare data from a test market and a control market, two markets which are identical to each other except for the desired change in the treatment variable.

The experimenter also has the opportunity to replicate any laboratory markets, an important feature which allows him to test any new, modified hypotheses as he should, with a new data set. In addition to allowing the experimenter to build on his own work, replication also allows others to check and modify his work in ways that would not be possible without a new data set. One also need not fear, at least as much, the possibility of ending with the weak conclusion that no hypothesis is rejected. One can always construct a richer data set by running more replications of markets with the same market parameters.

These advantages of experimental methods are most fully exploited when evaluating and developing theories of economic behavior. While one approach, the one followed in most conventional empirical work, is to generate mountains of empirical data with the intention of supporting a particular theory, the

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1. Smith (1976a) provides a full discussion of the theory of induced values.

most efficient use of the experimental methodology is to develop data that leads you to reject a theory. If a supposedly general theory is inadequate for explaining behavior in the simple special case provided by the experimental market, we can reject the theory as being applicable generally. As a result, the reasons used to support such a theory become suspect in applications to markets in which policy decisions must be made.

In theory the chief disadvantage of using laboratory markets, at least for some purposes, is the possibility these markets may not have any good parallels within naturally occurring markets. By design, laboratory markets are simplified to contain only those features from naturally occurring markets thought to be most important for determining market behavior. The possibility exists that some important features have been left out. This same problem, of course, exists with our theories, which have been simplified in the same fashion. Thus, if the laboratory markets are used to test theories, this simplicity is not a disadvantage but another advantage. In practice the chief disadvantage of using laboratory markets is their expense, both in time and money. The experiments to be run have to be carefully chosen to keep the expense down.

Previous Experiments with Similar Oligopolies

Before examining the structure of our laboratory markets in detail, we will consider the general outline of some findings from other laboratory markets which were similar to those to be examined here. While this is not the place for a complete survey of this work,[2] some of the more important themes of it are presented.

The structure of the first laboratory markets led Vernon L. Smith, and later some others, to systematically examine behavior in several types of auctions.[3] Enough data have been

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2. Plott (1982) provides a good survey of laboratory experiments that were conducted to examine topics in industrial organization.

3. Chamberlin (1948) was the first to construct laboratory markets for experiments in economics. These first laboratory markets were auctions somewhat similar to the markets on the New York Stock Exchange. Since then Smith and others have examined many different auction institutions, auctions which

generated with these markets that they now provide an appropriate experimental benchmark for studies of many other types of markets. The striking finding within this work, a finding that makes this pool of data very valuable to any experimentalist, is the robustness of competitive predictions for this type of market. For most double auctions, where both buyers and sellers actively make bids and offers, the "large" number of buyers and sellers necessary for the competitive model to apply appears to be only four of each. Also, the data from these markets show this competitive outcome is approached very quickly, often within three or four trading periods. As for other types of auctions, they may converge more slowly to the competitive outcome or from a different direction, but for all of them the competitive model is, at least from some perspectives, surprisingly accurate. The data from these auctions, especially the double auctions, provide the experimental benchmark of efficient, competitive behavior.

F. Williams (1973) was the first experimenter to explicitly use a posted-offer institution, one where sellers post their prices and quantities at the beginning of a trading period and buyers respond on a take-it-or-leave-it basis. He attempted to study only the effect of having multi-unit supply and demand schedules, rather than the single unit "schedules" commonly used in earlier auctions, but his data were contaminated with another change he made in the market environment, one that he felt wouldn't have a major effect. He changed the institutional environment by constructing a posted-offer market instead of an auction. The data from his study and later ones by Plott and Smith (1982), Hong and Plott (1982), and Ketcham, Smith, and Williams (1984) amply demonstrate this was not a minor change.

Within the laboratory markets reported on in these studies, posted-offer prices were usually seen to be higher than those

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have had a wide variety of different parameter values (over a thousand different auctions have been run since this environment was computerized at the University of Arizona). Some of this work is reported by Smith (1962, 1964, 1967, 1976b, 1981); Plott and Smith (1978); Coppinger, Smith, and Titus (1980); Cox, Roberson, and Smith (1982); and Smith, Williams, and Bratton (1982); Isaac, Ramey, and Williams (1984); and Ketcham, Smith, and Williams (1984).

observed in an otherwise identical double auction. Along with the higher prices, these posted-offer markets were seen to be less efficient than the comparable double auctions. In these data, posted-offer markets were seen to converge much more slowly to a competitive equilibrium than an otherwise equivalent double auction, or possibly not at all. In addition, these markets had buyers who quickly acted as if they were perfectly competitive. This implies any inefficiencies within these markets must have been due to the sellers' behavior and not the buyers'. After examining these markets, one finds market behavior can be very sensitive to changes in the institutional environment, a conclusion drawn within many different contexts within different experimental studies. Even seemingly small changes in the institutional environment can significantly change market performance. Because of this conclusion, we shall almost exclusively confine our attention to oligopolies using a posted-offer institution, which is the institution used in our laboratory markets.

While it need not have been so, it appears the behavior observed in the classic set of price-setting experiments by Fouraker and Siegel (1963) can be interpreted as if it occurred within a posted-offer institution. These markets constructed by Fouraker and Siegel had a structure that differed from that of a posted-offer market, as traders did not have to make the same decisions as in a posted-offer market. Sellers chose only the prices rather than both the prices and the quantities offered to the market, and the buyers' behavior was simulated rather than having human decisionmakers choosing the quantities to purchase. Nevertheless, since it appears buyers typically do act competitively and sellers typically do offer large quantities within a large class of posted-offer markets, it is not unexpected that behavior appears to be similar within these two different markets.

This pathbreaking work by Fouraker and Siegel has provided us with many experimental procedures commonly used today. One of the most important was their use of cash awards to induce the desired preferences on their subjects. Another was the use of repeating market periods which all had the same structure, so one could observe behavior that had stabilized and had reached an equilibrium, in some operational sense.

One treatment examined within the Fouraker and Siegel price-setting experiments concerns the information available to the subjects before they had to make a decision. Markets were compared with complete information, where each seller knew the payoffs for all sellers, to those with private information, where only a subject's own profits were known to him and not those of his rivals. With private information they observed almost competitive behavior (*i.e.* the Nash equilibrium outcome for these markets), but with complete information they saw more variable, more "cooperative" outcomes. Similar findings have been seen in several experimental studies that have followed their work. The specification of the information made available to the subjects shall be re-examined in the next chapter.

The economist's primary concern with an oligopoly is determining the market conditions that are likely to lead to reduced efficiency. Fouraker and Siegel provided an early look at this when they varied the number of sellers, a factor often felt to influence the extent of any harm from an oligopoly. They compared the market behavior in some duopoly markets to that in otherwise identical triopolies. While the data from their price-setting experiments show duopolies with higher average prices than the triopolies, one striking observation is how close all prices are to the competitive price. These data provide little evidence that even a very small number of sellers can tacitly collude effectively and earn monopoly profits.

One experimental benchmark to measure against the behavior in an oligopoly, in addition to the competitive behavior observed within a double auction, is the behavior observed within a monopoly. Smith (1981) provides the data for this monopolistic benchmark with his study of monopoly markets operating under different institutions. As with other markets, the most useful comparison is between the double-auction form of the market and the otherwise identical posted-offer markets. When a posted-offer institution was used, we see a few periods where subjects appear to be sampling the market demand (the subjects have no demand information initially), followed by the repeated choice of the monopoly price. The monopoly model appears to work very well for this market. On the other hand, we see quite different behavior in a double auction. It appears buyers sometimes strategically withhold demand within a double auction, so a

monopoly price is difficult to maintain. In many periods we see prices all the way down to the competitive level. These data suggest, at the least, that many periods of trading are necessary within this institution before the inefficiencies expected from the monopoly outcome are achieved. Similar results are reported by Isaac, Ramey, and Williams (1984).

After observing the monopoly outcomes, a natural next step is to observe behavior within some oligopolies where there are opportunities for explicit collusion. This step was taken by Isaac, Ramey, and Williams (1984) in their study comparing the following six types of markets: double-auction monopoly, double-auction oligopoly without conspiracy, double-auction oligopoly with conspiracy, posted-offer monopoly, posted-offer oligopoly without conspiracy, and posted-offer oligopoly with conspiracy. In the data for these markets, they see the opportunities for conspiracy leading to higher prices, but prices still below the monopoly level. Again, prices in posted-offer markets were seen to be higher than those in otherwise identical double auctions.

The next natural step is to observe posted-offer oligopolies where only tacit collusion is possible, markets where the only means of communication between rivals is with actual price and quantity choices. This is the area where the bulk of experimental work is to be expected, since under at least a variety of the still unspecified market conditions, this is where different economists' predictions typically differ. As mentioned earlier, Fouraker and Siegel (1963) present data where triopolies yield lower prices than duopolies, but both are near the competitive level. Murphy (1966) presents data from similar markets, but ones where sellers could make losses and markets were run for more periods than previously (i.e. 24 time periods versus 14 time periods). These markets yielded more "cooperative" behavior, especially as the number of the trading period increased.

Stoecker (1980) reports on similar oligopoly markets, but ones where subjects often had a great deal of experience in his market environment. More cooperative behavior is observed in these markets when compared to the behavior observed in previous posted-offer oligopolies, especially with experienced subjects. Also, these markets show subjects with previous

experience of successfully colluding were more likely to collude successfully than those subjects without this experience. It was also noted in these markets, instead of prices converging gradually to some equilibrium price, prices often changed with big jumps. And finally, as before, if the number of sellers was increased, prices became closer to the competitive level.

Ketcham, Smith, and Williams (1984) report on oligopoly markets that use either the posted-offer institution or are double auctions. They also observe prices in posted-offer markets that tend to be higher than those in double auctions, but still fairly close to the competitive price, as average prices over all markets are closer to the competitive price than to other alternatives, such as, say, the Cournot price. Their results seem much more like the near-competitive results of Fouraker and Siegel, rather than the more "cooperative" results described by Murphy and Stoecker.

Overview

This report describes the progress to date on a project to study oligopoly markets within the laboratory. The purpose of the project is to expand the empirical base in directions suitable for testing the oligopoly models used to justify antitrust policy. We will proceed as if nothing has been well established for these markets. We will start with the simplest oligopoly markets we can imagine, and then build up incrementally to add more features commonly found in naturally occurring oligopoly markets. As the use of laboratory experiments is relatively new to economics, there will be a fair amount of attention paid to experimental design and analysis.

There are several distinguishing features of this study when it is compared to similar studies presented previously in the literature. First, our markets can be run much faster than previous laboratory markets. Our markets allow the subjects as much time as they wish to make their decisions, but each market period can run almost as fast as the subjects can make their choices. This extra speed allows us to continue operating our markets until observed behavior stabilizes and all subjects continue making similar choices repeatedly. Our extra speed

comes from both computerizing the market environment and simulating the buyers' behavior.

Second, an attempt was made to start with markets that would be the easiest to analyze among those having the same market structure as some interesting, naturally occurring markets. Each market consists of a sequence of market periods where every market period has a structure that is independent of any other market period. There are no stochastic elements in the structure. Each market uses the relatively simple posted-offer institution. All goods are, in effect, homogeneous and made to order.

And finally, some emphasis has been placed on the form of formal statistical tests that would most effectively describe and test our resulting data. In many previous experimental studies, this would almost be considered a luxury because of the number of data points involved, but with the design used here markets can be replicated relatively cheaply, and as a result a fair amount of data has been generated.

Much of the progress to date should have its biggest impact on what will be felt to be appropriate experimental technique and analysis for future studies such as this. After setting the ground work, describing our market environment in detail in Chapter II and then describing the oligopoly models we wish to test in Chapter III, we find the first chapter describing some of our experimental results, Chapter IV, is entirely devoted to examining the effect of one common procedure of previous experiments, that is, using all experimental data available to test different equilibrium models, including some from markets which had not reached an equilibrium. A substantial amount of evidence is presented which indicates, for our markets at least, using disequilibrium data produces misleading results for some tests of our equilibrium models, and actually discarding disequilibrium data would have led to superior estimates of equilibrium behavior.

The following chapter, Chapter V, describes the results of some direct tests of our oligopoly models. We test whether the centers of our observed distributions provide unbiased estimates of our equilibrium predictions, and whether the behavior in our oligopolies could be the same as for our monopolies. We also examine the effect on equilibrium behavior of changing the

cost of searching for market demand information, the number of sellers, the opportunity cost of not selling, different experience levels for the subjects, and the information lag about rivals' choices. Some emphasis is placed on examining designs and statistical tests that are likely to exploit the advantages of controlled experiments using laboratory markets. The last chapter draws together and summarizes our results, and it presents some ideas for future work suggested by our results.

More detail about our markets is provided in several appendices. The first provides representative instructions given to the subjects, the second provides a summary of our equilibrium data, the third presents graphs of the price histories of all markets, and the fourth provides a complete description of our market parameters along with a complete description of the market outcomes for selected periods.

Chapter II

OUR MARKET ENVIRONMENT

The bulk of this chapter is a detailed discussion of the structural features induced upon our laboratory markets. The flexibility possible from our computerized laboratory environment, an environment available now for future oligopoly experiments, is also discussed.

Basic structural features of our markets, including the market institution itself, were chosen by trying to apply the following principles: (1) Create markets with the simplest structure possible among those that can be described by our standard oligopoly models. This would allow the cleanest tests of these standard theories, giving us the best opportunity to reach strong conclusions. (2) Choose the same institution as in some interesting, naturally occurring market. Each decisionmaker in the naturally occurring market should have an associated decisionmaker in the laboratory market that makes the same type of decisions as in this naturally occurring market. This would lessen the possibility that behavior observed in our laboratory markets is unlike behavior in some naturally occurring markets of interest. (3) Choose features used in previous experimental studies. This would allow the cleanest comparisons with earlier experimental data.

Following these principles, we consider only oligopoly markets for a homogeneous product. We consider only markets within a posted-offer institution where sellers post their prices and quantities and buyers respond on a take-it-or-leave-it basis. We consider only markets without any stochastic elements in their structure -- there is no uncertainty, except for that stemming from a rival's choices. We consider only markets with no potential entrants. We consider only markets where demand and costs in one period are independent from other periods, markets where the structure of each period is the same as another.

These choices are largely consistent with the principles given above. Many experimental markets have been motivated by the desire to understand oligopoly markets. The posted-offer institution is commonly used in economic experiments, is the

dominant institution within naturally occurring retail markets (especially where managers have been removed from the final sale of any goods), and has a very simple structure when compared to some alternatives (say, some types of auctions). We do not consider the complexities due to differentiated products; technical uncertainty; entry; or changes in cost or demand due to inventories, advertising, search, learning the technology, R&D, or the depletion of a natural resource. We remain in markets where the existence of theoretical equilibria is not an issue (unlike some markets where goods are produced before they are offered for sale).

One choice concerning our markets' basic structural features violated one of these principles. The choice was made to simulate the buyers' behavior even though naturally occurring markets have humans, not computers, for buyers. This one exception shall be addressed in some detail later in this chapter.

Our Laboratory Markets as Viewed by Our Subjects

Now we will consider the structure of our laboratory markets as viewed by our subjects. All of our laboratory markets operated within the PLATO computer lab at the University of Arizona. The subjects, University of Arizona students, entered the lab and received $3.00 for keeping the previously-made appointment. Subjects were seated randomly in front of individual, separated terminals and were logged into the program that controlled the instructions and the operation of our markets. The instructions explained the operation of our markets and included some practice trading periods as a part of them. As experienced subjects discovered, the instructions were tailored somewhat to the type of market to be run in that session. Representative instructions, instructions that would have been presented to the subjects on a terminal, are given in the first appendix.

Within the instructions each subject learned the computer was used to store and control the relevant market information. The instructions did not explain the fact that the computer was also used to simulate the buyers' behavior and calculate the market outcomes given the subjects' decisions. Observant

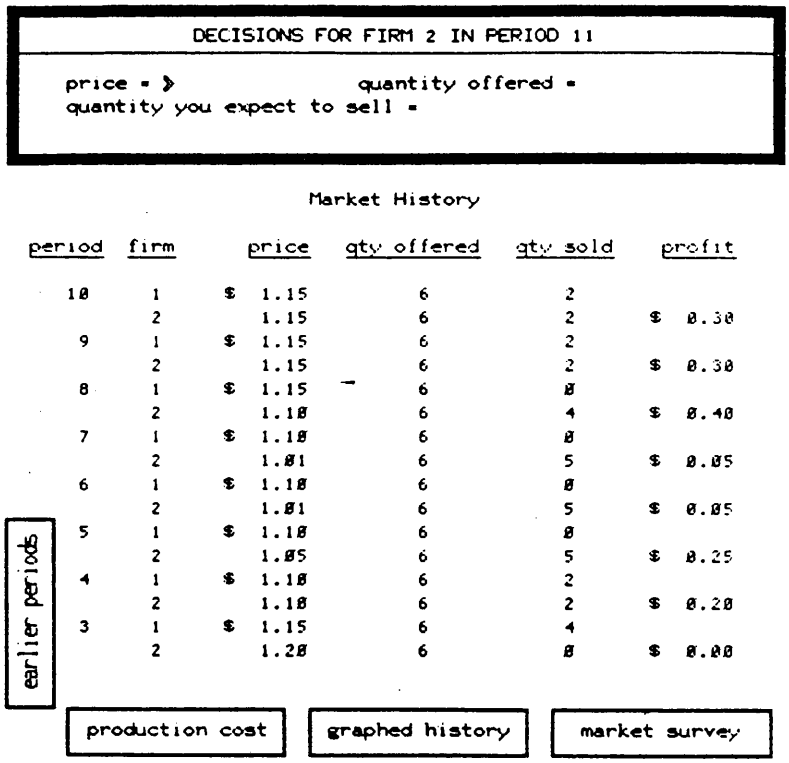
subjects would see that all interactions with other subjects during the experimental session were limited to those using the terminal. There was no direct communication between any of the subjects.

The subjects learned the market was a sequence of market periods, and the screen display they faced most often within each period was like the one given in Figure 2.1. The decision box at the top of the display indicated the decisions that had to be entered for each time period. Each seller had to enter the price he would charge for his fictitious good, the quantity he would offer to the market, and the quantity he expected to sell given the previous choices. The remainder of the display indicated the information available to the seller before these decisions had to be made.

Each seller was given information on his own costs and on the market history. Cost information could have been obtained directly by touching the cost box (the PLATO terminals used had touch sensitive screens). This took the seller to another display that gave a graph of the cost function and allowed queries about the total cost for specified quantities. Cost information could also have been obtained indirectly when the expected profit was shown to the seller. Once the expected quantity sold was entered, the computer calculated this expected profit, by taking the revenue and subtracting the costs for this quantity. The market history was given in the table in the center of the display and also in graphical form, if the subject pressed the graphed history box.

In some treatments, explicit market demand information was available, but in most it was not. If it was available, a seller could access it by pressing a "market survey" box, which would then take him to a new display on his terminal. This display gave a graph of the market demand function, and, for those subjects that might feel uncomfortable with a graph, it also gave the same information in a repeatable query at the bottom of the display that would allow the seller to determine directly the total quantity buyers wished to purchased at any price.

In most markets, the entire market history was made available to each seller immediately at the beginning of each time period. For these markets, all past prices and quantities



period	firm	price	qty offered	qty sold	profit
10	1	$ 1.15	6	2	
	2	1.15	6	2	$ 0.30
9	1	$ 1.15	6	2	
	2	1.15	6	2	$ 0.30
8	1	$ 1.15	6	0	
	2	1.10	6	4	$ 0.40
7	1	$ 1.10	6	0	
	2	1.01	6	5	$ 0.05
6	1	$ 1.10	6	0	
	2	1.01	6	5	$ 0.05
5	1	$ 1.10	6	0	
	2	1.05	6	5	$ 0.25
4	1	$ 1.10	6	2	
	2	1.10	6	2	$ 0.20
3	1	$ 1.15	6	4	
	2	1.20	6	0	$ 0.00

Figure 2.1: Primary Screen Display seen in each Period (reduced in size)

offered, and the resulting quantities sold were common knowledge. In other markets, the rivals' market history was given to a seller only after a lag of 101 (an arbitrarily-chosen large number of) time periods. In these markets each seller saw only the consequences of his rivals' actions, and could only indirectly infer what those actions might have been. In all markets, each seller had access to his own market history plus the profits he earned each period. The profits actually earned by a rival (and his costs) always remained private information, as this information was never revealed to a seller.

While seeing this display, new choices could have been entered at any time prior to confirming them. (The expected profit was updated with each new entry, so that the subject had the opportunity to consider the possible effect of different alternative choices.) Choices were made final by touching the decision box twice to confirm them. After all subjects had made their decisions, each seller went to the next period, going to this same display but updated for the next trading period.

The Induced Preferences of Each Seller

The subjects' characteristics within each market period were induced onto them by the profit structure of our experimental markets, and the profits earned by the subjects were paid to them in cash. The profit structures used were intended to give our subjects the same incentives as sellers in oligopoly markets that share the following revenue and cost functions.

The revenue function we use here is a function which describes the revenue earned by each seller for any feasible choices that could be made by the sellers. Once all prices and all quantities offered to the market by the sellers are given, the value of this revenue function is determined by the buyers' responses to these choices. As mentioned previously, in our markets no subjects were actually acting as buyers, but the buyers' behavior was simulated to follow that of perfectly competitive buyers. In effect, the buyers could purchase the

amounts they wished to purchase at the offered prices, up to the quantities offered for sale.

The choices entered for our buyers, choices which determined the quantities actually sold, were themselves determined by the market demand function and the rationing rule used to specify the market outcome for choices where markets would not clear automatically.[1] The market demand function of each of our experimental markets was linear. The market demand function shared by most of our markets gives us a line intersecting the points (0 units, $1.48) and (12 units, $1.00).[2] The rationing rule was incorporated implicitly, along with this market demand function, within the individual sellers' demand functions. For our duopoly markets, the amount demanded from an individual firm was calculated in the following way: if the firm was offering the lowest price, it faced the entire market demand; if both firms were offering the same price, then market demand was split in the same proportions as the amounts offered for sale; if the firm was offering a price higher than its rival, then it received any unsatisfied demand, under the assumption buyers with higher reservation prices purchased first. Similar calculations were made for markets with more than two sellers.

For most markets, each seller's cost function gave him a constant marginal cost of $1.00, up to a maximum capacity of 12 units, an amount which would cover any demand from this market. The quantity actually produced and sold by any firm (*i.e.* the amount that determined the total cost) was either the quantity demanded from the firm or the quantity offered, whichever was smaller. Thus, sellers were assessed the costs only

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1. After an economist's initial theoretical training, where all models quickly assume markets will clear automatically, many of us do not seem to think naturally of the use of a rationing rule. Nevertheless, in our markets many price and quantity choices were feasible where markets would not clear automatically and a rule was needed to determine the final outcome. See Alger (1979) or Shubik (1980) for game-theoretic oligopoly models that require the use of a rationing rule.

2. Some markets had a market demand function and marginal cost functions that were shifted by a constant, so the market parameters would be somewhat disguised for experienced subjects. A few markets, ones which will be identified when their data are first introduced, had market demand functions with 1/2 the slope of our standard.

for those units they sold, and not those that were offered to the market but were unsold. Because costs were assessed in this way, we say the goods were made to order in our markets.

Also, for both the revenue function and the cost function for each seller, there was an additional requirement that the goods in these markets could only be produced and sold in integral amounts.

Now, if a static model adequately predicts equilibrium behavior in our markets, the only relevant characteristics for each seller are those described above concerning the revenue and the cost functions. However, if a dynamic model is sometimes necessary, other characteristics, those that tie the market periods together for each subject, will sometimes be essential. Equilibrium behavior would then sometimes depend upon personal characteristics for the subject that allow him to use information concerning earlier periods, say, discount factors used to calculate the discounted value of a stream of rewards. Since all payments were made at the same time, we would not have the usual discount factor based upon the passage of time, but there would be an implicit discount factor incorporating the probability of participating in a future market period. Unfortunately for us, these discount factors are uncontrolled and unobservable within our experiments. We will have to watch for this.

Terminating Our Markets

The only remaining feature of our market environment that needs to be discussed is the rule used to terminate each market. As the primary purpose of this research is to test equilibrium models, two alternative rules for terminating the experimental markets suggested themselves. One was to run each market a fixed number of time periods or until a fixed real time limit was met, and later screen out the data from those markets that did not satisfy an operational definition of an equilibrium. Another was to terminate the operation of any market as soon as such a definition was satisfied. With this approach we would be assuming that if the market had continued operating, this same "equilibrium" behavior would have been observed indefinitely. To reduce any potential bias from the

termination rule[3] and, it was hoped, to reduce the amount of subject payments needed to generate a given amount of useful data,[4] the second approach was used whenever possible.

To have been able to test if an equilibrium had been reached, an operational definition of an equilibrium was needed. Our ideal would be a definition that indicated when each buyer and seller would repeatedly make the same choices after being given sufficient experience within the same decision-making environment. Unfortunately, such a standard could never be guaranteed since, obviously, an infinite number of trials could never be observed. This means an operational definition based upon actual choices could only be an approximation, and inherently some elements of it would have to be rather arbitrary. Such a definition requires two choices, one on the number of time periods the same behavior would need to be observed before the experimenter would assume it would last indefinitely, and another on a measure of how close market choices would have to be before they would be considered the "same." Our choices are incorporated into our measures of a "variation" in behavior, which are both the largest deviation in profits over the last five periods and the largest deviation in profits over the last ten periods.[5]

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3. An approach that discards outcomes that have not reached equilibrium before some fixed number of time periods or before some real time limit has been reached could potentially create some bias in the data. A bias might be introduced as the discarded markets might yield different equilibria than those markets whose data are kept. This might happen, for example, if "noncooperative" subjects typically have an extremely long disequilibrium period and then reach an equilibrium with relatively low prices and profits. In this case, we would be systematically eliminating low profit equilibria.

4. Quitting only after an equilibrium has been reached reduces the number, and thus the expenses, for those markets which do not reach an equilibrium, and it reduces the expenses for those market periods after the market has been shown to be in equilibrium and this behavior is just maintained. This procedure may also decrease the number of markets run per dollar spent, reducing the number of quickly achieved equilibria. The overall effect could go in either direction, but I expect this procedure would produce more usable data for less.

5. This type of measure for changes in behavior is not appropriate if either a cyclic pattern is followed or some strategies are not fully revealed, such as with mixed strategies or actions that depend upon some previous actions. Using rolling averages of profits over, say, ten periods might be an improvement with cyclic patterns and mixed strategies, but for our markets it turned out that

An alternative approach for constructing an operational definition of an equilibrium, one that was also used in this study, was to have each subject demonstrate that, in some sense, he had some understanding of the consequences of his choices. If each subject demonstrated this understanding we would have some assurance that each subject's future choices would remain unchanged. To be able to calculate our measure of this "understanding," each subject was asked to enter, along with his market decisions, the quantity he expected to sell given his market decisions. The subject's "understanding" was then measured by the difference from the expected profit implied by this entry and the actual profit. If over five or ten periods there was no difference between the expected profit and the actual profit, a certain amount of understanding seems to have been demonstrated. Less weight was intended to be put on this second criterion because each subject's response on the expected quantity sold, necessary to calculate this difference, was not well-motivated (*i.e.* it did not affect the cash reward). Nevertheless, it was thought this measure might have been useful if behavior did not appear to have stabilized after very many periods, but in fact a subtler stabilized pattern had developed.

In any event, most of our markets were terminated only when all of our different measures indicated an equilibrium had been reached. Most of our markets were terminated only if the subjects exhibited some constancy of behavior across time periods by having zero deviation in profits for at least five periods (usually ten periods) or if an obvious cyclic pattern developed. Also, most of our markets were terminated only if the subjects had shown some understanding of the market by having no difference between expected profit and actual profit over at least five time periods (and usually ten periods). In some of our markets these criteria were not satisfied at termination, but were stopped because a two and a half hour time limit for the computer lab had been passed.

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changing these measures in this way would not have changed when any markets would have been terminated. I am not sure what criterion would be most useful for strategies where actions depend upon the previous history of the market.

The use of our termination rule means some of the experimental markets could continue, as some did, for very many periods. Allowing for a larger number of time periods meant either the length of the sessions had to increase or the real time needed for each market period had to decrease. Increasing the length of the sessions is difficult since fewer students are willing to participate beyond three hour intervals, and running a market across several days is not desirable because any communication among subjects within this break in the session is uncontrolled. The alternative approach was taken and the amount of time necessary to operate each market period was drastically shortened. This was done by simulating the behavior of the buyers, so that in effect the buyers' choices were made instantaneously. (An added benefit of simulating the buyers' behavior was the large decrease in subject payments, as no buyers needed to be paid.) The cost of doing this is the possibility that actual buyers might not behave as if they were perfect competitors, as assumed, and the sellers might react differently because of it. Fortunately, this cost now seems acceptable as data from previous experimental markets suggest that in this market environment the buyers do act competitively, even with a relatively small number of them.[6]

The termination rule used for our markets were not revealed to the subjects. The intention was to minimize end effects similar to those noted by Stoecker (1980), by creating a setting where the conditional probability of playing more time periods past the current time period would always be high. An infinite horizon model that would describe such a setting would have, then, relatively low discount factors for future periods.[7] With the small amount of time needed for each market

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6. The data considered in Ketcham, Smith, and Williams (1984) and Isaac, Ramey, and Williams (1984) seem to suggest that in markets similar to ours, even a relatively small number of buyers quickly develop the behavior of perfect competitors. If this is not felt to be convincing, then one would want to apply any findings from our markets only to those markets with very many buyers, where the buyers would almost certainly act competitively.

7. We certainly intended to avoid the repeated-play fixed-horizon game described in Luce and Raiffa (1957) [pp. 97-102], where the equilibrium theory predicts "cooperative" outcomes would unravel with a now-familiar backwards induction argument.

period in our laboratory markets, it's felt we have a reasonable implementation of these goals.

This completes the discussion of the market structure of our laboratory markets.

The Flexibility of Our Laboratory Environment for Future Experiments

The computer program controlling our market environment offers a fair amount of flexibility that could be used in other future experiments. While creating the program was difficult (no one should ask me soon to try something on this scale), it is now available for other similar experiments, so they might be done relatively cheaply.

The program allows quite a variety of oligopoly markets to be run. There may be anywhere from one to sixteen firms in each market. The costs in each market period may take on any form. These costs may be entered individually for each unit, if the largest quantities involved are relatively small, or they may be entered using an analytical function. Any specification of fixed and marginal costs can be made within the restriction that all quantities produced must be in integral amounts.

The buyers' behavior is always simulated to follow that of a perfectly competitive buyer, but still, the overall market demand function and the rationing rule can be varied. Any market demand function can be entered given the restriction of integral quantities. Reservation prices (*i.e.* the inverse of the market demand) can be entered individually, if the maximum quantity demanded is relatively small, or with an analytical function. The rationing rule, a rule necessary to define the outcome when non-market-clearing choices are made, could take on any form that specifies a fixed ordering (possibly stochastic) of the "buyers" associated with each reservation price. This specified queue is then used to order the "buyers" so we can determine who is involved in which sales.

A parameter is available to shift all marginal cost and demand schedules so market conditions can be somewhat disguised for any experienced subjects. A lump-sum payment to be earned upon entering a market can be specified for each market.

The information available to the subjects before they must make their decisions can be varied in several ways. Market demand information can be given to the subjects freely or completely withheld, so it could only be learned from experience. Direct information on the rivals' choices can be given to a subject after any specified number of time periods following the decisions.

Several markets can be run simultaneously, a large number of them if multi-site experiments are run. These markets can be run in two forms, one called the dynamic form and the other the static form. The dynamic form is the market environment typically considered in economics, one where the same sellers meet each other repeatedly in successive market periods. It is called "dynamic" because, at least in some models, a seller's behavior may depend upon the past behavior of some rivals. The alternative static form has several identical markets running simultaneously and subjects are randomly re-assigned to different markets at the beginning of each market period. This form is intended to approximate an environment where in each market period each subject faces new rivals, making it impossible to choose behavior conditional on the current rivals' past behavior, since this previous behavior is unknown.

This program also allows a choice among several, related market institutions. All of these institutions have the sellers post their prices and have the buyers respond on a take-it-or-leave-it basis. They vary on when the quantities produced are determined and when these quantity choices are known to rivals. We are examining markets where the goods are made to order. The quantities produced are determined after each individual firms' demand is known, so there are no unsold units. Another alternative is to determine the quantity to produce before it is offered for sale, as in the typical market for any manufactured product. A third alternative, not fully operational at this writing, is to determine the quantity to produce before it is offered for sale, and have all quantity choices known to all sellers before price choices are made. With these last two alternatives, there may be some goods produced that later remain unsold.

Chapter III

OLIGOPOLY MODELS TO TEST

This chapter describes the models, with their associated predictions, that we will compare against our laboratory data. We first consider two models, the perfectly competitive model and the monopoly model, which provide us with a "ruler" for measuring good or bad performance. We then consider the oligopoly models we actually wish to test, the standard oligopoly models attributed to Cournot, Bertrand, Chamberlin, and Stigler. There is then some discussion on three related topics: the information our subjects must have to guarantee our oligopoly models are applicable, the noise we might allow around our models' predictions and still be able to presume a good fit with our data, and the design of the formal statistical tests we will use.

Benchmarks for Good and Bad Performance

The first model we consider, the perfectly competitive model, is our benchmark for good performance. With each seller in our markets having a constant $1.00 marginal cost up to a capacity of 12 units, any perfectly competitive seller would want to sell 12 units for any price over $1.00, would want to sell nothing for any price under $1.00, and would be indifferent among any feasible quantities if the price were exactly $1.00. With such a supply correspondence for each seller plus our market demand function, we find the price in any competitive equilibrium must be $1.00 and each seller would earn a profit of zero. Supply and demand curves for our markets are illustrated in Figure 3.1.

The second model we consider, the monopoly model, is our benchmark for poor performance. To maximize profits the monopolist must choose a price of $1.24 and sell a quantity of 6 units. This yields a profit of $1.44 for the monopolist.

As there are no income effects within our markets, an appropriate measure of welfare within our laboratory markets is the total of consumers' surplus plus producers' surplus. Nevertheless, since almost all prices are between the

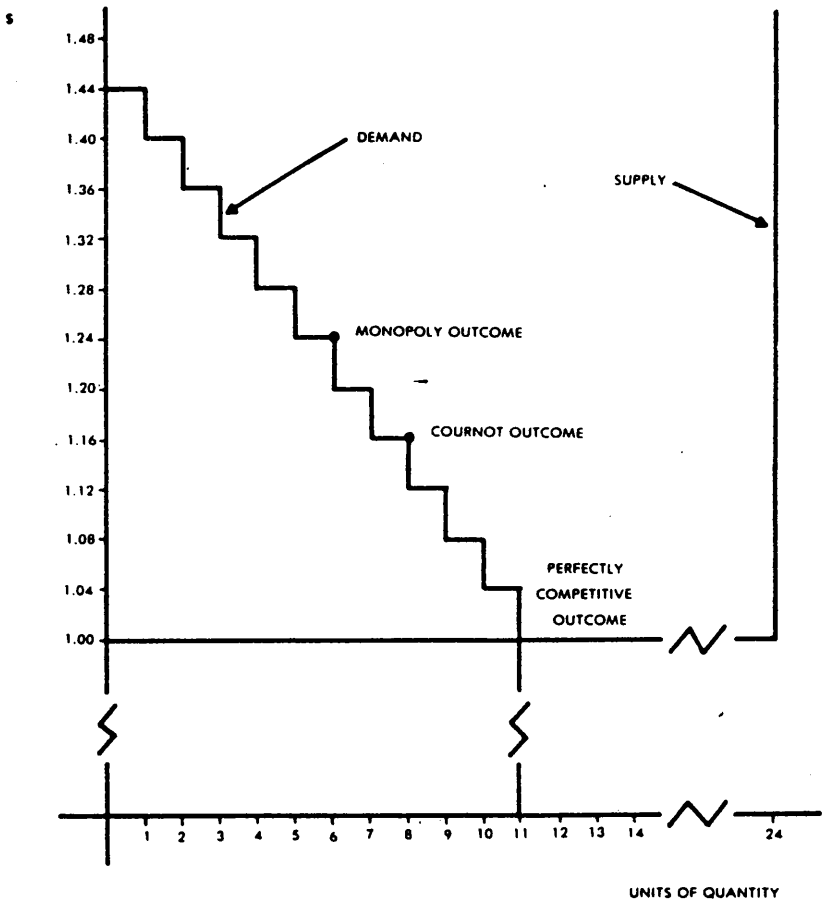

Figure 3.1: Demand and Supply for Our Duopolies

competitive and monopolistic prices, and the surplus measure of welfare is consistent, as an ordinal measure, with the market price, we will consider the market price as our measure of welfare.

Oligopoly Models to Test

Now consider the oligopoly models we actually wish to test against our data. The basic essentials for each oligopoly model considered are provided below. For each model the predicted outcome and the minimum necessary to calculate it are described. We will not consider here the logical arguments that usually accompany each oligopoly model, those that must provide each model's *raison d'etre* since none of the models have particularly strong empirical support. These arguments can easily be found in a more traditional economic hymnal.

The oldest oligopoly model, one still commonly used today, is the Cournot model[1]. In a Cournot equilibrium each seller chooses a quantity that maximizes his profit assuming his rivals' quantities remain fixed and prices are automatically given by the demand curve. For our duopoly markets the Cournot equilibrium yields a price of $1.16 with each firm selling 4 units. For our triopoly markets the Cournot equilibrium yields a price of $1.12 with each firm selling 3 units. For four sellers the Cournot model predicts a price of $1.12 or $1.08 (with integral quantities sometimes multiple equilibria exist).

If we follow Bertrand's criticism of Cournot's model,[2] that price should be the appropriate decision variable while the quantity is automatically determined by the market, then the competitive outcome is predicted, which yields a price of $1.00.

If we follow Chamberlin's suggestions for an oligopoly,[3] that markets with only a few sellers should easily be able to cooperate, then the monopoly outcome is predicted, which yields a price of $1.24.

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1. See Cournot (1838).
2. See Bertrand (1883).
3. See Chamberlin (1948).

These standard oligopoly models attributed to Cournot, Bertrand, and Chamberlin each have adherents believing they are applicable to the typical oligopoly market, so each of these models is to be tested against our laboratory data. Since the original contributions of Cournot, Bertrand, and Chamberlin, the mathematics of multi-person decisionmaking, known as game theory, has been developing. As game theory now provides the conventional theoretical framework for oligopoly theory, it is now well known that each of these oligopoly models can be formulated as a game theoretic model. Each model can be constructed as a game by specifying the set of players and their feasible strategies, and the predicted outcome is generated by the Nash equilibrium from this game.

If game theory is to be properly applied, the only game theoretic model to ultimately matter is the one where the players, their feasible strategies, and their payoffs mirror those in the markets of interest. In our laboratory markets the sellers did not choose quantities and have prices determined automatically by some outside agent. They did not choose prices and have quantities determined by some outside agent. And they were not physically united to act as one seller. The standard reformulations of the Cournot, Bertrand, and Chamberlin models are not those that will ultimately matter for our markets if game theory is to be properly applied here.

We can construct a proper game theoretic model for our laboratory markets rather easily. In any period, the sellers in our markets were the real decisionmakers, and we must mirror them in our game as the players. After being given the information supplied to them, our sellers chose a price to charge and a quantity to offer to the market, and we must mirror these choices in our description of the players' feasible strategies. Our sellers' choices determined the cash awards to them, and we must mirror this reward structure in the payoff functions for the players in our game.

If we believe a static model should be appropriate, a model where only the structure and behavior from the current period is necessary to predict current behavior, then a single period game theoretic model with the structure described above is appropriate. If such a model is created for our markets, where both the price to charge and the quantity to offer are decision

variables, then we find any Nash equilibrium for our markets yields a competitive outcome.[4]

For our markets this game theoretic perspective largely supports the outcome and the rationale behind Bertrand's prediction. In our game theoretic model we find strategies with large quantities offered to the market dominate strategies with small quantities, so the quantity choices are relatively automatic and the price choices become the "important" choices. One difference between the conclusions reached from our game theory model and from Bertrand's, or at the least, a point not emphasized by Bertrand (depending upon how one is to extend the meaning of the very few sentences actually written by Bertrand on oligopoly), is the requirement in our model's prediction that each firm must offer to the market more than it expects to sell rather than just what it expects to sell.[5]

Other models are suggested if we feel a dynamic model might be required, one where sometimes the behavior from past periods must be known to predict behavior for the current period. One of these is the Stigler model, or actually the class of models suggested by Stigler.[6] The markets he envisioned have firms wishing to collude, to maximize their joint profits, but their success depends upon the effectiveness of policing any cooperative agreement. In our markets, no cooperative agreement with positive profits could be maintained without policing, as some firm would be able to earn higher profits by cheating on the agreement. To maintain such an agreement, there must be some mechanism to detect any cheating and some punishment available, so each firm finds the short-term gain in profits

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4. See Alger (1979).

5. If this was not done and only the amount actually sold was offered at the competitive price, each firm would have an incentive to raise its price, using the market power it had among the buyers not served by its rivals at the competitive price. On the other hand, if, for example, 12 units were offered by each firm at the competitive price of $1.00, then any firm contemplating a higher price would see all its buyers automatically buying from another firm, giving it no reason to raise its price. If every firm were to offer a quantity of 12 units at the competitive price of $1.00, no firm would have the incentive to change unilaterally either its price or its quantity.

6. See Stigler (1968).

from cheating on the agreement is overpowered by the later loss in profits after the cheating has been caught and punished.

Attempts have been made to formalize these dynamic elements by creating the appropriate multi-period game theory models.[7] In the process of creating these formal models, there has been concern, not only with the features described above, but also with the credibility of any threatened punishment.[8] A general model of this type is still evolving within the literature, but the special case provided by our markets has been fully determined. All of the theoretical equilibrium outcomes for our markets can be generated by strategies where the choices from a cooperative agreement will be played as long as rivals have never cheated on the agreement in the past, but competitive strategies will be played forever if anyone has previously cheated.[9] An outcome is an equilibrium outcome if with these strategies one finds, for each seller, the discounted value of the gain from any cheating before its detection is less than the discounted value of the loss after detection.

Information Requirements to Apply Our Models

All of our oligopoly models require certain information to be made available to our traders before the models must apply. Usually these requirements are only implicit but when made explicit, the decisionmakers are said to require complete information, where each decisionmaker must know the reward structure for himself and those for all of his rivals.

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7. See Alger (1979), Friedman (1980), Green and Porter (1984), and Abreu (1984).

8. The credibility of threats has been addressed by some strengthening of the equilibrium concept. Some variations of this new equilibrium concept are the perfect equilibrium in Selten (1975) and the sequential equilibrium in Kreps and Wilson (1984).

9. With no uncertainty only the harshest credible punishments need to be considered, since they never have to be carried out in equilibrium. The strategies used in the competitive equilibrium are credible (they form a Nash equilibrium), and since they limit any rival's profits to zero and any rival can guarantee itself a profit of zero by offering a quantity of zero, it is the harshest credible punishment. See Abreu (1984) for the development of known results concerning agreements policed by the harshest credible punishments.

Nevertheless, these complete information conditions were not met in our experiments. The remainder of this section is spent discussing why these conditions were not met and whether this should make any difference.

Our sellers were not given complete information primarily because of a greater degree of control over preferences within our markets. We would have perfect control over a subject's preferences if they depended only upon his own cash reward, but we may lose control for subjects with more arguments to their underlying utility function. The ideal solution is to avoid those subjects with multiple arguments in their utility function and find new subjects. This is the reason friends or close acquaintances are often avoided when recruiting for an experiment. But if these subjects cannot be avoided, the severity of the problem should be reduced by not giving the subjects any information about these other possible arguments during the course of the experiment. Thus, if some subject's preferences may be based on the rewards earned by others, as well as her own reward, experimental environments can be constructed which give her no information on any other subject's rewards. Most economic experiments now follow this path, making any information on rewards strictly private.[10]

Information on rewards is kept private also because this information is private in most naturally occurring markets. In most naturally occurring markets buyers and sellers cannot know the subjective elements of another's preferences or costs, just like any outside observer trying to study them. Maybe, if these are truly the markets of interest and if complete information were truly required for our oligopoly models to apply, a better response to this problem would be to change our choice of models rather than our markets' information conditions.

In any case, regardless of our reasons for keeping information on rewards private, we will consider a decisionmaking environment where complete information is not required, one where much less information is truly necessary before these models can be applied. The arguments needed to support the

10. The data in Smith (1981) and in Fouraker and Siegel (1963) provide examples where market behavior changes significantly between markets with complete information and markets with private information.

conclusions discussed below can be found in Alger and Huang (1985), where this discussion is presented more formally and more completely.

Reconsider the most basic notion of an equilibrium. The concept of an equilibrium was originally borrowed from physics where it's viewed as a state where adjustments have stopped as all forces that may lead to change are exhausted. If this notion is more directly applied to economics, we might say an equilibrium is a state where adjustments in the selection of strategies and beliefs have stopped as the forces of self-interest and learning are exhausted.

Consider a decisionmaking environment, like each trading period within our markets, that can be described formally as a game. Now, say this game is played repeatedly infinitely often. To avoid fundamental changes in strategy stemming from this repetition, assume the players at each play have no memory of any previous actions with their current rivals. One might think of many copies of the game being played simultaneously, and before each play the players are re-assigned to meet new, anonymous rivals. Before each play of the game some information is revealed to each of the players. With this information, each player develops beliefs about the strategies to be used by his rivals. Given these beliefs each player makes his choices. The choices in which we are interested are those made out in the tail of this sequence of plays of our game. When the same choices are made out in this tail, when choices have stabilized, we have an equilibrium.

Now add the assumptions that all players initially know the strategies available to each player and their own payoffs, and that all strategy choices are revealed to all players at the end of each play of the game. In such an environment the set of equilibrium outcomes must equal the set of Nash equilibria. This conclusion shows that in such an environment where one learns from experience, the standard Nash equilibrium concept can be applied. The Nash equilibrium concept, used in all of our oligopoly models, does not require complete information for such an environment.

The information conditions described for this repeated-play game are satisfied for some of our laboratory markets. Each market period can be described as a game. Information is

provided at the end of each market period on the choices made by all of the subjects. Information is given to the subjects prior to their first decisions that describes the feasible choices available to each player. For some of our markets, those where market demand information was provided freely, each subject also knew his own payoffs initially. In such an environment, the Nash equilibrium concept used in our game theoretic model is applicable. For other markets, where market demand information needed to be learned through experience, the Nash equilibrium concept need not apply without modification. We shall return to this case later.

Allowable Noise Around Our Equilibrium Predictions

Now we have our models, and they offer their predictions, often of a single, unique outcome. Do we reject a model after seeing the first observation different from the theoretical prediction? Certainly such a standard is too strict. If such a standard were to be applied generally, in very short order we would reject all models economists have ever offered. We must allow some deviation around our predicted outcome to allow for the effect of market elements left out of the model.[11]

One example of a market element not incorporated into the standard models, but one that may affect equilibrium behavior, is the transaction cost associated with making decisions. Decisions require time and energy from the decisionmaker, and a complete accounting of all costs must include these implicit costs. However, even within our laboratory environment the value of this transaction cost is uncontrolled and unobservable. How might we expect our predicted outcome to change if these transactions costs were incorporated into the model? We might expect this cost to vary with different subjects faced with the same decision or for the same subject faced with different decisions. Over many laboratory markets with the same observable structure but with different subjects the equilibrium outcome might be expected to vary. A model

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11. We should also allow for any measurement error. Even though measurement error may be important in naturally occurring markets, it's of minimal concern in the laboratory.

incorporating these transactions costs might yield equilibrium outcomes that differ somewhat from the previous theoretical predictions when only the observable structure of the market is known.

Another example of a possibly important but unmodeled market element, one that may be particularly relevant to our markets where market demand can only be learned from experience, is the opportunity cost of searching for the price yielding the highest profit. If we were to extend our perfect collusion model to incorporate learning within an environment with these search costs, we would predict some sellers would choose a price slightly different from the $1.24 prediction.[12] A profit maximizer would choose the price yielding the highest profits among those sampled but he would not have sampled every point along the market demand curve. He would not sample any further after he judged the opportunity cost of searching exceeded the expected benefit given his current expectations. Some samples will lead the profit maximizer to expectations concerning market demand that are inconsistent with actual market demand. And, since he has stopped sampling, even repeated exposure to the market would never provide any information that contradicted these "false" expectations. Thus, after adding this search a model following all standard principles could predict a non-degenerate price distribution in equilibrium.

So some noise should be allowable around our predicted outcomes. How much? The direct approach to solving this problem is to consider explicitly the more complete models that incorporate the most important of these extra elements, and develop predictions that yield non-degenerate price distributions. But we do not do this. First, even when it is feasible, this approach is not felt to be the most efficient way to test our oligopoly models. The models we selected were chosen because some economists feel they already incorporate the most important elements of our oligopoly markets. The added complexities, and the extra theoretical work needed to incorporate them, should be dealt with in future work after the simpler

12. See Rothschild (1974).

forms of the models are tested. Second, some of the market elements being considered are unobservable, even in the laboratory, so the direct approach is not even feasible when considering some new market elements. But, without this direct approach, theory offers no guidance on the amount of allowable noise. How might we proceed?

One possibility is to use a unique predicted outcome from the theory as a prediction concerning the center of the observed distribution. The hypothesis to be tested is whether the center of the observed distribution equals the unique predicted outcome. This approach sidesteps the question of how much noise is allowable, but it must assume this noise does not change the center of the observed distribution of outcomes.

Another possibility is to use distributions generated in the laboratory and to use these as the theoretical standard. The idea is to find a class of experimental markets where each market in that class is felt to behave as the more complete model would predict and to use the data generated by this class as an experimental benchmark. We then compare the observed outcomes in two sets of markets, one set within this class and one outside of it. The hypothesis to be tested is whether the observed distributions for the two sets of markets are equal. This test of our theoretical predictions is the one I find most appealing. Unfortunately, the appropriate experimental benchmarks are not always available.

The Design of Our Oligopoly Tests

Given the general structure of our tests described above, we need to consider the precise form they will take. We need to know exactly what is to be examined and exactly what statistical tests are to be performed.

What about the market outcomes is to be examined? A full description of our market outcomes would specify all of the actions chosen by all of the traders. For our markets, this is a description of all price and all quantity choices. Such a description would, of course, include the prices and quantities for any amounts actually sold, but it would also include offers made to the buyers and then rejected. If the primary interest is in individual behavior, using this full description of the

outcomes is appropriate, but our primary interest is narrower. Here we are primarily interested in the market's performance, not the individual's. We are ultimately concerned only with the prices and quantities for the goods that were actually sold. While the study of individual behavior would be very interesting and potentially more rewarding, studying market behavior, rather than individual behavior, is the standard approach. Remember that data from naturally occurring markets almost never include information on rejected offers.

Since market demand is expected to be (and actually was) usually satisfied for the prices and quantities chosen in our markets, we only consider a one-dimensional description of each market outcome -- the market price. Specifying the market price is unambiguous for the typical case where sellers with prices higher than the lowest price have no sales, the case where market demand is satisfied by the lowest priced firms, but some outcomes did have sales occurring at more than one price. Within our analysis we set our market price equal to the average revenue, which gives us a weighted average of the prices for those goods actually sold.

For both types of tests proposed for our analysis, non-parametric tests are felt to be the ideal. The primary reason for choosing a non-parametric test, in spite of such a test's relatively low power, is that only relatively weak statistical assumptions must be added to the null hypothesis, so that we are much closer to testing only the economic statements within the hypothesis and not so much the statistical statements.[13]

With a non-parametric test, the relevant center of the distribution is its median. We then test whether the median of the underlying distribution of observed equilibrium prices for some population of markets could equal the predicted prices, or actually whether the differences between the observed equilibrium prices and the associated predicted prices could have a zero median. The hypothesis of a zero median for the difference between the equilibrium price and the predicted price is tested by taking the sample distribution of these differences

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13. See Chapter I for a fuller discussion of this.

and using a sign test, a standard non-parametric test for such an hypothesis.

To describe this sign test in more detail, suppose all of the differences between the equilibrium prices and the predicted prices, except those that are exactly zero, are described by the random variable D. Under the null hypothesis one half the distribution of D can be found above zero and one half below. Now consider the random variable X that takes a value of one if the value of D is positive, and a value of zero otherwise. This random variable must have a binomial distribution for one trial and a probability of "success" of one half. Next, consider the binomial random variable Y that adds up the number of "successful" independent trials of X out of a total of n trials. To conduct our test we calculate y, the value of this random variable Y. If under the null hypothesis we have a sufficiently small probability that the random variable Y is outside the range (y,n-y), then we will reject the null hypothesis. An additional consideration before applying the sign test is to determine which outcomes come from independent trials of the random variable X.

For our second test we compare the distribution of outcomes for an experimental benchmark against the distribution of outcomes in other similar markets. We test the hypothesis that the two price distributions are the same. We use a Kolmogorov-Smirnov test here, a standard non-parametric test of an equal-distribution hypothesis. For this test we measure the difference between the two cumulative probability distributions by the largest absolute value of the difference in the values of these functions, and test whether the observed difference is within some particular critical region for this test.

Chapter IV

LABORATORY TESTS OF EQUILIBRIUM PREDICTIONS WITH DISEQUILIBRIUM DATA

This chapter is primarily concerned with examining one common practice used within previous studies of laboratory markets. This practice is testing equilibrium models using some data from markets that have not reached an equilibrium.[1] The data set used typically consists of all available laboratory data from the last period, an average of the last few periods, an average of all periods, or from the *n*th period for some fixed *n*. I know of no attempt, at least formally, to assure all data were from markets in equilibrium. The primary question here is: Could the use of disequilibrium data significantly affect the results of tests we might make of our equilibrium models if we use data from our laboratory markets?

This practice would be desirable if the disequilibrium data provided a useful estimate of the behavior that would have been observed if an equilibrium had been obtained. On the other hand, if some disequilibrium behavior is qualitatively different from the behavior that would be observed in an equilibrium, this practice could produce misleading results. Within this chapter, we examine the effect of this practice when it is used on our laboratory data.

Two types of tests are done. The first examines paired data generated by our markets where the outcome from a particular market period is linked with the equilibrium outcome from the same market. For different specified periods and markets, we test the hypothesis that the disequilibrium outcomes center around the equilibrium outcomes. If this hypothesis is rejected, then the median of the disequilibrium outcomes is not

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1. We are referring to a notion of an equilibrium where strategy choices and beliefs have stabilized, one where traders are no longer learning from their environment. We use an operational definition of this notion (discussed in Chapter III) to determine if our laboratory markets are likely to be in equilibrium. In our markets, we call an equilibrium outcome one of those outcomes used to demonstrate this definition is satisfied; any other outcome is called a disequilibrium outcome.

likely to provide a useful point estimate of an equilibrium outcome. This type of test has a particularly strong design, but it cannot use all of the data generated within our laboratory markets, as many of our markets did not reach equilibrium, and it can only address the relatively narrow question of bias in our point estimate of an equilibrium.

The second type of test gives us a little less control over some market elements, but it uses data from all of our laboratory markets and it addresses a more relevant question: when can we generate a useful equilibrium estimate from our disequilibrium data? We test, for different specified periods, whether the price distribution for markets which have not been shown to be in equilibrium could be the same as the equilibrium price distribution. If not, these data are not expected to provide a useful estimate of equilibrium behavior.

Our primary goal with these data is to determine, for our markets, when disequilibrium outcomes would have provided a reasonable estimate of our equilibria, either a point estimate or an estimate of the entire distribution of the equilibrium outcomes. We are particularly interested in those tests using data from approximately the same market periods analyzed in similar previous studies.

Our data suggest that, for our markets, using all data available after approximately the same number of market periods as in some previous studies would lead to significantly different equilibrium test results than restricting tests to equilibrium data. If the sequence of data generated in our markets is truncated to approximately the same number of market periods used in these previous studies, significantly different behavior is observed than in equilibrium. Following this common practice with our markets would have generated misleading results.

The Design of Our Tests

Laboratory markets were created with the characteristics described in Chapter II. In our laboratory, several types of oligopolies reached equilibrium. Most of these markets had two sellers, some had three, and one four. Most of our markets had a constant marginal cost, but some provided an extra incentive

to trade by giving the sellers a relatively low cost for producing the first unit. Some of these markets had sellers who were inexperienced with our market environment and others had experienced sellers. Some of our markets gave the sellers free market demand information, while others forced the sellers to gather this information from their own experience with the market. Most of our markets provided information on a rival's actions as soon as all choices were made, but one provided this information only after a very long lag. We examine the effect of some of these differences on the usefulness of estimating equilibria from disequilibrium data.

We will compare the disequilibrium prices in different time periods to the eventual equilibrium prices. The time periods in which we are most interested, for both types of tests made, are those analyzed in similar previous studies. These previous studies include Fouraker and Siegel (1963), Murphy (1966), Stoecker (1980), and Ketcham, Smith, and Williams (1984). The markets examined by Fouraker and Siegel that are most like our laboratory markets are their price-setting duopoly and triopoly markets with incomplete information. The data examined from these markets are from their 14th market period. The markets examined by Murphy ran for 24 market periods. Stoecker examined the 20th market period from his markets. The markets examined by Ketcham, Smith, and Williams that are most like ours (their Design II) ran for 15, 20, or 25 time periods. Given this previous practice, we shall concentrate on the range of market periods from 15 to 35.

To help us determine when a useful point estimate of the equilibrium price would have been available, we examine the paired data generated by our markets where the disequilibrium price from a particular market period is linked with the equilibrium price from the same market. For several different market periods, we test the hypothesis that the median of the difference between these prices is zero. If this hypothesis is rejected, the median of the disequilibrium outcomes is not likely to provide a useful estimate of an equilibrium outcome.

This paired-data design was chosen, in spite of its eliminating laboratory data from those markets that did not reach an equilibrium, because it provides more control over some possibly important market elements that are subject specific.

Subject-specific characteristics not under our direct control, such as experience with similar environments outside of the laboratory or basic learning ability, are controlled in this design, since these characteristics are the same for each observation within the pair. Our equilibrium models suggest these subject-specific characteristics are not important in equilibrium, but they may be important nonetheless, especially in disequilibrium. This design also improves comparisons between markets whose structures differ somewhat, since we examine only the difference between the disequilibrium and equilibrium prices, not the absolute level of these prices.

The hypothesis of a zero median for the difference between the disequilibrium price and the eventual equilibrium price is tested by taking the sample distribution of these differences and using a sign test. To apply the sign test to our paired data, we must first determine which outcomes come from independent trials of the random variable X. It seems safe to assume each market is independent of another, but what of the market periods within a single market? If a static model were found to apply to our laboratory markets, these outcomes might plausibly be independent. After all, the independence of behavior in different time periods is the essence of the definition of being "static."[2] On the other hand, if these models do not apply and a dynamic model is necessary, then this full independence between time periods is certainly lost. As this question of independence between time periods has not been answered at this stage (nor will it be addressed here), this section presents the results of the appropriate sign tests for three different levels of independence. We present tests that consider only one observation from each market, some that consider observations from every fifth period of each market, and some that consider the observations from every period.

To shed some light on when a reasonable estimate of the entire distribution of equilibrium outcomes would have been available (not just the median), we compare, for several specified periods, the disequilibrium price distribution against the

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2. Even if some static model does apply in equilibrium, it does not require our disequilibrium behavior in different time periods to be independent.

equilibrium price distribution. For each of the specified periods, we test the hypothesis that the disequilibrium price distribution for the period is the same as the equilibrium price distribution with a Kolmogorov-Smirnov test. If the equal-distribution hypothesis is rejected, then we have shown the disequilibrium price distribution for that period does not provide a useful estimate of the equilibrium distribution.

Initial Laboratory Observations

A large subset of our laboratory data is described in the market data appendices at the end of this report. You are urged to examine these data yourself, so you may find for yourself the patterns or regularities you feel are represented within these data.

A Common Pattern?: I see a pattern in the data that, if present, would imply disequilibrium data should not be used for testing equilibrium behavior. For some markets it appears there is an initial period where firms gain some information about market demand, typically with one firm undercutting the price of the other in each period, and prices fall to somewhere near the competitive level. Later it appears some firm signals a willingness to go to a higher price with a relatively large jump in its price choice, and this is sometimes followed by a higher price from the rival. This jump to a higher price level by all firms sometimes breaks down with price cutting, falling back to a near-competitive level; sometimes, after staying at this price for a short while, it is followed by another jump to a still higher price (giving us a graph of their price history that seems to have "stair steps"); and sometimes the market remains at this price, resulting in an equilibrium. If the price level does fall after a price jump, this process may be repeated. Many equilibria appear to have started with one of these jumps to a higher price level. The most obvious of our

markets to follow such a pattern yield a graph of their price history that is roughly *U*-shaped.[3]

If this is a typical pattern for our markets, then some behavior prior to an equilibrium is drastically different from that observed in equilibrium. The near-competitive prices in the trough of the *U* would be quite different from the high equilibrium prices achieved at the top of the *U*. This may help explain the contrast in the near-monopoly equilibrium prices in our markets and the near-competitive prices noted in previous studies. Maybe some of the earlier laboratory markets were following this *U*-shaped pattern, but this pattern was not seen as the markets were terminated in the trough of the *U*.

Do Our Disequilibrium Prices Center Around the Equilibrium Prices?

Consider first the most conservative of our sign tests where we consider only one observation per market, tests with the weakest independence requirements which allow for interdependent behavior between any market periods. Taking specific market periods of interest, consider the sign tests where we take only the outcomes from the individual market periods 15, 20, 25, 30, 35, 40, 50, 60, and 70 against their respective equilibrium outcomes. The data for these tests, the values of the random variable *D* for each of these periods, are graphed in Figure 4.1. Each graph in the figure also indicates the sample median with a ">" to the left of the axis. In addition to these graphs, this figure also provides, for each of these periods, the values of y (the number of times the disequilibrium price exceeds the equilibrium price), n (the sample size), y/n, and the probability Y lies outside the critical region for the null hypothesis. Of these nine tests, six reject the null hypothesis at a 5% significance level, and one more rejects it at a 10% level.

We also consider similar tests where we take as our observation a five-period average instead of the single observation

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3. Some of our laboratory markets that seem to follow this pattern are copies 1, 2, and 11 of the market named "2slrs;mto;d;01;" copy 9 of "2slrs;-mto;d;02;" and copy 5 of "2slrs;mto;d;08."

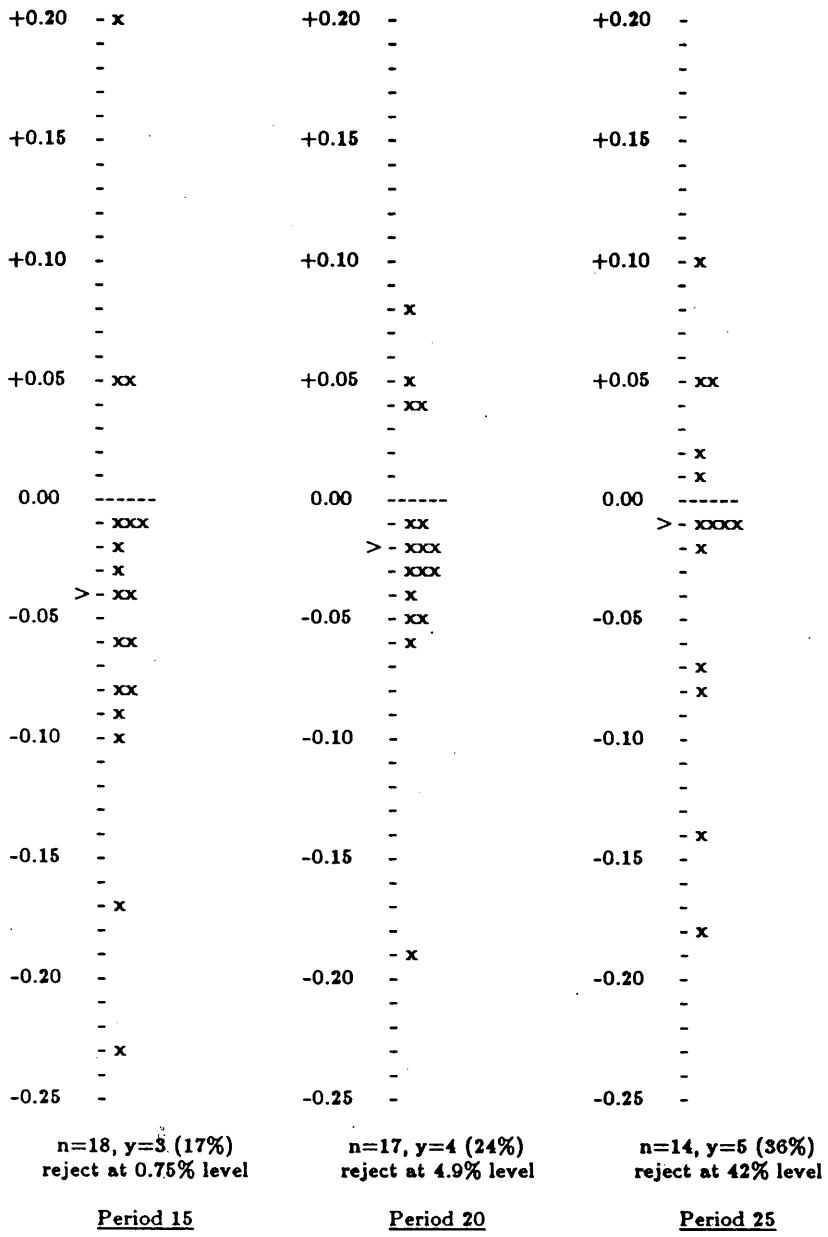


Figure 4.1a: Price Difference from Equilibrium

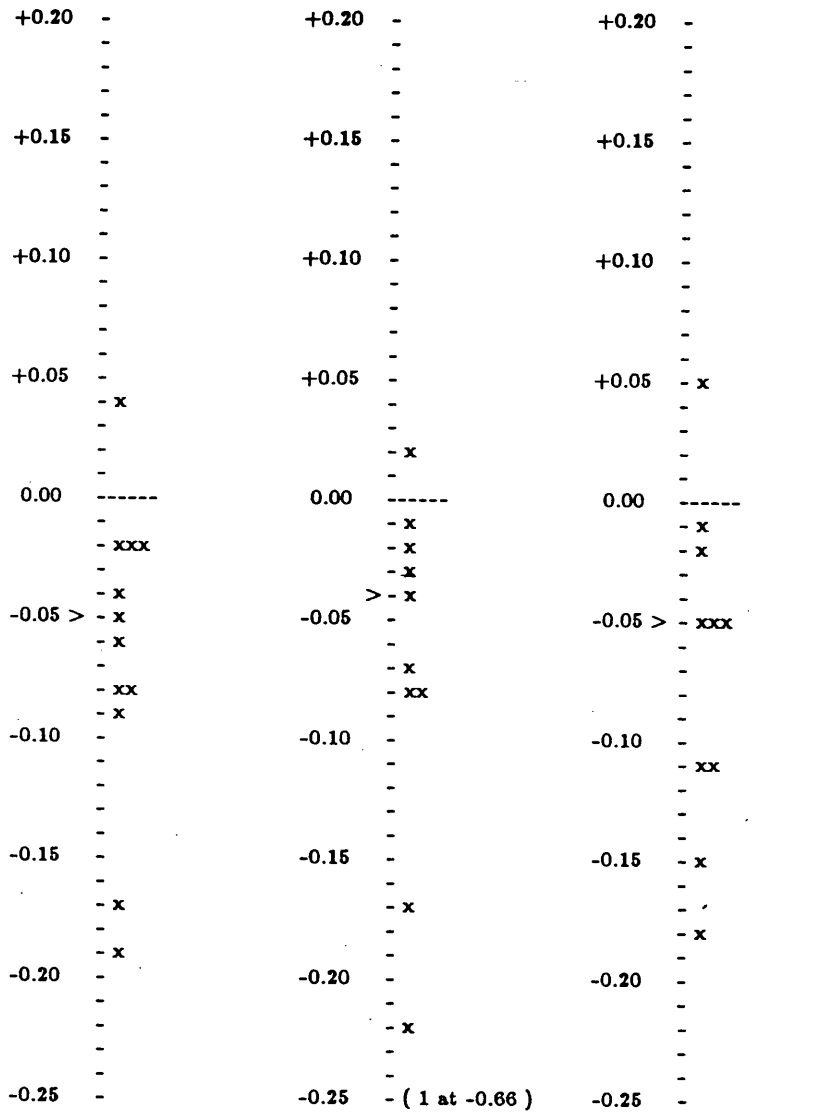
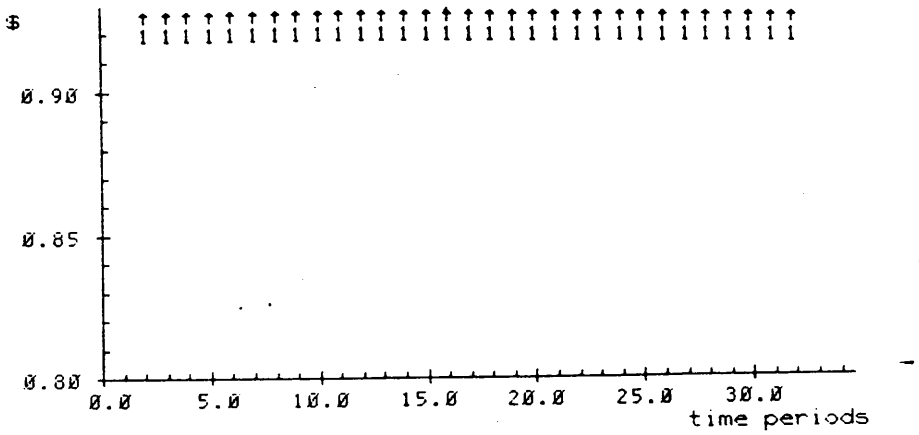


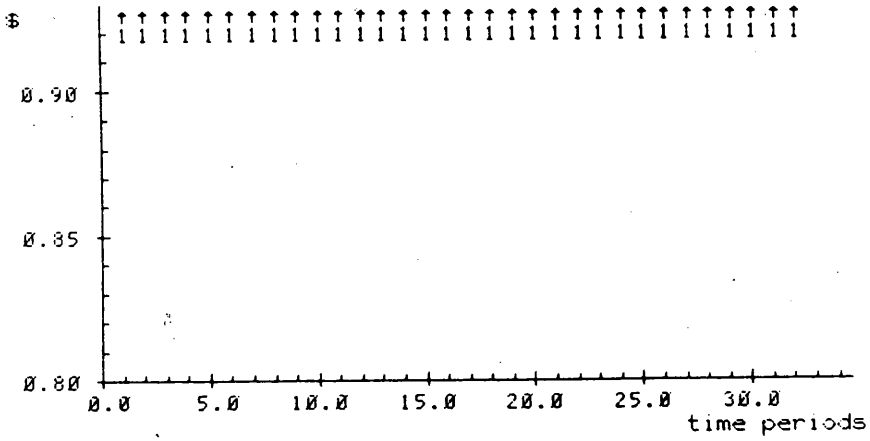
Figure 4.1b: Price Difference from Equilibrium

1slr;mto;d;03 copy 4

Price History of All Goods Sold



History of All Price Offers



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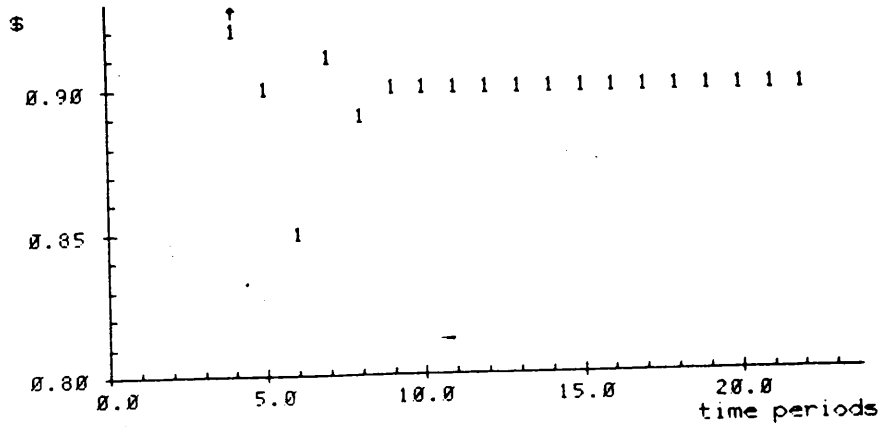
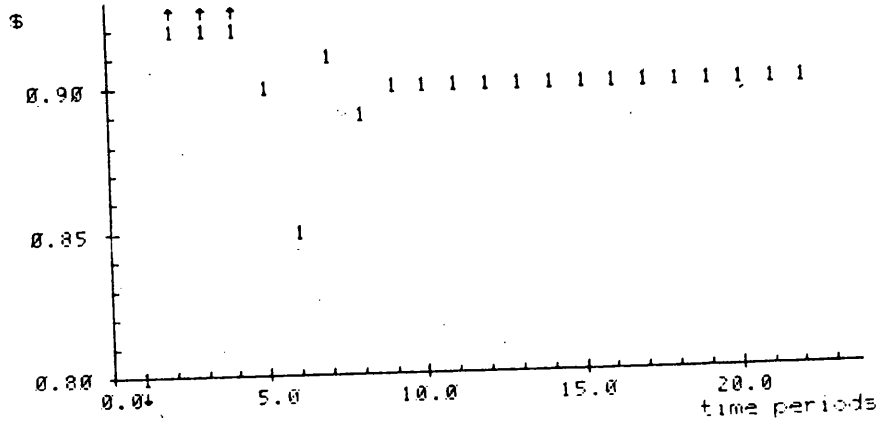
Price History of All Goods Sold



History of All Price Offers



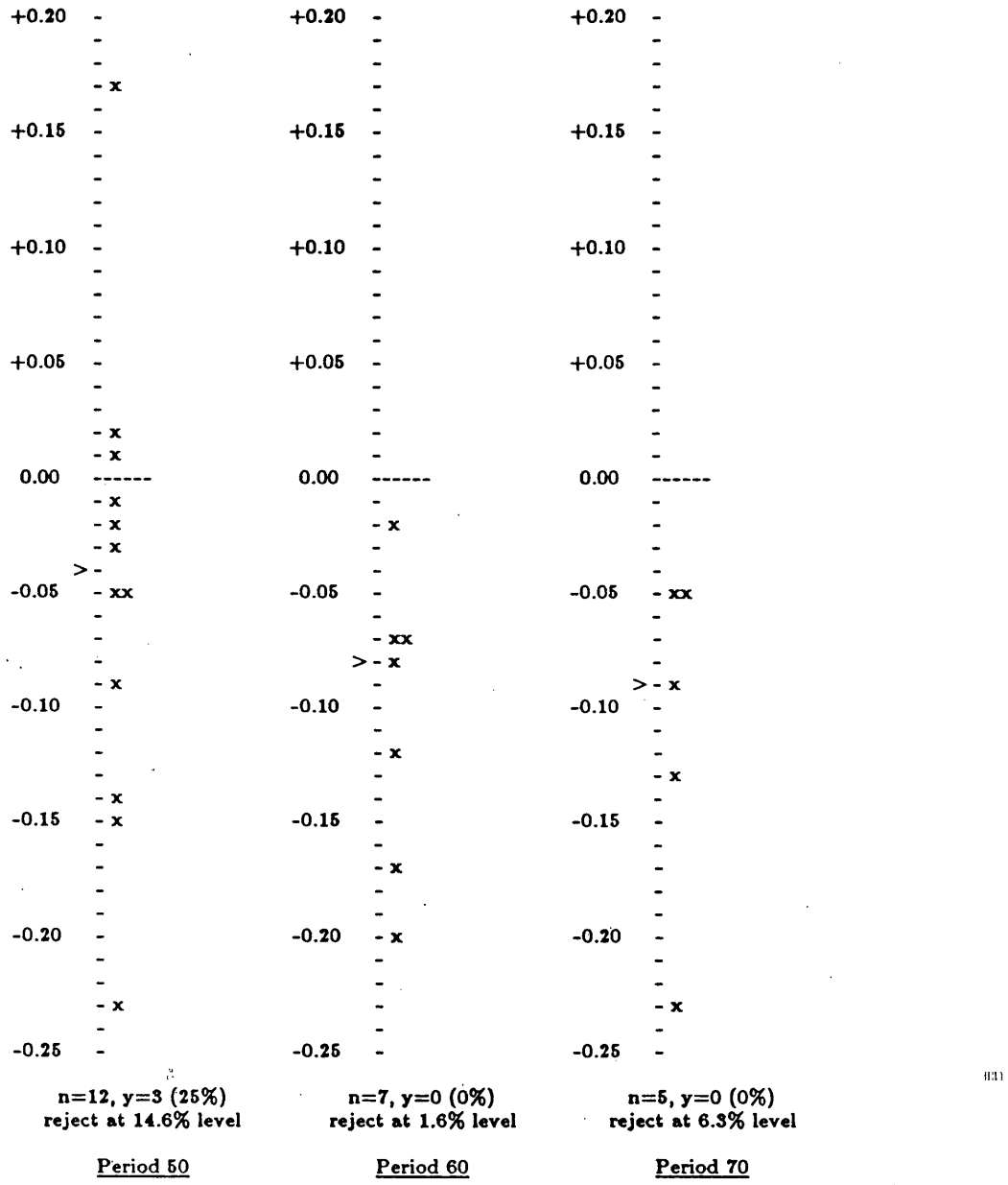


Figure 4.1c: Price Difference from Equilibrium

for any particular period. In Table 4.2 we see the results for these tests for the periods 11-15, 16-20, 21-25, 26-30, and 31-35. Each of the tests with a sample size large enough to do it rejects the null hypothesis at the 5% level. We might also note with this data that the ratio of y/n is fairly constant up to about period 30, but after this it seems to drop significantly. Restricting our attention to disequilibrium data from later periods does not appear to help our null hypothesis.

A similar test is presented where the single disequilibrium price considered for each market is the average price for all disequilibrium periods. For this test, $n = 31$ and $y = 7$ (23%), so we reject the null hypothesis at the 0.33% level. Of the tests given to test if the disequilibrium prices center around their equilibrium prices, this may be the most reasonable of the more conservative ones.

periods	n	y (y/n)	significance level
11-15	23	4 (17.4%)	0.26%
16-20	21	5 (23.8%)	2.66%
21-25	22	5 (22.7%)	1.69%
26-30	17	4 (23.5%)	4.90%
31-35	14	0 (0.0%)	0.01%
36-40	12	0 (0.0%)	0.05%
46-50	11	0 (0.0%)	0.10%
56-60	7	0 (0.0%)	1.56%
66-70	5	0 (0.0%)	6.25%

Table 4.2: Average Price Difference from Equilibrium

Now consider some tests where we consider observations from every fifth market period, so our null hypothesis adds an assumption that behavior in different market periods is independent except for any behavior within five periods. If we consider the data from every disequilibrium period divisible by five, we find $n = 214$ and $y = 42$ (20%), so we may reject the

null hypothesis at the $10^{-17}\%$ level. If we consider the five-period averages, we find $n = 262$ and $y = 45$ (17%), so we may reject the null hypothesis at the $10^{-25}\%$ level.

If we assume the choices in all market periods are independent, we may consider data from each time period. With this assumption, $n = 1114$ and $y = 205$ (18.5%), so our test rejects the null hypothesis at a $10^{-100}\%$ level.

Do Some Disequilibrium Prices Center Around the Equilibrium Prices?

Our data clearly demonstrates the median of the difference between the disequilibrium price and the equilibrium price is not zero. Can we find a subset of market periods or markets where the disequilibrium data might be expected to yield an unbiased estimate of an equilibrium? In addressing this question, we will either drop early market periods, use only experienced subjects, or consider oligopolies with more than two sellers. We hope a subset of the market data can be identified where we can expect disequilibrium data to yield useful information concerning equilibrium behavior.

We first examine whether, after an initial learning period, our disequilibrium outcomes center around their equilibrium outcomes. After early experience with the market, maybe the subjects are hovering near their equilibrium, but they have not quite achieved the stability necessary for an equilibrium. On the other hand, if the *U*-shaped pattern is common, even later disequilibrium behavior would be expected to be below the eventual equilibrium outcome.

Consider the following tests to determine if all disequilibrium outcomes beyond the 35th or the 70th market period center around their equilibrium outcomes. If interdependent behavior limits us to only one observation per market, some of the appropriate tests are included within Figures 4.1 and 4.2. Another test with a single observation per market takes the average disequilibrium price for all periods from the 35th period and above. It has $n = 15$ and $y = 3$ (20%), and the null hypothesis is rejected at the 3.5% level. With the average of all disequilibrium prices from period 70 and above, $n = 7$ and $y = 2$ (28%), leading to rejection only at the 45% level.

Considering observations from every fifth period (our five-period averages) from the 35th market period and above, $n = 136$ and $y = 21$ (15%), leading us to reject at the 10^{-14}% level, and from the 70th market period and above, $n = 54$ and $y = 7$ (13%), leading us to reject at the 10^{-5}% level. Considering all outcomes from the 35th market period and above, $n = 531$ and $y = 61$ (11.5%). Considering only outcomes from the 70th market period and above, $n = 209$ and $y = 14$ (6.7%). Each of these two tests rejects the null hypothesis at the 10^{-39}% level. The results of these tests offer little hope that eliminating outcomes from early periods would help our null hypothesis. It even seems any bias in the equilibrium estimate might be increasing, as y/n tends to fall as data from early periods are eliminated. The increasing probability Y is in the test's critical region when we drop more early periods is due solely to the dropping sample size.

Now consider tests to determine if the disequilibrium outcomes from just the experienced subjects center around their eventual equilibrium outcomes. It is these subjects in which we are most interested, and their behavior may differ from that of the inexperienced subjects. We find our hypothesis is soundly rejected here too. In our markets with experienced subjects, considering our five-period averages we have $n = 93$ and $y = 17$ (18%) and considering every observation we have $n = 478$ and $y = 79$ (16.5%). With the first test we reject the null hypothesis at the 10^{-7}% level, and with the second test we reject at the 10^{-49}% significance level. It appears the disequilibrium behavior of experienced subjects does differ from that of the inexperienced subjects, but if anything, the bias appears worse with experienced subjects who have still not reached an equilibrium.[4]

The great bulk of our markets are duopoly markets. Does this hypothesis fare any better with three or four sellers? With our triopolies, considering our five-period averages we have $n = 31$ and $y = 7$ (23%), so we reject the null hypothesis at a 0.33% significance level. If we consider all observations

4. Dropping early periods seems to worsen the problem here too. With experienced subjects, y/n equals 7.2% for periods 35 on and 1.2% for periods 70 on.

in our triopolies, we have $n = 142$ and $y = 33$ (23%), so we reject the null hypothesis at a 10^{-7}% significance level. With four sellers and our five-period averages, $n = 10$ and $y = 0$ (0%), and we reject the hypothesis at the 0.20% level. Using all observations with four sellers, we have n = 47 and $y = 2$ (4.3%), and we reject the hypothesis at the 10^{-8}% level. In our markets, more sellers do not help our null hypothesis.[5]

With our market data, we find no subset of market periods or markets that are expected to have disequilibrium data centering around its eventual equilibrium outcomes.

When Do Disequilibrium Prices Look the Same as Equilibrium Prices?

We test the hypothesis that the disequilibrium price distribution for the indicated period is the same as the final equilibrium distribution. The results are given in Table 4.3, where n is the sample size of the equilibrium distribution, m is the sample size of those not in equilibrium by the indicated period, and c/nm is the largest absolute value of the difference between the two distribution functions (the Kolmogorov-Smirnov test statistic). Graphs of the cumulative equilibrium distribution, the price distribution for period 15, and the price distribution for period 70 are given in Figure 4.4. Even though we are considering only one observation per market for these tests, their results clearly demonstrate the disequilibrium price distributions are different from the equilibrium price distributions.

If we continue the pattern of tests we used when testing for bias by offering tests appropriate for different levels of independence between market periods, and consider the same test but using either a single five-period average for each market, all five-period averages, or all disequilibrium prices, we reject the null hypothesis at even lower significance levels.

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5. Dropping early periods does not appear to help with three or four sellers either. With three sellers y/n = 9.3% for the periods 35 on and with four sellers y/n = 0.0% for the periods 35 on. (The sample size is too small for the periods 70 on.)

period	n	m	c	significance level
15	31	52	648	0.38 %
20	31	48	591	0.52 %
25	31	45	494	2.00 %
30	31	45	539	0.83 %
35	31	45	556	0.57 %
40	31	43	585	0.19 %
50	31	41	592	0.016%
60	31	38	619	0.016%
70	31	29	514	0.011%

Table 4.3: Tests of Equality Between Disequilibrium and Equilibrium Price Distributions

In any case, our data clearly demonstrates, regardless of any independence assumptions, the distribution of disequilibrium prices is different from the distribution of equilibrium prices. If we continue our previous pattern further and consider the same test for a subset of our data--drop early periods, use only experienced subjects, or consider only markets with three of four sellers--we again reject the null hypothesis at low significance levels. We find no subset of market periods or markets where we may expect the distribution of disequilibrium prices to be the same as the distribution of equilibrium prices.

For both types of tests done within this chapter, if we had suspected the *U*-shaped pattern in our data, a one-tailed version of each test could have been adopted to test whether the disequilibrium prices tended to be lower than the equilibrium prices. The results of such tests have not been presented here, as by definition the statistical results for the one-tailed tests would be even stronger than for the comparable two-tailed tests that are presented here. In our markets, disequilibrium prices clearly tend to be lower than the eventual equilibrium prices.

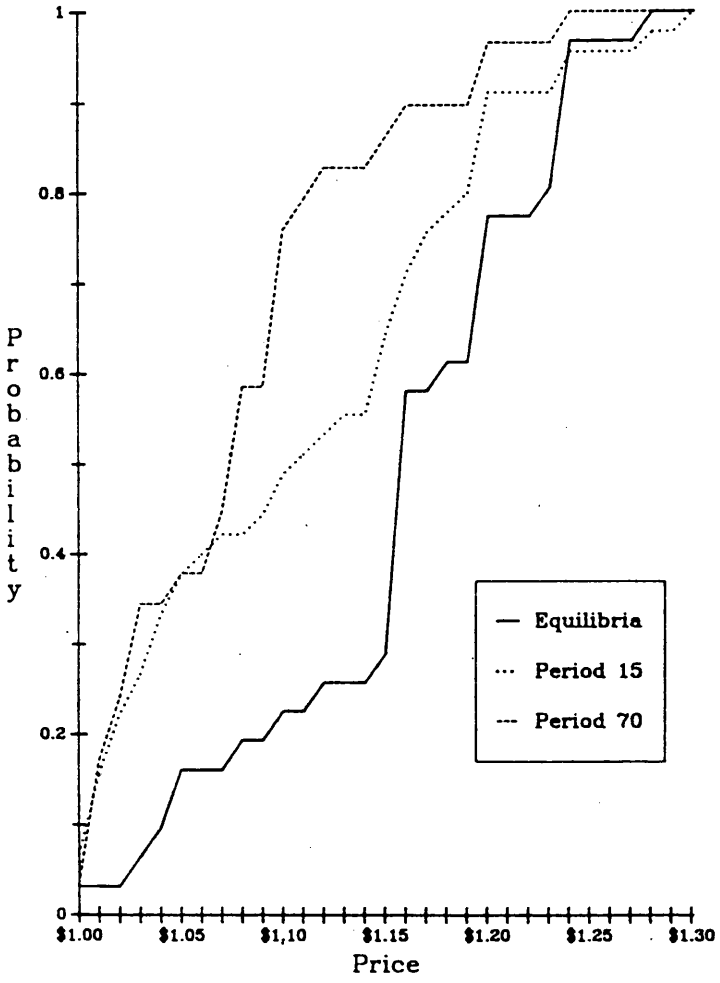

Figure 4.4: Disequilibrium vs. Equilibrium Price Distributions

Final Observations Concerning Disequilibrium Data

The results of our tests lead to the conclusion that, at least for our laboratory markets, disequilibrium behavior is significantly different from equilibrium behavior. For our laboratory markets, those markets not yet in equilibrium are more likely to give prices nearer the competitive level while equilibria tend to yield more "cooperative" outcomes. These results are consistent with our markets tending to have *U*-shaped graphs of their market prices over time. With our data we find no time periods, no group of subjects, no subset of our oligopoly markets where disequilibrium data are likely to provide a useful estimate of equilibrium behavior. It appears that, for our laboratory markets, disequilibrium data are not useful for testing equilibrium models.

Eliminating data from markets that have not achieved an equilibrium can result in the loss of an appreciable amount of data. If we had been forced, say by real time constraints, to terminate our laboratory markets by the 15th time period, only 13% (7/55) of our markets had reached an equilibrium; by the 20th period the same 13%; by the 25th period 19%; by the 30th 23%; by the 35th 22%; by the 40th 24%; by the 50th 27%; by the 60th 36%; and by the 70th period only 48%. While equilibrium tends to be reached more quickly by experienced subjects, even with experienced subjects an appreciable number of markets may not reach an equilibrium within the time available. For our markets with experienced subjects, the following percentage of markets had reached equilibrium by each of the indicated periods: 15th 29%; 20th 29%; 25th 33%; 30th 40%; 35th 40%; 40th 40%; 50th 45%; 60th 50%; and 70th 70%. Results that lead to eliminating all disequilibrium data are certainly disappointing, as the cost of obtaining useful laboratory data for some tests of equilibrium models may be raised significantly.

It should be stressed the conclusions indicated in this chapter may only apply to our own laboratory markets. Nevertheless, with these results I feel prudence dictates that, in testing equilibrium models, either some equilibrium criterion should be used to weed out disequilibrium data, or some arguments or evidence should be presented that indicate the disequilibrium data used should be useful. For many previous

experiments, say those within a double-auction environment, I certainly expect the problems discussed here are of no practical importance, as I expect reasonable equilibrium criterion could have been met fairly quickly. Almost by their definition, these problems are most important for those markets where equilibrium is expected to be reached only after a long learning process. This long learning process might be expected with an environment that is especially complex for the subjects. Markets with this complexity might include those where tacit cooperation between the subjects can develop, such as in some oligopoly markets; markets where personal reputations can be built; or markets where uncertainty plays a large role.

Chapter V

TESTING OUR OLIGOPOLY MODELS

The primary purpose for conducting these experiments is to test our oligopoly models, and, to this end, this chapter presents the results of some of these tests using our data. Because of the results of the last chapter, which indicate using disequilibrium data may produce misleading results in tests of equilibrium models, only equilibrium data is used with these tests. The data used for these tests is given in Appendix II. Other tests and other observations, including some on markets that never demonstrated an equilibrium was attained, are presented following these tests of our oligopoly models.

We present two sets of tests in this chapter. In the first set we compare our equilibrium data to the specific theoretical predictions made outside of the laboratory. In particular, we use sign tests to test whether the medians of the observed equilibrium distributions are equal to one of several theoretical predictions. In the second set we compare one subset of our equilibrium data against another. We test whether the equilibrium distributions for the two subsets of data are equal with a Kolmogorov-Smirnov test. These comparisons are made to test qualitative predictions of our models.

Median Tests of Our Oligopoly Models

The theoretical predictions from our models can be tested by testing for a zero median of the difference between the observed equilibrium prices and the predicted monopoly price ($1.24 for our standard market), Cournot price ($1.24 for monopoly, $1.16 for duopoly, $1.12 for triopoly, and either $1.12 or $1.08 for an oligopoly market with four sellers), or perfectly competitive price ($1.00). We want to test each of these with the following subsets of our data: all monopolies, all oligopolies, all duopolies, all triopolies, all oligopolies with more than two sellers, all oligopoly markets with experienced subjects, and all duopolies with experienced subjects. For each of these cases, Table 5.1 gives the significance level

at which the null hypothesis can be rejected with a sign test, along with the statistics used in each test, the number of trials above the predicted price y and the sample size n. This table also gives the sample median of the distribution of the standardized equilibrium prices for each of these cases, along with the total sample size.

		significance level for rejection (y/n)		
sellers	median(n)	monopoly	Cournot	perfect competition
1	1.22 (8)	68.8% (2/6)	68.8% (2/6)	0.8% (8/8)
>1	1.16 (31)	<0.01% (1/27)	13.4% (15/22)	<0.01% (31/31)
2	1.16 (25)	<0.01% (1/21)	33.2% (11/17)	<0.01% (25/25)
3	1.20 (5)	6.3% (0/5)	62.5% (3/4)	6.3% (5/5)
>2	1.18 (6)	3.1% (0/6)	37.5% (4/5)	3.1% (6/6)
>1 exp	1.20 (15)	0.3% (1/13)	3.9% (10/12)	<0.01% (15/15)
2 exp	1.20 (9)	12.5% (1/7)	12.5% (6/7)	0.4% (9/9)
>1 w/ dmd	1.16 (11)	0.4% (0/9)	100.0% (1/2)	0.1% (11/11)

Table 5.1: Median Tests of Bias in Our Equilibrium Predictions

I interpret these results in the following way: our monopoly markets acted in a way that was consistent with the theory of monopoly markets, just as in Smith (1981) where he examined a similar monopoly market that was created in the laboratory. I feel a 69% probability of having the test statistic in the critical region of this test is reasonable support for the monopoly theory. (With only one seller, the Cournot model collapses to the monopoly model, so this model too receives

support.) The observed prices very plausibly may have a median equal to $1.24. On the other hand, our monopoly data clearly rejects the perfectly competitive price as the median of the equilibrium price distribution for our monopoly markets.

With our oligopoly markets, we find the hypotheses that the median of the equilibrium price distribution is equal to either the monopoly price or the perfectly competitive price are clearly rejected. The evidence is strongest against the perfectly competitive prediction, but this conclusion appears firm in either case. In either case, we find the theoretical prediction, either the monopoly prediction or the perfectly competitive prediction, is not a reasonable single-point estimate of the equilibrium distribution.

Nevertheless, even with these conclusions that the predicted outcome is a biased estimator of the median of our observed outcomes, we may not have put our models to a fair test. A more complicated model with non-degenerate distributions for predictions may force the center of the predicted distribution away from our earlier prediction. We shall test some related issues later in this chapter.

The outcome with the most support among these three predictions is the Cournot outcome. The median price for our duopolies is exactly the Cournot price of $1.16. Among the three predictions from our static models, for each case examined the significance level, the probability the test statistic is in the test's critical region if the null hypothesis is true, is highest for the Cournot prediction. Nevertheless, the support for this model appears to drop with more than two sellers or with experienced subjects. Prices tend to be above the Cournot price more consistently as more sellers are added to the market (65% with two sellers, 75% with three, and 80% with four) or as subjects become more experienced (50% with inexperienced duopolists and 86% with experienced duopolists). We shall return to some related issues later in this chapter.

Do Our Oligopolies Act as Our Monopolies?

For the remainder of this chapter we shall examine some tests that test entire distributions of observed prices rather than just the median. The first of these tests between distri-

butions is whether the prices from some specified oligopolies could have the same distribution as the observed monopoly prices. Our standard for these tests, the distribution of our standardized monopoly prices, is indicated in Figure 5.2. If we use this sample distribution as our estimate of the theoretical equilibrium distribution, making this our experimental benchmark, then we are also testing whether the behavior in these specified oligopolies is consistent with the predictions of the monopoly model. With such a test of the monopoly model, the experimental data determines the appropriate amount of variation allowed around the theoretical prediction, a procedure which seems appropriate since theory provides us with no guidelines here.

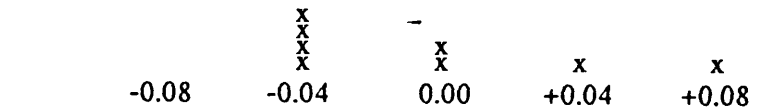

Figure 5.2: Observed Monopoly Prices - $1.24

	n	*m*	*c*	significance level
all oligopolies	8	31	85	44%
all duopolies	8	25	68	49%
all oligopolies with >2 sellers	8	6	16	84%

Table 5.3: Tests of the Perfect Collusion Model

We test the hypothesis that the predictions from the perfect collusion model are consistent with our data for all oligopolies, all duopolies, and all oligopolies with more than two sellers. The sample size of the monopoly distribution *n*, the sample size of the specified distribution *m*, the value of

the Kolmogorov-Smirnov test statistic c, and an approximation of the lowest significance level for which this hypothesis can be rejected are given in Table 5.3. For each of these tests we cannot reject the hypothesis at any standard significance level, so the perfect collusion model is given some support.

Do Market Demand Search Costs Matter?

Even when these perfect collusion tests offer their strongest support, we see the oligopoly distributions tend to give prices below the monopoly prices. Upon re-examining the data, I found the subjects of many of the oligopolies had chosen the price that maximized their total profits from among those prices they had sampled, but they had not actually sampled the true monopoly price, so they did not earn the maximum profit available. Since the standard form of our markets did not provide market demand information to the subjects initially, and the only market demand information they gained was through experience, maybe implicit search costs to gain some market demand information affected observed behavior.

Reconsider a model of perfect collusion. If the opportunity cost of searching for higher profit outcomes were incorporated into the perfect collusion model, we might expect the new theoretical predictions to lie heavily to one side of the previously predicted outcome. The cost of sampling the market demand curve differs for prices below the current price relative to prices above. To sample a price below the current price all one seller must do is choose the lower price, but to sample a higher price all sellers must be persuaded to increase their price (otherwise, if one seller had a lower price, that would be the price sampled). Thus, a model of perfect collusion incorporating this search cost would predict prices that tend to be below the simple monopoly price.

By contrast, if the market demand search cost is incorporated into a monopoly model, the center of the predicted distribution is likely to remain at the old monopoly price. Search costs seem to be the same for a price increase or for a price decrease in a monopoly. No rivals ever need to be convinced to change their behavior for a price to be sampled. One consistent observation from our data is a higher percentage of above-

monopoly prices in our monopolies (33%) than in our oligopolies (4%).

These arguments led us to run identical laboratory markets, but some with no market demand information provided (*i.e.* our standard treatment) and some with market demand information offered freely to the subjects. To test the comparative statics predictions suggested by our old and new perfect collusion models, we compare the data from our oligopolies with free market demand information to those where demand could only be learned through experience. Our null hypothesis for this test is that the underlying distribution with free market demand information is not below the underlying distribution without this information. As indicated in Table 5.4, we reject this hypothesis at the 1.0% level, indicating prices with free market demand information do tend to be higher than those in markets without this information. This result is consistent with the hypothesized effect of changing the implicit search costs of gaining market demand information.

	n	m	c	significance level
oligopolists w/o free mkt. dmd. info.	15	16	149	1.0%
monopoly	8	10	56	1.2%

Table 5.4: Comparisons with Oligopolies with Free Market Demand Information

We also compare the observed behavior in our oligopolies with free market demand information to that in our monopolies, our experimental benchmark for the monopoly model. Our null hypothesis is that the monopoly distribution is equal to this oligopoly distribution. As shown in Table 5.4, we reject this hypothesis at a 1.2% level. For our oligopoly models, this result is inconclusive since our monopolists had no market

demand information provided while these oligopolists did. A better comparison would have been between these oligopolies and some monopolies where market demand information is provided freely. Unfortunately, these latter markets were not run.

Do the Number of Sellers Matter?

Usually the first concern with oligopoly markets is with the effect of the number of sellers. Most economists would predict oligopoly prices will move closer to the efficient competitive level as the number of firms increases. Of our oligopoly models, if the number of sellers is increased from two to three to four, the Cournot model predicts a lower price for each increase; the perfect collusion model of Chamberlin and the competitive outcome attributed to Bertrand predict no change; and the multi-period game theoretic models of collusion allow price drops but they may not occur for each of these changes. This suggests a test of the comparative statics prediction that our duopoly prices will tend to be above the prices in our oligopoly markets with more than two sellers. Our null hypothesis for this test is that the underlying distribution of duopoly prices is not below the underlying price distribution for the oligopolies with more than two sellers. As indicated in Table 5.5, we cannot reject this hypothesis at any standard significance level. For our markets we find no significant change in behavior as the number of sellers changes. If this result were to hold, even with stronger data, it would be inconsistent with the predictions of the Cournot model.

	n	m	c	significance level
2 sellers versus >2 sellers	25	6	44	80%

Table 5.5: A Test on the Effect of the Number of Sellers

Do Changes in the Opportunity Cost of Not Selling Matter?

Frequent comments by subjects indicated there were long periods of frustration when prices were near the competitive level. The source of frustration almost universally voiced by these subjects was not being able to coordinate their actions with their rivals' to get the prices higher. These comments led to re-examining the preferences induced on the subjects for near-competitive price choices.

At the competitive price of $1.00 our standard market yielded a zero profit for every firm. The firm's price equaled its constant marginal cost. The question to be re-asked here was whether a zero cash reward for the subject would induce preferences identical to those of a seller with a zero opportunity cost for participating in the market. If not, we may have introduced some new elements into the market which might have shifted the center of the predicted competitive outcome.

Say that a subject's underlying preferences depend upon her reward and a subjective element of "fun" in playing the game. If attempting to achieve a high profit outcome is more fun than automatically choosing the zero-profit competitive price, then she will prefer to attempt to cooperate, even while failing and earning no cash reward, to choosing the competitive price. These would not be the preferences intended. Because of this consideration, some markets were run with a lower marginal cost on the first unit sold by a seller, so there would be a positive cash reward at the competitive price.[1] If this cash reward at the competitive price is sufficiently high, its effect will swamp the effect of any uncontrolled elements determining the subject's preferences that are unaffected by the cash rewards.

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1. If there is no cost to her for leaving, a subject may consider the alternative of leaving the experiment and using her time in another way that has some positive value to her. A sufficiently high penalty for leaving before the experiment has been terminated should eliminate this problem. In our experiments several subjects, in different markets, indicated they wanted to leave before the experiments had ended. They were told they would not receive the profits they had earned up to that point. All subjects stayed except one (he had earned very little).

This change in the cost of the first unit sold does not affect the monopoly outcome or the Cournot outcome, but it may affect the perfectly competitive outcome as indicated. It might also change the predicted outcome from our multi-period game theory model. In this model, some outcome is an equilibrium outcome if the discounted value of any gain from cheating on an agreement before it's detected is smaller than the discounted value of any loss from any punishment after it's detected. Decreasing the cost of this first unit sold does not change the gain from cheating on a potential agreement, but it does increase the loss from some punishments. Some outcomes may become equilibrium outcomes that were not previously.

The hypothesis tested here is whether the equilibrium distribution from the markets with the lowered cost on the first unit is the same as the equilibrium distribution for those markets with constant marginal cost. As indicated in Table 5.6, we cannot reject this hypothesis at any standard significance level. For our oligopoly models, this is an inconclusive result.

	n	*m*	*c*	significance level
constant MC versus low cost 1st unit	14	16	52	82%

Table 5.6: Changing the Cost of the First Unit Sold

Does Experience Matter?

A final test is presented which does not test any of our oligopoly models, but may have some effect on how laboratory experiments such as these should be run. It concerns the experience of our subjects.

While none of our oligopoly models predict any effect from different levels of experience (*i.e.* they may all be interpreted as requiring fully experienced subjects), earlier results

from Stoecker (1980) suggest that the level of experience may affect equilibrium behavior. Subjects that have successfully cooperated previously may be more likely to achieve higher profit equilibria than those that do not have this history. We even observed earlier that a higher percentage of experienced subjects had above Cournot prices than did inexperienced subjects. We will examine this contention by testing to determine whether the equilibrium distribution for experienced oligopolists is likely to be the same as the equilibrium distribution for inexperienced oligopolists. The results of this test, given in Table 5.6, seem to indicate these two distributions could very well be the same. Unlike what seemed indicated by previous results, we find no significant difference in the equilibrium behavior of experienced versus inexperienced subjects.

	n	m	c	significance level
all oligopolies	15	16	45	95%
all duopolies	9	15	30	94%

Table 5.6: Comparisons of Experience versus Inexperience

It is possible this may not be a good test of the effect of experience, since our duopolies had a heavier proportion of inexperienced subjects and the effect of the number of sellers may be distorting our results. Therefore, this test has also been run on just our duopolies, where there can be no effect from the number of sellers, and the results of this test are also given in Table 5.6. Both give similar results. Along with our previous observations given in the last chapter, these results appear to show experience increases the speed of attaining an equilibrium but has little effect on the equilibrium finally attained in our markets. Previous studies may have seen a change in behavior from experience when in fact one did not exist, because with inexperienced subjects they

were more likely to see a low disequilibrium price while with experienced subjects they were more likely to see a relatively high equilibrium price.

More Observations

Equalizing Profits: A fairly common pattern seen in the data is an apparent attempt to keep profits equal between the sellers. Because of the requirement to produce and sell only integral quantities, maintaining some agreements (*e.g.* those where an odd amount was sold) meant one firm always sold more than another. The sellers were not given any rival's costs, but if they assumed other sellers' costs were equal to their own, an assumption that would be accurate for these markets, they could determine the rival's profit. In any case, in several duopoly markets ways were found to split the profits evenly over time.[2] These markets developed a cyclic pattern that gave each of the traders average profits equal to what would have been earned if they could have sold fractional units. Most commonly the sellers would offer the largest quantities they could (12 units) and would alternate their price choices each period, say alternating between $1.20 and $1.25, which would lead to sales alternating between seven units and none. In one market, quantity choices were alternated instead of the price choices, so sales alternated between three units and four instead of seven and zero, and the choices were alternated every eight periods instead of every period.

The Effect of the Information Lag: Five markets[3] were run where the price and quantity choices made by a seller's rivals were not revealed to the seller (or actually not until after 101 market periods had passed). The intent was to give the sellers the least amount of information possible in such a

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2. Profits were obviously shared over time in copies 4, 11, and 13 of the market named "2slrs;mto;d;01" and copy 10 of "2slrs;mto;d;02." The behavior in other markets also seemed to be affected by the same considerations, as outcomes where the same quantities were sold by all seemed to be favored over outcomes with higher total profits but unequal profits.
3. The markets named "2slrs;mto;d;06."

market. Only one market out of the five reached an equilibrium, even though all ran past 100 periods. At the least, it appears that this treatment has slowed down the speed at which an equilibrium is attained. During most time periods it appeared these markets had lower prices than those markets that gave the sellers their rivals' choices at the end of each period. It is not clear if the choice of an equilibrium was affected by this change. The one market that reached an equilibrium settled on a fairly low price of $1.10, and most of the prices before equilibrium varied in five cent increments. Maybe, if it is harder to achieve a cooperative outcome in such a market, a larger variation around the average equilibrium price would be tolerated within an equilibrium. Possibly, since prices were so often so close to the competitive level, these markets were affected by the inappropriate incentives described in the earlier section on the opportunity cost of not selling. This factor may have prevented some near-competitive equilibria from developing when compared to a market with the desired incentive structure. More experiments are needed to test these conjectures.

Addendum: Using the Old Standard of OLS Regression

While non-parametric tests are preferable because of weaker statistical assumptions, some readers may find it useful, or perhaps gain some comfort, in seeing the results of standard ordinary-least-squares regression tests. In our markets that reached equilibrium, the only structural differences were: the number of sellers, the marginal cost of the first unit sold, the level of the subjects experience with our markets, whether market demand information was provided freely, and the length of the information lag before knowing a rival's choices. An OLS regression was run with these independent variables, a constant term, and the standardized price as the dependent variable. The results are indicated in Table 5.7. From these tests, while five out of six of the coefficients have the expected sign, it appears that no coefficient is significantly different from zero. Note in particular the coefficient for the number of sellers is not significantly different from zero,

but it is significantly different from $0.04, which is the coefficient implied by the Cournot model.

dependent variable	estimated coefficient	standard error	t-ratio
intercept	$1.1814	$0.0584	20.23
number of sellers	-0.0024	0.0299	-0.08
MC of first unit	-0.0382	0.0346	-1.11
experienced subjects vs. inexp. subjects	0.0259	0.0296	0.88
free mkt dmd info vs. no mkt dmdinfo	0.0242	0.0275	0.88
number of periods of information lag	-0.0006	0.0007	-0.93
$R^2 = 0.17$		F = 1.02	

Table 5.7: OLS Regression of Price

Chapter VI

FINAL OBSERVATIONS

The primary purpose of this project is to empirically test oligopoly models used to justify different antitrust policy choices. Our laboratory markets have provided us with some interesting, suggestive results from such tests. Along the way, we have examined some substantial evidence comparing different procedures concerning experimental technique and analysis. In this chapter, our findings are drawn together and summarized. The emphasis is on what lessons have been learned from the laboratory markets studied here. In addition, considering this project as part of an ongoing scientific investigation of oligopoly markets, this chapter provides a discussion of promising next steps for this research.

Suggestive Results of Our Oligopoly Tests

Several treatment variables were varied in our experiments. These included the number of sellers (1,2,3, or 4), the experience level of the subjects, the market demand information available initially (free or not available), and the cost of the first unit sold (a standardized cost of -$0.20, $0.20, $0.90, $0.95, and $1.00). Unfortunately, more replications appear to be necessary before some interesting results suggested by our data would be conclusive. The sample sizes available in our data are too small for some obvious questions to be answered, especially if we restrict ourselves to considering only the ideal comparisons, those between two markets where only the value of a single treatment variable changes. Here, when we examined the effect of one of these variables, all markets with the same value of a particular treatment variable were grouped together, even if other parameters were changed. This means any of the parameters whose values changed could have been responsible for the results obtained. More replications of some markets are needed for more convincing results.

Even so, our experimental data seems to suggest the following. Equilibrium behavior in our monopoly markets is consistent with the predictions of the monopoly model. This finding

for our eight markets replicates the same finding of Smith (1981) when a similar monopoly market was analyzed.

We found the perfect collusion model of Chamberlin, the model that yields the monopoly outcome for an oligopoly, does not offer a good point estimate of the behavior in any of our oligopoly markets. It might, however, offer a reasonable estimate of the equilibrium distribution if the model is modified to include other market elements such as the opportunity cost of searching for market demand information. The perfect collusion model is a better predictor for those markets for which market demand information is free.

The Cournot model offers the best point estimate of our static models. But, its performance worsens with markets with more sellers and markets with more experienced subjects. These would seem to be the most interesting and important markets to consider. More replications are needed here.

The predictions of the Bertrand model and the single-period game theory model, where each predict the perfectly competitive outcome, are clearly rejected. The perfectly competitive outcome is the poorest point estimate of our equilibrium predictions, and it is clear, even though a formal test was not done, that it would offer a poor estimate of the equilibrium distribution. The results of these tests of our oligopoly models differ from those of Fouraker and Siegel (1959) and Ketcham, Smith, and Williams (1984).

The multi-period game theory model, which may allow many outcomes as equilibria, was not adequately tested with our data. The one test we made that could have separated the predictive efficiency of this model from the others, one involving different comparative statics predictions for this model versus the other oligopoly models we considered, was inconclusive.

Modifications of Experimental Technique and Analysis

We found our strongest results concerned experimental technique. Our strongest conclusions from our data concern the use of disequilibrium data for testing equilibrium models. For our oligopoly markets, we saw the common practice of using all available data at the time when previous similar laboratory

markets have commonly been terminated would have led to misleading equilibrium test results. Under all the conditions we tested, our evidence indicates disequilibrium data should not be used to test equilibrium models. Using only the available data from markets that have demonstrated they are in equilibrium was always superior to using all available data. Our evidence convincingly demonstrates that for some markets (*e.g.* our own laboratory markets) using disequilibrium data is inappropriate for testing equilibrium models.

When examining our disequilibrium data, we found prices were significantly lower in the markets' disequilibrium periods than in equilibrium. It appears when subjects are learning to cooperate, the observed behavior is much closer to the predicted non-cooperative outcome than to the highest-profit cooperative outcomes. Our evidence is consistent with markets tending to have *U*-shaped graphs of their price histories. Our evidence is consistent with a conjecture that previous experiments often terminated their markets in the trough of the *U* rather than at its later peak.

This finding on the use of disequilibrium data is, at the least, unfortunate. Even for our laboratory markets, which ran for many more market periods than previous experiments, approximately one half of them never demonstrated an equilibrium had been achieved, so only one half of the markets yielded any usable data for our equilibrium tests. This certainly raises the cost of doing oligopoly research in the laboratory. Luckily, our data also indicate the heavy use of experienced subjects may dampen this effect somewhat, as experienced subjects appear to reach roughly the same equilibria as inexperienced subjects, but they get there faster.

Our conclusions concerning our disequilibrium data lead to a recommendation that tests of equilibrium models should consider only equilibrium data or other data shown to be useful in estimating equilibrium data. These considerations seem especially important in market environments where we expect the learning process for the market participants to be particularly slow.

Other design features of our markets were explored also, and several of these seem as if they would increase the efficiency of future laboratory research as well. One concerns the

market demand information available initially to each subject. It's true that we are ultimately interested in predicting behavior in naturally occurring markets, that market demand information is always uncertain in these markets, and that this information is usually learned through experience in these markets, as in our standard laboratory markets. But, it's desirable to find the environments where our models work well, as a starting point, and then incrementally add in doses of "reality." Our data and theory indicates our models would work best when this market demand information is provided freely to the subjects.

A major effort was made in this study to find and use formal statistical tests appropriate for our experimental data. Formal tests were included to complement the eyeball, so a solid common ground is provided for all of us trying to analyze our data. These tests help describe the data so one reader is more likely to see in the data the same things as another. The hope is that this concern for the most appropriate statistical tests will start a more thorough search for them, even if the tests adopted in our analysis are finally not seen as the most appropriate.

A goal was to use statistical tests that embedded the minimum of statistical assumptions within the null hypothesis. We would then be testing primarily economic statements and not statistical ones. For this reason, to avoid assumptions on the form of some particular distribution, nonparametric tests were used. We used two standard nonparametric tests: sign tests to test the medians of different distributions and Kolmogorov-Smirnov tests to test for equality between different pairs of distributions.

Many experimenters have been concerned for some time about the amount of variation to allow around a theoretical prediction before one should say the model's predictions are rejected. Even though most theories offer a single outcome as their prediction, some variation around this prediction is usually expected. Unfortunately, these theories provide no guidance on the amount of this expected variation. One approach followed in this study was to let the data provide this guidance. We can do this by finding an experimental benchmark for each model, finding a market structure where behavior is deemed

to be consistent with the model's predictions. This observed distribution of behavior is then substituted for the theoretical prediction in our tests, and we compare the distribution of other data to it. Another approach followed here is to assume the expected variation in outcomes will not change the center of the observed distribution of outcomes, and to test the theoretical prediction against this center.

Some of what we learned in this study about experimental design had already been known in other market environments, but since our original design did not incorporate these features, it appears I needed to re-learn them for our market environment. I needed to re-learn how to properly control factors affecting the subject's underlying preferences other than his own cash reward, a feature which is especially important for choices where the cash rewards are particularly low. Many earlier experimental studies have dealt with this in their market environments, but our original design had some low profit choices (*i.e.* those with near-competitive prices) where the effect of the cash reward might not outweigh the effect of some other factors in a subject's underlying preferences. We found, whenever trading takes place each subject should earn some positive reward large enough to outweigh these other factors that would lead the subject to not trade.

I also needed to re-learn the form of the experimental design that would be ideal, even if it's not always attainable. In our study we found an experimental design that generates linked data offers a great deal of control for our statistical tests. The idea is to compare two or three identical markets, even with the same subjects, except for the change of value of one treatment variable. Comparing two identical markets except for some variation in one treatment variable was certainly known to be ideal, but the original design controlled only those variables used in our economic models, and not any other controllable variables that might also have an effect on behavior. Using the same subjects in the markets providing these linked data gives us this extra control. When even the same subjects are involved, even subject specific market elements such as the subjects' experience from outside of the laboratory, their learning ability, or their attitudes toward risk are controlled. This experimental

design is not new, not in economic experiments, and especially not in psychology experiments, but this appears a valuable lesson to re-learn.

Where Do We Go From Here?

Science is supposed to advance by forming theory, testing it against empirical data, modifying the theory, re-testing, and so on in a continuous cycle. Given what we have learned from this study, what appear to be promising next steps in this cycle?

Some of our findings suggest procedures that should be followed for any future oligopoly markets run within the laboratory. Markets should continue operating until an operational definition of an equilibrium has been satisfied. Use experienced subjects as often as possible, without using any subjects more than once in any one treatment. At least until a large pool of data is available from such markets, market demand information should be given freely to all subjects. There should be some positive reward for trading over not trading, such as having the cost of the first unit sold lower than others. Whenever possible, use a linked data design for the experiments.

Given these procedures are used, a strong effort should be made to establish good experimental benchmarks for each model to be tested. One unused feature of the computer program controlling our experiments is the "static" form of the market. With the static form, several identical markets are run simultaneously and subjects are reassigned to the different markets at the beginning of each market period. The intention is to make cooperative behavior impossible, while still giving each subject plenty of experience with his market environment. This type of environment might give a static, noncooperative model its best chance to succeed. A benchmark for the Bertrand model might be established by running the same type of markets run in this study, except in their static form. (This might be compared to some double auctions run with the same cost and demand parameters.) A benchmark for the Cournot model might be established by using the two stage institution described at the end of Chapter II and running it in its static form.

Having created these benchmarks, run these same markets in their dynamic form. If there is any change in behavior it would be due to the extra opportunities available in the dynamic environment. These extra opportunities are not elements of any static model, so any change in behavior would also be evidence to reject any static model. On the other hand, if there were no change in market behavior, the data would be offering a fair degree of support for that noncooperative model.

Once any extremes of behavior are demonstrated, market elements that are supposed to lead in the opposite direction should be added incrementally. If the extremes have not been met, add market elements incrementally that should lead to them. Especially important are those changes which affect the theoretical predictions of one model, but have no effect on the predictions of another alternative model. These appear to be the changes that could yield the most interesting results for antitrust policy.

Within our laboratory environment, I see more replications are needed of our markets using three or four sellers, using varying experience levels, using different costs for obtaining market demand information, and using different relative costs for the first unit sold. One could also consider changes in: physical capacities, slopes of cost or demand curves, the rationing rule, the information lag before receiving information on a rival's choices, or the possibilities for limited but direct communication. If you see other promising possibilities, please contact me. Maybe together we can add to the empirical base for oligopolies.

Appendix I

REPRESENTATIVE INSTRUCTIONS

The instructions given to each subject were tailored to the structure to be imposed upon the market in which he would participate later. Nevertheless, all of our subjects saw instructions that closely followed the copy of the instructions which follow. In presenting these instructions, I have tried to approximate those seen on the computer terminal, by separating each display that would be seen on the terminal.

This is an experiment in the economics of market decision-making. You and the other subjects participating in this experiment will make all of the decisions necessary for this market to operate. PLATO is used to explain and enforce the rules of the market, and to store and transmit different information on decisions made by you and the other participants in the market.

Funds for this experiment have been provided by various research organizations. The instructions are simple, and if you follow them carefully and make wise decisions, you may earn a considerable amount of money, which will be paid to you in cash at the end of the experiment.

At any time in the instructions you may press BACK to review the previous display. Press NEXT to continue the instructions, or after completing any typed entry. When in doubt press NEXT or HELP.

[The decision box is shown here.]

Each market consists of a series of trading periods. In each period, as a seller of a fictitious good, you will be asked to make the three decisions indicated in the table above. You must choose the price to charge for the good, the quantity to offer to the market, and an estimate of how much you expect to sell given your other choices.

After all of the sellers' choices have been made, the buyers will choose the amounts they wish to buy. Their choices then determine your profit, which is then yours to keep. Your

total profit for all periods will be paid to you at the end of the experimental session.

The profit you earn in each period represents the amount of revenue you receive from the buyers minus the necessary production costs.

The revenue you receive from the buyers equals, of course, the price you charge times the quantity you actually sell (or equivalently, the amount the buyers buy). The buyers choose how much they wish to buy from you, up to the maximum quantity you have chosen to offer to the market.

For example, if the buyers wish to buy 10 units from you and you offer 50, then you sell 10; or if they want 100 while you offer 50, then you sell 50.

When you are faced with the decisions indicated above, you will have access to some information learned from a market survey. To see this information, touch the market survey box now.

[The market survey box is seen here.]

[The subject now sees a graph of the market demand and the repeatable option of entering a price, so that he may be given the quantity demanded at that price.]

Before the sellers have made any choices, the buyers will have indicated how much they want to purchase at each price. This information is available to you in a graph such as this, and in a query like the one below. You may give a price or press NEXT to proceed.

Your costs represent the amount of money you would pay to produce your good, and they depend upon the quantity you actually produce. Information on your costs is available to you by touching the production cost box on the screen.

[The subject sees a graph of total cost and the repeatable question "what quantity?", so that he may be given the total cost for that quantity.]

In this market all goods are made to order, which means no good is produced until after a buyer has been found. You produce exactly what you sell. The amount you will sell (and produce) is whatever the buyers want to buy from you, up to the amount you offered to the market.

You will be charged for every unit of the good that you produce. This amount, the cost to you of producing your goods, will be subtracted from the money you earn from selling your good. The difference, your profit, you will get to keep. You will not be charged for any units that were offered to the market but were not sold, as these units are not produced.

To see how this works we will go through a few market periods as a trial run. In addition to not having any money on the line, this trial market differs from those in the experiments by having only one seller. Later you will participate in markets with other sellers. Other market parameters may also differ, but the general operating procedures are the same.

[The subject sees the decision box for the current market period within the instructions.]

In each period you need to make the decisions indicated above. Within each period you may enter new choices for these decisions, examine some market information which is available to you before these decisions must be made, or confirm the choices already made to make then final.

When an arrow appears you may enter a new choice for the market variable indicated, completing the entry by pressing NEXT, and the arrow will move to another market variable. You may also just press NEXT to keep the current value of the variable, and then move on to another market variable. (At the beginning of the period the price and quantity offered are the final ones chosen from the previous period.) You can keep making entries until you are satisfied with your choices.

After new choices are entered your expected profit is calculated and shown to you. This is done only as an aid to you, to help you in determining what your actual profits might be with different choices.

This expected profit is your expected revenue minus your expected production costs. These expected values are calculated assuming you sell what you expect. (Your actual profits may be different, as they will depend upon the buyers' choices as well as your own.)

Note that your choice of an estimate of how much you expect to sell has no effect on your profits -- it has no effect on either your actual revenue or your actual costs. The only purpose for making this choice is to calculate this expected profit.

After you are satisfied with your choices, you need to confirm them by touching the screen within the decision box. You will then be asked to double check your choices, and if these are indeed your desired choices, you confirm them again by touching within the box.-

After this confirmation your choices are final. The choices of all of the sellers are then given to the buyers, all at once, and the buyers may then purchase as much as they wish from those goods that have been made available to them. You will then move on to the next period, but markets will have been reassigned so that you will face new sellers and new buyers, and their identities will be withheld from you. (PLATO runs many markets simultaneously at several sites.)

[The subject goes through the first trading period within the instructions and then proceeds to the second period, where the market history is displayed.]

After the final choices of all the buyers and sellers have been entered for this period, you move on to the next period and the results from all previous periods are given to you in the market history.

The market history shows your market choices, but it also tells you how much the buyers purshased (or, equivalently, how much you sold and produced), and your resulting profits. If there were other sellers in this market, you would have all of this information for each of the sellers, except for the profits. Only you know your profit.

When you are in a market and are beyond the first period,

you will see the market history along with the decision box, the production cost box, and the market survey box.

[The subject returns to the displays seen at the beginning of the second trading period.]

Before starting this period, let me explain another option that is available to you. Whenever you see the market history, you will see a graphed history box. You may touch it to see a graphical version of the market history. While this alternative picture of the market history is not particularly useful when there is only one seller, let's look at it now anyway.

[The subject sees a graph of the price history of his market and a graph of the distribution of the quantities sold for the last period (when this graph is seen in later periods it can be shown for any specified period).]

The price history shows all past prices (all past periods--usually more than one). For each period, a "1" is for firm 1's price, a "2" is for firm 2's price, and so on. The price distribution shows the amount sold (the X's) and the amount offered (the |'s) at each price. This graph will be more useful with other sellers in the market.

[The subject proceeds to the next period.]

As you can see this market history accumulates, adding period after period. After awhile, all of the past periods in the market will not fit on the screen. When this occurs, you have some additional options.

If there are any earlier periods in the market history that are not shown, you will see an earlier periods box. You may touch it then to see the history for these earlier periods. Similarly, if there are any later periods that are not shown, you will see a later periods box, which you may touch to see the history for these later periods.

This completes our description of how the market operates and what market information will be available to you before your market decisions must be made. Other market information which might be useful for making your decisions will have to be learned from experience.

Now that we have covered the basics, continue with this trial market until you feel comfortable with its procedures.

[The subject proceeds through several trial periods, a process he can stop when he indicates he is comfortable with how the market operates.]

The only remaining options for you, while you are in the market, are common to most PLATO lessons.

One is to press TERM (which is the same as SHIFT ANS) and then type "comments". You can then provide any comments you wish to the experimenters. This might include suggestions on how to improve the operation of these markets, or possibly a description of any strategy you used in the market.

Another is to press STOP if you want to stop the presentation of some display. This might be useful if you have seen enough of the market history and wish to enter your decisions as soon as possible.

And the last, but most important to remember, is to press HELP for a short summary of all of the options available to you while you are in the market.

Whenever you are in doubt, press HELP or NEXT.

[The subject sees a full summary of the options available during the market's operation.]

You have now completed the instructions and are ready for the real thing. G O O D L U C K !

Appendix II:

A SUMMARY OF OUR EQUILIBRIUM DATA

Our laboratory markets provide too much data to supply all of it here. In this and the following two appendices we have: a summary of all equilibrium data; a graphical summary of the price history for each market (including those that failed to reach an equilibrium as well as those that did); and a description for each market of the market parameters used plus the entire market outcome for each of a representative sample of time periods. I hope this meets your needs, but if you wish to see more I encourage you to contact me directly.

The summary of the equilibrium data provides, for each market that reached an equilibrium, the standardized market price and the values of any market parameters varied for the markets in this study. The parameters varied were the number of sellers, the marginal cost of the first unit sold by a seller, whether all subjects in the market were experienced with our markets, whether the subjects were provided market demand information freely, and the number of periods of the time lag before a subject learns his rivals' choices.

The following data are all that are used in the formal tests of our oligopoly models within this study.

Summary of All Equilibrium Data

price	no. of sellers	1st MC	experienced subjects	initial demand info	info lag
$1.10	1	$1.00	no	no	1
1.10	1	1.00	no	no	1
1.24	1	1.00	no	no	1
1.20	1	1.00	no	no	1
1.24	1	1.00	no	no	1
1.32	1	1.00	no	no	1
1.20	1	1.00	no	no	1
1.28	1	1.00	no	no	1

price	no. of sellers	1st MC	experienced subjects	initial demand info	info lag
$1.24	2	$1.00	no	no	1
1.18	2	1.00	no	no	1
1.20	2	1.00	no	no	1
1.03	2	1.00	no	no	1
1.20	2	1.00	yes	no	1
1.05	2	1.00	no	no	1
1.20	2	1.00	no	no	1
1.08	2	0.95	yes	no	1
1.15	2	0.95	no	no	1
1.20	2	0.95	no	no	1
1.16	2	0.95	no	yes	1
1.16	2	1.00	yes	yes	1
1.16	2	1.00	no	yes	1
1.16	2	1.00	yes	yes	1
1.16	2	1.00	no	yes	1
1.24	2	0.95	yes	yes	1
1.16	2	0.95	no	yes	1
1.16	2	0.95	yes	yes	1
1.16	2	0.95	no	yes	1
1.10	2	0.95	no	yes	101
1.04	2	0.20	no	no	1
1.20	2	-0.20	yes	no	1
1.20	2	-0.20	yes	no	1
1.24	2	-0.20	yes	no	1
1.28	2	-0.20	yes	no	1
1.23	3	1.00	yes	no	1
1.20	3	1.00	yes	no	1
1.24	3	0.90	yes	yes	1
1.12	3	1.00	yes	no	1
1.05	3	1.00	yes	no	1
1.16	4	0.90	yes	no	1

Appendix III:

GRAPHED PRICE HISTORIES FOR EACH MARKET

This appendix provides two graphs of the price history for each market. Both plot the prices offered by sellers in different time periods. The seller's identity is indicated by the seller's identification number appearing within the graph (e.g. a "1" is plotted for a price from seller 1, a "2" for seller 2, etc.). An arrow above or below some number indicates the price offer was outside the range of prices given in the graph. Sometimes numbers plotted for markets that ran many time periods overlap on a graph. An extreme example of this occurs when such a market has reached an equilibrium, where the graph almost appears cross-hatched.

The top graph gives all prices for goods that actually sold. This is analagous to the market prices that would be seen in a naturally occurring market. Typically, different sellers offered different prices and relatively large quantities, so that only the seller offering the lowest price actually sold anything that period. In that case only one price is entered on this graph for that time period. If more than one firm had a postive level of sales, all of the associated firm numnbers are plotted on the graph, possibly with one on top of the other.

The bottom graph gives all price offers, including those for which there were no takers. Since the sellers could only communicate through their choice of actions and price appears to be the dominant choice variable in our laboratory markets, this graph provides some information on any communication between sellers.

The data for each laboratory market are identified by a market name and by a copy number. Associated with each market name is the set of market parameters chosen, and this set of market parameters was intended to be unique to this market name. The copy number indicates which replication of the market is being examined. Thus, we find the market structures for two markets with the same market name but a different copy number are identical, and the only differences between two of these markets are the subjects that participate in each.

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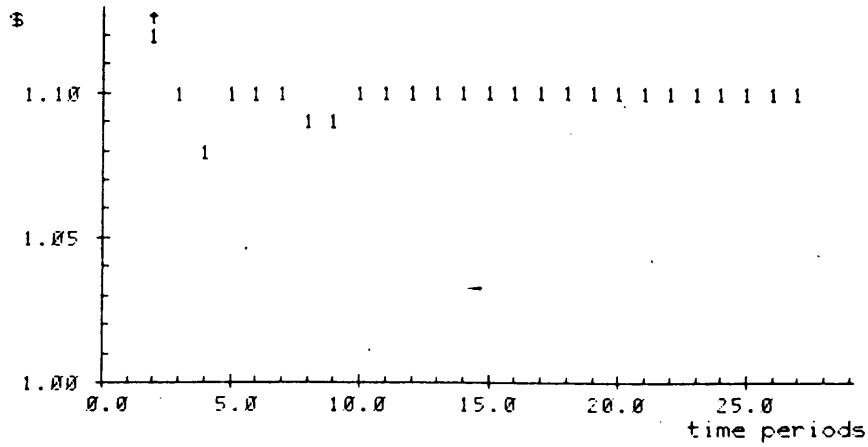

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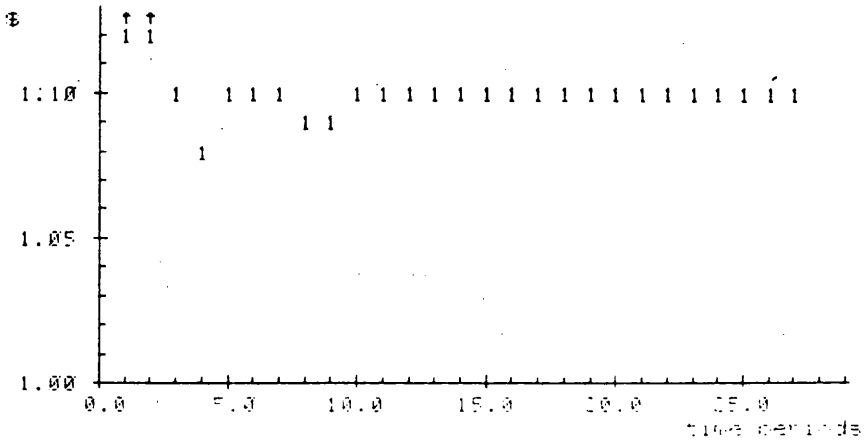

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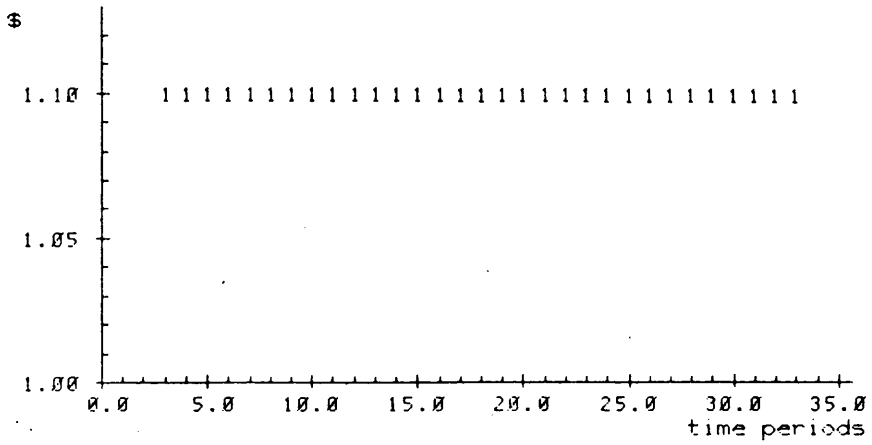

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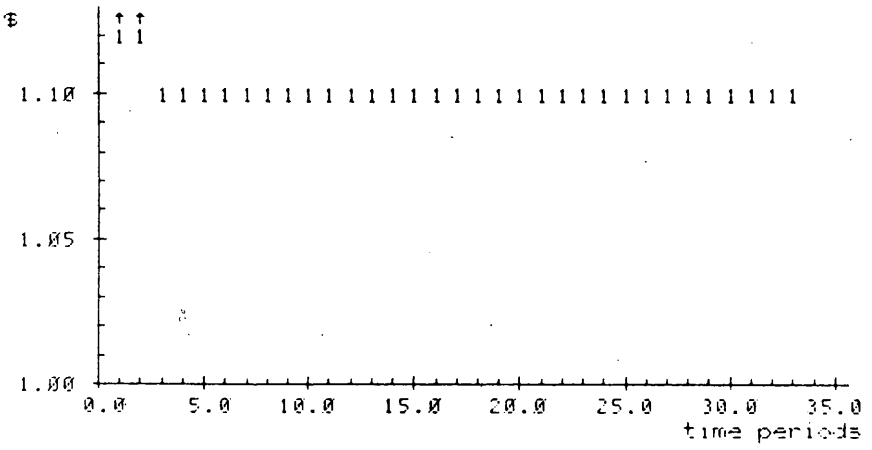

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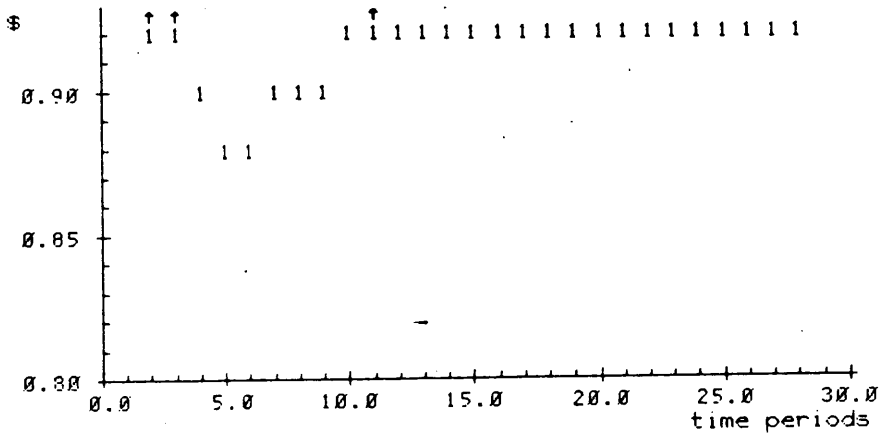

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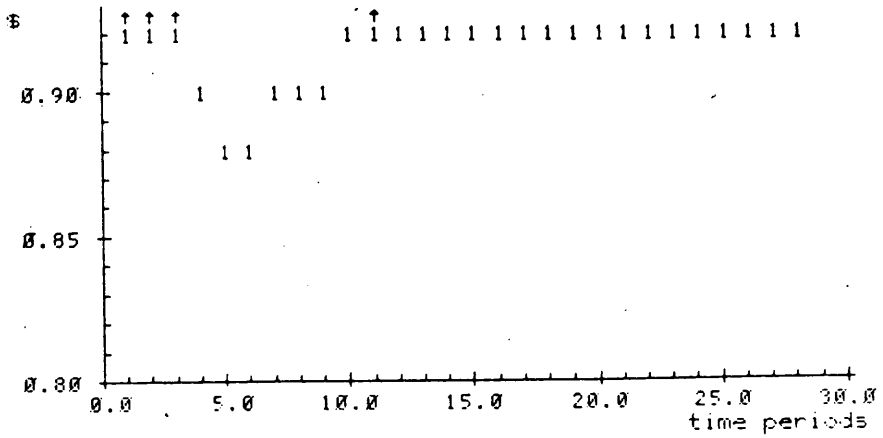

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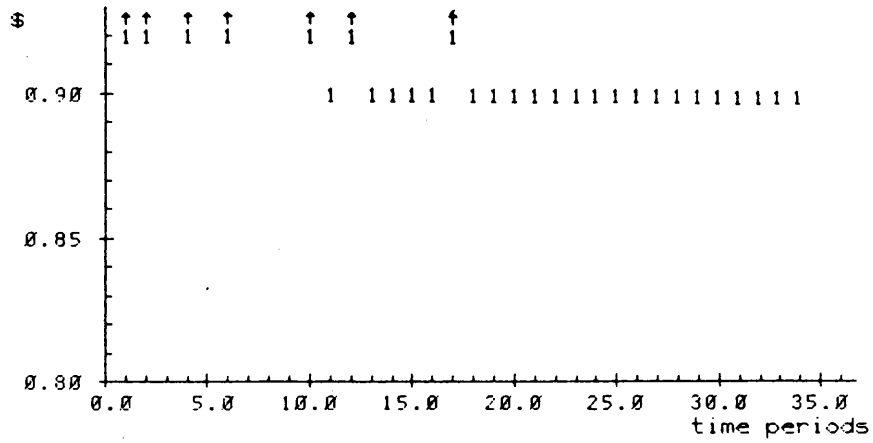

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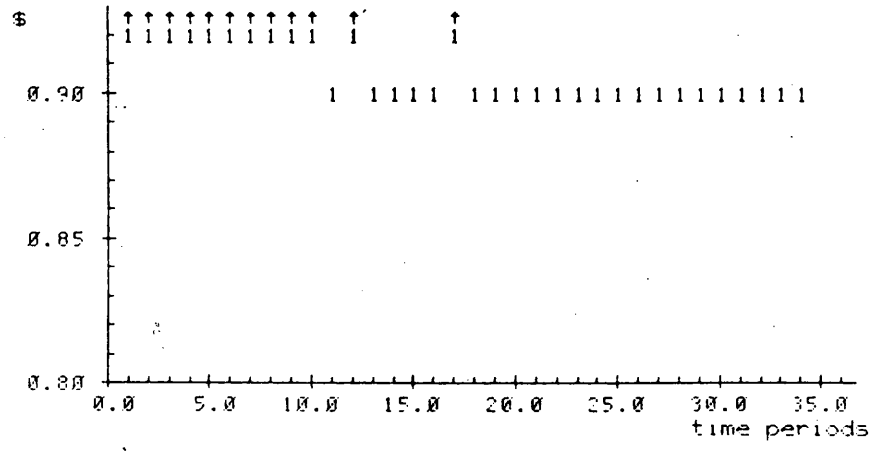

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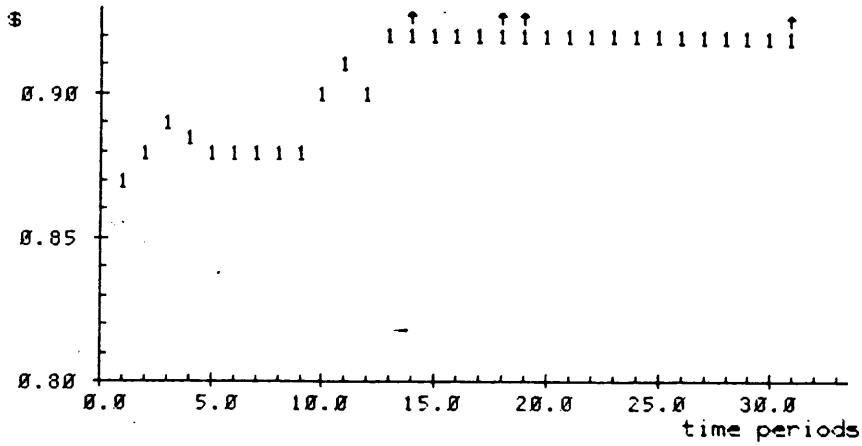

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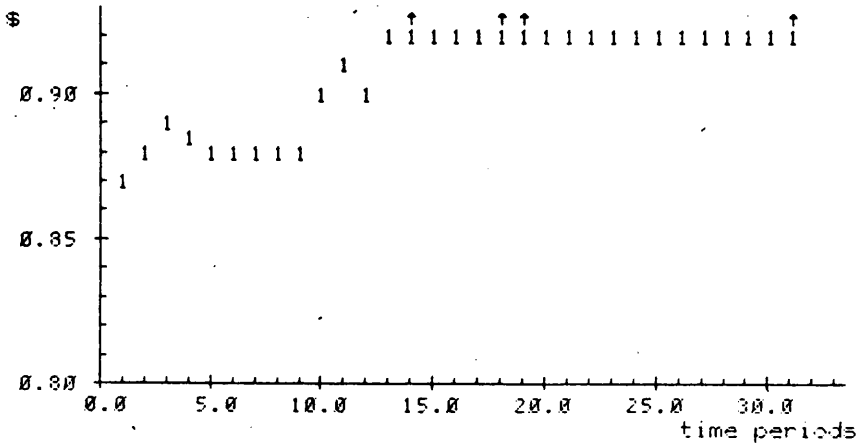

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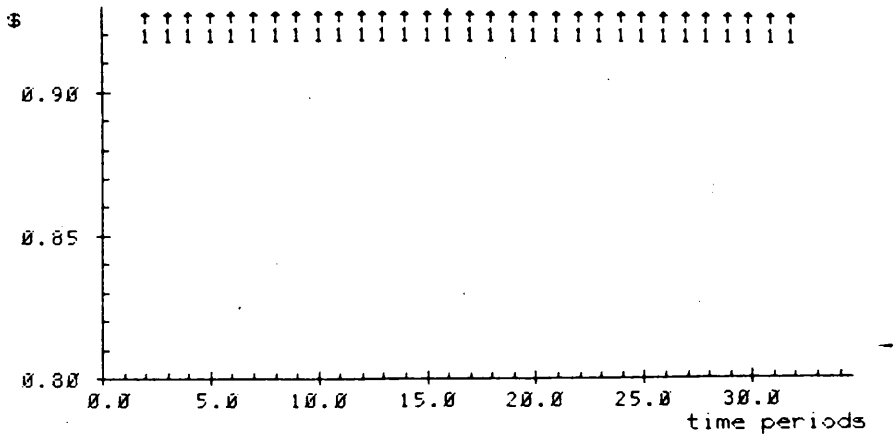

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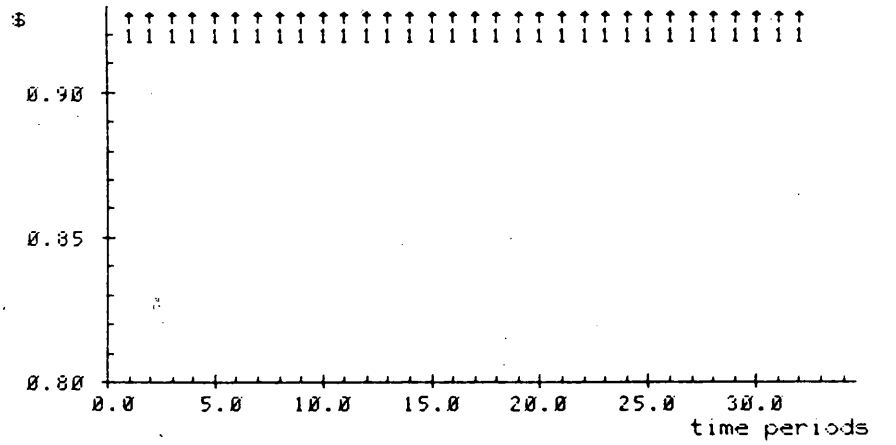

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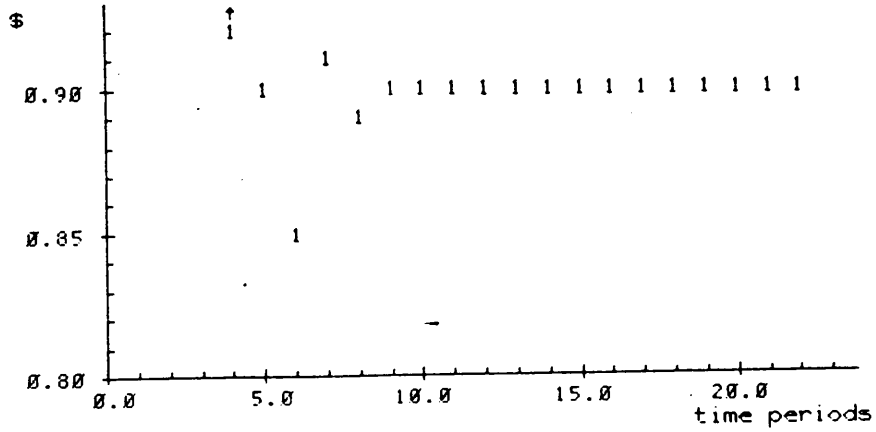

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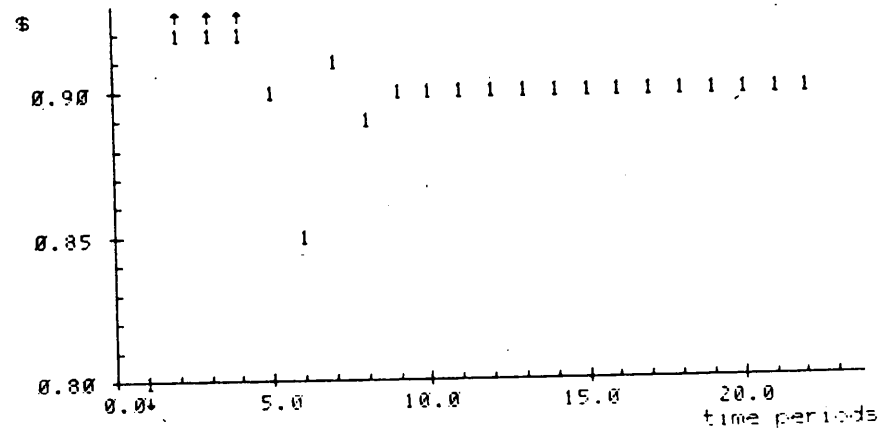

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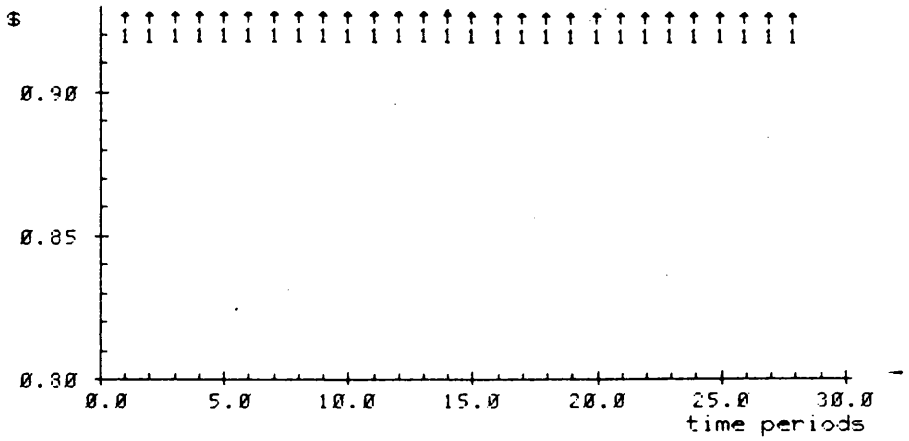

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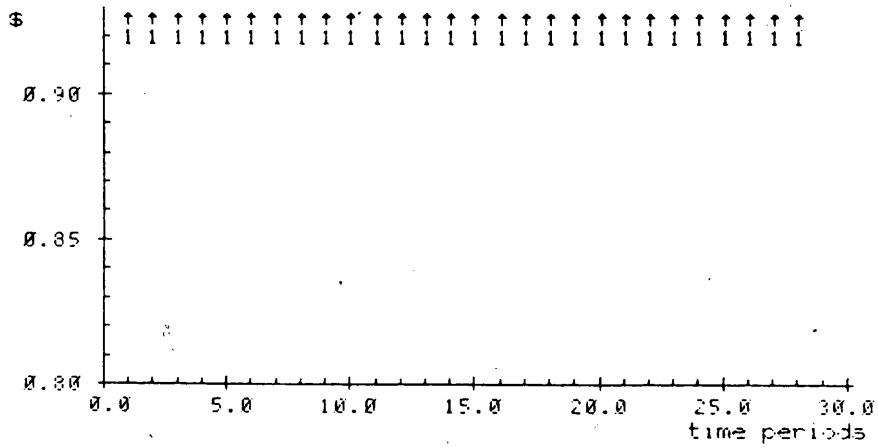

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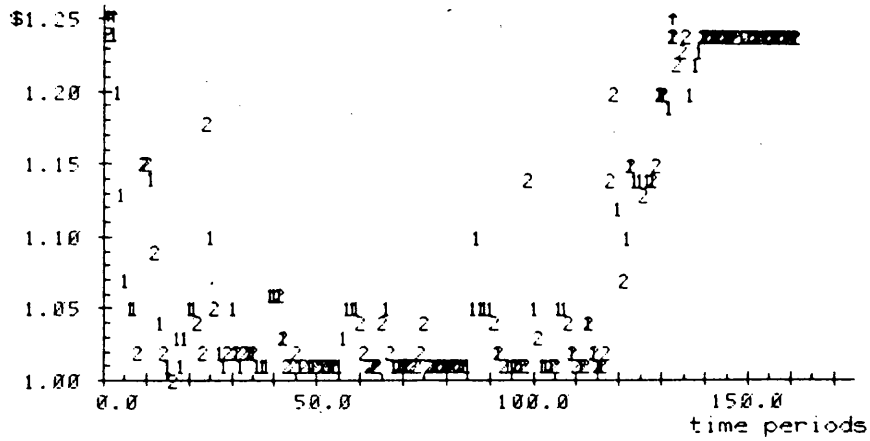

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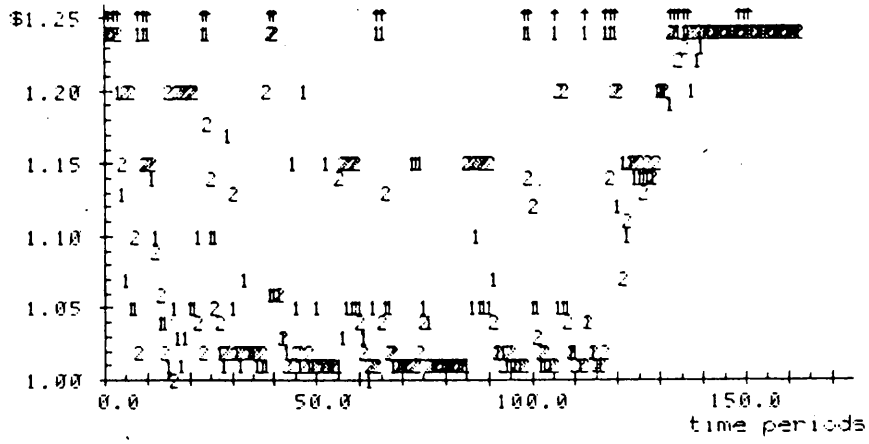

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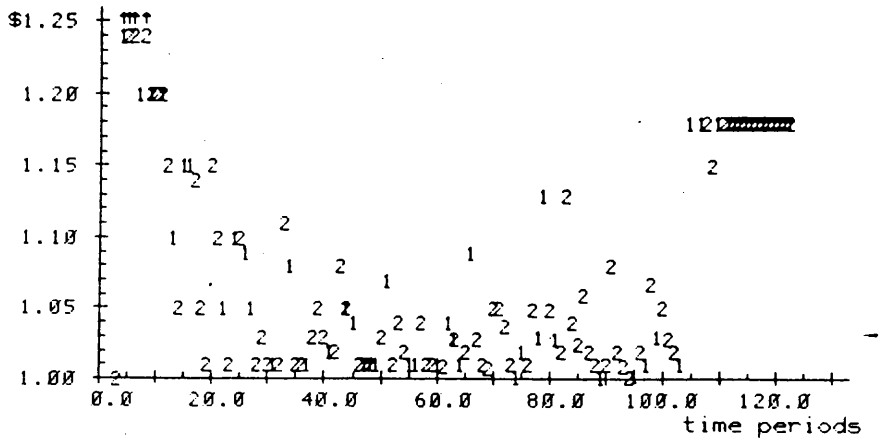

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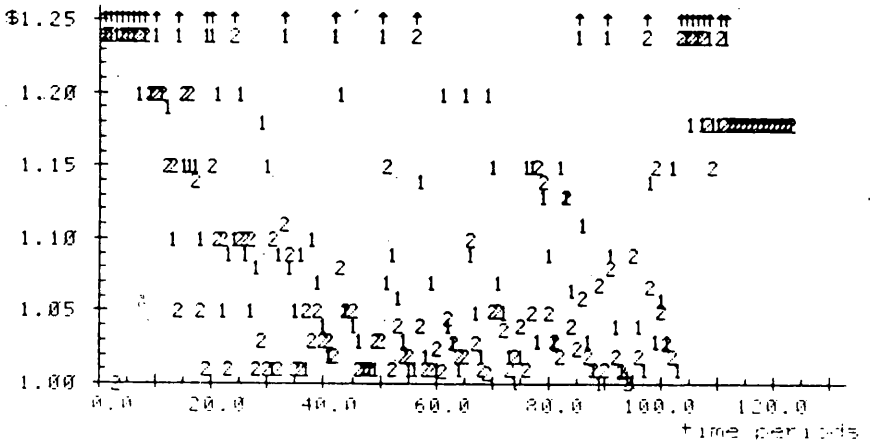

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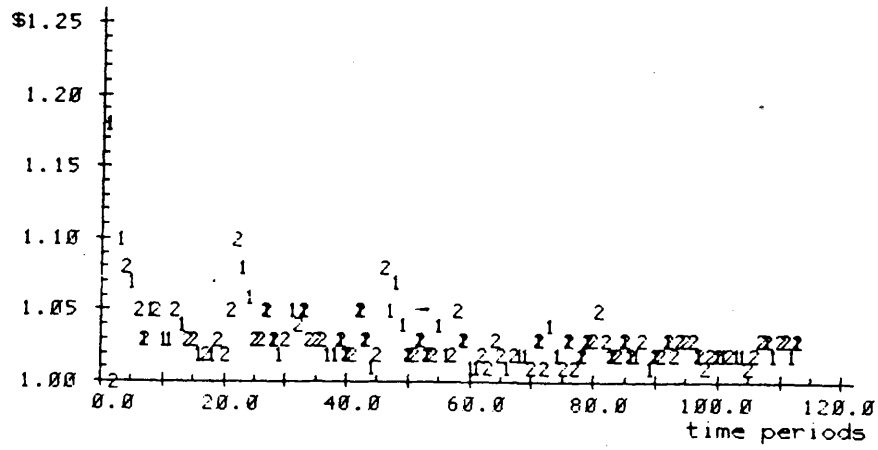

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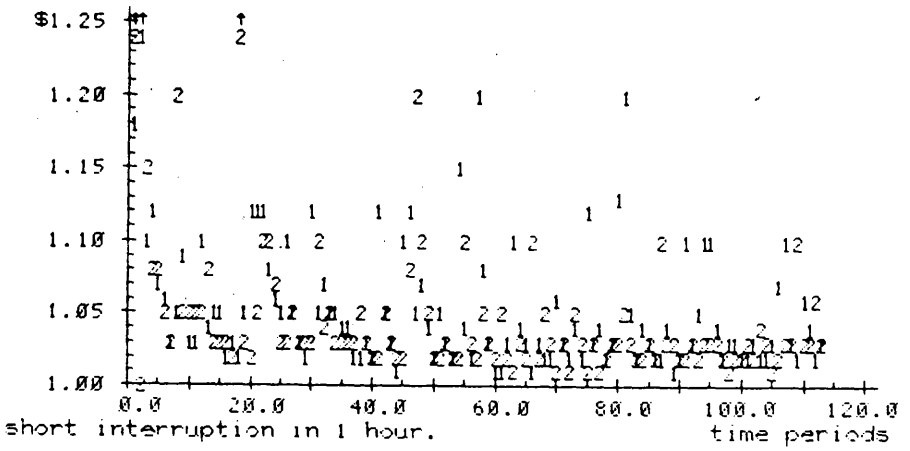

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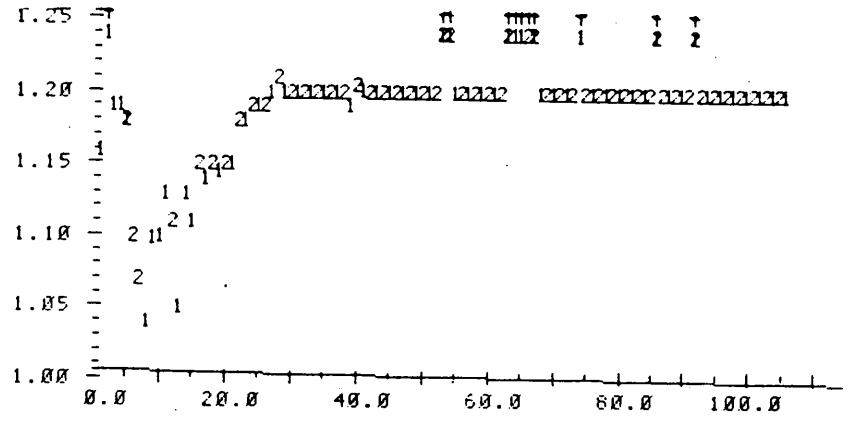

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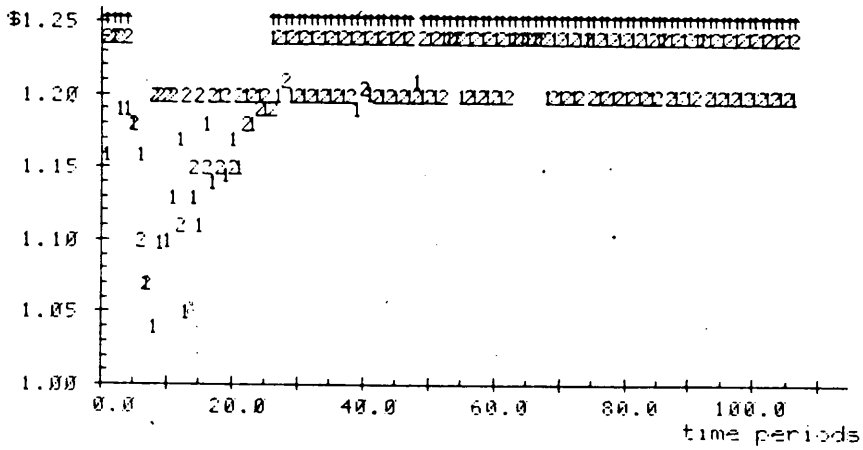

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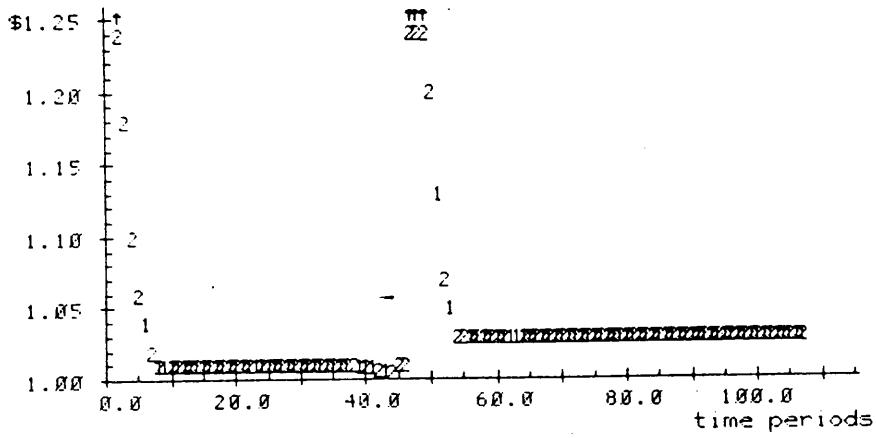

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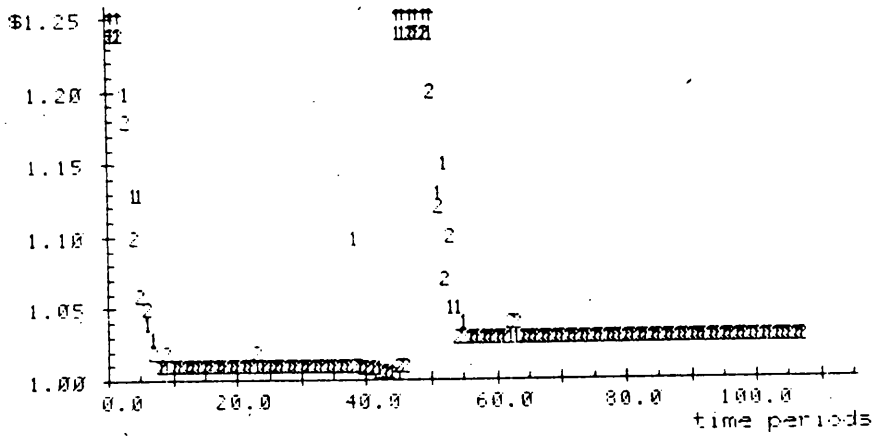

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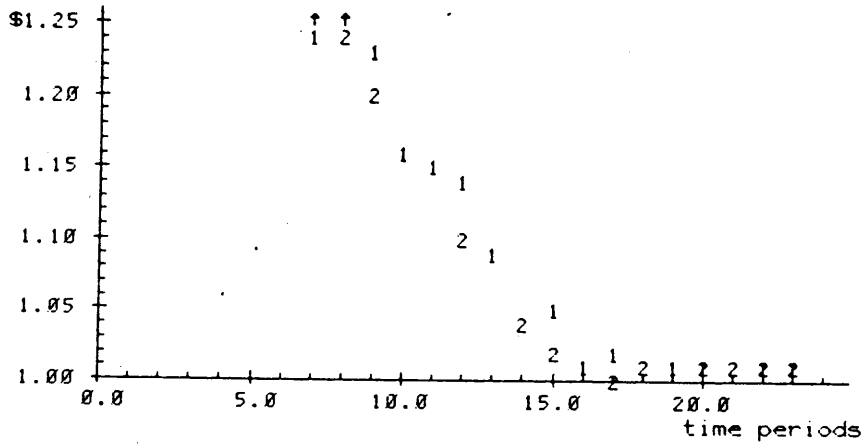

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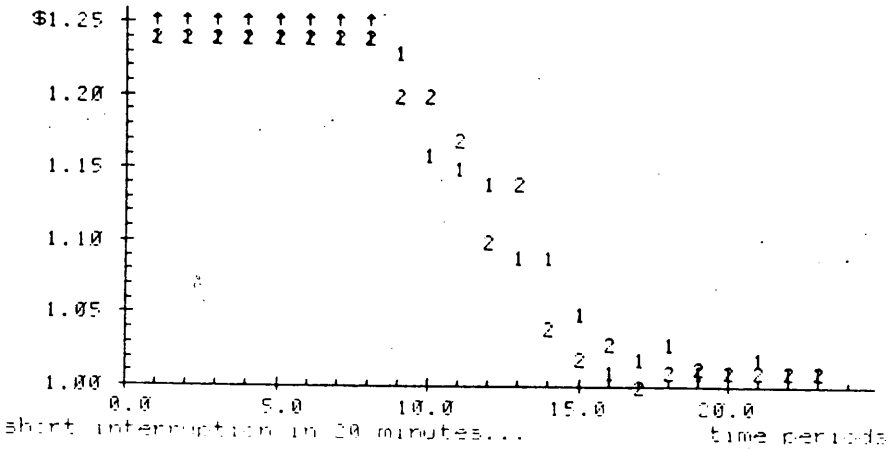

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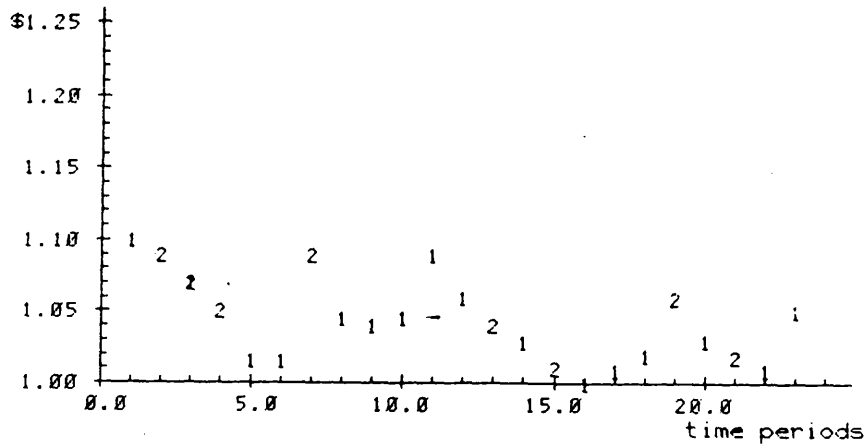

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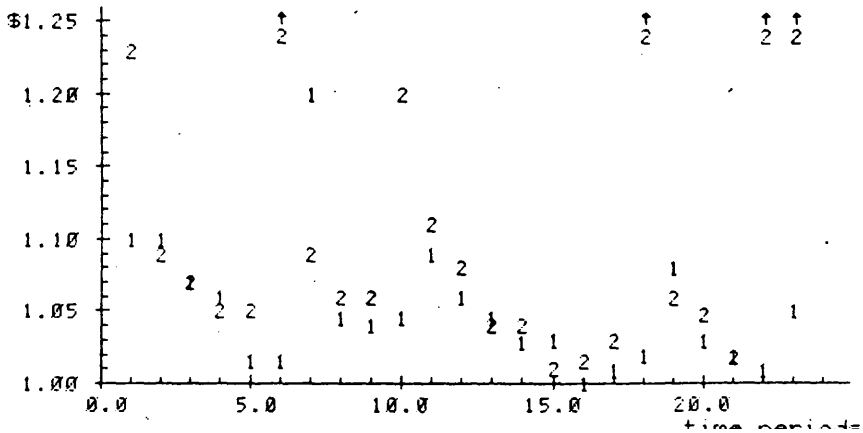

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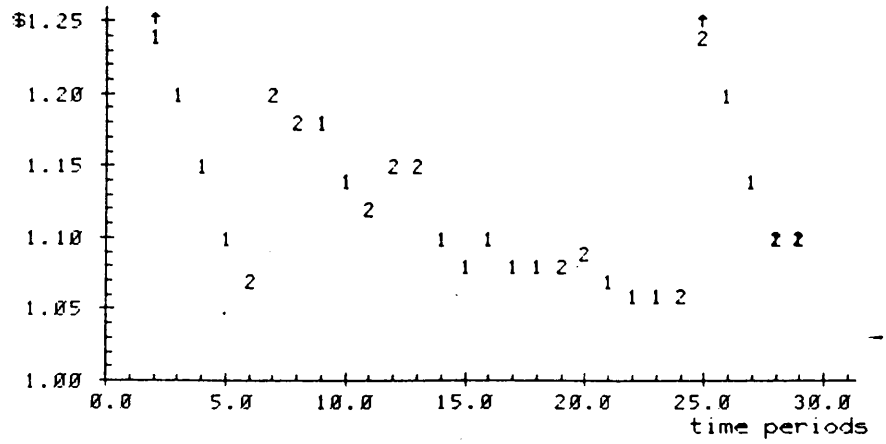

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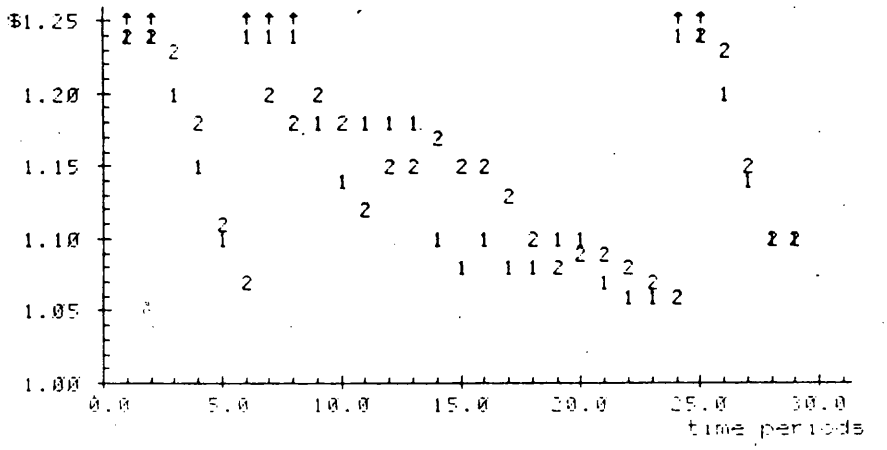

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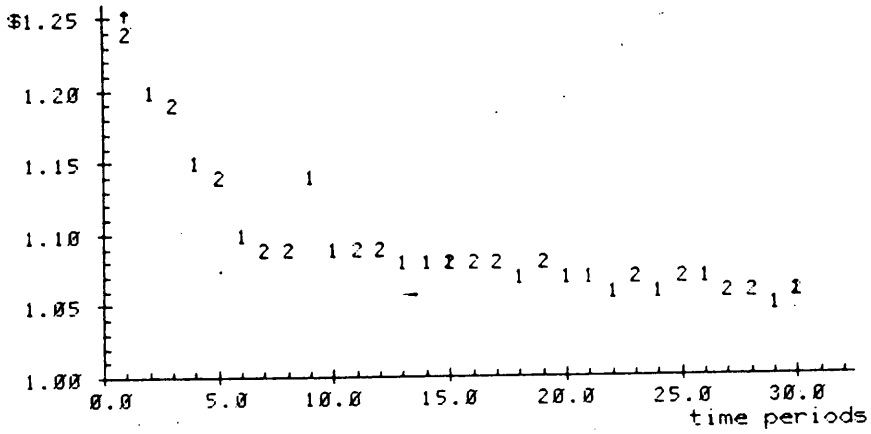

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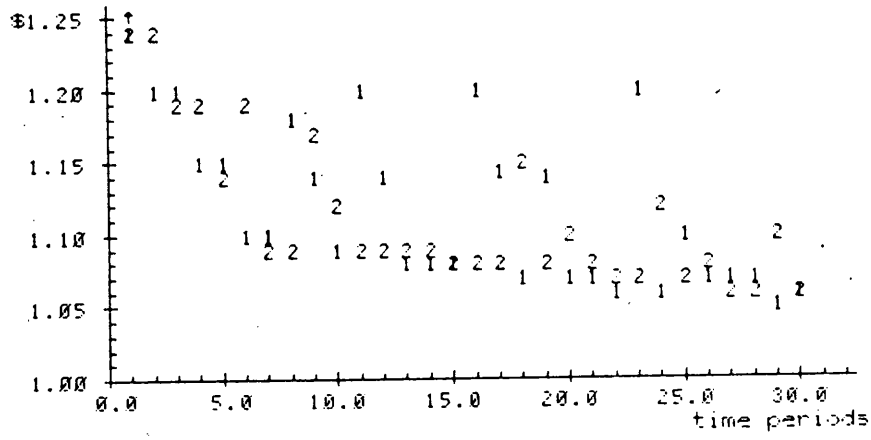

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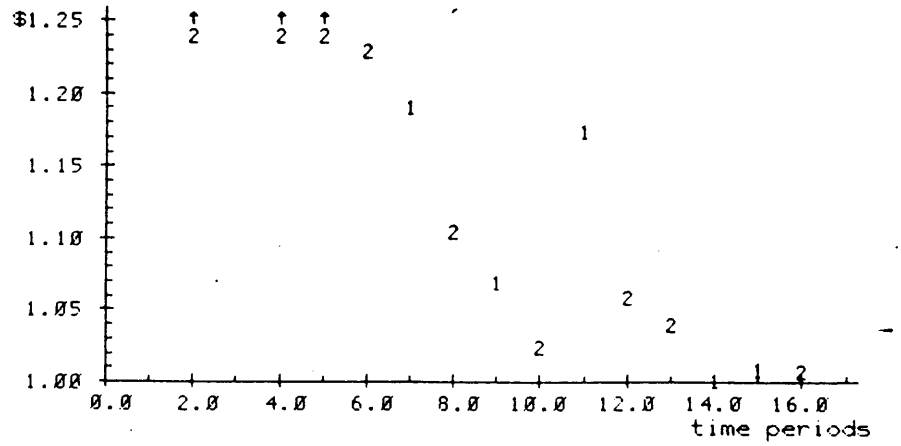

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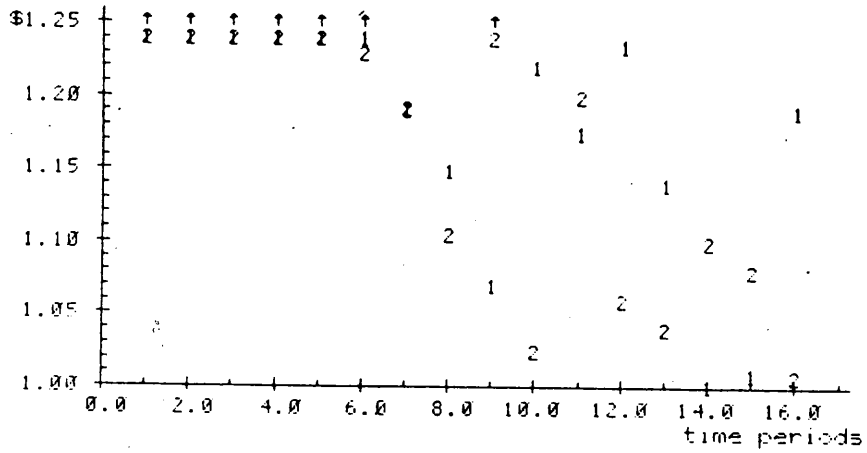

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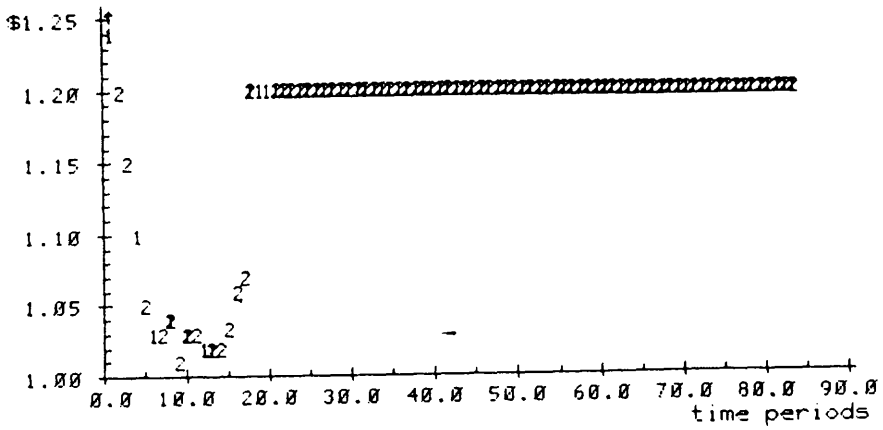

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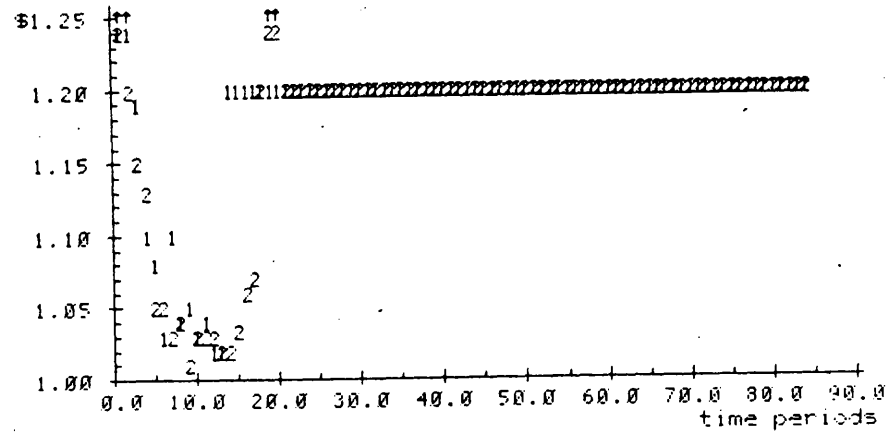

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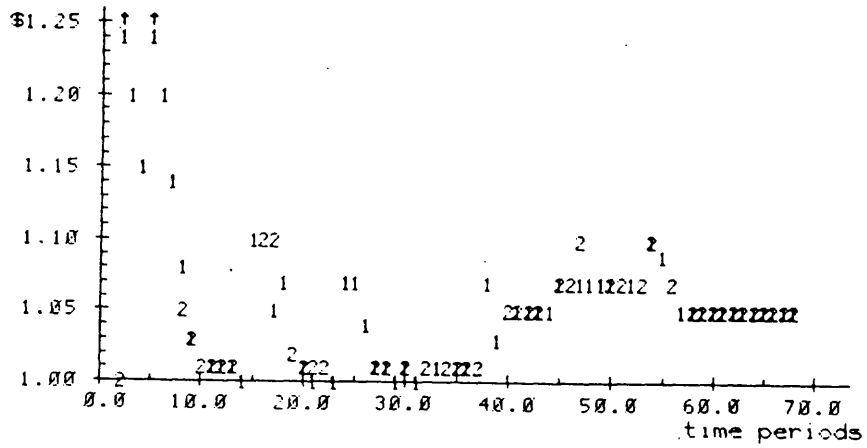

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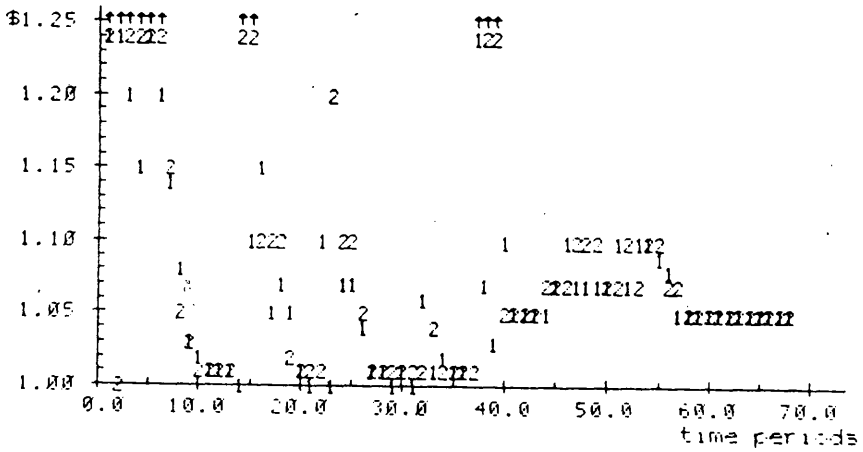

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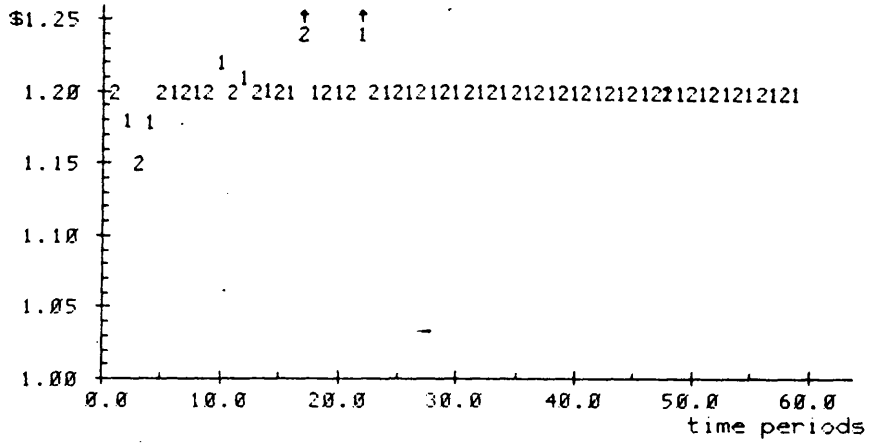
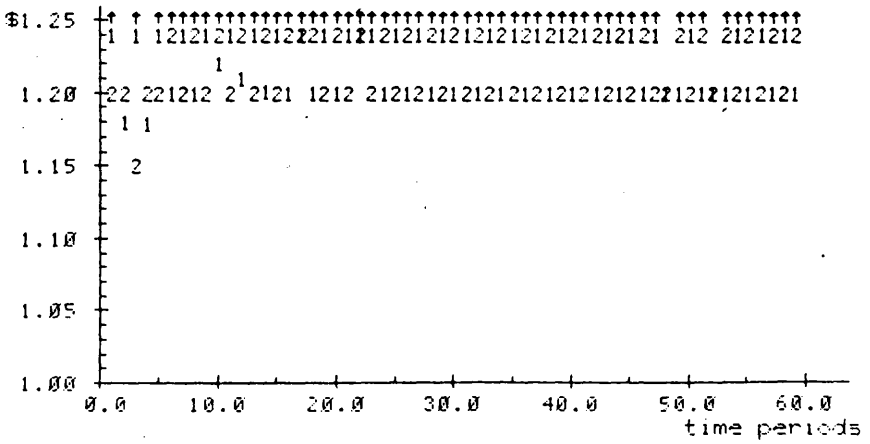


History of All Price Offers



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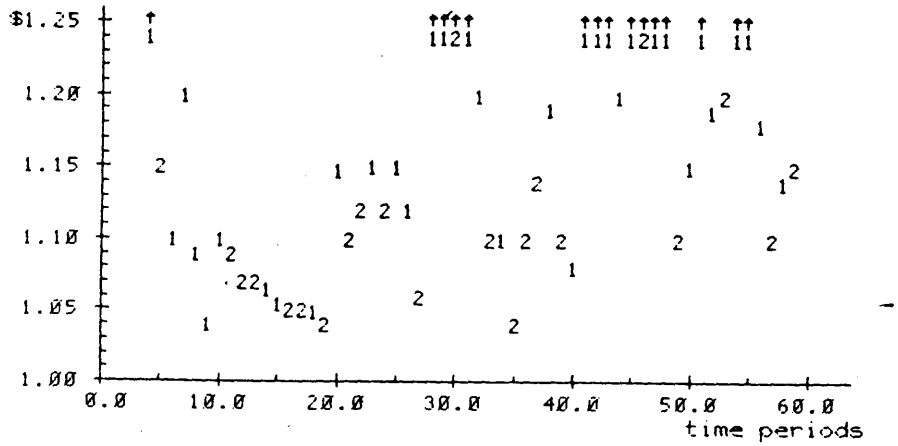

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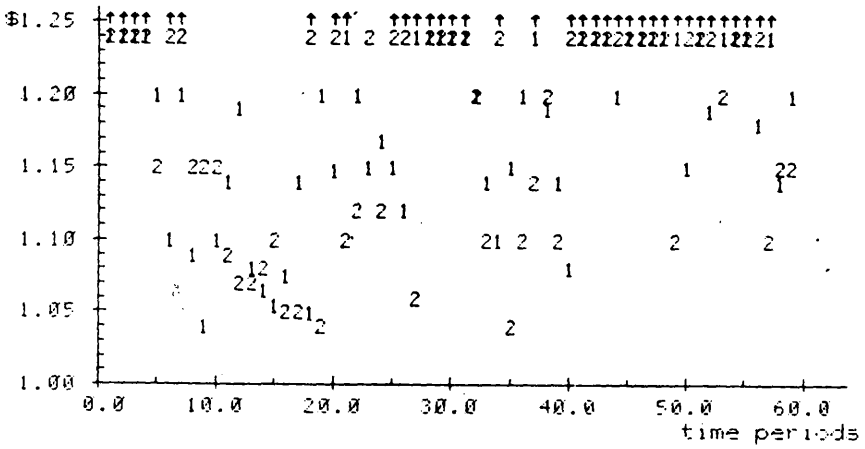

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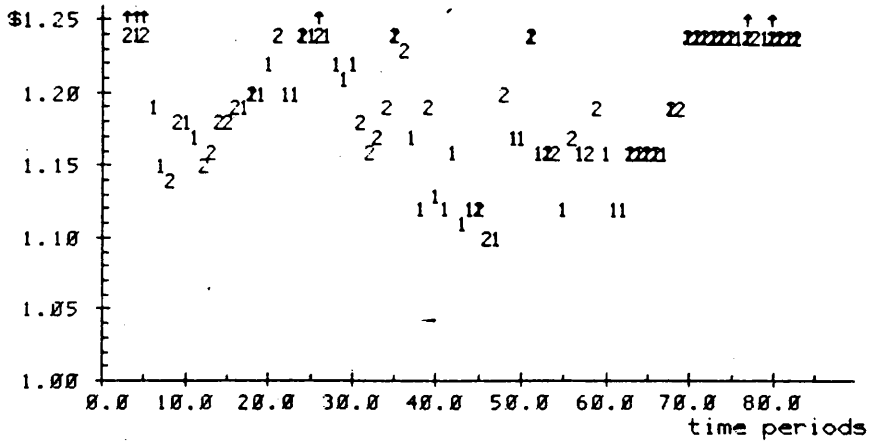

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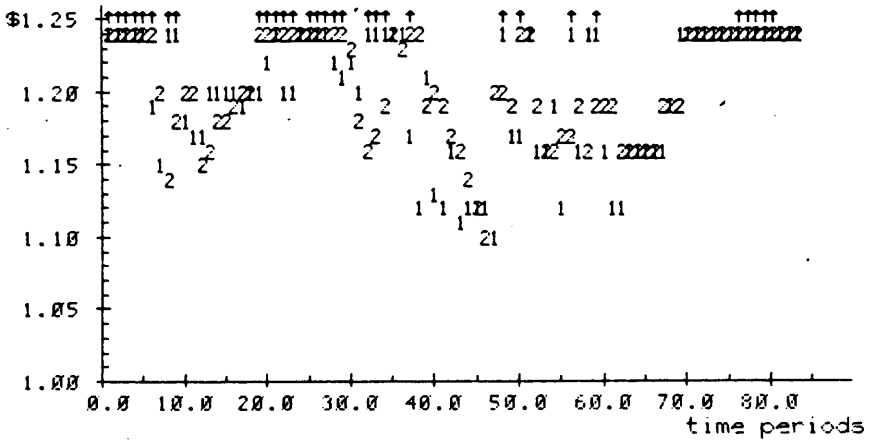

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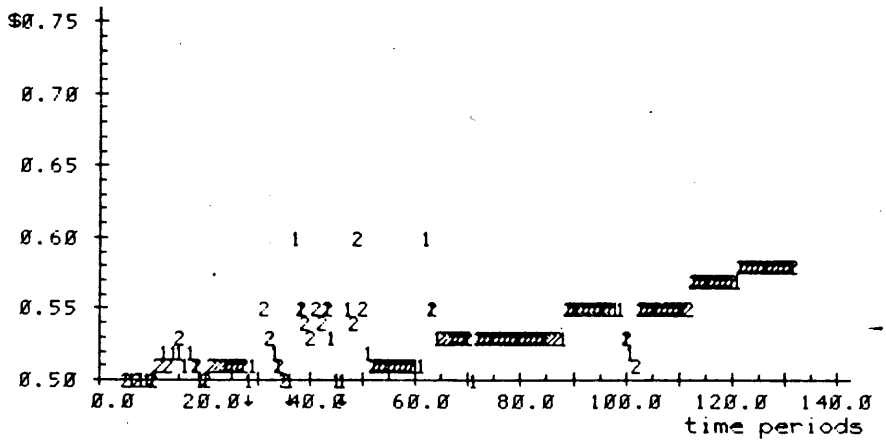

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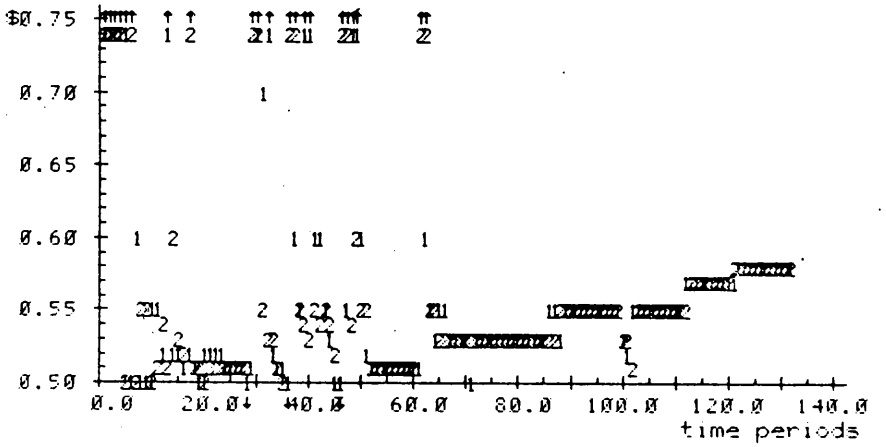

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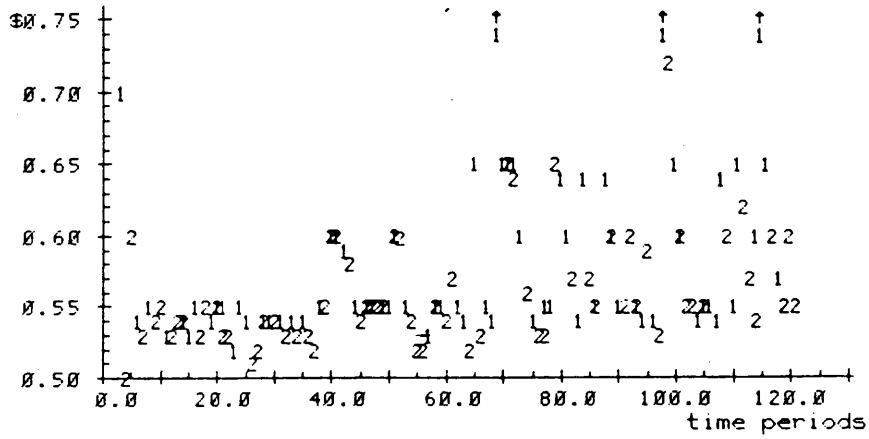

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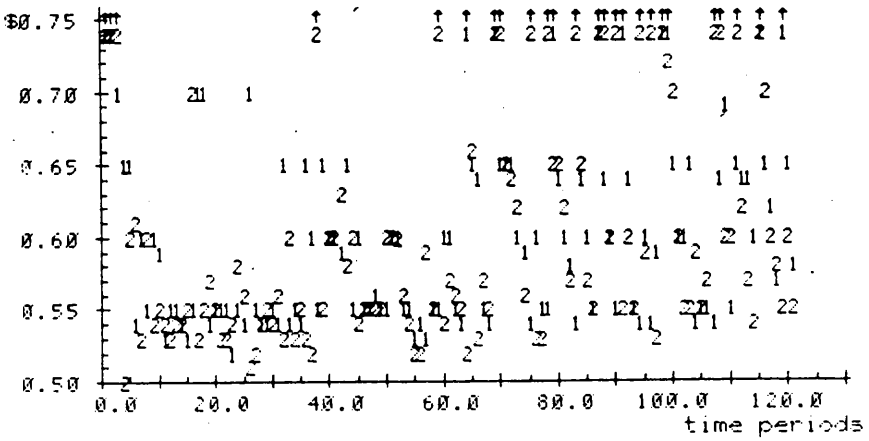

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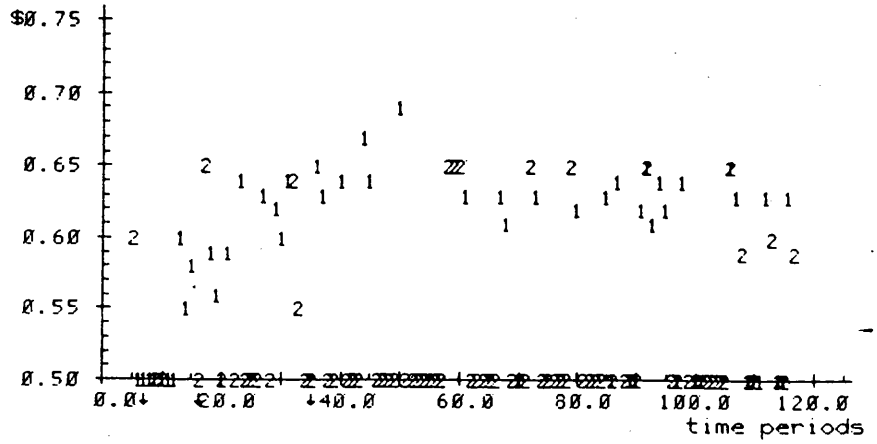

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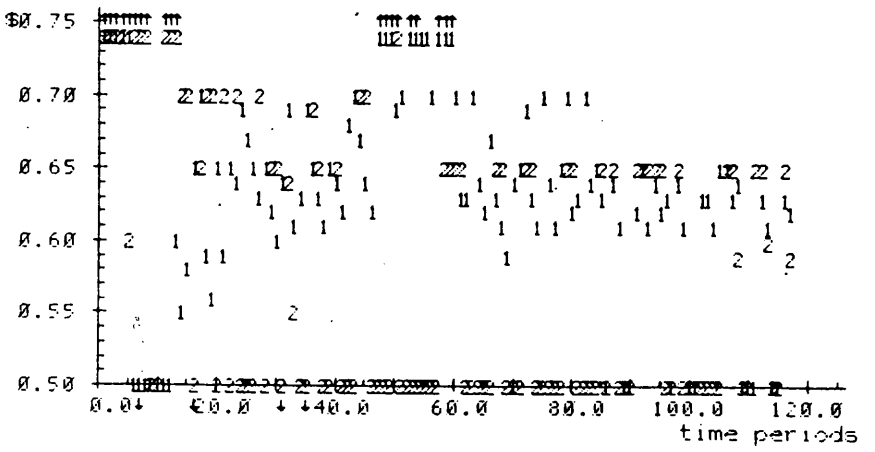

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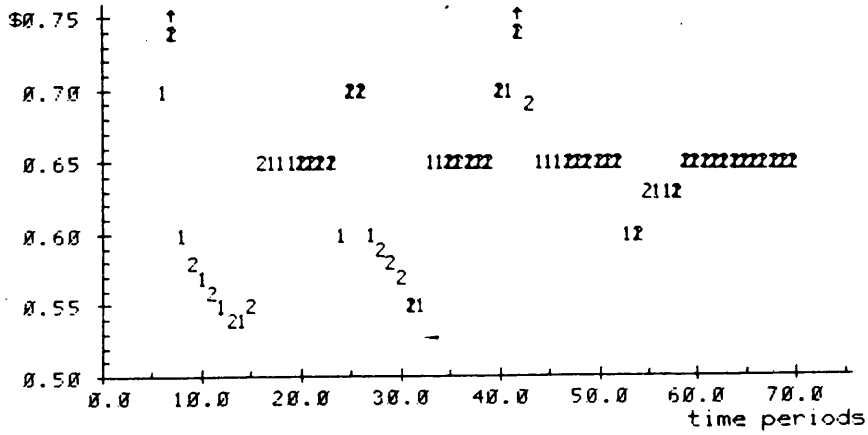

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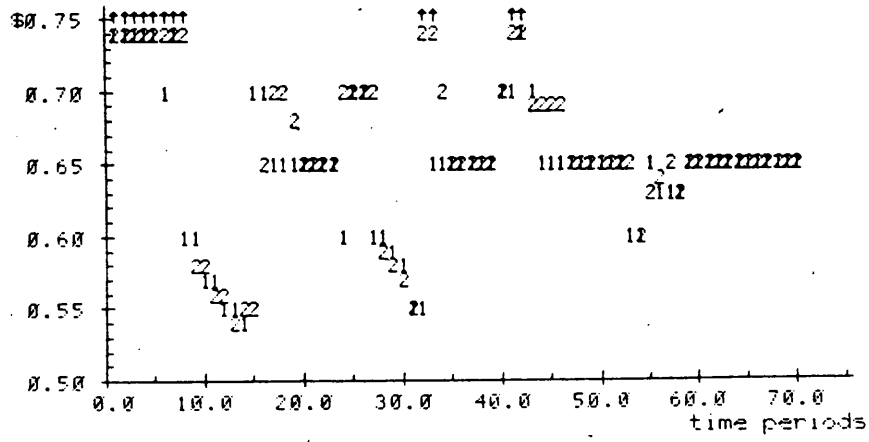

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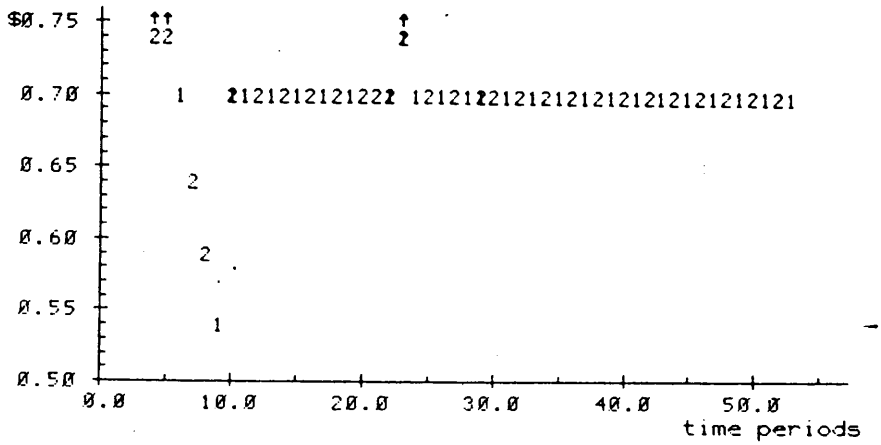

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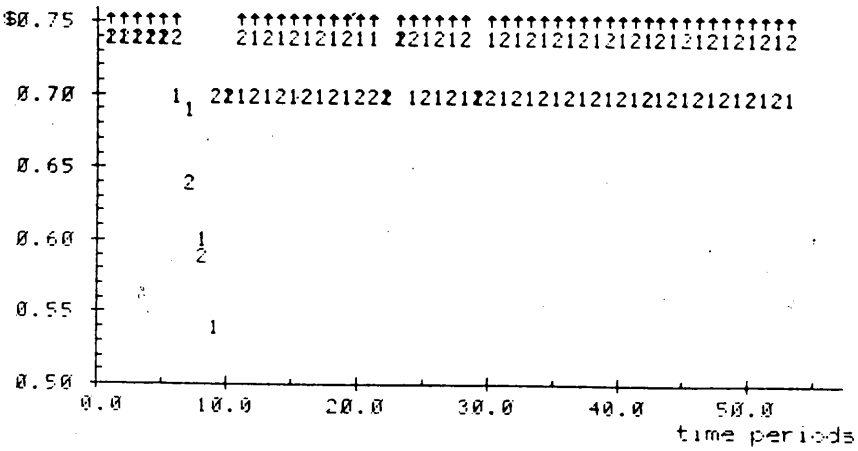

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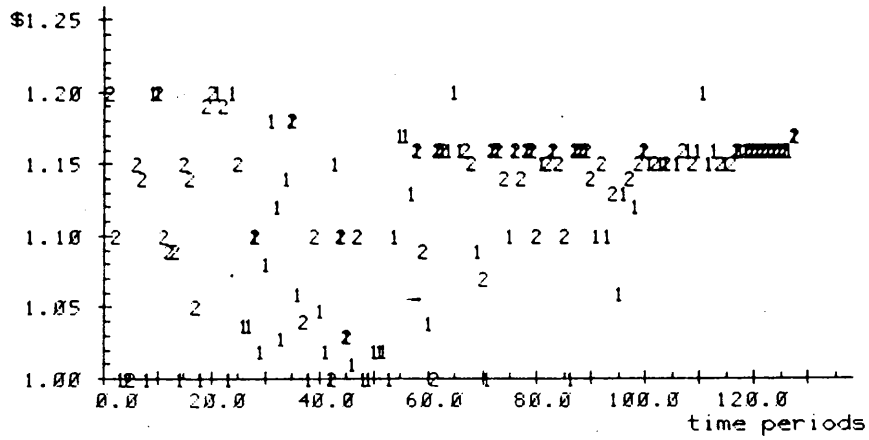

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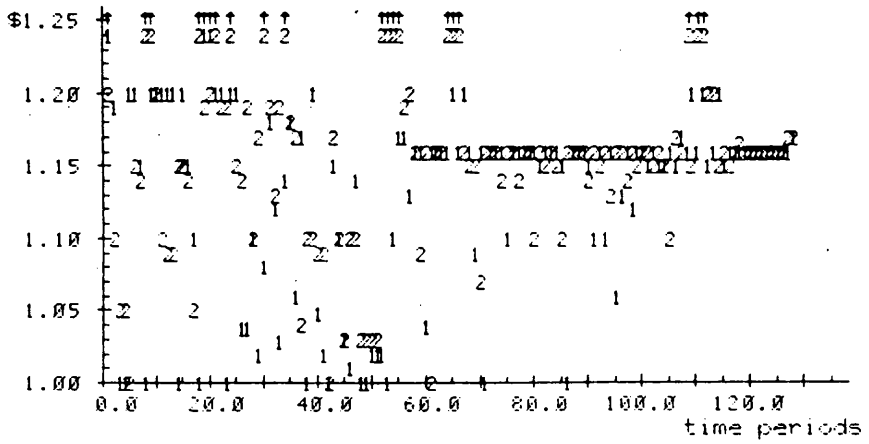

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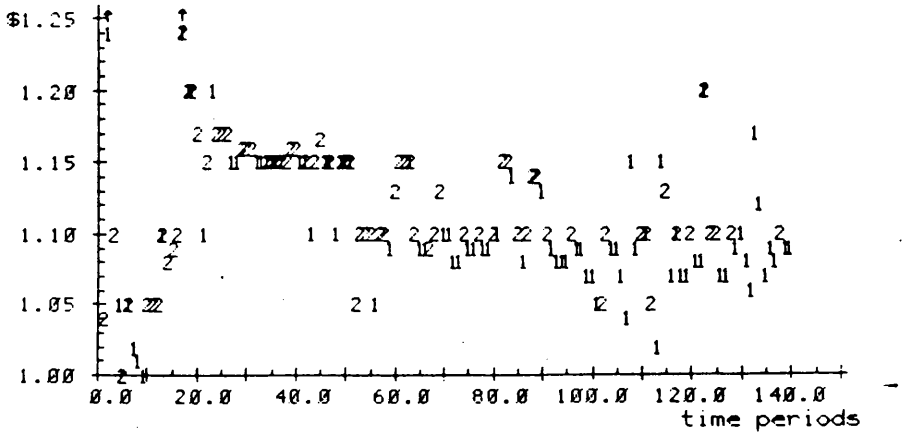

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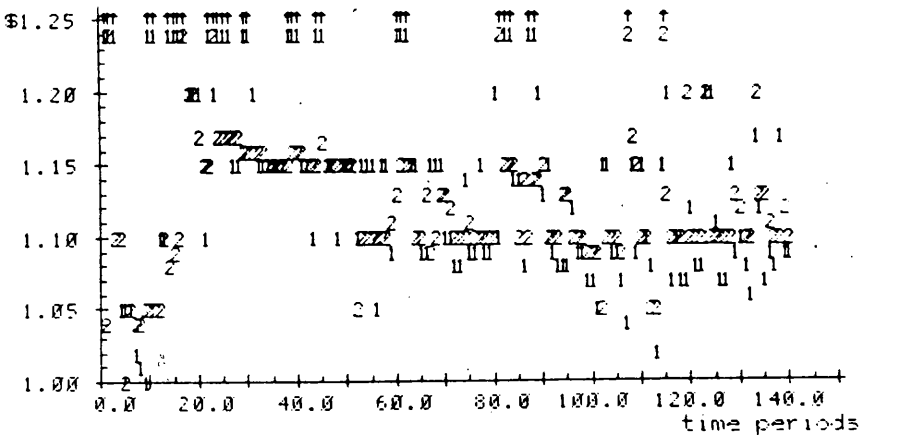

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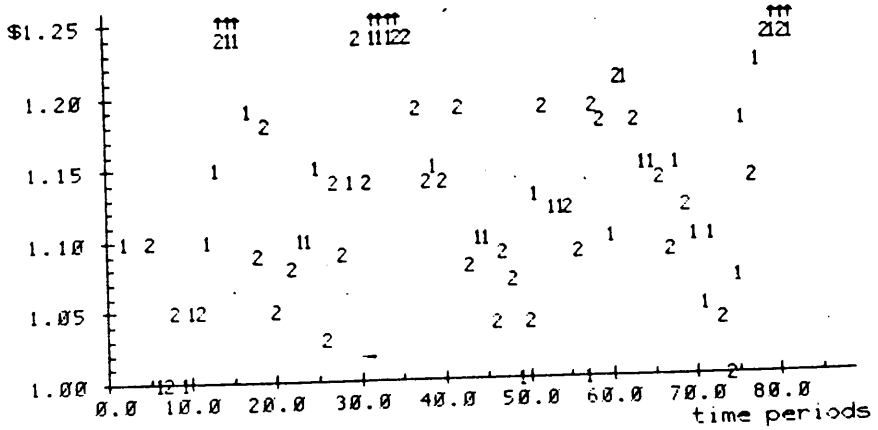

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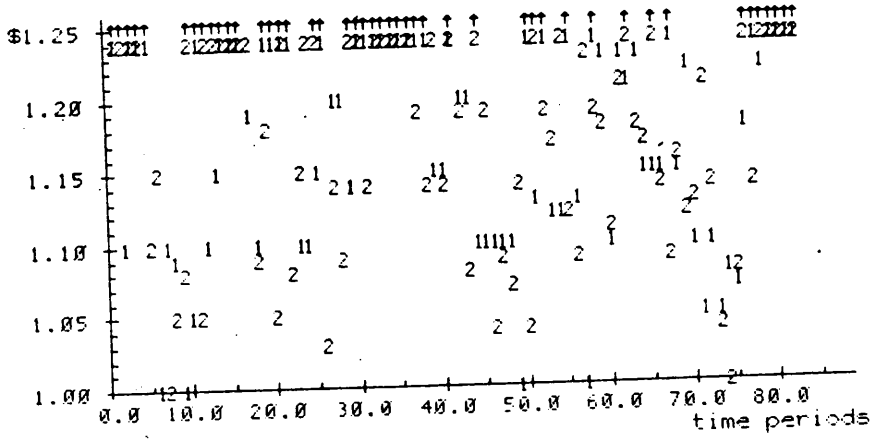

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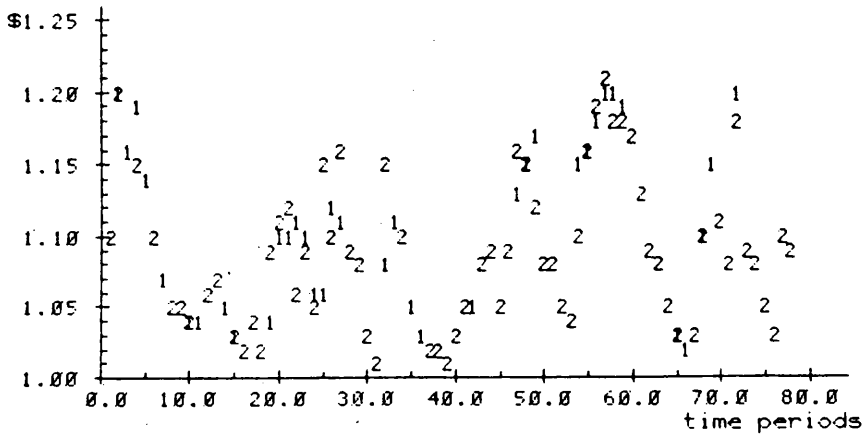

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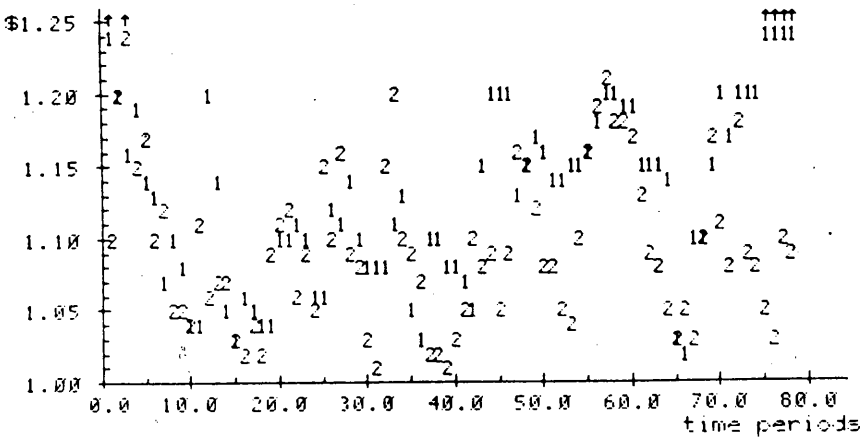

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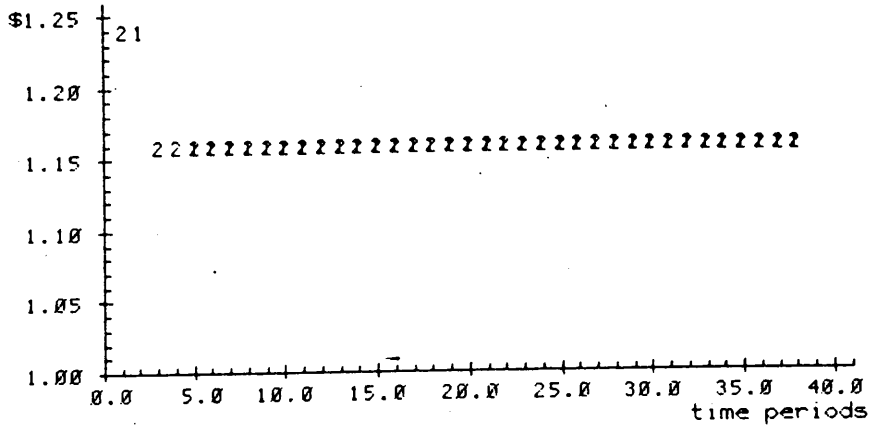

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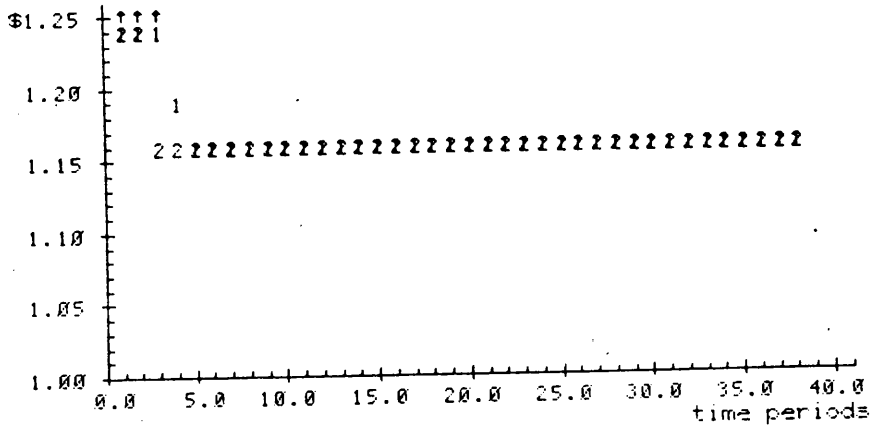

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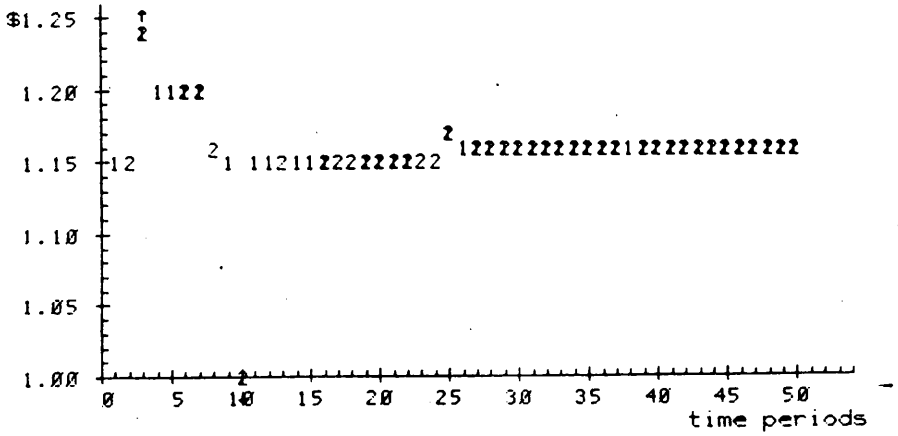

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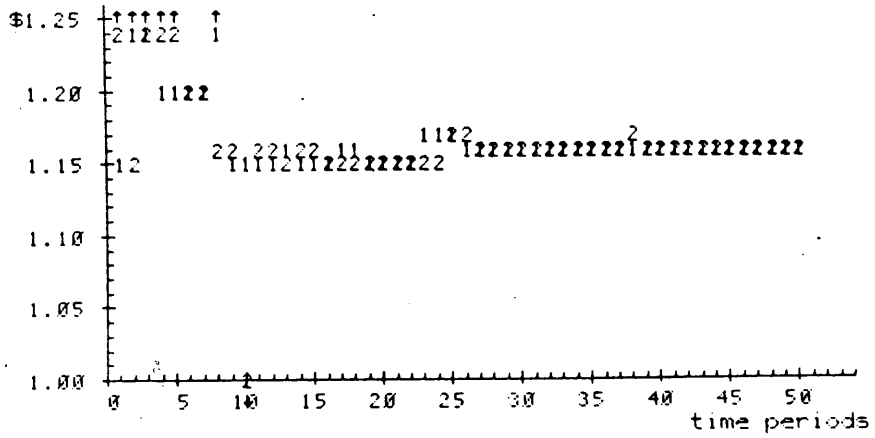

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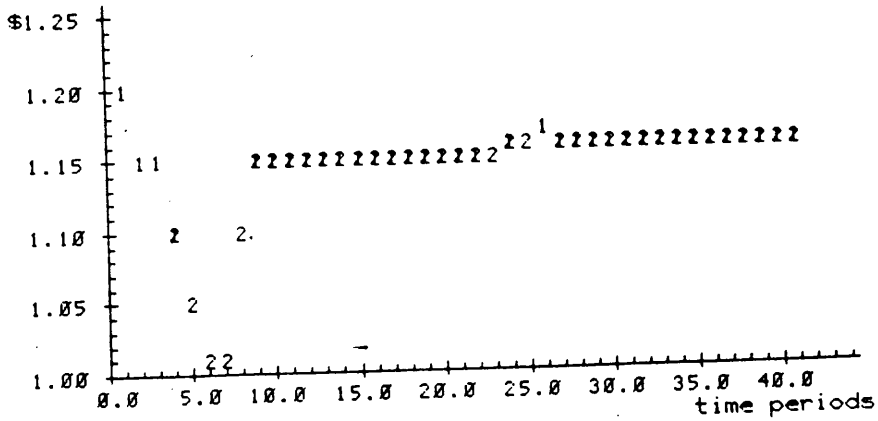

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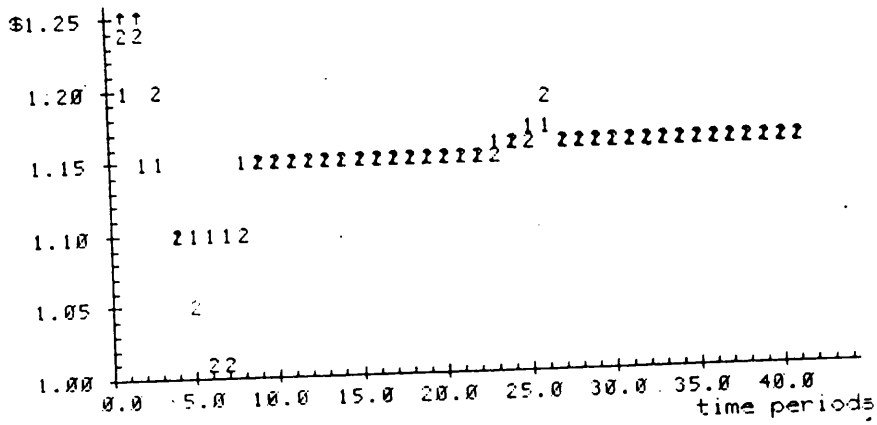

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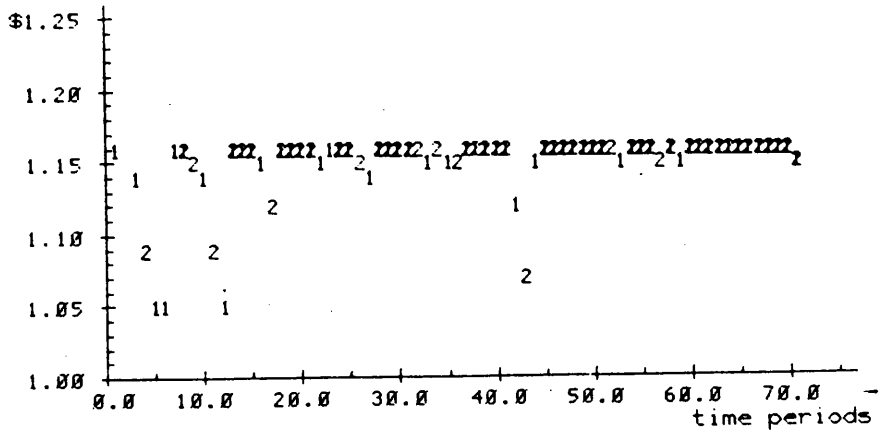

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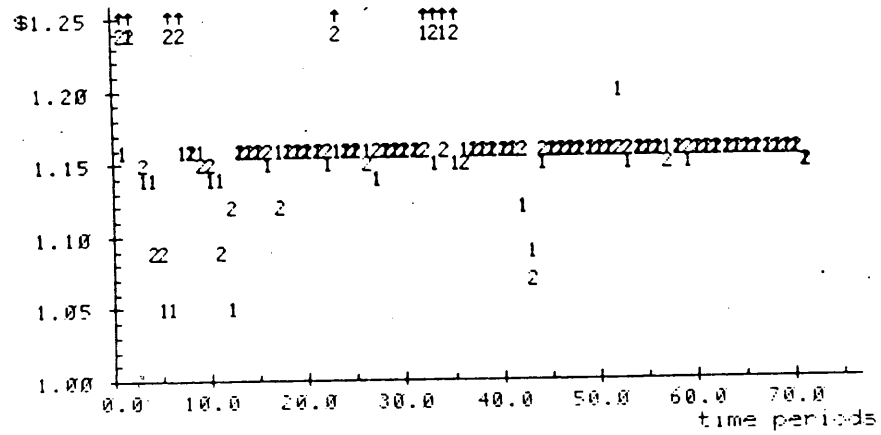

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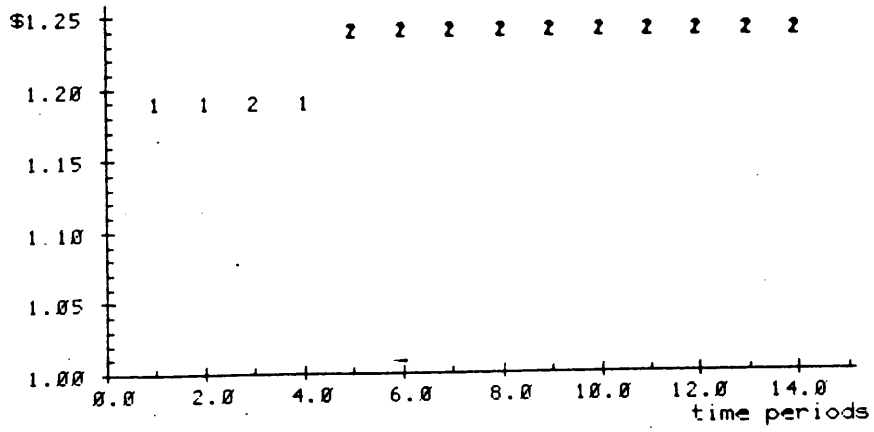

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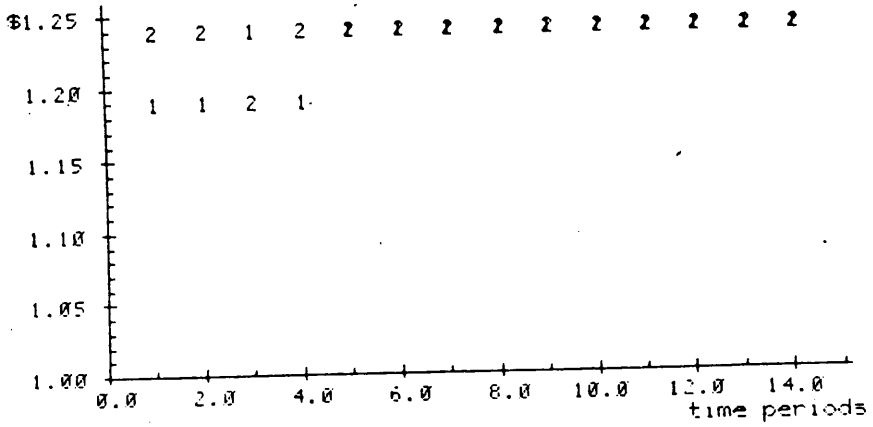

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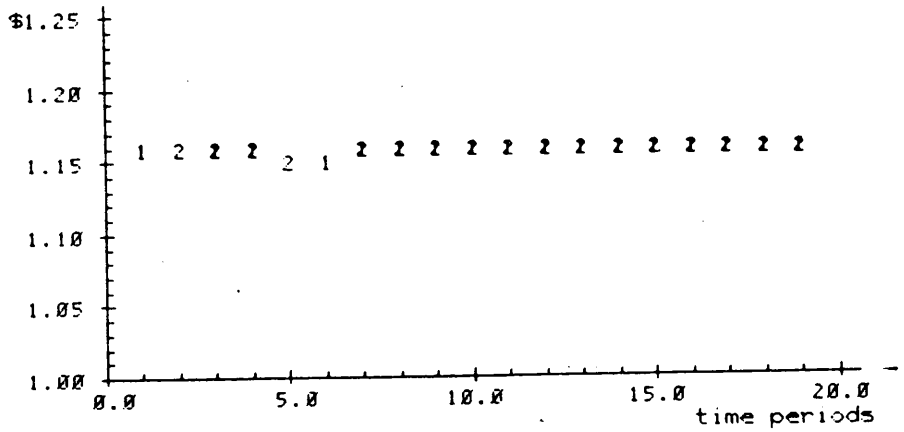

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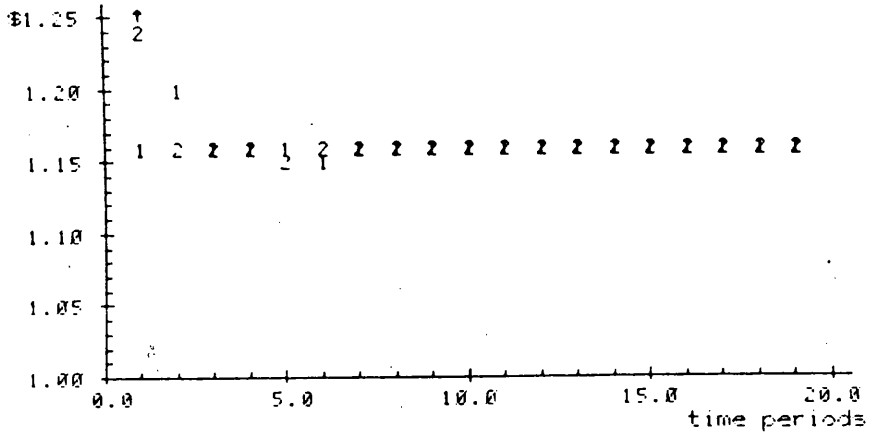

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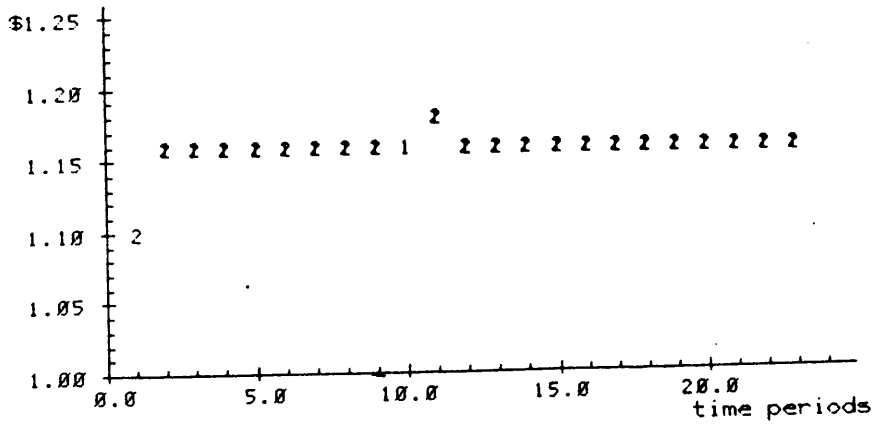

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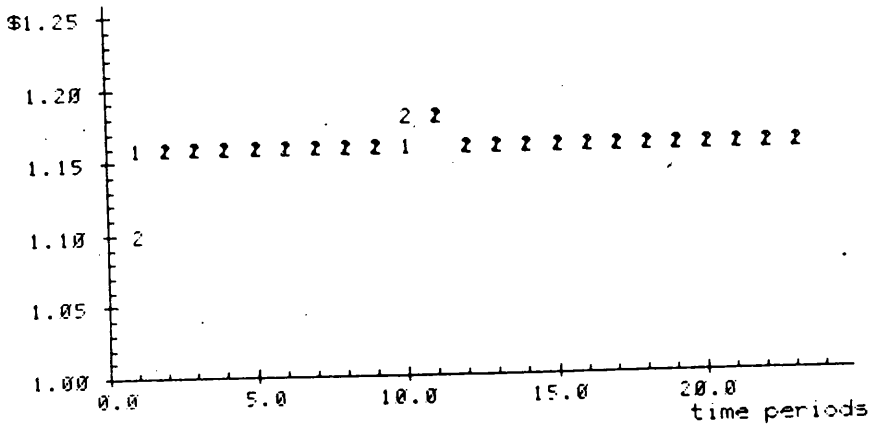

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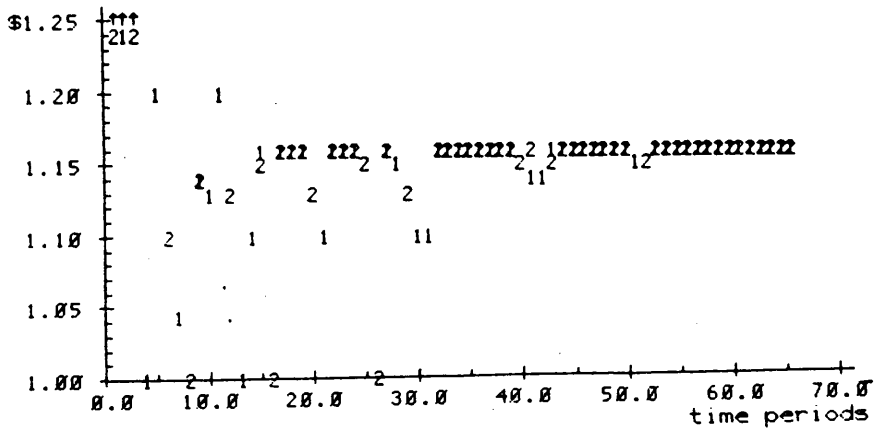

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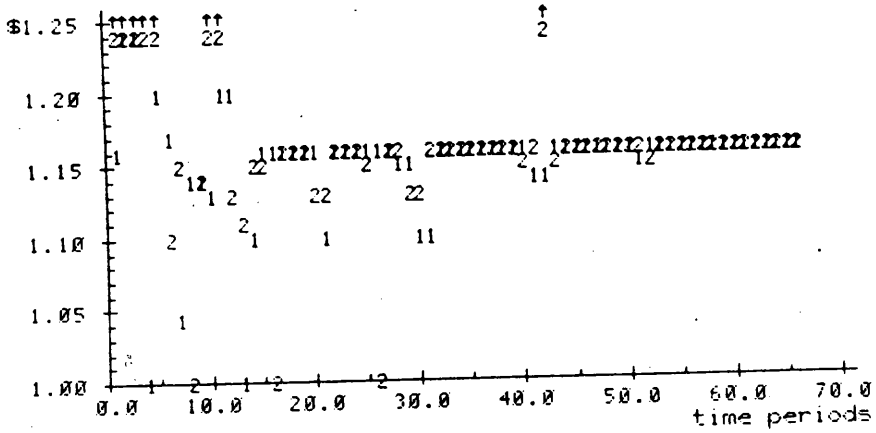

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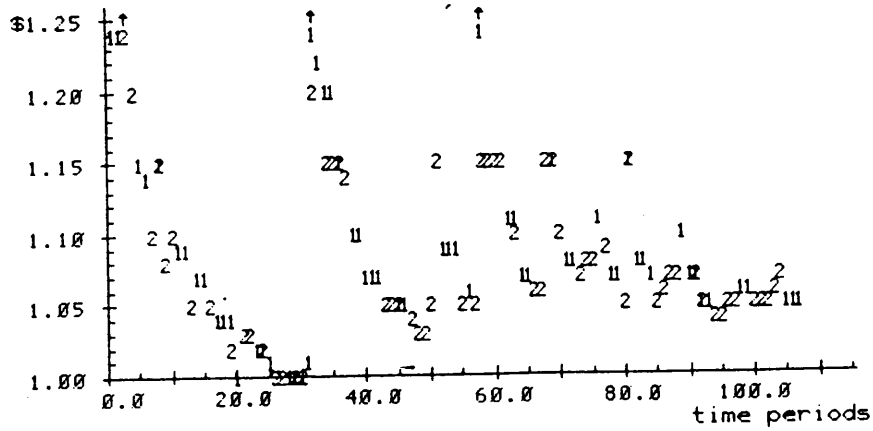

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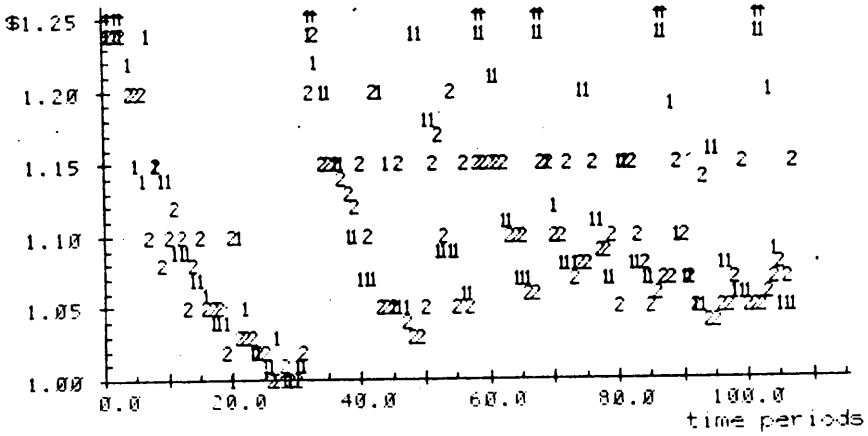

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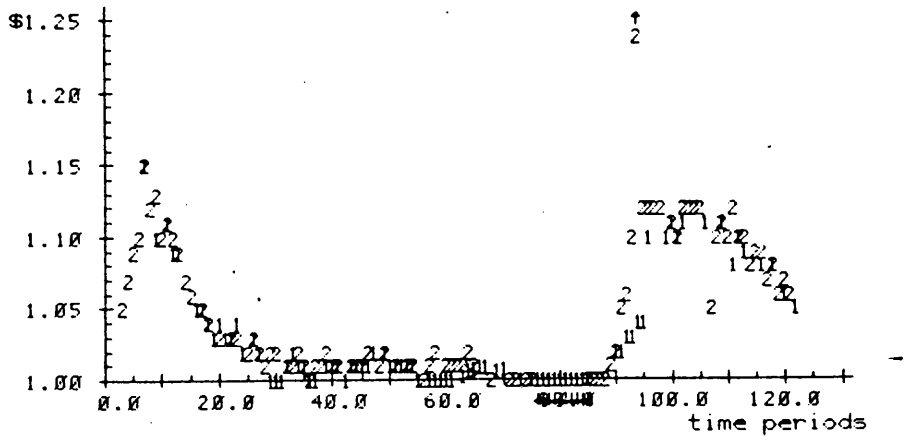

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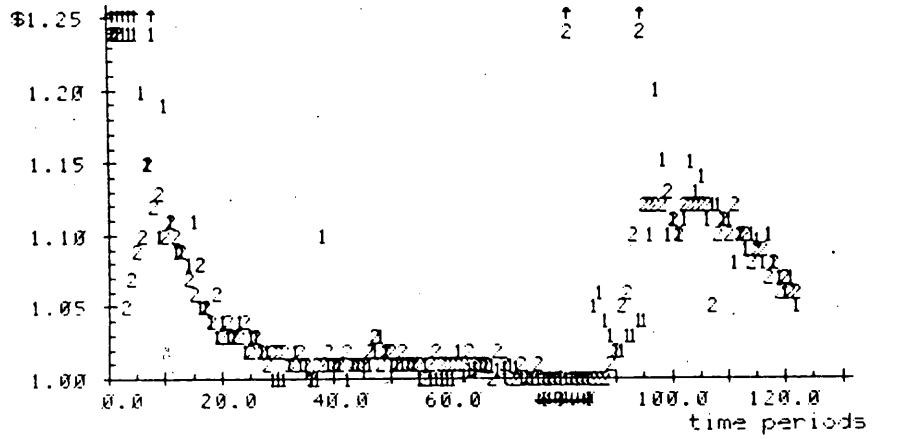

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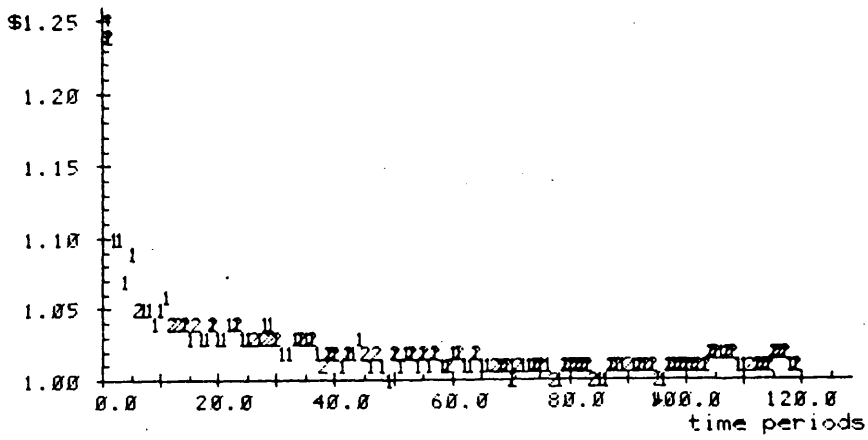

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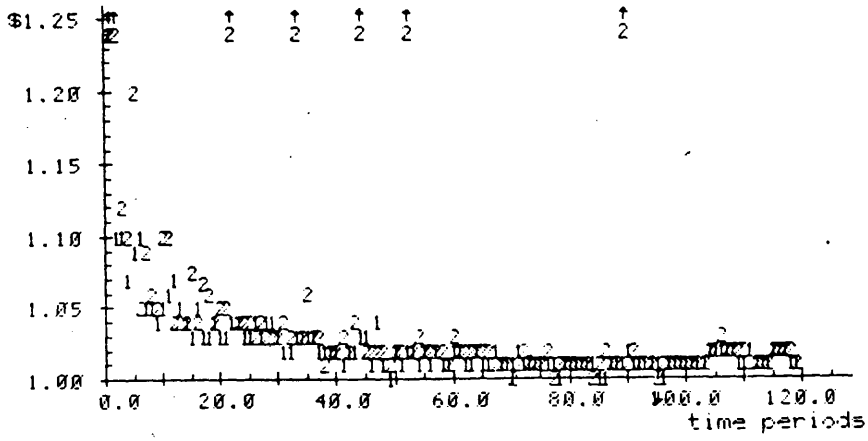

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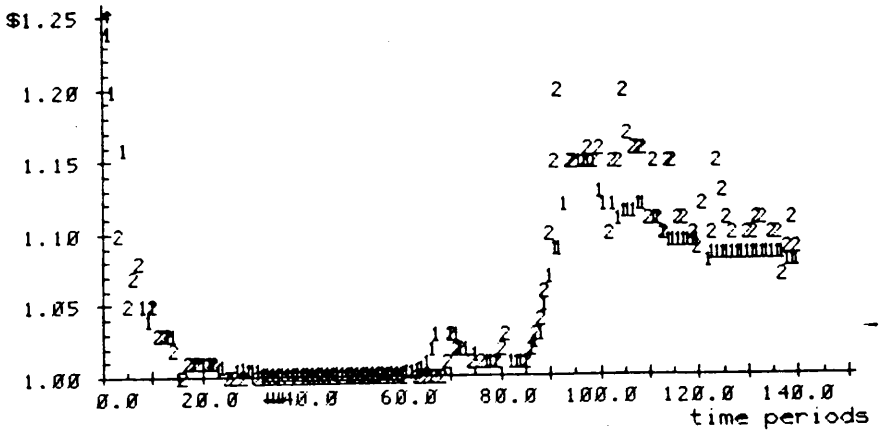

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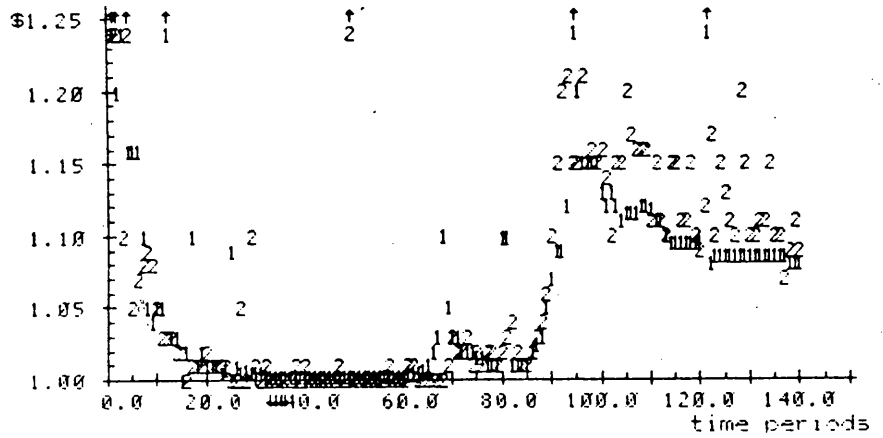

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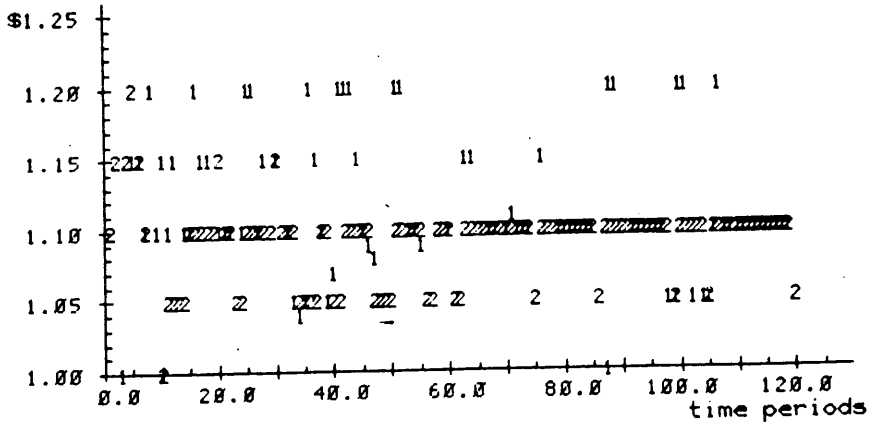

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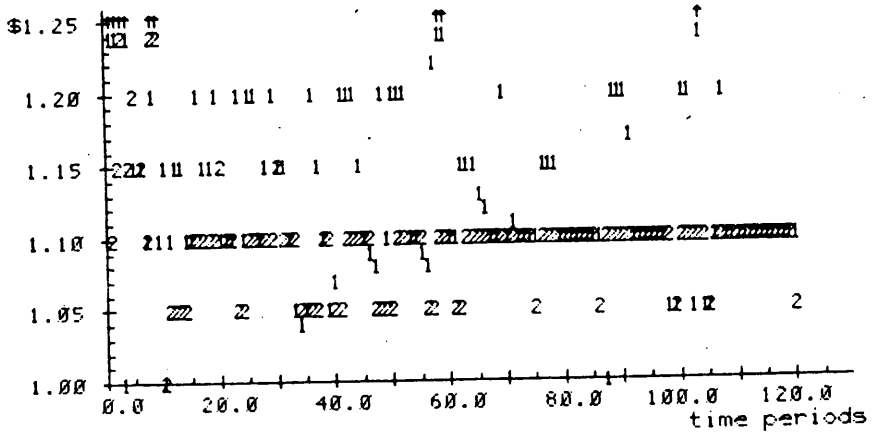

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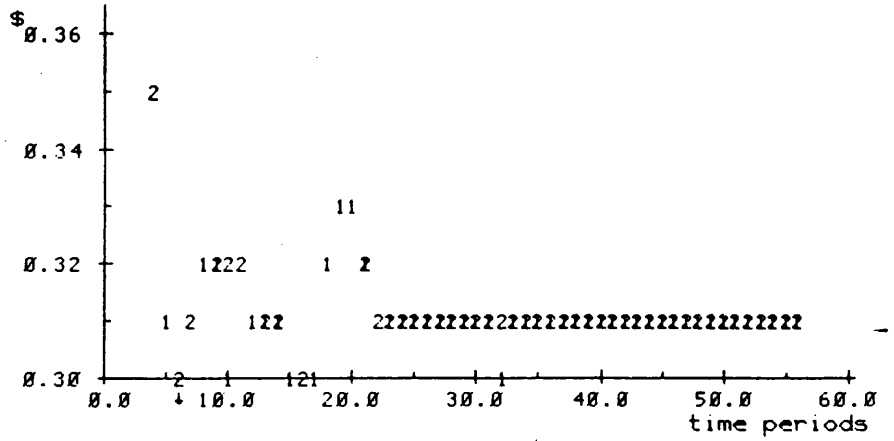

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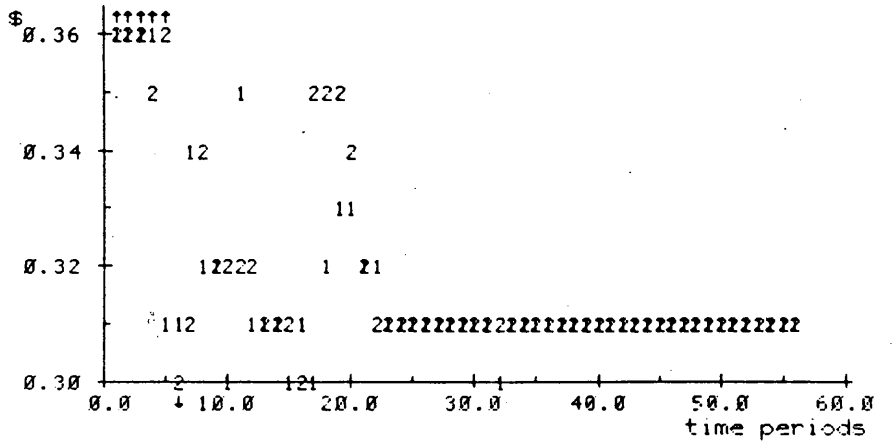

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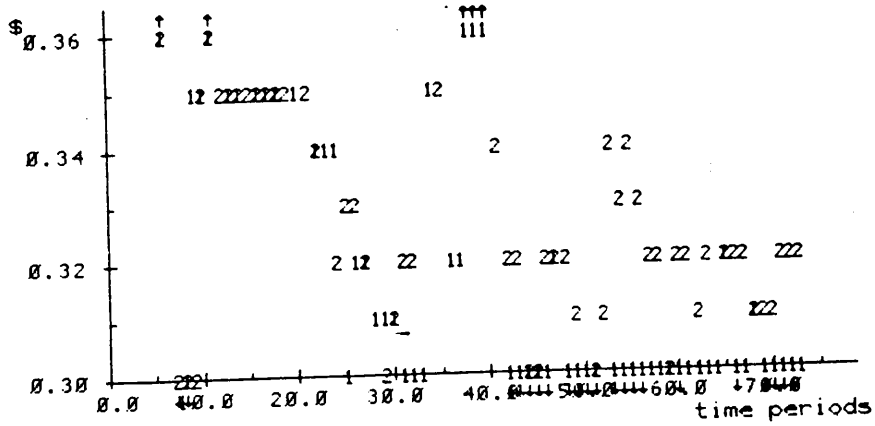

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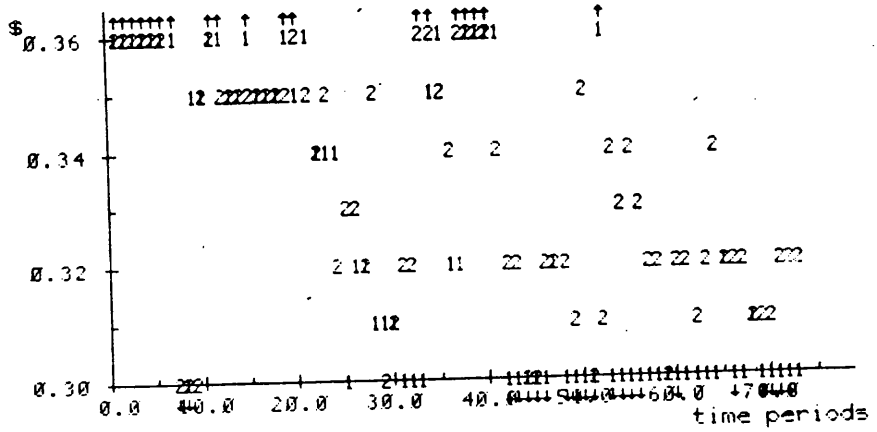

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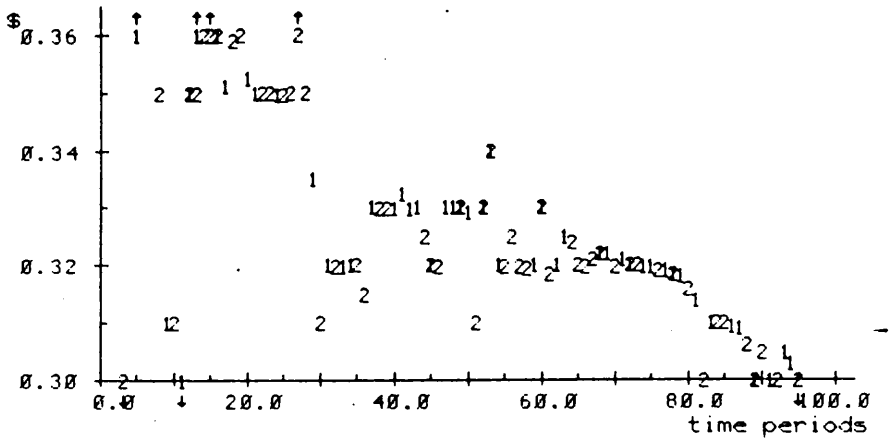

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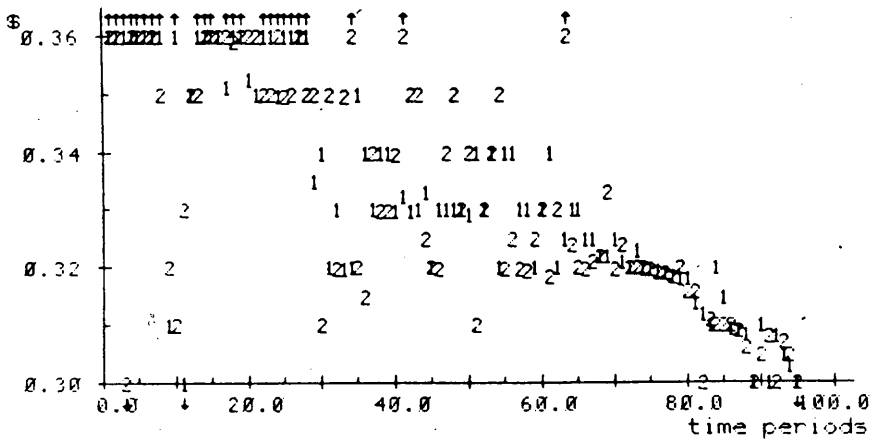

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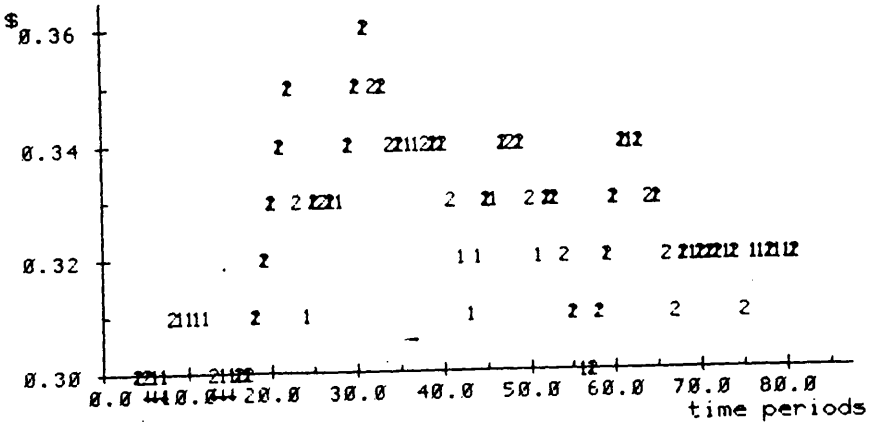
Price History of All Goods Sold



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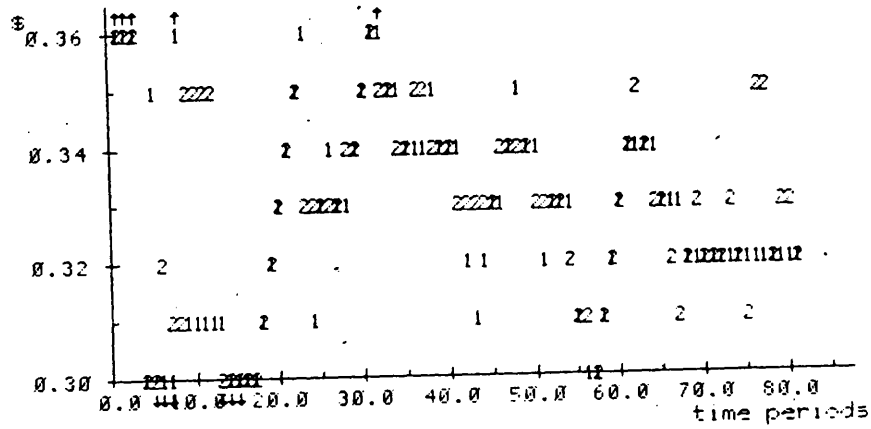

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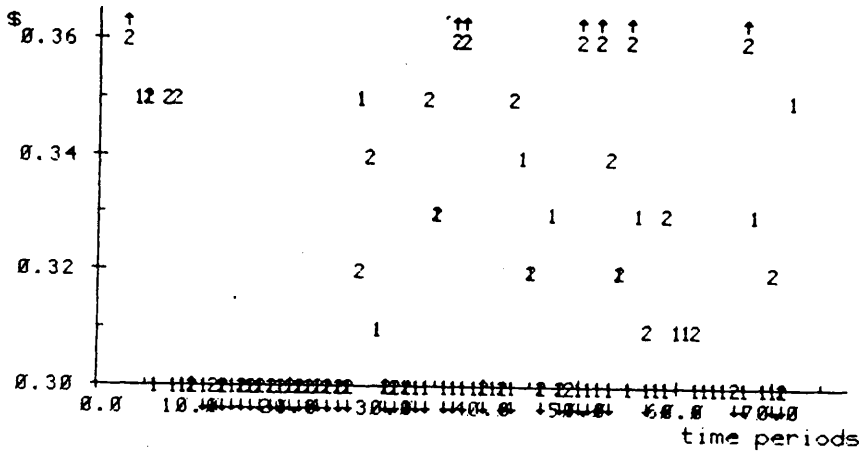

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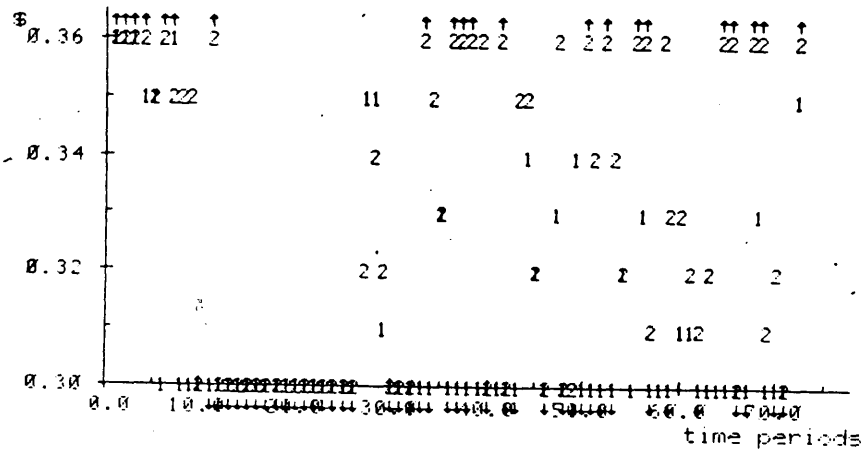

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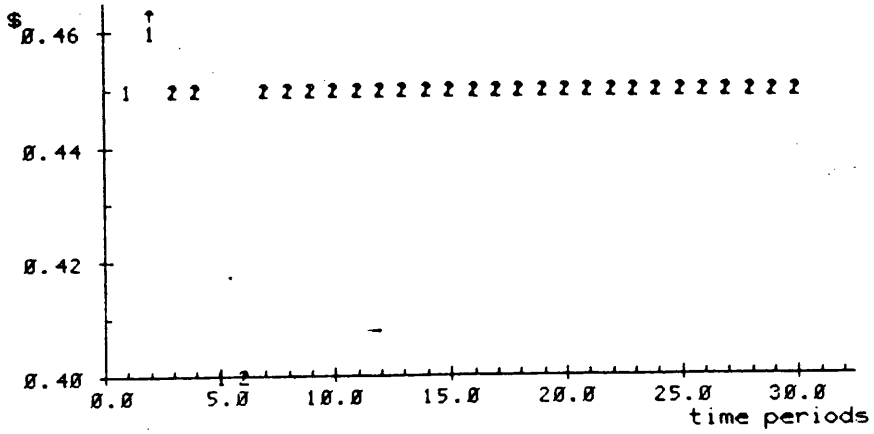

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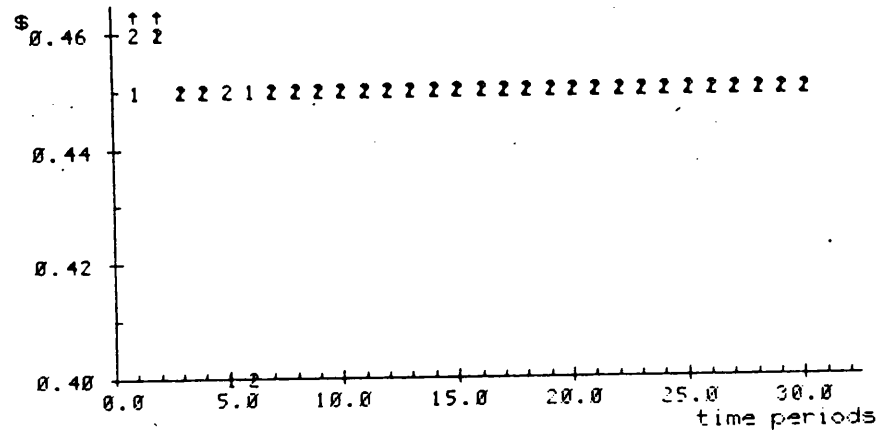

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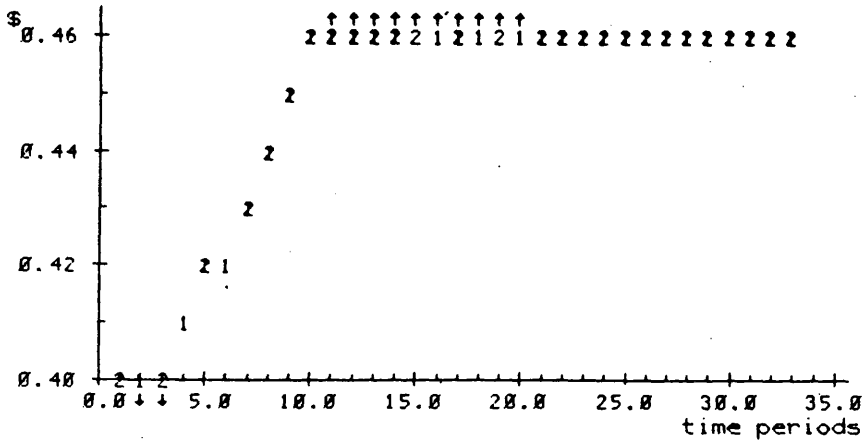

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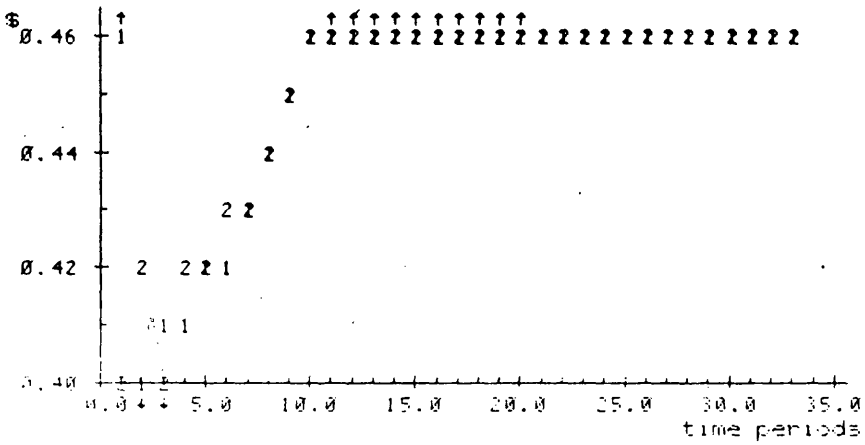

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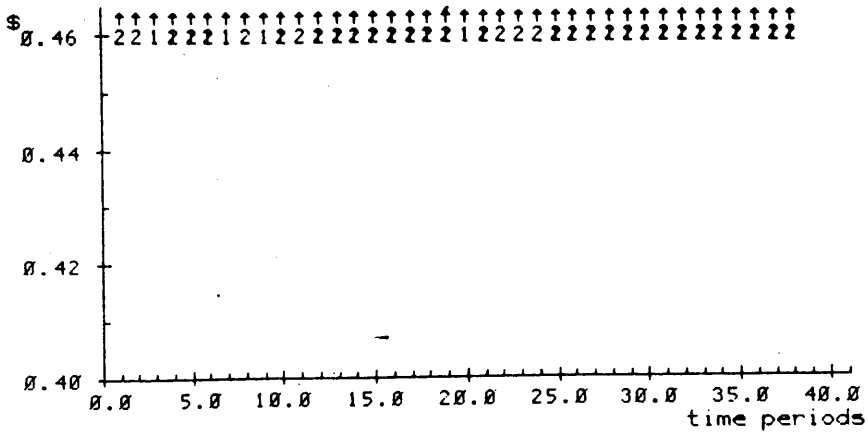

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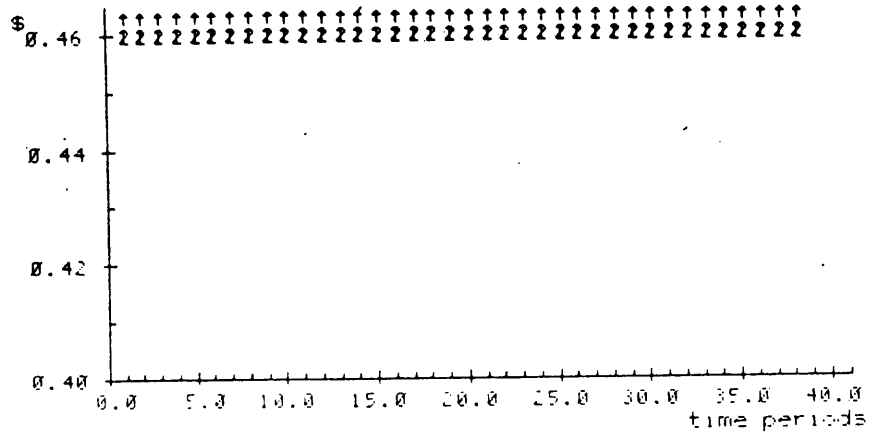

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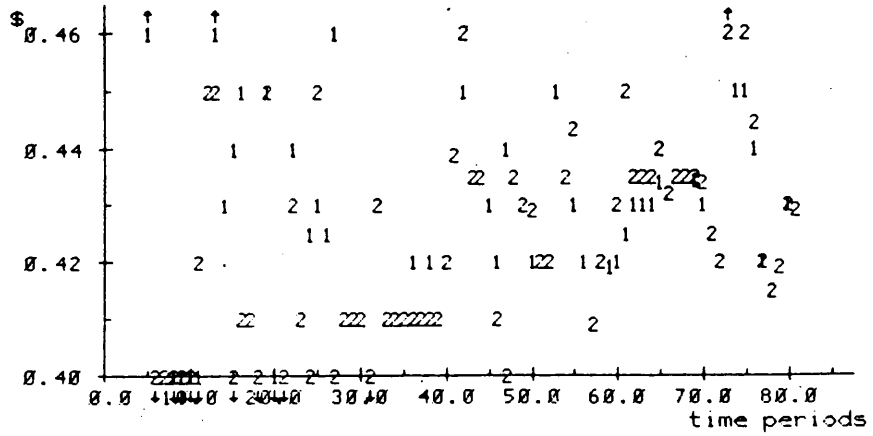

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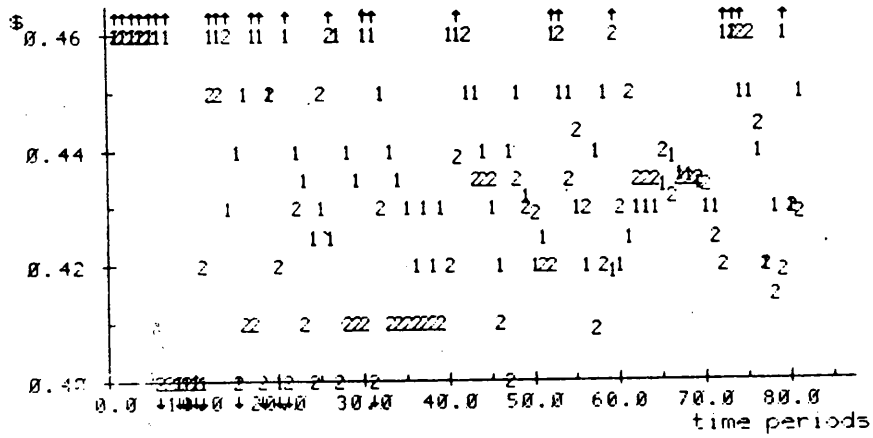

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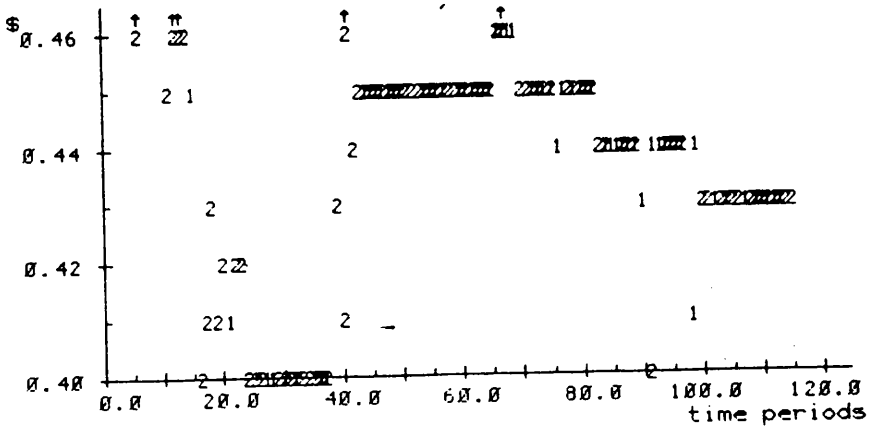

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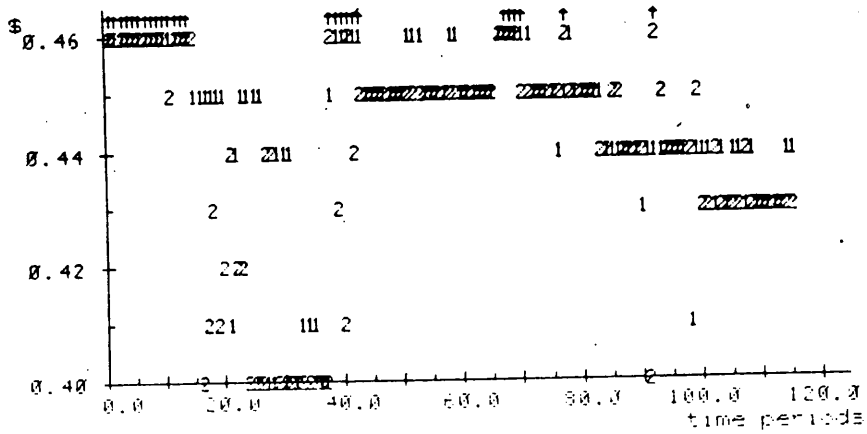

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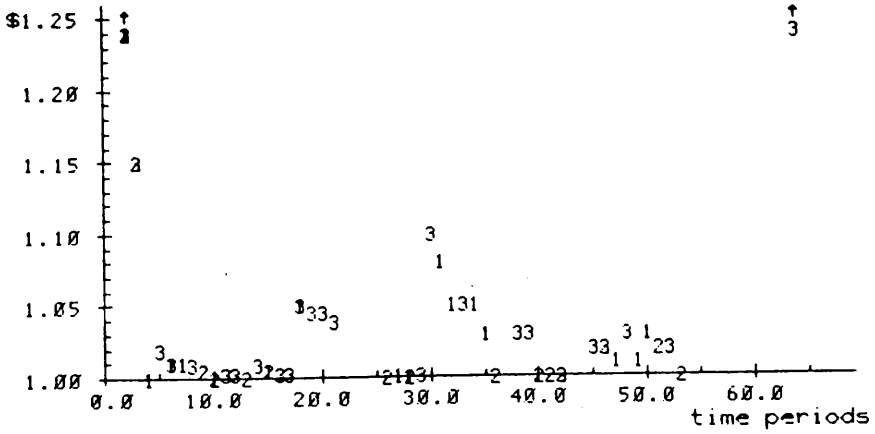

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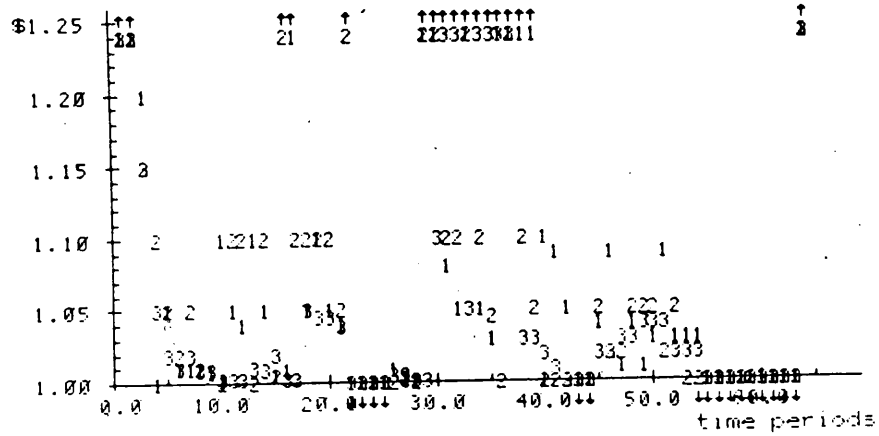

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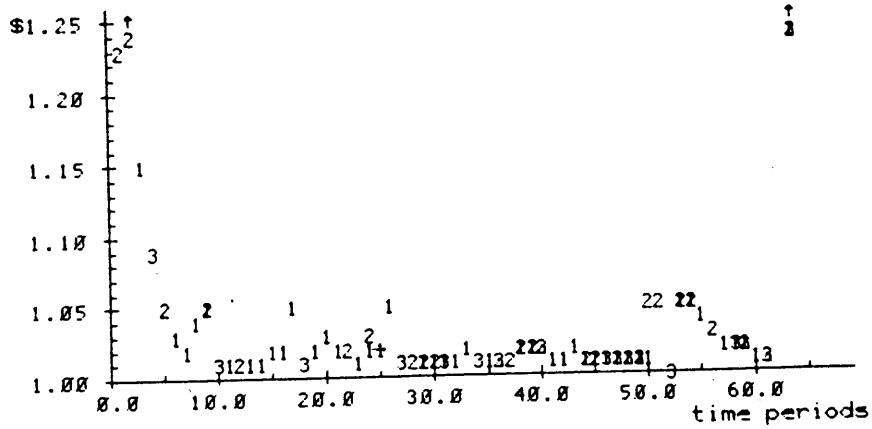

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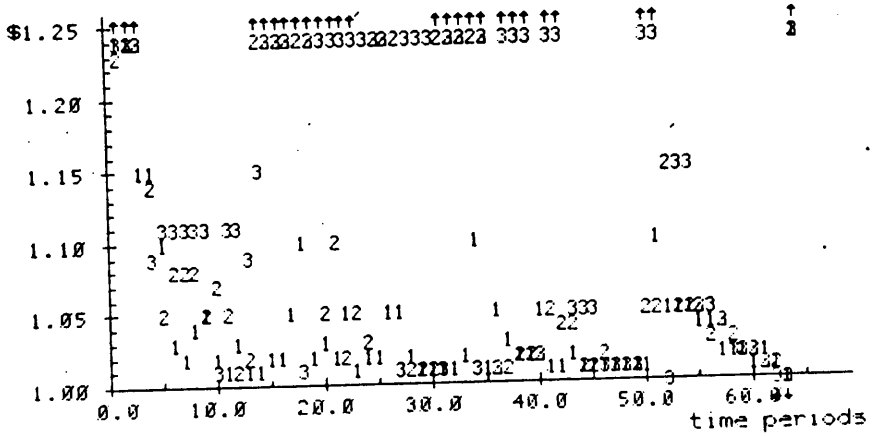

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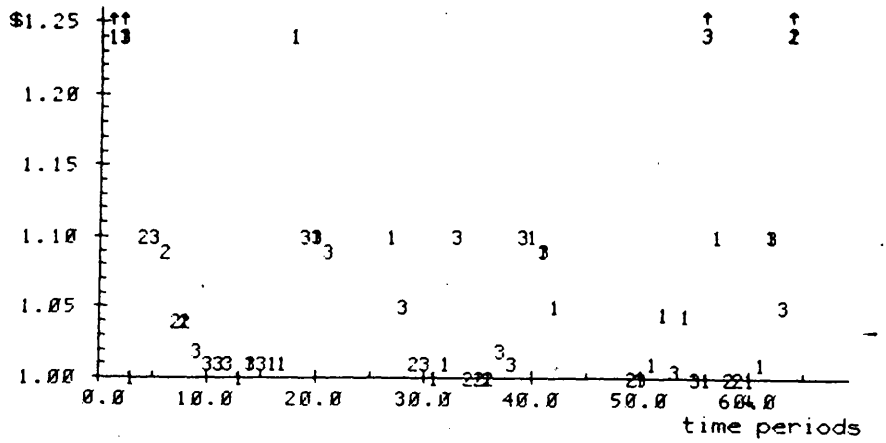

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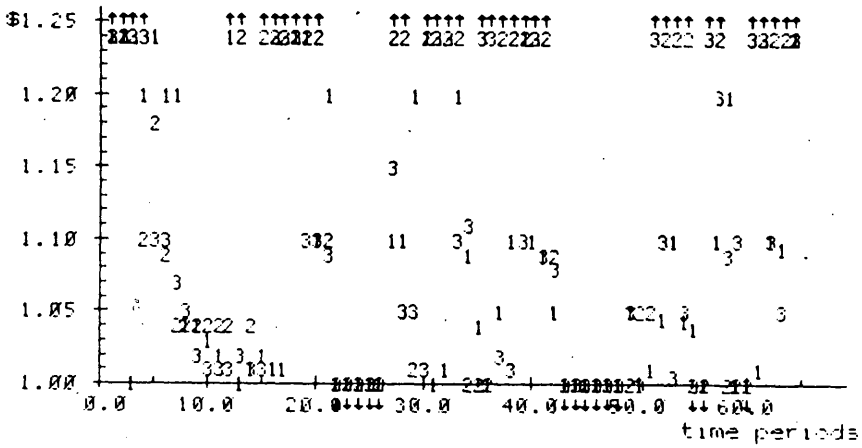

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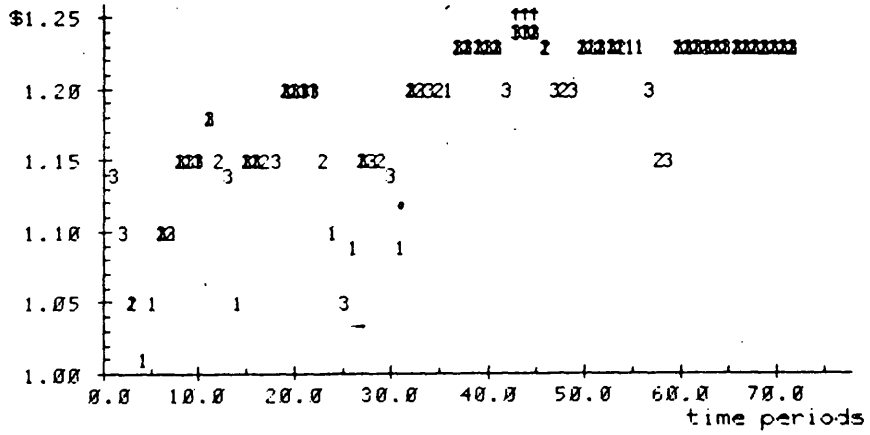

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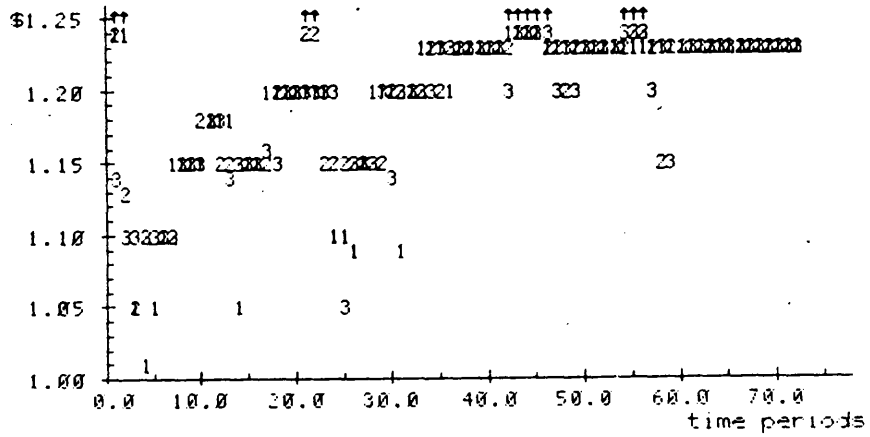

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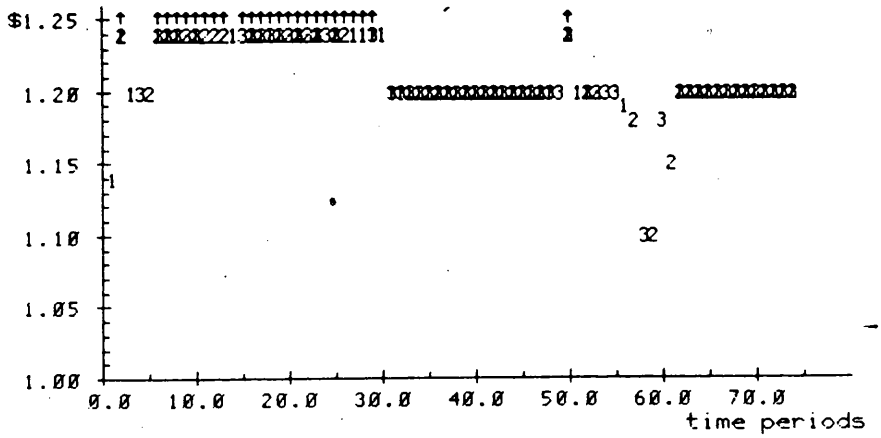

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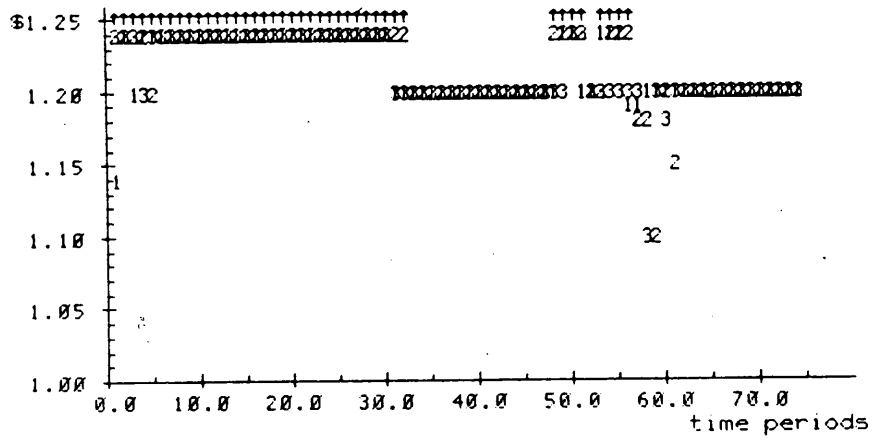

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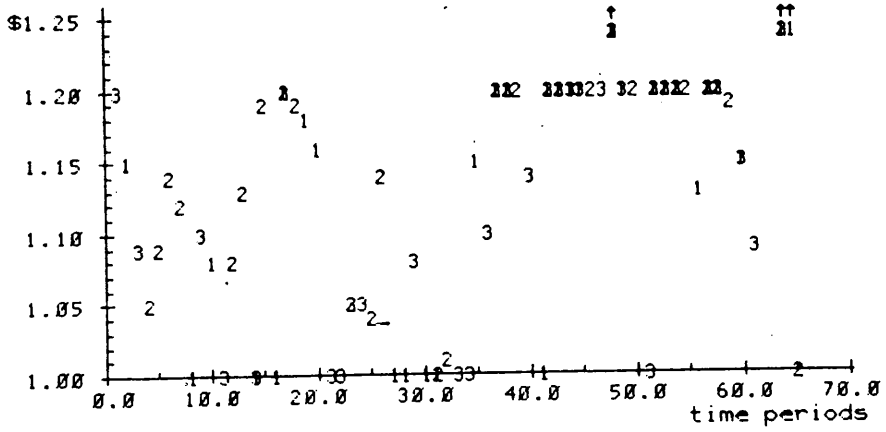

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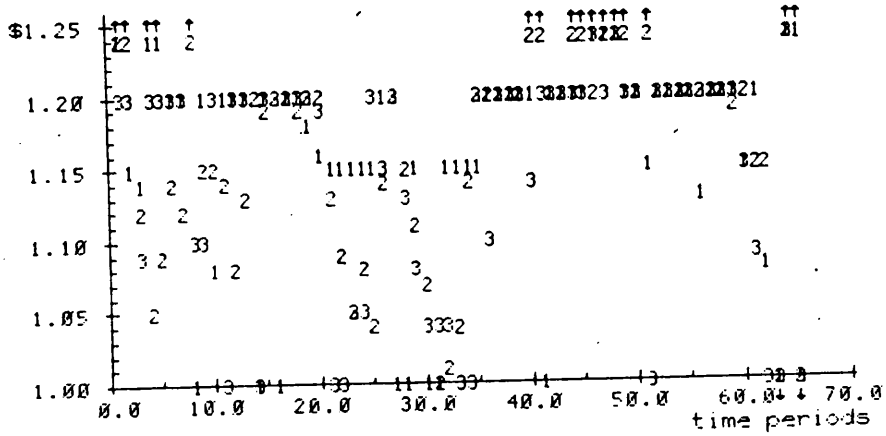

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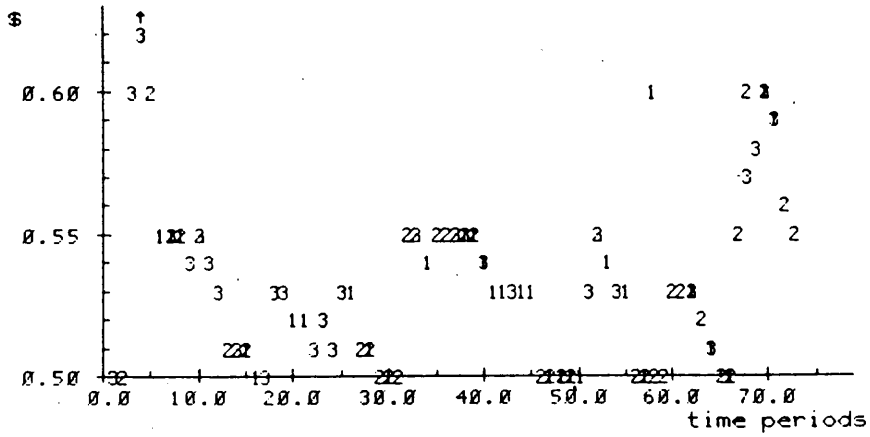

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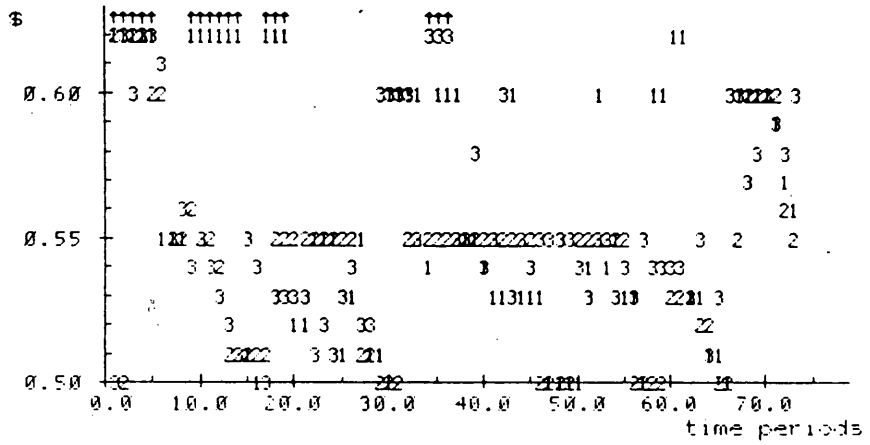

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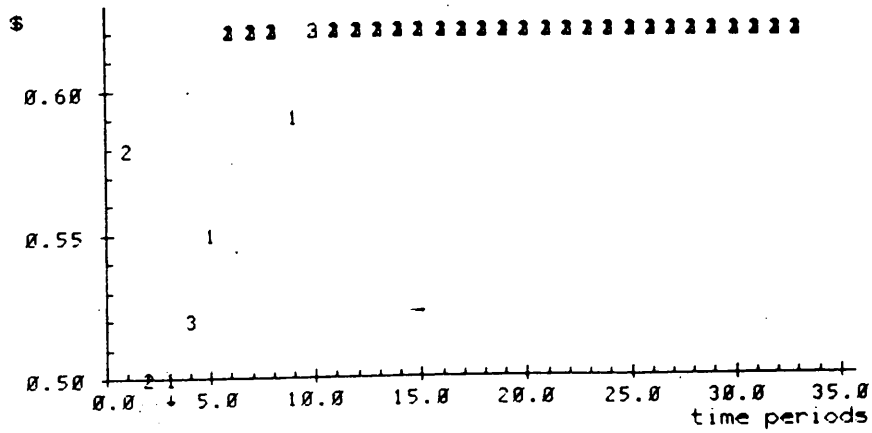

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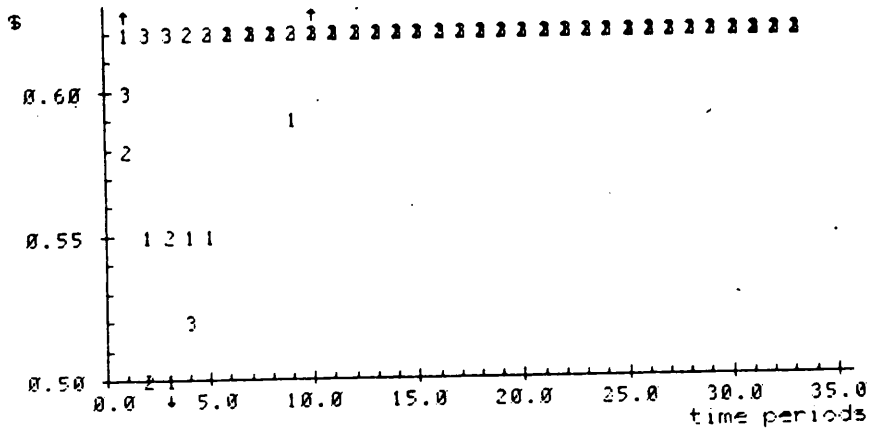

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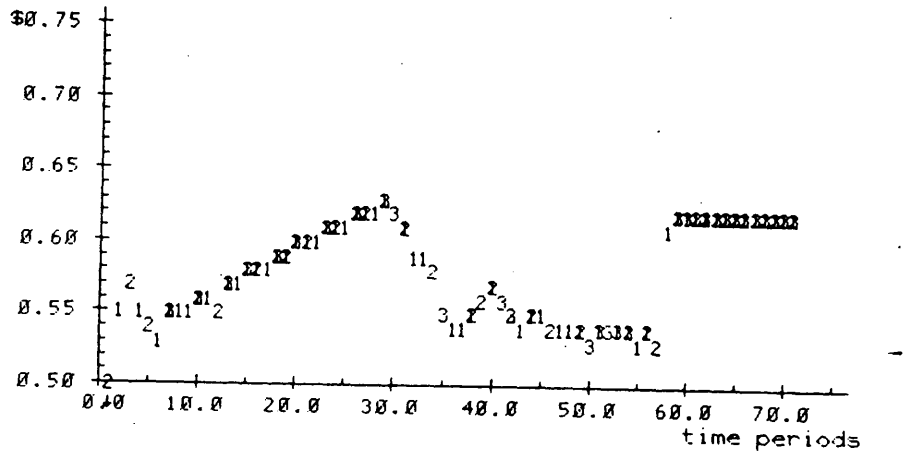

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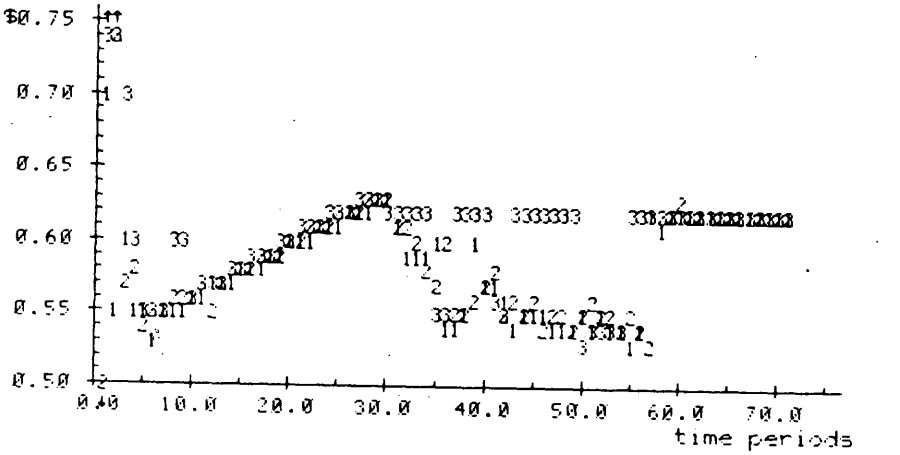

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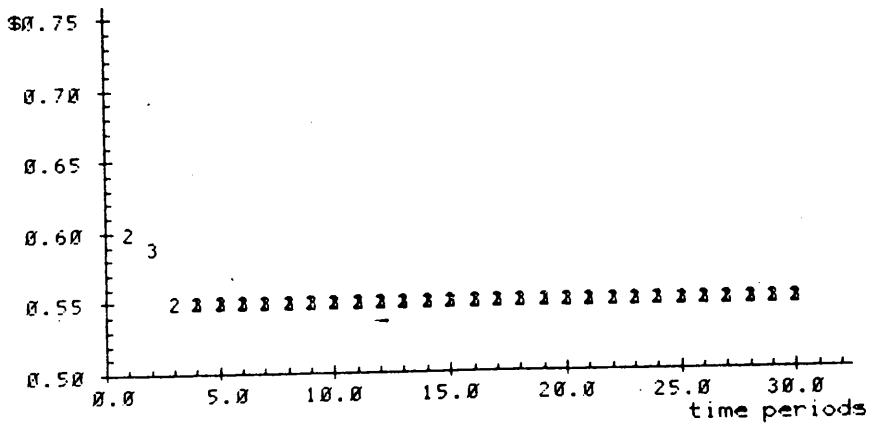

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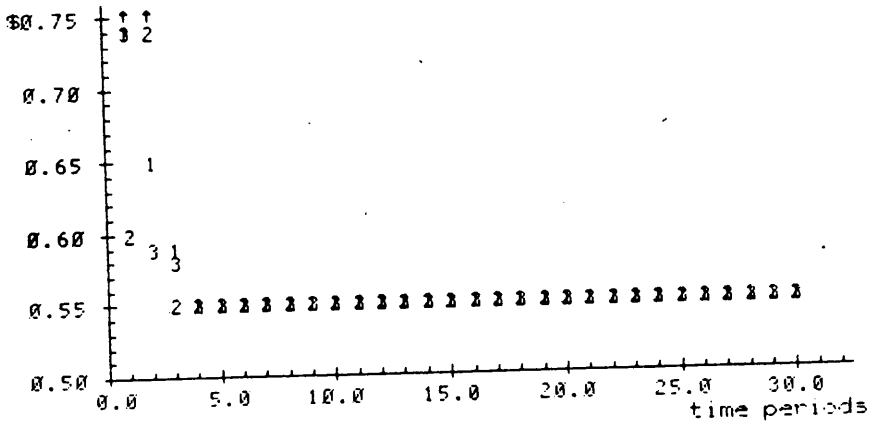

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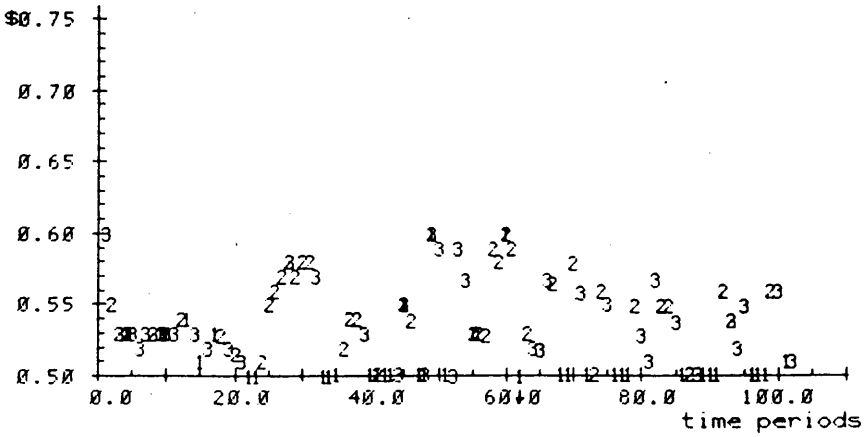

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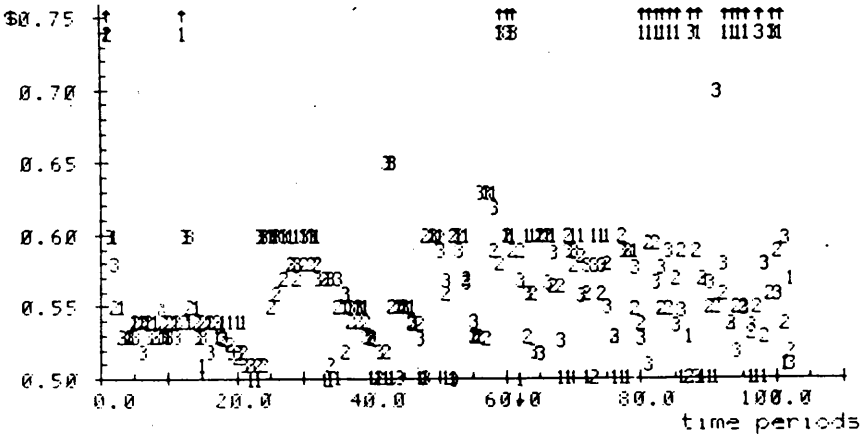

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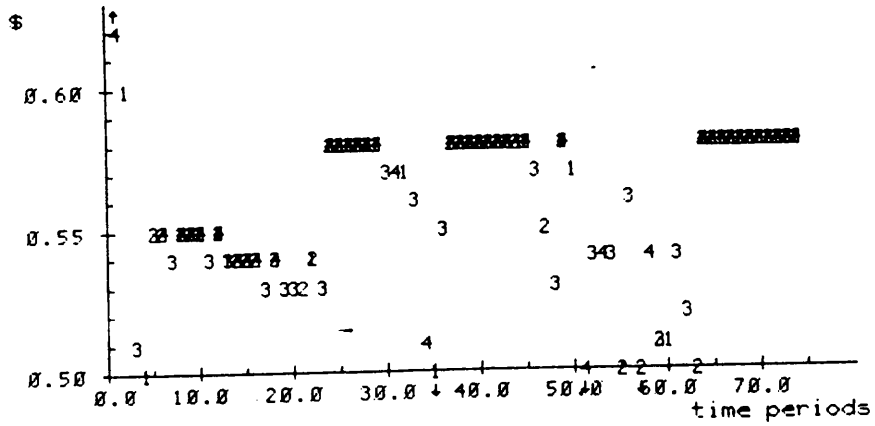

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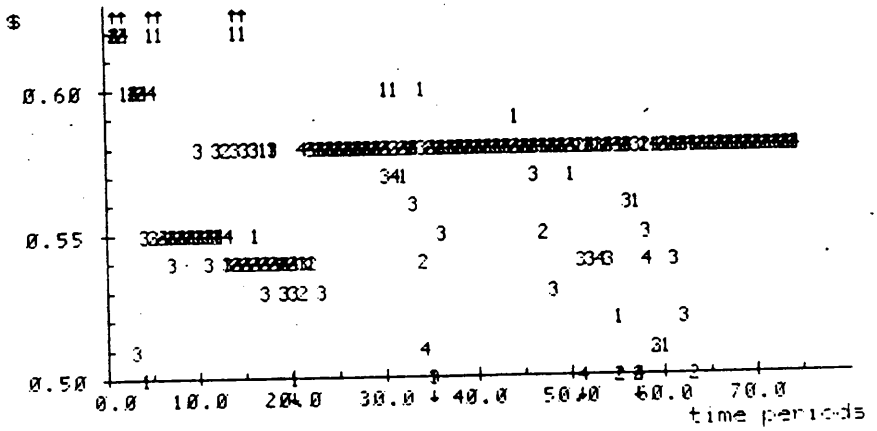

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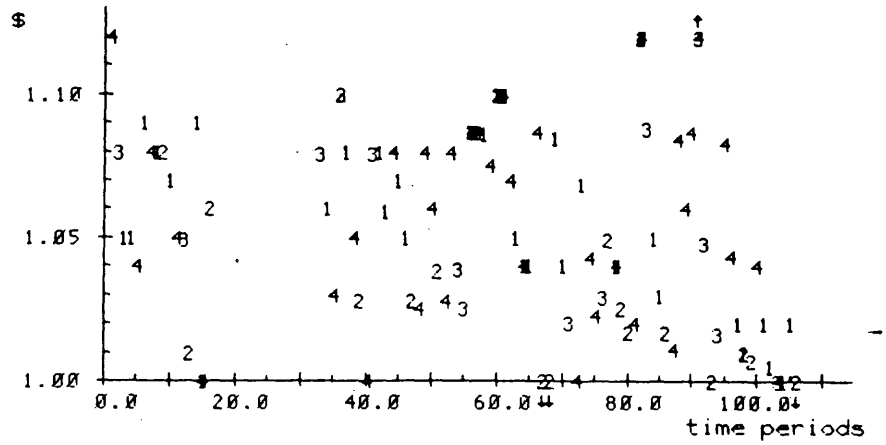

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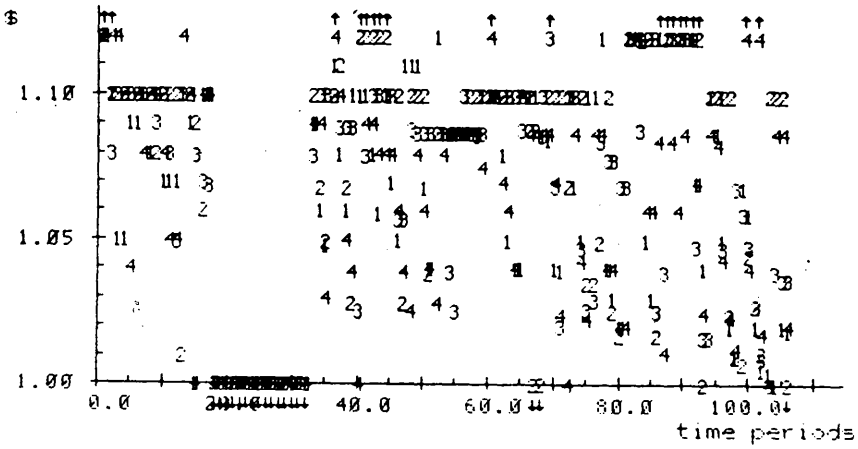

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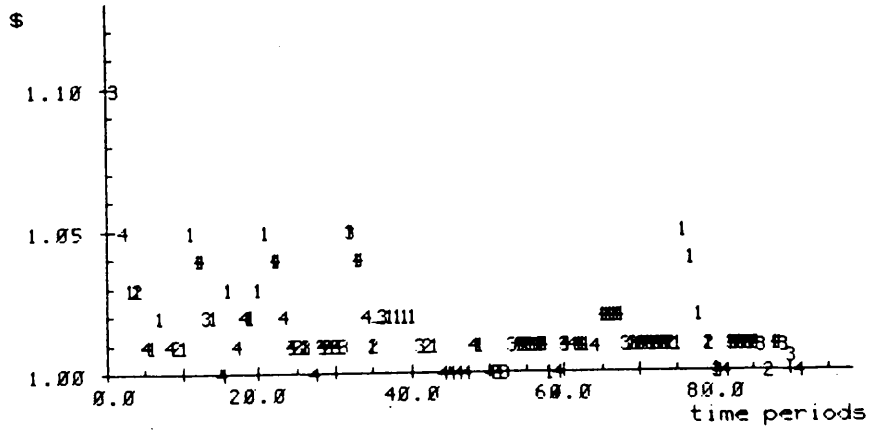

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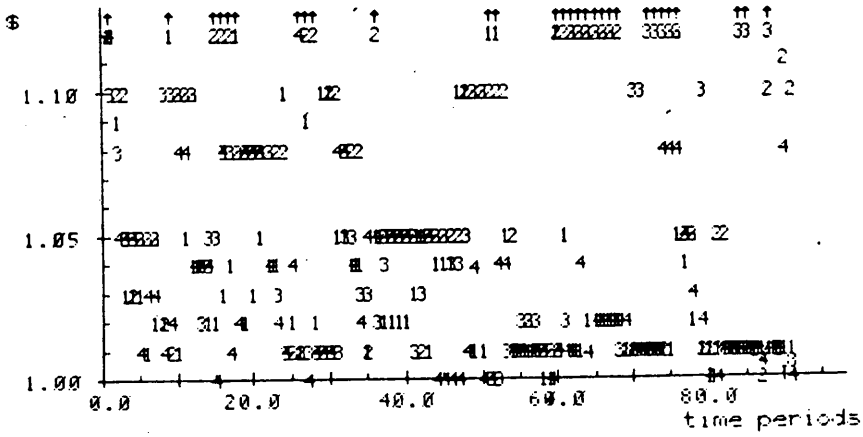

Appendix IV:

MARKET PARAMETERS AND SELECTIVE MARKET DATA

This appendix provides the market parameters used in the markets run for this study, those that reached an equilibrium and those that, for one reason or another, did not. As market parameters were constant for all markets with the same market name, any deviations from our standard set of market parameters described in Chapter II are noted whenever a new market name is introduced.

In the analysis of the data, prices for each market are standardized by the formula $a(P-b)+1.00$, where P is the market price [the standard market has a=1 and b=1]. For each market, we are given the values of a and b (with the monopoly price M and the perfectly competitive price PC) along with any deviations from the standard structure described in Chapter II.

This appendix also provides a complete description of the outcomes for a representative sample of time periods for each market run for this study. For each of these periods, we give all price and quantity choices, the resulting quantities sold, and the profits earned by each seller. The periods we use always include the last ten periods for each market. A * by the last period indicates the outcomes in these last ten periods were identical. We also include any period divisible by five.

1slr;mto;d;02 -- a=2, b=1 (M=$1.12, PC=$1.00); 1 seller

Copy 1

period	firm	price	qty offered	qty sold	profit
26*	1	$ 1.10	12	7	$ 0.70
15	1	1.10	12	7	0.70
10	1	1.10	12	7	0.70
5	1	1.10	12	7	0.70

Copy 2

period	firm	price	qty offered	qty sold	profit
32*	1	$ 1.10	12	7	$ 0.70
20	1	1.10	12	7	0.70
15	1	1.10	12	7	0.70
10	1	1.10	12	7	0.70
5	1	1.10	12	7	0.70

1slr;mto;d;03 -- a=2, b=.8 (M=$0.92, PC=$0.80); 1 seller

Copy 1

period	firm	price	qty offered	qty sold	profit
27*	1	$ 0.92	12	6	$ 0.72
15	1	0.92	12	6	0.72
10	1	0.92	12	6	0.72
5	1	0.88	12	8	0.64

Copy 2

period	firm	price	qty offered	qty sold	profit
33*	1	$ 0.90	12	7	$ 0.70
20	1	0.89999	12	7	0.69993
15	1	0.90	12	7	0.70
10	1	0.95	12	4	0.60
5	1	1.10	12	0	0.00

Copy 3

period	firm	price	qty offered	qty sold	profit
30*	1	$ 0.92	12	6	$ 0.72
20	1	0.92	12	6	0.72
15	1	0.92	12	6	0.72
10	1	0.90	12	7	0.70
5	1	0.88	12	8	0.64

Copy 4

period	firm	price	qty offered	qty sold	profit
31*	1	$ 0.96	12	4	$ 0.64
20	1	0.96	12	4	0.64
15	1	0.96	12	4	0.64
10	1	0.966	12	3	0.498
5	1	0.95	12	4	0.60

Copy 5

period	firm	price	qty offered	qty sold	profit
21*	1	$ 0.90	12	7	$ 0.70
10	1	0.90	12	7	0.70
5	1	0.90	12	7	0.70

Copy 6

period	firm	price	qty offered	qty sold	profit
27*	1	$ 0.94	12	5	$ 0.70
15	1	0.94	12	5	0.70
10	1	0.95	12	4	0.60
5	1	0.94	12	5	0.70

2slrs;mto;d;01 -- a=1, b=1 (M=$1.24, PC=$1.00); 2 sellers

Copy 1

period	firm	price	qty offered	qty sold	profit
161*	1	$ 1.24	12	3	$ 0.72
	2	1.24	12	3	0.72
150	1	1.25	12	0	0.00
	2	1.24	12	6	1.44
145	1	1.24	12	3	0.72
	2	1.24	12	3	0.72
140	1	1.24	12	3	0.72
	2	1.24	12	3	0.72
135	1	1.25	12	0	0.00
	2	1.23	12	6	1.38
130	1	1.20	12	3	0.60
	2	1.20	12	4	0.80
125	1	1.14	12	8	1.12
	2	1.15	12	0	0.00
120	1	1.12	12	9	1.08
	2	1.20	12	0	0.00
115	1	1.01	12	5	0.05
	2	1.01	12	6	0.06
110	1	1.02	12	0	0.00
	2	1.01	12	11	0.11
105	1	1.25	12	0	0.00
	2	1.01	12	11	0.11

100	1	1.05	12	10	0.50
	2	1.12	12	0	0.00
95	1	1.01	12	11	0.11
	2	1.02	12	0	0.00
90	1	1.05	12	10	0.50
	2	1.15	12	0	0.00
85	1	1.01	12	11	0.11
	2	1.15	12	0	0.00
80	1	1.01	12	5	0.05
	2	1.01	12	6	0.06
75	1	1.05	12	0	0.00
	2	1.04	12	11	0.44
70	1	1.01	12	5	0.05
	2	1.01	12	6	0.06
65	1	1.25	12	0	0.00
	2	1.04	12	11	0.44
60	1	1.05	12	0	0.00
	2	1.04	12	11	0.44
55	1	1.01	12	11	0.11
	2	1.14	12	0	0.00
50	1	1.05	12	0	0.00
	2	1.01	12	11	0.11
45	1	1.05	12	0	0.00
	2	1.02	12	11	0.22
40	1	1.06	12	10	0.60
	2	1.50	12	0	0.00
35	1	1.02	12	5	0.10
	2	1.02	12	6	0.12
30	1	1.05	12	10	0.50
	2	1.13	12	0	0.00
25	1	1.10	12	9	0.90
	2	1.14	12	0	0.00
20	1	1.05	12	10	0.50
	2	1.20	12	0	0.00
15	1	1.01	12	11	0.11
	2	1.20	12	0	0.00
10	1	1.30	12	0	0.00
	2	1.15	12	8	1.20
5	1	1.07	12	10	0.70
	2	1.20	12	0	0.00

Copy 2

period	firm	price	qty offered	qty sold	profit
122*	1	$ 1.18	12	3	$ 0.54
	2	1.18	12	4	0.72
110	1	1.18	12	7	1.26
	2	1.30	12	0	0.00
105	1	1.18	12	7	1.26
	2	1.50	12	0	0.00
100	1	1.058	12	0	0.00
	2	1.05	12	10	0.50
95	1	1.002	12	11	0.022
	2	1.09	12	0	0.00
90	1	1.39	12	0	0.00
	2	1.01	12	11	0.11
85	1	1.27	12	0	0.00
	2	1.024	12	11	0.264
80	1	1.09	12	0	0.00
	2	1.049	12	10	0.49
75	1	1.02	12	11	0.22
	2	1.04	12	0	0.00
70	1	1.15	12	0	0.00
	2	1.0499	12	10	0.499
65	1	1.20	12	0	0.00
	2	1.019	12	11	0.209
60	1	1.01	12	11	0.11
	2	1.025	12	0	0.00
55	1	1.01	12	11	0.11
	2	1.02	12	0	0.00
50	1	1.35	12	0	0.00
	2	1.03	12	11	0.33
45	1	1.04	12	11	0.44
	2	1.05	12	0	0.00
40	1	1.04	12	0	0.00
	2	1.03	12	11	0.33
35	1	1.05	12	0	0.00
	2	1.01	12	11	0.11
30	1	1.15	12	0	0.00
	2	1.01	12	11	0.11
25	1	1.20	12	0	0.00
	2	1.10	12	9	0.90
20	1	1.25	12	0	0.00
	2	1.15	12	8	1.20

15	1	1.15	12	8	1.20
	2	1.20	12	0	0.00
10	1	1.50	12	0	0.00
	2	1.20	12	7	1.40
5	1	1.60	10	0	0.00
	2	1.40	12	2	0.80

Copy 3

period	firm	price	qty offered	qty sold	profit
112	1	$ 1.02	12	11	$ 0.22
	2	1.06	12	0	0.00
111	1	1.04	12	0	0.00
	2	1.03	12	11	0.33
110	1	1.06	12	0	0.00
	2	1.03	12	11	0.33
109	1	1.02	12	11	0.22
	2	1.10	12	0	0.00
108	1	1.03	12	5	0.15
	2	1.03	12	6	0.18
107	1	1.10	12	0	0.00
	2	1.03	12	11	0.33
106	1	1.07	12	0	0.00
	2	1.02	12	11	0.22
105	1	1.03	12	0	0.00
	2	1.01	12	11	0.11
104	1	1.02	12	11	0.22
	2	1.03	12	0	0.00
103	1	1.02	12	11	0.22
	2	1.04	12	0	0.00
100	1	1.02	12	5	0.10
	2	1.02	12	6	0.12
95	1	1.10	12	0	0.00
	2	1.03	12	11	0.33
90	1	1.02	12	5	0.10
	2	1.02	12	6	0.12
85	1	1.03	12	5	0.15
	2	1.03	12	6	0.18
80	1	1.13	12	0	0.00
	2	1.03	12	11	0.33
75	1	1.12	12	0	0.00
	2	1.01	12	11	0.11

70	1	1.06	12	0	0.00
	2	1.01	12	11	0.11
65	1	1.03	12	0	0.00
	2	1.02	12	11	0.22
60	1	1.01	12	11	0.11
	2	1.02	12	0	0.00
55	1	1.04	12	11	0.44
	2	1.10	12	0	0.00
50	1	1.02	12	5	0.10
	2	1.02	12	6	0.12
45	1	1.10	12	0	0.00
	2	1.02	12	11	0.22
40	1	1.02	12	5	0.10
	2	1.02	12	6	0.12
35	1	1.04	12	0	0.00
	2	1.03	12	11	0.33
30	1	1.12	12	0	0.00
	2	1.03	12	11	0.33
25	1	1.05	12	0	0.00
	2	1.03	12	11	0.33
20	1	1.12	12	0	0.00
	2	1.02	12	11	0.22
15	1	1.05	12	0	0.00
	2	1.03	12	11	0.33
10	1	1.03	12	11	0.33
	2	1.05	12	0	0.00
5	1	1.07	12	10	0.70
	2	1.08	12	0	0.00

Copy 4

period	firm	price	qty offered	qty sold	profit
105	1	$ 1.25	8	0	$ 0.00
	2	1.20	8	7	1.40
104	1	1.20	8	7	1.40
	2	1.25	8	0	0.00
103	1	1.25	8	0	0.00
	2	1.20	8	7	1.40
102	1	1.20	8	7	1.40
	2	1.25	8	0	0.00
101	1	1.25	8	0	0.00
	2	1.20	8	7	1.40

100	1	1.20	8	7	1.40
	2	1.25	8	0	0.00
99	1	1.25	8	0	0.00
	2	1.20	8	7	1.40
98	1	1.20	8	7	1.40
	2	1.25	8	0	0.00
97	1	1.25	8	0	0.00
	2	1.20	8	7	1.40
96	1	1.20	8	7	1.40
	2	1.25	8	0	0.00
95	1	1.25	8	0	0.00
	2	1.20	8	7	1.40
90	1	1.20	8	7	1.40
	2	1.25	8	0	0.00
85	1	1.25	8	0	0.00
	2	1.20	8	7	1.40
80	1	1.20	8	7	1.40
	2	1.25	12	0	0.00
75	1	1.25	8	0	0.00
	2	1.20	12	7	1.40
70	1	1.20	7	7	1.40
	2	1.25	12	0	0.00
65	1	1.25	7	5	1.25
	2	1.29	12	0	0.00
60	1	1.25	7	0	0.00
	2	1.20	12	7	1.40
55	1	1.20	7	7	1.40
	2	1.26	12	0	0.00
50	1	1.25	7	0	0.00
	2	1.20	7	7	1.40
45	1	1.20	7	7	1.40
	2	2.45	9	0	0.00
40	1	1.25	1	0	0.00
	2	1.2049	10	6	1.2294
35	1	1.20	7	7	1.40
	2	1.25	8	0	0.00
30	1	1.25	10	0	0.00
	2	1.20	10	7	1.40
25	1	1.19	10	7	1.33
	2	1.20	7	0	0.00
20	1	1.17	10	0	0.00
	2	1.15	12	8	1.20

15	1	1.11	10	9	0.99
	2	1.20	6	0	0.00
10	1	1.10	11	9	0.90
	2	1.20	5	0	0.00
5	1	1.18	12	3	0.54
	2	1.18	10	4	0.72

Copy 5

period	firm	price	qty offered	qty sold	profit
106*	1	$ 1.03	12	5	$ 0.15
	2	1.03	12	6	0.18
95	1	1.03	12	5	0.15
	2	1.03	12	6	0.18
90	1	1.03	12	5	0.15
	2	1.03	12	6	0.18
85	1	1.03	12	5	0.15
	2	1.03	12	6	0.18
80	1	1.03	12	5	0.15
	2	1.03	12	6	0.18
75	1	1.03	12	5	0.15
	2	1.03	12	6	0.18
70	1	1.03	12	5	0.15
	2	1.03	12	6	0.18
65	1	1.03	12	5	0.15
	2	1.03	12	6	0.18
60	1	1.03	12	5	0.15
	2	1.03	12	6	0.18
55	1	1.04	12	0	0.00
	2	1.03	12	11	0.33
50	1	1.30	12	0	0.00
	2	1.20	12	7	1.40
45	1	5.95	12	0	0.00
	2	1.01	12	11	0.11
40	1	1.009	12	5	0.045
	2	1.009	12	6	0.054
35	1	1.01	12	5	0.05
	2	1.01	12	6	0.06
30	1	1.01	12	5	0.05
	2	1.01	12	6	0.06
25	1	1.01	12	5	0.05
	2	1.01	12	6	0.06

20	1	1.01	12	5	0.05
	2	1.01	12	6	0.06
15	1	1.01	12	5	0.05
	2	1.01	12	6	0.06
10	1	1.01	12	5	0.05
	2	1.01	12	6	0.06
5	1	1.13	12	0	0.00
	2	1.06	12	10	0.60

Copy 6

period	firm	price	qty offered	qty sold	profit
22	1	$ 1.01	12	5	$ 0.05
	2	1.01	12	6	0.06
21	1	1.02	12	0	0.00
	2	1.01	12	11	0.11
20	1	1.01	12	5	0.05
	2	1.01	12	6	0.06
19	1	1.01	12	11	0.11
	2	1.0127	11	0	0.00
18	1	1.03	12	0	0.00
	2	1.011	12	11	0.121
17	1	1.02	12	7	0.14
	2	1.00	4	4	0.00
16	1	1.01	12	11	0.11
	2	1.03	7	0	0.00
15	1	1.05	12	2	0.10
	2	1.02	8	8	0.16
14	1	1.09	12	0	0.00
	2	1.04	9	9	0.36
13	1	1.09	12	9	0.81
	2	1.14	8	0	0.00
10	1	1.16	10	8	1.28
	2	1.20	6	0	0.00
5	1	2.00	10	0	0.00
	2	4.00	4	0	0.00

Copy 7

period	firm	price	qty offered	qty sold	profit
22	1	$ 1.009	12	11	$ 0.099
	2	1.35	12	0	0.00
21	1	1.02	12	0	0.00
	2	1.018	12	11	0.198

20	1	1.03	12	11	0.33
	2	1.048	12	0	0.00
19	1	1.08	12	0	0.00
	2	1.06	12	10	0.60
18	1	1.02	12	11	0.22
	2	1.25	12	0	0.00
17	1	1.009	12	11	0.099
	2	1.03	12	0	0.00
16	1	1.00	12	11	0.00
	2	1.015	12	0	0.00
15	1	1.03	12	0	0.00
	2	1.01	12	11	0.11
14	1	1.029	12	11	0.319
	2	1.04	12	0	0.00
13	1	1.045	12	0	0.00
	2	1.04	12	11	0.44
10	1	1.045	12	10	0.45
	2	1.20	12	0	0.00
5	1	1.015	12	11	0.165
	2	1.05	12	0	0.00

Copy 8 -- experienced subjects

period	firm	price	qty offered	qty sold	profit
28	1	$ 1.10	12	4	$ 0.40
	2	1.10	12	5	0.50
27	1	1.14	12	8	1.12
	2	1.15	12	0	0.00
26	1	1.20	12	7	1.40
	2	1.23	12	0	0.00
25	1	1.45	12	0	0.00
	2	1.25	12	5	1.25
24	1	1.45	12	0	0.00
	2	1.06	12	10	0.60
23	1	1.06	12	10	0.60
	2	1.07	12	0	0.00
22	1	1.06	12	10	0.60
	2	1.08	12	0	0.00
21	1	1.07	12	10	0.70
	2	1.09	12	0	0.00
20	1	1.10	12	0	0.00
	2	1.09	12	9	0.81

19	1	1.10	12	0	0.00
	2	1.08	12	10	0.80
15	1	1.08	12	10	0.80
	2	1.15	12	0	0.00
10	1	1.14	12	8	1.12
	2	1.18	12	0	0.00
5	1	1.10	12	9	0.90
	2	1.11	12	0	0.00

Copy 9

period	firm	price	qty offered	qty sold	profit
29	1	$ 1.05	12	10	$ 0.50
	2	1.10	12	0	0.00
28	1	1.07	12	0	0.00
	2	1.06	12	10	0.60
27	1	1.07	12	0	0.00
	2	1.06	12	10	0.60
26	1	1.07	12	10	0.70
	2	1.08	12	0	0.00
25	1	1.10	12	0	0.00
	2	1.07	12	10	0.70
24	1	1.06	12	10	0.60
	2	1.12	12	0	0.00
23	1	1.20	12	0	0.00
	2	1.07	12	10	0.70
22	1	1.06	12	10	0.60
	2	1.07	12	0	0.00
21	1	1.07	12	10	0.70
	2	1.08	12	0	0.00
20	1	1.07	12	10	0.70
	2	1.10	12	0	0.00
15	1	1.08	12	5	0.40
	2	1.08	12	5	0.40
10	1	1.09	12	9	0.81
	2	1.12	12	0	0.00
5	1	1.15	12	0	0.00
	2	1.14	12	8	1.12

Copy 10

period	firm	price	qty offered	qty sold	profit
15	1	$ 1.009	12	11	$ 0.099
	2	1.08	12	0	0.00

14	1	1.0009	12	11	0.0099
	2	1.0999	12	0	0.00
13	1	1.1395	12	0	0.00
	2	1.03999	12	11	0.439889+
12	1	1.235	12	0	0.00
	2	1.059999	12	10	0.59999
11	1	1.175	12	7	1.225
	2	1.9999	12	0	0.00
10	1	1.22	12	0	0.00
	2	1.025	12	11	0.275
9	1	1.0699	12	10	0.699
	2	1.845	12	0	0.00
8	1	1.149	12	0	0.00
	2	1.1053	12	9	0.9477
7	1	1.19	12	7	1.33
	2	1.1912	12	0	0.00
6	1	1.25	12	0	0.00
	2	1.23	12	6	1.38
5	1	1.29	12	0	0.00
	2	1.28	12	5	1.40

Copy 11 -- experienced subjects

period	firm	price	qty offered	qty sold	profit
83	1	$ 1.20	12	4	$ 0.80
	2	1.20	5	3	0.60
82	1	1.20	12	3	0.60
	2	1.20	12	4	0.80
81	1	1.20	12	3	0.60
	2	1.20	12	4	0.80
80	1	1.20	12	3	0.60
	2	1.20	12	4	0.80
79	1	1.20	12	3	0.60
	2	1.20	12	4	0.80
78	1	1.20	12	3	0.60
	2	1.20	12	4	0.80
77	1	1.20	12	3	0.60
	2	1.20	12	4	0.80
76	1	1.20	12	3	0.60
	2	1.20	12	4	0.80
75	1	1.20	12	3	0.60
	2	1.20	12	4	0.80

74	1	1.20	12	4	0.80
	2	1.20	5	3	0.60
70	1	1.20	12	4	0.80
	2	1.20	5	3	0.60
65	1	1.20	12	3	0.60
	2	1.20	12	4	0.80
60	1	1.20	12	3	0.60
	2	1.20	12	4	0.80
55	1	1.20	12	4	0.80
	2	1.20	5	3	0.60
50	1	1.20	12	3	0.60
	2	1.20	12	4	0.80
45	1	1.20	12	3	0.60
	2	1.20	12	4	0.80
40	1	1.20	12	4	0.80
	2	1.20	7	3	0.60
35	1	1.20	12	3	0.60
	2	1.20	11	4	0.80
30	1	1.20	12	3	0.60
	2	1.20	12	4	0.80
25	1	1.20	12	3	0.60
	2	1.20	12	4	0.80
20	1	1.20	12	7	1.40
	2	9.00	12	0	0.00
15	1	1.20	12	0	0.00
	2	1.034	12	11	0.374
10	1	1.03	12	5	0.15
	2	1.03	12	6	0.18
5	1	1.08	12	0	0.00
	2	1.05	12	10	0.50

Copy 12

period	firm	price	qty offered	qty sold	profit
67*	1	$ 1.05	12	5	$ 0.25
	2	1.05	12	5	0.25
55	1	1.09	12	9	0.81
	2	1.10	5	0	0.00
50	1	1.07	12	5	0.35
	2	1.07	12	5	0.35
45	1	1.07	12	5	0.35
	2	1.07	12	5	0.35

40	1	1.10	12	0	0.00
	2	1.05	12	10	0.50
35	1	1.01	12	5	0.05
	2	1.01	12	6	0.06
30	1	1.01	12	5	0.05
	2	1.01	12	6	0.06
25	1	1.07	12	10	0.70
	2	1.10	5	0	0.00
20	1	1.01	12	5	0.05
	2	1.01	12	6	0.06
15	1	1.10	8	8	0.80
	2	1.40	5	0	0.00
10	1	1.02	10	0	0.00
	2	1.01	12	11	0.11
5	1	1.25	7	5	1.25
	2	1.50	6	0	0.00

Copy 13

period	firm	price	qty offered	qty sold	profit
58	1	$ 1.30	7	0	$ 0.00
	2	1.20	12	7	1.40
57	1	1.20	12	7	1.40
	2	1.30	12	0	0.00
56	1	1.30	7	0	0.00
	2	1.20	12	7	1.40
55	1	1.20	12	7	1.40
	2	1.30	12	0	0.00
54	1	1.30	7	0	0.00
	2	1.20	12	7	1.40
53	1	1.20	12	7	1.40
	2	1.30	12	0	0.00
52	1	1.20	1	0	0.00
	2	1.20	12	7	1.40
51	1	1.20	12	7	1.40
	2	1.30	12	0	0.00
50	1	1.30	7	0	0.00
	2	1.20	12	7	1.40
49	1	1.20	12	7	1.40
	2	1.40	12	0	0.00
45	1	1.30	7	0	0.00
	2	1.20	12	7	1.40

40	1	1.20	12	7	1.40
	2	1.30	12	0	0.00
35	1	1.30	7	0	0.00
	2	1.20	12	7	1.40
30	1	1.20	12	7	1.40
	2	1.30	12	0	0.00
25	1	1.30	7	0	0.00
	2	1.20	12	7	1.40
20	1	1.20	12	7	1.40
	2	1.30	12	0	0.00
15	1	1.30	7	0	0.00
	2	1.20	12	7	1.40
10	1	1.22	12	6	1.32
	2	1.30	12	0	0.00
5	1	1.25	6	0	0.00
	2	1.20	12	7	1.40

Copy 14

period	firm	price	qty offered	qty sold	profit
58	1	$ 1.1399	12	8	$ 1.1192
	2	1.15	10	0	0.00
57	1	1.24998	12	0	0.00
	2	1.10	10	9	0.90
56	1	1.1799	12	7	1.2593
	2	1.27	10	0	0.00
55	1	1.2998	12	4	1.1992
	2	1.30	10	0	0.00
54	1	1.349	12	3	1.047
	2	1.40	10	0	0.00
53	1	1.45	12	0	0.00
	2	1.20	10	7	1.40
52	1	1.189	12	7	1.323
	2	1.26	10	0	0.00
51	1	1.248	12	5	1.24
	2	1.299	10	0	0.00
50	1	1.1499	12	8	1.1992
	2	1.299	10	0	0.00
49	1	1.3499	12	0	0.00
	2	1.10	12	9	0.90
45	1	1.30	12	4	1.20
	2	1.45	10	0	0.00

40	1	1.0799	12	10	0.799
	2	1.50	10	0	0.00
35	1	1.1499	12	0	0.00
	2	1.04	12	11	0.44
30	1	1.35	12	0	0.00
	2	1.25	10	5	1.25
25	1	1.1499	12	8	1.1992
	2	1.60	9	0	0.00
20	1	1.148	12	8	1.184
	2	1.45	10	0	0.00
15	1	1.055	12	10	0.55
	2	1.10	12	0	0.00
10	1	1.10	12	9	0.90
	2	1.15	12	0	0.00
5	1	1.20	12	0	0.00
	2	1.15	12	8	1.20

Copy 15

period	firm	price	qty offered	qty sold	profit
82	1	$ 1.24	12	3	$ 0.72
	2	1.24	8	3	0.72
81	1	1.24	12	3	0.72
	2	1.24	8	3	0.72
80	1	1.25	12	3	0.75
	2	1.25	8	2	0.50
79	1	1.24	12	6	1.44
	2	1.25	8	0	0.00
78	1	1.25	12	0	0.00
	2	1.24	8	6	1.44
77	1	1.29	12	2	0.58
	2	1.29	6	2	0.58
76	1	1.24	12	6	1.44
	2	1.29	10	0	0.00
75	1	1.24	12	3	0.72
	2	1.24	8	3	0.72
74	1	1.24	12	3	0.72
	2	1.24	8	3	0.72
73	1	1.24	12	3	0.72
	2	1.24	8	3	0.72
70	1	1.24	12	3	0.72
	2	1.24	9	3	0.72

65	1	1.16	12	5	0.80
	2	1.16	6	3	0.48
60	1	1.16	12	8	1.28
	2	1.19	8	0	0.00
55	1	1.12	12	9	1.08
	2	1.17	9	0	0.00
50	1	1.17	12	7	1.19
	2	1.35	6	0	0.00
45	1	1.12	12	5	0.60
	2	1.12	9	4	0.48
40	1	1.13	12	8	1.04
	2	1.20	8	0	0.00
35	1	1.24	12	3	0.72
	2	1.24	12	3	0.72
30	1	1.22	12	6	1.32
	2	1.23	12	0	0.00
25	1	1.24	12	6	1.44
	2	1.30	12	0	0.00
20	1	1.22	12	6	1.32
	2	1.25	12	0	0.00
15	1	1.20	12	0	0.00
	2	1.18	10	7	1.26
10	1	1.18	12	7	1.26
	2	1.20	12	0	0.00
5	1	1.28	12	0	0.00
	2	1.25	12	5	1.25

2slrs;mto;d;02 -- a=1, b=.5 (M=0.74, PC=0.50); 2 sellers; cost for first unit for each seller was $0.45

Copy 6 -- experienced subjects

period	firm	price	qty offered	qty sold	profit
131*	1	$ 0.58	12	5	$ 0.45
	2	0.58	12	5	0.45
120	1	0.57	12	5	0.40
	2	0.57	12	5	0.40
115	1	0.57	12	5	0.40
	2	0.57	12	5	0.40
110	1	0.55	12	5	0.30
	2	0.55	12	5	0.30

105	1	0.55	12	5	0.30
	2	0.55	12	5	0.30
100	1	0.53	11	5	0.20
	2	0.53	12	6	0.23
95	1	0.55	12	6	0.35
	2	0.55	12	4	0.25
90	1	0.55	11	5	0.30
	2	0.55	11	5	0.30
85	1	0.53	11	5	0.20
	2	0.53	11	6	0.23
80	1	0.53	11	5	0.20
	2	0.53	11	6	0.23
75	1	0.53	11	5	0.20
	2	0.53	11	6	0.23
70	1	0.53	11	5	0.20
	2	0.53	11	6	0.23
65	1	0.55	11	0	0.00
	2	0.53	12	11	0.38
60	1	0.5099	11	11	0.1589
	2	0.51	11	0	0.00
55	1	0.51	11	5	0.10
	2	0.51	11	6	0.11
50	1	0.60	11	0	0.00
	2	0.55	12	10	0.55
45	1	0.55	11	11	0.05
	2	0.52	11	0	0.00
40	1	2.00	2	0	0.00
	2	0.53	12	11	0.38
35	1	0.51	11	0	0.00
	2	0.50	11	11	0.05
30	1	1.00	11	0	0.00
	2	3.00	11	0	0.00
25	1	0.51	11	5	0.10
	2	0.51	11	6	0.11
20	1	0.52	11	0	0.00
	2	0.50	12	11	0.05
15	1	0.52	10	10	0.25
	2	0.53	12	1	0.08
10	1	0.55	11	0	0.00
	2	0.50	12	11	0.05
5	1	12.00	12	0	0.00
	2	0.50	12	11	0.05

Copy 7

period	firm	price	qty offered	qty sold	profit
120	1	$ 0.65	12	0	$ 0.00
	2	0.60	10	9	0.95
119	1	0.75	12	0	0.00
	2	0.55	10	10	0.55
118	1	0.57	12	10	0.75
	2	0.58	10	0	0.00
117	1	0.62	12	0	0.00
	2	0.60	10	9	0.95
116	1	0.65	12	8	1.25
	2	0.70	8	0	0.00
115	1	0.75	12	5	1.30
	2	1.00	6	0	0.00
114	1	0.60	12	3	0.35
	2	0.54	6	6	0.29
113	1	0.64	12	0	0.00
	2	0.57	9	9	0.68
112	1	0.64	12	0	0.00
	2	0.62	10	9	1.13
111	1	0.65	12	8	1.25
	2	0.999	9	0	0.00
110	1	0.55	12	10	0.55
	2	0.60	6	0	0.00
105	1	0.55	12	5	0.30
	2	0.55	10	5	0.30
100	1	0.65	12	8	1.25
	2	0.70	12	0	0.00
95	1	0.60	12	0	0.00
	2	0.59	11	9	0.86
90	1	0.55	12	10	0.55
	2	1.05	3	0	0.00
85	1	0.60	12	0	0.00
	2	0.57	12	10	0.75
80	1	0.64	12	8	1.17
	2	0.65	12	0	0.00
75	1	0.54	12	11	0.49
	2	0.76	4	0	0.00
70	1	0.65	12	8	1.25
	2	0.77	12	0	0.00
65	1	0.65	12	8	1.25
	2	0.66	10	0	0.00

60	1	0.60	12	0	0.00
	2	0.54	9	9	0.41
55	1	0.52999	12	0	0.00
	2	0.52	12	11	0.27
50	1	0.55	12	10	0.55
	2	0.60	10	0	0.00
45	1	0.60	12	0	0.00
	2	0.54	12	11	0.49
40	1	0.60	12	4	0.45
	2	0.60	12	5	0.55
35	1	0.54	12	11	0.49
	2	0.55	12	0	0.00
30	1	0.55	12	0	0.00
	2	0.54	11	11	0.49
25	1	0.54	12	11	0.49
	2	0.56	12	0	0.00
20	1	0.55	12	5	0.30
	2	0.55	12	5	0.30
15	1	0.53	12	11	0.38
	2	0.55	10	0	0.00
10	1	0.59	12	0	0.00
	2	0.55	10	10	0.55
5	1	0.65	12	0	0.00
	2	0.60	12	9	0.95

Copy 8 -- experienced subjects

period	firm	price	qty offered	qty sold	profit
116	1	$ 0.63	12	8	$ 1.09
	2	0.65	12	0	0.00
115	1	0.50	12	5	0.05
	2	0.50	12	6	0.05
114	1	0.50	12	5	0.05
	2	0.50	12	6	0.05
113	1	0.61	12	0	0.00
	2	0.60	12	9	0.95
112	1	0.63	12	8	1.09
	2	0.65	12	0	0.00
111	1	0.50	12	11	0.05
	2	0.65	12	0	0.00
110	1	0.50	12	5	0.05
	2	0.50	12	6	0.05

109	1	0.50	12	5	0.05
	2	0.50	12	6	0.05
108	1	0.64	12	0	0.00
	2	0.59	12	9	0.86
107	1	0.63	12	8	1.09
	2	0.65	12	0	0.00
105	1	0.65	12	0	0.00
	2	0.50	12	11	0.05
100	1	0.50	12	5	0.05
	2	0.50	12	6	0.05
95	1	0.62	12	9	1.13
	2	0.65	12	0	0.00
90	1	0.50	12	5	0.05
	2	0.50	12	6	0.05
85	1	0.63	12	8	1.09
	2	0.65	12	0	0.00
80	1	0.62	12	9	1.13
	2	0.65	12	0	0.00
75	1	0.70	12	0	0.00
	2	0.50	12	11	0.05
70	1	0.64	12	0	0.00
	2	0.50	12	11	0.05
65	1	0.62	12	0	0.00
	2	0.50	12	11	0.05
60	1	0.70	12	0	0.00
	2	0.65	12	8	1.25
55	1	0.74	12	0	0.00
	2	0.50	12	11	0.05
50	1	0.69	12	7	1.38
	2	0.75	12	0	0.00
45	1	0.64	12	8	1.17
	2	0.70	12	0	0.00
40	1	0.64	12	8	1.17
	2	0.65	12	0	0.00
35	1	0.69	12	0	0.00
	2	0.49	12	11	-0.06
30	1	0.60	12	9	0.95
	2	0.65	12	0	0.00
25	1	0.67	12	0	0.00
	2	0.50	12	11	0.05
20	1	0.65	12	0	0.00
	2	0.50	12	11	0.05

15	1	0.58	12	10	0.85
	2	0.70	12	0	0.00
10	1	0.50	12	5	0.05
	2	0.50	12	6	0.05
5	1	1.25	12	0	0.00
	2	0.60	12	9	0.95

Copy 9

period	firm	price	qty offered	qty sold	profit
69*	1	$ 0.65	12	4	$ 0.65
	2	0.65	12	4	0.65
55	1	0.65	12	0	0.00
	2	0.63	12	8	1.25
50	1	0.65	12	4	0.65
	2	0.65	12	4	0.65
45	1	0.65	12	8	1.09
	2	0.69	12	0	0.00
40	1	0.70	12	3	0.65
	2	0.70	12	4	0.85
35	1	0.65	12	4	0.65
	2	0.65	12	4	0.65
30	1	0.58	12	0	0.00
	2	0.57	12	10	0.75
25	1	0.70	12	3	0.65
	2	0.70	12	4	0.85
20	1	0.65	12	4	0.65
	2	0.65	12	4	0.65
15	1	0.70	12	0	0.00
	2	0.55	12	10	0.55
10	1	0.57	12	10	0.75
	2	0.58	12	0	0.00
5	1	1.00	12	0	0.00
	2	3.00	12	0	0.00

Copy 10

period	firm	price	qty offered	qty sold	profit
52	1	$ 0.80	10	0	$ 0.00
	2	0.70	12	7	1.45
51	1	0.70	10	7	1.45
	2	0.80	12	0	0.00
50	1	0.80	10	0	0.00
	2	0.70	12	7	1.45

49	1	0.70	10	7	1.45
	2	0.80	12	0	0.00
48	1	0.80	10	0	0.00
	2	0.70	12	7	1.45
47	1	0.70	10	7	1.45
	2	0.80	12	0	0.00
46	1	0.80	10	0	0.00
	2	0.70	12	7	1.45
45	1	0.70	10	7	1.45
	2	0.80	12	0	0.00
44	1	0.80	10	0	0.00
	2	0.70	12	7	1.45
43	1	0.70	10	7	1.45
	2	0.80	12	0	0.00
40	1	0.80	10	0	0.00
	2	0.70	12	7	1.45
35	1	0.70	10	7	1.45
	2	0.80	12	0	0.00
30	1	0.80	10	0	0.00
	2	0.70	12	7	1.45
25	1	0.80	10	0	0.00
	2	0.70	12	7	1.45
20	1	0.80	10	0	0.00
	2	0.70	12	7	1.45
15	1	0.70	10	7	1.45
	2	0.80	12	0	0.00
10	1	0.70	10	3	0.65
	2	0.70	12	4	0.85
5	1	0.84	5	0	0.00
	2	0.75	12	5	1.30

2slrs;mto;d;03 -- a=1, b=1 (M=\$1.24, PC=\$1.00); 2 sellers; cost of first unit for each seller was \$0.95; market demand information provided

Copy 1

period	firm	price	qty offered	qty sold	profit
127	1	\$ 1.16	12	8	\$ 1.33
	2	1.17	12	0	0.00

126	1	1.16	12	4	0.69
	2	1.16	12	4	0.69
125	1	1.16	12	4	0.69
	2	1.16	12	4	0.69
124	1	1.16	12	4	0.69
	2	1.16	12	4	0.69
123	1	1.16	12	4	0.69
	2	1.16	12	4	0.69
122	1	1.16	12	4	0.69
	2	1.16	12	4	0.69
121	1	1.16	12	4	0.69
	2	1.16	12	4	0.69
120	1	1.16	12	4	0.69
	2	1.16	12	4	0.69
119	1	1.16	12	4	0.69
	2	1.16	12	4	0.69
118	1	1.16	12	8	1.33
	2	1.166	12	0	0.00
115	1	1.15	12	8	1.25
	2	1.16	12	0	0.00
110	1	1.16	12	8	1.33
	2	1.35	12	0	0.00
105	1	1.16	12	0	0.00
	2	1.10	12	9	0.95
100	1	1.16	12	4	0.69
	2	1.16	12	4	0.69
95	1	1.06	12	10	0.65
	2	1.16	12	0	0.00
90	1	1.15	12	0	0.00
	2	1.14	12	8	1.17
85	1	1.15	12	0	0.00
	2	1.10	12	9	0.95
80	1	1.16	12	0	0.00
	2	1.10	12	9	0.95
75	1	1.10	12	9	0.95
	2	1.16	12	0	0.00
70	1	1.16	12	0	0.00
	2	1.07	12	10	0.75
65	1	1.20	12	7	1.45
	2	1.35	12	0	0.00
60	1	1.039	12	11	0.479
	2	1.16	12	0	0.00

55	1	1.17	12	7	1.24
	2	1.40	12	0	0.00
50	1	1.02	12	11	0.27
	2	1.03	12	0	0.00
45	1	1.03	12	5	0.20
	2	1.03	12	6	0.23
40	1	1.0478	12	10	0.528
	2	1.09	12	0	0.00
35	1	1.18	12	3	0.59
	2	1.18	12	4	0.77
30	1	1.08	12	10	0.85
	2	1.40	12	0	0.00
25	1	1.20	12	0	0.00
	2	1.15	12	8	1.25
20	1	1.30	12	0	0.00
	2	1.20	12	7	1.45
15	1	1.20	12	0	0.00
	2	1.15	12	8	1.25
10	1	1.20	12	3	0.65
	2	1.20	12	4	0.85
5	1	1.20	12	0	0.00
	2	1.00	12	11	0.05

Copy 2

period	firm	price	qty offered	qty sold	profit
139	1	$ 1.09	12	9	$ 0.86
	2	1.12	12	0	0.00
138	1	1.17	12	0	0.00
	2	1.10	12	9	0.95
137	1	1.08	12	10	0.85
	2	1.10	12	0	0.00
136	1	1.09	12	9	0.86
	2	1.11	12	0	0.00
135	1	1.07	12	10	0.75
	2	1.13	12	0	0.00
134	1	1.12	12	9	1.13
	2	1.13	12	0	0.00
133	1	1.17	12	7	1.24
	2	1.20	12	0	0.00
132	1	1.06	12	10	0.65
	2	1.10	12	0	0.00

131	1	1.08	12	10	0.85
	2	1.10	12	0	0.00
130	1	1.10	12	9	0.95
	2	1.12	12	0	0.00
125	1	1.11	12	0	0.00
	2	1.10	12	9	0.95
120	1	1.12	12	0	0.00
	2	1.10	12	9	0.95
115	1	1.20	12	0	0.00
	2	1.13	12	8	1.09
110	1	1.15	12	0	0.00
	2	1.10	12	9	0.95
105	1	1.09	12	9	0.86
	2	1.10	12	0	0.00
100	1	1.07	12	10	0.75
	2	1.09	12	0	0.00
95	1	1.08	12	10	0.85
	2	1.13	12	0	0.00
90	1	1.13	12	8	1.09
	2	1.15	12	0	0.00
85	1	1.14	12	0	0.00
	2	1.10	12	9	0.95
80	1	1.20	12	0	0.00
	2	1.10	12	9	0.95
75	1	1.09	12	9	0.86
	2	1.11	12	0	0.00
70	1	1.10	12	9	0.95
	2	1.13	12	0	0.00
65	1	1.09	12	9	0.86
	2	1.10	12	0	0.00
60	1	3.55	12	0	0.00
	2	1.13	12	8	1.09
55	1	1.15	12	0	0.00
	2	1.10	12	9	0.95
50	1	1.15	12	4	0.65
	2	1.15	12	4	0.65
45	1	1.25	12	0	0.00
	2	1.166	12	7	1.212
40	1	1.50	12	0	0.00
	2	1.16	12	8	1.33
35	1	1.15	12	4	0.65
	2	1.15	12	4	0.65

30	1	1.50	12	0	0.00
	2	1.16	12	8	1.33
25	1	1.25	12	0	0.00
	2	1.17	12	7	1.24
20	1	1.20	12	0	0.00
	2	1.17	12	7	1.24
15	1	1.30	12	0	0.00
	2	1.09	12	9	0.86
10	1	1.30	12	0	0.00
	2	1.05	12	10	0.55
5	1	1.05	12	0	0.00
	2	1.00	12	11	0.05

Copy 3

period	firm	price	qty offered	qty sold	profit
81	1	$ 8.88	12	0	$ 0.00
	2	1.30	12	4	1.25
80	1	1.25	12	5	1.30
	2	7.77	12	0	0.00
79	1	6.66	12	0	0.00
	2	1.24	12	6	1.49
78	1	1.22	12	6	1.37
	2	9.99	12	0	0.00
77	1	8.88	12	0	0.00
	2	1.14	12	8	1.17
76	1	1.18	12	7	1.31
	2	4.54	12	0	0.00
75	1	1.07	12	10	0.75
	2	1.08	12	0	0.00
74	1	1.08	12	0	0.00
	2	1.00	12	11	0.05
73	1	1.05	12	0	0.00
	2	1.04	12	11	0.49
72	1	1.10	12	9	0.95
	2	1.14	12	0	0.00
70	1	1.10	12	9	0.95
	2	1.13	12	0	0.00
65	1	1.15	12	8	1.25
	2	1.31	12	0	0.00
60	1	1.10	12	9	0.95
	2	1.11	12	0	0.00

55	1	1.25	12	0	0.00
	2	1.12	12	9	1.13
50	1	1.25	12	0	0.00
	2	1.04	12	11	0.49
45	1	1.10	12	9	0.95
	2	1.19	12	0	0.00
40	1	1.15	12	0	0.00
	2	1.14	12	8	1.17
35	1	1.30	12	0	0.00
	2	1.28	12	5	1.45
30	1	1.25	12	0	0.00
	2	1.24	12	6	1.49
25	1	1.15	12	8	1.25
	2	1.45	12	0	0.00
20	1	3.00	12	0	0.00
	2	1.05	12	10	0.55
15	1	1.25	12	5	1.30
	2	2.50	12	0	0.00
10	1	1.05	12	10	0.55
	2	2.50	3	0	0.00
5	1	1.25	12	0	0.00
	2	1.10	12	9	0.95

Copy 4

period	firm	price	qty offered	qty sold	profit
77	1	$ 1.35	12	0	$ 0.00
	2	1.10	8	8	0.85
76	1	1.40	12	0	0.00
	2	1.03	11	11	0.38
75	1	1.55	12	0	0.00
	2	1.05	11	10	0.55
74	1	1.20	12	0	0.00
	2	1.08	11	10	0.85
73	1	1.20	12	0	0.00
	2	1.09	12	9	0.86
72	1	1.20	12	1	0.25
	2	1.18	6	6	1.13
71	1	1.17	12	0	0.00
	2	1.08	11	10	0.85
70	1	1.20	12	0	0.00
	2	1.11	11	9	1.04

69	1	1.15	12	8	1.25
	2	1.17	5	0	0.00
68	1	1.10	12	5	0.55
	2	1.10	7	4	0.45
65	1	1.03	12	5	0.20
	2	1.03	11	6	0.23
60	1	1.19	4	0	0.00
	2	1.17	8	7	1.24
55	1	1.16	3	3	0.53
	2	1.16	5	5	0.85
50	1	1.16	4	0	0.00
	2	1.08	8	8	0.69
45	1	1.20	6	0	0.00
	2	1.05	10	10	0.55
40	1	1.08	6	0	0.00
	2	1.03	10	10	0.35
35	1	1.05	12	10	0.55
	2	1.09	9	0	0.00
30	1	1.08	10	0	0.00
	2	1.03	10	10	0.35
25	1	1.06	5	5	0.35
	2	1.15	4	3	0.50
20	1	1.10	8	8	0.85
	2	1.11	5	1	0.16
15	1	1.03	12	5	0.20
	2	1.03	11	6	0.23
10	1	1.04	12	5	0.25
	2	1.04	11	6	0.29
5	1	1.14	12	8	1.17
	2	1.17	5	0	0.00

2slrs;mto;d;04 -- a=1, b=1 (M=\$1.24, PC=\$1.00); 2 sellers; one half the number of units demanded at each price; market demand information provided

Copy 1 -- experienced subjects

period	firm	price	qty offered	qty sold	profit
37*	1	\$ 1.16	6	2	\$ 0.32
	2	1.16	6	2	0.32
25	1	1.16	6	2	0.32
	2	1.16	6	2	0.32

20	1	1.16	6	2	0.32
	2	1.16	6	2	0.32
15	1	1.16	6	2	0.32
	2	1.16	6	2	0.32
10	1	1.16	6	2	0.32
	2	1.16	6	2	0.32
5	1	1.16	6	2	0.32
	2	1.16	6	2	0.32

Copy 2

period	firm	price	qty offered	qty sold	profit
49	1	$ 1.16	6	2	$ 0.32
	2	1.16	6	2	0.32
48	1	1.16	6	2	0.32
	2	1.16	6	2	0.32
47	1	1.16	6	2	0.32
	2	1.16	6	2	0.32
46	1	1.16	6	2	0.32
	2	1.16	6	2	0.32
45	1	1.16	6	2	0.32
	2	1.16	6	2	0.32
44	1	1.16	6	2	0.32
	2	1.16	6	2	0.32
43	1	1.16	6	2	0.32
	2	1.16	6	2	0.32
42	1	1.16	6	2	0.32
	2	1.16	6	2	0.32
41	1	1.16	6	3	0.48
	2	1.16	2	1	0.16
40	1	1.16	6	2	0.32
	2	1.16	6	2	0.32
35	1	1.16	6	2	0.32
	2	1.16	6	2	0.32
30	1	1.16	6	2	0.32
	2	1.16	6	2	0.32
25	1	1.17	6	1	0.17
	2	1.17	6	2	0.34
20	1	1.15	6	2	0.30
	2	1.15	6	2	0.30
15	1	1.15	6	4	0.60
	2	1.16	6	0	0.00

10	1	1.15	6	0	0.00
	2	0.16	6	5	-4.20
5	1	1.20	6	3	0.60
	2	1.25	6	0	0.00

Copy 3 -- experienced subjects

period	firm	price	qty offered	qty sold	profit
40*	1	$ 1.16	6	2	$ 0.32
	2	1.16	6	2	0.32
30	1	1.16	6	2	0.32
	2	1.16	6	2	0.32
25	1	1.17	6	0	0.00
	2	1.16	6	4	0.64
20	1	1.15	6	2	0.30
	2	1.15	6	2	0.30
15	1	1.15	6	2	0.30
	2	1.15	6	2	0.30
10	1	1.15	6	2	0.30
	2	1.15	6	2	0.30
5	1	1.10	6	0	0.00
	2	1.05	6	5	0.25

Copy 4

period	firm	price	qty offered	qty sold	profit
70*	1	$ 1.16	6	2	$ 0.32
	2	1.16	6	2	0.32
60	1	1.16	6	2	0.32
	2	1.16	6	2	0.32
55	1	1.16	6	2	0.32
	2	1.16	6	2	0.32
50	1	1.16	6	2	0.32
	2	1.16	6	2	0.32
45	1	1.16	6	2	0.32
	2	1.16	6	2	0.32
40	1	1.16	6	2	0.32
	2	1.16	6	2	0.32
35	1	1.15	6	4	0.60
	2	2.00	6	0	0.00
30	1	1.16	6	2	0.32
	2	1.16	6	2	0.32
25	1	1.16	6	2	0.32
	2	1.16	6	2	0.32

20	1	1.16	6	2	0.32
	2	1.16	6	2	0.32
15	1	1.16	6	2	0.32
	2	1.16	6	2	0.32
10	1	1.14	6	4	0.56
	2	1.15	6	0	0.00
5	1	1.05	6	5	0.25
	2	1.09	6	0	0.00

2slrs;mto;d;05 -- a=1, b=1 (M=$1.24, PC=$1.00); 2 sellers; cost for first unit for each seller was $0.95; market demand information provided

Copy 1 -- experienced subjects

period	firm	price	qty offered	qty sold	profit
13	1	$ 1.24	10	3	$ 0.77
	2	1.24	10	3	0.77
12	1	1.24	10	3	0.77
	2	1.24	10	3	0.77
11	1	1.24	10	3	0.77
	2	1.24	10	3	0.77
10	1	1.24	10	3	0.77
	2	1.24	10	3	0.77
9	1	1.24	10	3	0.77
	2	1.24	10	3	0.77
8	1	1.24	10	3	0.77
	2	1.24	10	3	0.77
7	1	1.24	10	3	0.77
	2	1.24	10	3	0.77
6	1	1.24	10	3	0.77
	2	1.24	10	3	0.77
5	1	1.24	10	3	0.77
	2	1.24	10	3	0.77
4	1	1.19	10	7	1.38
	2	1.24	10	0	0.00

Copy 2

period	firm	price	qty offered	qty sold	profit
18*	1	$ 1.16	12	4	$ 0.69
	2	1.16	12	4	0.69
5	1	1.16	12	0	0.00
	2	1.15	12	8	1.25

Copy 3 -- experienced subjects

period	firm	price	qty offered	qty sold	profit
22*	1	$ 1.16	12	4	$ 0.69
	2	1.16	12	4	0.69
10	1	1.16	12	8	1.33
	2	1.18	12	0	0.00
5	1	1.16	12	4	0.69
	2	1.16	12	4	0.69

Copy 4

period	firm	price	qty offered	qty sold	profit
65*	1	$ 1.16	12	4	$ 0.69
	2	1.16	12	4	0.69
55	1	1.16	12	4	0.69
	2	1.16	12	4	0.69
50	1	1.16	12	4	0.69
	2	1.16	12	4	0.69
45	1	1.16	12	4	0.69
	2	1.16	12	4	0.69
40	1	1.16	12	0	0.00
	2	1.15	12	8	1.25
35	1	1.16	12	4	0.69
	2	1.16	12	4	0.69
30	1	1.10	12	9	0.95
	2	1.13	12	0	0.00
25	1	1.16	12	0	0.00
	2	1.15	12	8	1.25
20	1	1.16	12	0	0.00
	2	1.13	12	8	1.09
15	1	1.16	12	7	1.17
	2	1.15	1	1	0.20
10	1	1.13	12	8	1.09
	2	1.95	12	0	0.00
5	1	1.20	12	7	1.45
	2	1.25	12	0	0.00

2slrs;mto;d;06 -- a=1, b=1 (M=\$1.24, PC=\$1.00); 2 sellers; cost for first unit for each seller was \$0.95; market demand information provided; 101 period lag before getting rival's choices

Copy 1

period	firm	price	qty offered	qty sold	profit
106	1	\$ 1.05	12	10	\$ 0.55
	2	1.07	11	0	0.00
105	1	1.05	12	10	0.55
	2	1.08	11	0	0.00
104	1	1.09	12	0	0.00
	2	1.07	11	10	0.75
103	1	1.20	12	0	0.00
	2	1.06	11	10	0.65
102	1	1.25	12	0	0.00
	2	1.05	12	10	0.55
101	1	1.25	12	0	0.00
	2	1.05	12	10	0.55
100	1	1.06	12	0	0.00
	2	1.05	12	10	0.55
99	1	1.06	12	10	0.65
	2	1.15	12	0	0.00
98	1	1.06	12	10	0.65
	2	1.07	11	0	0.00
97	1	1.08	12	0	0.00
	2	1.05	11	10	0.55
95	1	1.16	12	0	0.00
	2	1.04	12	11	0.49
90	1	1.07	12	10	0.75
	2	1.10	10	0	0.00
85	1	1.07	12	0	0.00
	2	1.05	11	10	0.55
80	1	1.15	12	0	0.00
	2	1.05	12	10	0.55
75	1	1.20	12	0	0.00
	2	1.08	12	10	0.85
70	1	1.12	12	0	0.00
	2	1.10	12	9	0.95
65	1	1.07	12	10	0.75
	2	1.10	8	0	0.00

60	1	1.21	12	0	0.00
	2	1.15	8	8	1.25
55	1	1.09	12	0	0.00
	2	1.05	12	10	0.55
50	1	1.18	12	0	0.00
	2	1.05	12	10	0.55
45	1	10.5	12	5	0.30
	2	1.05	12	5	0.30
40	1	1.07	12	10	0.75
	2	1.15	6	0	0.00
35	1	1.20	12	3	0.65
	2	1.15	4	4	0.65
30	1	1.011	12	0	0.00
	2	1.00	12	11	0.05
25	1	1.01	12	11	0.16
	2	1.02	12	0	0.00
20	1	1.00	12	11	0.05
	2	1.10	9	0	0.00
15	1	1.07	12	10	0.75
	2	1.10	9	0	0.00
10	1	1.14	12	0	0.00
	2	1.10	9	9	0.95
5	1	1.15	12	8	1.25
	2	1.20	7	0	0.00

Copy 2

period	firm	price	qty offered	qty sold	profit
121	1	$ 1.07	3	0	$ 0.00
	2	1.06	11	10	0.65
120	1	1.06	5	5	0.35
	2	1.07	12	5	0.40
119	1	1.07	10	0	0.00
	2	1.06	12	10	0.65
118	1	1.08	7	3	0.29
	2	1.08	12	7	0.61
117	1	1.10	4	0	0.00
	2	1.07	12	10	0.75
116	1	1.08	5	5	0.45
	2	1.09	12	4	0.41
115	1	1.096	6	0	0.00
	2	1.09	12	9	0.86

114	1	1.10	5	0	0.00
	2	1.08	12	10	0.85
113	1	1.09	5	5	0.50
	2	1.10	12	4	0.45
112	1	1.10	4	2	0.25
	2	1.10	12	7	0.75
110	1	1.11	2	0	0.00
	2	1.10	12	9	0.95
105	1	1.14	4	0	0.00
	2	1.12	12	9	1.13
100	1	1.11	12	4	0.49
	2	1.11	12	5	0.60
95	1	1.04	5	5	0.25
	2	1.12	12	4	0.53
90	1	1.02	4	2	0.09
	2	1.02	12	9	0.23
85	1	1.00	2	1	0.05
	2	0.99	10	10	-0.05
80	1	0.9999	12	11	0.0489
	2	1.00	11	0	0.00
75	1	1.00	12	5	0.05
	2	1.00	12	6	0.05
70	1	1.008	12	11	0.138
	2	1.01	12	0	0.00
65	1	1.008	10	10	0.13
	2	1.01	12	1	0.06
60	1	1.00	4	4	0.05
	2	1.01	12	7	0.12
55	1	1.00	12	11	0.05
	2	1.01	12	0	0.00
50	1	1.01	12	11	0.16
	2	1.02	11	0	0.00
45	1	1.01	10	5	0.10
	2	1.01	12	6	0.11
40	1	1.01	12	5	0.10
	2	1.01	12	6	0.11
35	1	1.01	12	5	0.10
	2	1.01	12	6	0.11
30	1	1.00	10	10	0.05
	2	1.02	12	1	0.07
25	1	1.03	12	0	0.00
	2	1.02	12	11	0.27

20	1	1.04	10	4	0.21
	2	1.03	7	7	0.26
15	1	1.11	10	0	0.00
	2	1.06	12	10	0.65
10	1	1.19	7	0	0.00
	2	1.10	12	9	0.95
5	1	1.30	3	0	0.00
	2	1.09	12	9	0.86

Copy 3

period	firm	price	qty offered	qty sold	profit
118	1	$ 1.01	12	11	$ 0.16
	2	1.02	12	0	0.00
117	1	1.02	12	5	0.15
	2	1.02	12	6	0.17
116	1	1.02	12	5	0.15
	2	1.02	12	6	0.17
115	1	1.02	12	5	0.15
	2	1.02	12	6	0.17
114	1	1.01	12	5	0.10
	2	1.01	11	6	0.11
113	1	1.01	12	5	0.10
	2	1.01	12	6	0.11
112	1	1.01	12	5	0.10
	2	1.01	12	6	0.11
111	1	1.02	12	0	0.00
	2	1.01	12	11	0.16
110	1	1.01	12	11	0.16
	2	1.02	12	0	0.00
109	1	1.01	12	11	0.16
	2	1.02	12	0	0.00
105	1	1.02	12	5	0.15
	2	1.02	12	6	0.17
100	1	1.01	12	5	0.10
	2	1.01	12	6	0.11
95	1	1.01	12	0	0.00
	2	0.01	12	11	-10.84
90	1	1.02	12	0	0.00
	2	1.01	12	11	0.16
85	1	1.00	12	11	0.05
	2	1.01	12	0	0.00

80	1	1.01	12	5	0.10
	2	1.01	12	6	0.11
75	1	1.01	12	5	0.10
	2	1.01	12	6	0.11
70	1	1.01	12	10	0.15
	2	1.00	1	1	0.05
65	1	1.01	12	11	0.16
	2	1.02	11	0	0.00
60	1	1.02	12	11	0.27
	2	1.03	10	0	0.00
55	1	1.02	12	5	0.15
	2	1.02	12	6	0.17
50	1	1.02	12	5	0.15
	2	1.02	11	6	0.17
45	1	1.03	12	0	0.00
	2	1.02	11	11	0.27
40	1	1.02	12	5	0.15
	2	1.02	12	6	0.17
35	1	1.03	12	11	0.38
	2	1.06	8	0	0.00
30	1	1.03	12	6	0.23
	2	1.03	10	5	0.20
25	1	1.03	12	11	0.38
	2	1.04	11	0	0.00
20	1	1.03	12	11	0.38
	2	1.05	10	0	0.00
15	1	1.03	10	10	0.35
	2	1.075	5	0	0.00
10	1	1.05	12	10	0.55
	2	1.10	8	0	0.00
5	1	1.09	12	9	0.86
	2	1.20	10	0	0.00

Copy 4

period	firm	price	qty offered	qty sold	profit
139	1	$ 1.08	6	6	$ 0.53
	2	1.11	10	3	0.38
138	1	1.08	4	4	0.37
	2	1.09	8	5	0.50
137	1	1.085	8	1	0.135
	2	1.07	8	8	0.61

136	1	1.085	8	8	0.73
	2	1.10	5	1	0.15
135	1	1.085	8	8	0.73
	2	1.10	10	1	0.15
134	1	1.085	8	8	0.73
	2	1.15	5	0	0.00
133	1	1.085	8	8	0.73
	2	1.11	10	1	0.16
132	1	1.085	8	8	0.73
	2	1.11	8	1	0.16
131	1	1.085	8	8	0.73
	2	1.10	9	1	0.15
130	1	1.085	8	8	0.73
	2	1.10	9	1	0.15
125	1	1.085	5	5	0.475
	2	1.13	7	3	0.44
120	1	1.095	8	1	0.145
	2	1.09	8	8	0.77
115	1	1.095	7	7	0.715
	2	1.15	10	1	0.20
110	1	1.118	6	0	0.00
	2	1.11	9	9	1.04
105	1	1.115	6	6	0.74
	2	1.20	10	1	0.25
100	1	1.13	6	6	0.83
	2	1.16	10	2	0.37
95	1	1.20	4	0	0.00
	2	1.15	10	8	1.25
90	1	1.07	5	5	0.40
	2	1.10	4	4	0.45
85	1	1.01	12	6	0.11
	2	1.01	10	5	0.10
80	1	1.099	12	0	0.00
	2	1.02	10	10	0.25
75	1	1.015	12	11	0.215
	2	1.02	10	0	0.00
70	1	1.03	12	6	0.23
	2	1.03	10	5	0.20
65	1	1.01	12	10	0.15
	2	1.00	1	1	0.05
60	1	1.003	12	10	0.08
	2	1.00	1	1	0.05

55	1	1.0027	12	10	0.077
	2	1.00	1	1	0.05
50	1	1.0025	12	10	0.075
	2	1.00	1	1	0.05
45	1	1.002	12	10	0.07
	2	1.00	1	1	0.05
40	1	1.002	12	11	0.072
	2	1.01	1	0	0.00
35	1	1.003	12	10	0.08
	2	0.99	1	1	0.04
30	1	1.005	12	11	0.105
	2	1.01	5	0	0.00
25	1	1.09	12	0	0.00
	2	1.00	12	11	0.05
20	1	1.01	12	11	0.16
	2	1.02	11	0	0.00
15	1	1.00	12	11	0.05
	2	1.02	10	0	0.00
10	1	1.05	12	5	0.30
	2	1.05	12	5	0.30
5	1	1.16	12	0	0.00
	2	1.05	12	10	0.55

Copy 5

period	firm	price	qty offered	qty sold	profit
119	1	$ 1.10	4	3	$ 0.35
	2	1.10	7	6	0.65
118	1	1.10	4	3	0.35
	2	1.10	7	6	0.65
117	1	1.10	4	3	0.35
	2	1.10	7	6	0.65
116	1	1.10	4	3	0.35
	2	1.10	7	6	0.65
115	1	1.10	4	3	0.35
	2	1.10	7	6	0.65
114	1	1.10	4	3	0.35
	2	1.10	7	6	0.65
113	1	1.10	4	3	0.35
	2	1.10	6	6	0.65
112	1	1.10	4	3	0.35
	2	1.10	6	6	0.65

111	1	1.10	4	3	0.35
	2	1.10	7	6	0.65
110	1	1.10	4	3	0.35
	2	1.10	8	6	0.65
105	1	1.05	10	4	0.25
	2	1.05	12	6	0.35
100	1	1.20	3	2	0.45
	2	1.10	5	5	0.55
95	1	1.10	4	3	0.35
	2	1.10	6	6	0.65
90	1	1.20	3	0	0.00
	2	1.10	7	7	0.75
85	1	1.10	4	3	0.35
	2	1.10	6	6	0.65
80	1	1.10	5	3	0.35
	2	1.10	7	6	0.65
75	1	1.10	6	0	0.00
	2	1.05	11	10	0.55
70	1	1.10	3	2	0.25
	2	1.10	7	7	0.75
65	1	1.13	5	0	0.00
	2	1.10	8	8	0.85
60	1	1.10	6	4	0.45
	2	1.10	7	5	0.55
55	1	1.09	6	6	0.59
	2	1.10	5	3	0.35
50	1	1.20	5	0	0.00
	2	1.05	12	10	0.55
45	1	1.10	6	4	0.45
	2	1.10	6	5	0.55
40	1	1.07	7	5	0.40
	2	1.05	5	5	0.30
35	1	1.05	6	5	0.30
	2	1.05	5	5	0.30
30	1	1.15	5	3	0.50
	2	1.15	6	5	0.80
25	1	1.20	4	2	0.45
	2	1.10	5	5	0.55
20	1	1.10	5	5	0.55
	2	1.15	6	3	0.50
15	1	1.10	5	3	0.35
	2	1.10	7	6	0.65

10	1	1.15	6	1	0.20
	2	1.00	7	7	0.05
5	1	1.15	6	6	0.95
	2	1.20	7	1	0.25

2slrs;mto;d;07 -- *a*=4, *b*=.3 (M=$0.36, PC=$0.30); 2 sellers; cost for first unit for each seller was $0.10

Copy 1

period	firm	price	qty offered	qty sold	profit
55*	1	$ 0.31	12	5	$ 0.25
	2	0.31	12	6	0.26
45	1	0.31	12	5	0.25
	2	0.31	12	6	0.26
40	1	0.31	12	5	0.25
	2	0.31	12	6	0.26
35	1	0.31	12	5	0.25
	2	0.31	12	6	0.26
30	1	0.31	12	5	0.25
	2	0.31	12	6	0.26
25	1	0.31	12	5	0.25
	2	0.31	12	6	0.26
20	1	0.33	12	9	0.47
	2	0.34	12	0	0.00
15	1	0.30	12	11	0.20
	2	0.31	12	0	0.00
10	1	0.30	5	5	0.20
	2	0.32	12	5	0.30
5	1	0.31	6	6	0.26
	2	0.40	12	0	0.00

Copy 2

period	firm	price	qty offered	qty sold	profit
72	1	$ 0.2999	8	8	$ 0.1992
	2	0.32	9	2	0.24
71	1	0.2999	8	8	0.1992
	2	0.32	8	2	0.24
70	1	0.299	8	8	0.192
	2	0.31	8	3	0.23

69	1	0.299	8	8	0.192
	2	0.31	8	3	0.23
68	1	0.31	8	5	0.25
	2	0.31	8	6	0.26
67	1	0.30	8	8	0.20
	2	0.32	8	2	0.24
66	1	0.29	8	8	0.12
	2	0.32	9	2	0.24
65	1	0.32	8	5	0.30
	2	0.32	6	5	0.30
64	1	0.30	8	8	0.20
	2	0.34	3	0	0.00
63	1	0.30	8	8	0.20
	2	0.32	7	2	0.24
60	1	0.28	8	8	0.04
	2	0.32	8	2	0.24
55	1	0.27	5	5	0.05
	2	0.34	9	3	0.32
50	1	0.28	8	8	0.04
	2	0.35	6	0	0.00
45	1	0.29	8	3	0.17
	2	0.28	8	8	0.04
40	1	0.37	9	5	0.55
	2	0.39	7	0	0.00
35	1	0.36	8	0	0.00
	2	0.35	7	7	0.55
30	1	0.31	8	6	0.26
	2	0.31	5	5	0.25
25	1	0.30	8	8	0.20
	2	0.33	7	1	0.23
20	1	0.35	8	7	0.55
	2	0.39	8	0	0.00
15	1	0.46	8	0	0.00
	2	0.35	6	6	0.50
10	1	0.35	8	3	0.35
	2	0.35	7	4	0.40
5	1	0.80	5	0	0.00
	2	3.00	5	0	0.00

Copy 3

period	firm	price	qty offered	qty sold	profit
94	1	$ 0.303	12	11	$ 0.233
	2	0.305	12	0	0.00
93	1	0.305	12	11	0.255
	2	0.307	12	0	0.00
92	1	0.308	12	0	0.00
	2	0.30	12	11	0.20
91	1	0.30	12	11	0.20
	2	0.308	12	0	0.00
90	1	0.31	12	0	0.00
	2	0.305	12	11	0.255
89	1	0.30	12	5	0.20
	2	0.30	12	6	0.20
88	1	0.3085	12	0	0.00
	2	0.306	12	11	0.266
87	1	0.309	12	11	0.299
	2	0.3091	12	0	0.00
86	1	0.3095	12	11	0.3045
	2	0.3099	12	0	0.00
85	1	0.315	12	0	0.00
	2	0.3099	12	11	0.308899+
80	1	0.318	12	0	0.00
	2	0.316	12	10	0.36
75	1	0.3197	12	10	0.397
	2	0.3199	12	0	0.00
70	1	0.325	12	0	0.00
	2	0.3199	12	10	0.399
65	1	0.33	12	0	0.00
	2	0.32	12	10	0.40
60	1	0.33	12	4	0.32
	2	0.33	12	5	0.35
55	1	0.34	12	0	0.00
	2	0.3199	12	10	0.399
50	1	0.329	12	9	0.461
	2	0.34	12	0	0.00
45	1	0.32	12	5	0.30
	2	0.32	12	5	0.30
40	1	0.3298	12	9	0.4682
	2	0.3395	12	0	0.00
35	1	0.35	12	0	0.00
	2	0.32	12	10	0.40

30	1	0.34	12	0	0.00
	2	0.31	10	10	0.30
25	1	0.86	2	0	0.00
	2	0.3496	12	7	0.5472
20	1	0.3525	12	6	0.515
	2	0.36	7	0	0.00
15	1	0.38	12	0	0.00
	2	0.37	8	5	0.55
10	1	0.30	11	0	0.00
	2	0.31	12	11	0.31
5	1	0.40	12	2	0.40
	2	0.90	8	0	0.00

Copy 4

period	firm	price	qty offered	qty sold	profit
80	1	$ 0.32	12	10	$ 0.40
	2	0.33	12	0	0.00
79	1	0.32	12	10	0.40
	2	0.33	12	0	0.00
78	1	0.32	12	5	0.30
	2	0.32	12	5	0.30
77	1	0.32	12	10	0.40
	2	0.35	12	0	0.00
76	1	0.32	12	10	0.40
	2	0.35	12	0	0.00
75	1	0.32	12	0	0.00
	2	0.31	11	11	0.31
74	1	0.32	12	5	0.30
	2	0.32	10	5	0.30
73	1	0.32	12	10	0.40
	2	0.33	12	0	0.00
72	1	0.32	12	5	0.30
	2	0.32	10	5	0.30
71	1	0.32	12	5	0.30
	2	0.32	10	5	0.30
70	1	0.32	12	5	0.30
	2	0.32	10	5	0.30
65	1	0.33	12	5	0.35
	2	0.33	9	4	0.32
60	1	0.33	12	4	0.32
	2	0.33	12	5	0.35

55	1	0.31	12	5	0.25
	2	0.31	12	6	0.26
50	1	0.34	12	0	0.00
	2	0.33	9	9	0.47
45	1	0.33	12	5	0.35
	2	0.33	9	4	0.32
40	1	0.34	12	4	0.36
	2	0.34	8	4	0.36
35	1	0.34	12	4	0.36
	2	0.34	8	4	0.36
30	1	0.35	12	4	0.40
	2	0.35	7	3	0.35
25	1	0.33	12	5	0.35
	2	0.33	9	4	0.32
20	1	0.33	12	4	0.32
	2	0.33	11	5	0.35
15	1	0.29	12	11	0.09
	2	0.30	11	0	0.00
10	1	0.31	12	11	0.31
	2	0.35	8	0	0.00
5	1	0.35	12	0	0.00
	2	0.29	12	11	0.09

Copy 5

period	firm	price	qty offered	qty sold	profit
71	1	$ 0.30	6	6	$ 0.20
	2	0.29	1	1	0.19
70	1	0.29	1	1	0.19
	2	0.32	12	9	0.38
69	1	0.30	12	11	0.20
	2	0.31	12	0	0.00
68	1	0.33	12	9	0.47
	2	0.38	8	0	0.00
67	1	0.29	1	1	0.19
	2	0.37	12	4	0.48
66	1	0.30	12	0	0.00
	2	0.29	12	11	0.09
65	1	0.30	12	11	0.20
	2	0.37	12	0	0.00
64	1	0.30	12	11	0.20
	2	0.37	12	0	0.00

63	1	0.30	12	11	0.20
	2	0.32	12	0	0.00
62	1	0.29	1	1	0.19
	2	0.31	12	10	0.30
60	1	0.31	10	10	0.30
	2	0.33	12	0	0.00
55	1	0.30	1	1	0.20
	2	0.37	5	4	0.48
50	1	0.28	2	2	0.16
	2	0.37	12	3	0.41
45	1	0.32	12	5	0.30
	2	0.32	12	5	0.30
40	1	0.30	8	8	0.20
	2	0.29	1	1	0.19
35	1	0.33	10	5	0.35
	2	0.33	6	4	0.32
30	1	0.29	12	10	0.10
	2	0.29	1	1	0.19
25	1	0.29	6	6	0.14
	2	0.29	1	1	0.19
20	1	0.29	6	6	0.14
	2	0.29	1	1	0.19
15	1	0.29	12	6	0.14
	2	0.29	7	5	0.15
10	1	0.30	10	5	0.20
	2	0.30	12	6	0.20
5	1	0.35	8	2	0.30
	2	0.35	12	5	0.45

2slrs;mto;d;08 -- a=4, b=.4 (M=\$0.46, PC=\$0.40); 2 sellers. cost for first unit for each seller was \$0.10

Copy 1

period	firm	price	qty offered	qty sold	profit
29*	1	\$ 0.45	12	3	\$ 0.55
	2	0.45	12	4	0.60
15	1	\$ 0.45	12	3	0.55
	2	0.45	12	4	0.60
10	1	\$ 0.45	12	3	0.55
	2	0.45	12	4	0.60

5	1	$ 0.40	12	11	0.40
	2	0.45	12	0	0.00

Copy 2

period	firm	price	qty offered	qty sold	profit
32*	1	$ 0.46	12	3	$ 0.58
	2	0.46	12	3	0.58
20	1	0.47	12	5	0.75
	2	0.48	12	0	0.00
15	1	0.51	12	0	0.00
	2	0.51	12	1	0.51
10	1	0.46	12	3	0.58
	2	0.46	12	3	0.58
5	1	0.42	12	5	0.50
	2	0.42	12	5	0.50

Copy 3

period	firm	price	qty offered	qty sold	profit
37*	1	$ 0.47	12	2	$ 0.54
	2	0.47	12	3	0.61
25	1	0.47	12	2	0.54
	2	0.47	12	3	0.61
20	1	0.47	12	5	0.75
	2	0.48	12	0	0.00
15	1	0.47	12	2	0.54
	2	0.47	12	3	0.61
10	1	0.48	12	2	0.56
	2	0.48	12	2	0.56
5	1	0.47	12	2	0.54
	2	0.47	12	3	0.61

Copy 4

period	firm	price	qty offered	qty sold	profit
80	1	$ 0.43	4	2	$ 0.46
	2	0.43	12	7	0.61
79	1	0.49	2	0	0.00
	2	0.419	12	10	0.59
78	1	0.43	4	0	0.00
	2	0.415	12	10	0.55
77	1	0.42	12	5	0.50
	2	0.42	12	5	0.50

76	1	0.44	6	6	0.64
	2	0.4444	12	1	0.4444
75	1	0.45	5	5	0.65
	2	0.46	12	1	0.46
74	1	0.45	5	5	0.65
	2	0.50	12	0	0.00
73	1	0.48	3	0	0.00
	2	0.47	12	5	0.75
72	1	0.49	3	0	0.00
	2	0.42	12	10	0.60
71	1	0.43	5	0	0.00
	2	0.425	12	9	0.625
70	1	0.43	6	6	0.58
	2	0.4341	12	2	0.4682
65	1	0.434	4	4	0.536
	2	0.44	12	4	0.56
60	1	0.42	4	4	0.48
	2	0.43	12	5	0.55
55	1	0.43	6	6	0.58
	2	0.4435	12	1	0.4435
50	1	0.42	4	4	0.48
	2	0.429	12	5	0.545
45	1	0.43	11	9	0.67
	2	0.435	9	0	0.00
40	1	0.46	2	0	0.00
	2	0.42	9	9	0.58
35	1	0.43	5	0	0.00
	2	0.41	9	9	0.49
30	1	0.50	1	0	0.00
	2	0.41	9	9	0.49
25	1	0.43	4	4	0.52
	2	0.45	9	3	0.55
20	1	0.39	10	10	0.30
	2	0.42	5	0	0.00
15	1	0.44	6	4	0.56
	2	0.38	4	4	0.32
10	1	0.392	2	2	0.384
	2	0.40	2	2	0.40
5	1	0.50	1	1	0.50
	2	0.65	9	0	0.00

Copy 5

period	firm	price	qty offered	qty sold	profit
114	1	$ 0.44	12	0	$ 0.00
	2	0.43	12	9	0.67
113	1	0.43	12	4	0.52
	2	0.43	12	5	0.55
112	1	0.43	12	4	0.52
	2	0.43	12	5	0.55
111	1	0.43	12	4	0.52
	2	0.43	12	5	0.55
110	1	0.43	12	4	0.52
	2	0.43	12	5	0.55
109	1	0.43	12	4	0.52
	2	0.43	12	5	0.55
108	1	0.44	12	0	0.00
	2	0.43	12	9	0.67
107	1	0.43	12	9	0.67
	2	0.44	12	0	0.00
106	1	0.44	12	0	0.00
	2	0.43	12	9	0.67
105	1	0.44	12	0	0.00
	2	0.43	12	9	0.67
100	1	0.44	12	0	0.00
	2	0.43	12	9	0.67
95	1	0.44	12	4	0.56
	2	0.44	12	4	0.56
90	1	0.43	12	9	0.67
	2	0.44	12	0	0.00
85	1	0.44	12	8	0.72
	2	0.45	12	0	0.00
80	1	0.45	12	3	0.55
	2	0.45	12	4	0.60
75	1	0.45	12	3	0.55
	2	0.45	12	4	0.60
70	1	0.48	12	0	0.00
	2	0.45	12	7	0.75
65	1	0.45	12	3	0.55
	2	0.45	12	4	0.60
60	1	0.45	12	3	0.55
	2	0.45	12	4	0.60
55	1	0.45	12	3	0.55
	2	0.45	12	4	0.60

50	1	0.45	12	3	0.55
	2	0.45	12	4	0.60
45	1	0.45	12	3	0.55
	2	0.45	12	4	0.60
40	1	0.55	12	0	0.00
	2	0.41	12	11	0.51
35	1	0.41	12	0	0.00
	2	0.40	12	11	0.40
30	1	0.44	12	0	0.00
	2	0.40	12	11	0.40
25	1	0.45	12	0	0.00
	2	0.40	12	11	0.40
20	1	0.45	12	0	0.00
	2	0.42	12	10	0.60
15	1	0.45	12	7	0.75
	2	0.46	12	0	0.00
10	1	0.65	12	0	0.00
	2	0.55	12	0	0.00
5	1	1.30	12	0	0.00
	2	1.00	12	0	0.00

3slrs;mto;d;01 -- a=1, b=1 (M=$1.24, PC=$1.00); 3 sellers

Copy 1

period	firm	price	qty offered	qty sold	profit
53	1	$ 1.03	12	0	0.00
	2	1.00	12	11	0.00
	3	1.02	12	0	0.00
52	1	1.03	12	0	0.00
	2	1.05	12	0	0.00
	3	1.0189	12	11	0.2079
51	1	1.09	12	0	0.00
	2	1.02	12	11	0.22
	3	1.04	12	0	0.00
50	1	1.03	12	11	0.33
	2	1.05	12	0	0.00
	3	1.04	12	0	0.00
49	1	1.01	12	11	0.11
	2	1.05	12	0	0.00
	3	1.04	12	0	0.00

48	1	1.04	12	0	0.00
	2	1.05	12	0	0.00
	3	1.03	12	11	0.33
47	1	1.01	12	11	0.11
	2	1.02	12	0	0.00
	3	1.03	12	0	0.00
46	1	1.09	12	0	0.00
	2	1.02	12	5	0.10
	3	1.02	12	6	0.12
45	1	1.04	12	0	0.00
	2	1.05	12	0	0.00
	3	1.02	12	11	0.22
44	1	problem -- no data entered for firm 1			
	2	problem -- no data entered for firm 2			
	3	problem -- no data entered for firm 3			
40	1	1.10	12	0	0.00
	2	1.00	12	11	0.00
	3	1.019	12	0	0.00
35	1	1.03	12	11	0.33
	2	1.045	12	0	0.00
	3	9.99	12	0	0.00
30	1	9.99	12	0	0.00
	2	9.99	12	0	0.00
	3	1.10	12	9	0.90
25	1	problem -- no data entered for firm 1			
	2	problem -- no data entered for firm 2			
	3	problem -- no data entered for firm 3			
20	1	1.05	12	0	0.00
	2	1 10	12	0	0.00
	3	045	12	10	0.45
15	1	005	12	5	0.025
	2	1.005	12	6	0.03
	3	1.02	12	0	0.00
10	1	1.10	3	0	0.00
	2	1.00	12	11	0.00
	3	1.0025	12	0	0.00
5	1	1.05	12	0	0.00
	2	1.05	12	0	0.00
	3	1.02	12	11	0.22

Copy 2

period	firm	price	qty offered	qty sold	profit
61	1	1.02	10	0	0.00
	2	1.01	12	8	0.08
	3	1.01	4	3	0.03
60	1	1.01	12	11	0.11
	2	1.02	12	0	0.00
	3	1.02	4	0	0.00
59	1	1.02	12	4	0.08
	2	1.02	12	5	0.10
	3	1.02	4	2	0.04
58	1	1.02	12	8	0.16
	2	1.03	12	0	0.00
	3	1.02	4	3	0.06
57	1	1.02	12	11	0.22
	2	1.04	12	0	0.00
	3	1.04	4	0	0.00
56	1	1.04	10	0	0.00
	2	1.03	12	11	0.33
	3	1.05	4	0	0.00
55	1	1.04	12	11	0.44
	2	1.05	12	0	0.00
	3	1.04	4	0	0.00
54	1	1.05	10	4	0.20
	2	1.05	12	6	0.30
	3	1.15	4	0	0.00
53	1	1.05	10	4	0.20
	2	1.05	12	6	0.30
	3	1.15	4	0	0.00
52	1	1.05	10	0	0.00
	2	1.15	12	0	0.00
	3	1.00	12	11	0.00
50	1	1.01	5	5	0.05
	2	1.05	12	5	0.25
	3	1.25	1	0	0.00
45	1	1.01	10	5	0.05
	2	1.01	12	6	0.06
	3	1.05	1	0	0.00
40	1	1.05	12	0	0.00
	2	1.02	12	5	0.10
	3	1.02	11	6	0.12

35	1	1.01	12	11	0.11
	2	1.75	12	0	0.00
	3	1.25	12	0	0.00
30	1	1.01	10	5	0.05
	2	1.01	12	6	0.06
	3	1.24	12	0	0.00
25	1	1.02	11	11	0.22
	2	1.24	12	0	0.00
	3	1.24	12	0	0.00
20	1	1.03	12	11	0.33
	2	1.05	12	0	0.00
	3	1.25	12	0	0.00
15	1	1.02	10	10	0.20
	2	1.25	12	0	0.00
	3	1.25	12	0	0.00
10	1	1.02	12	0	0.00
	2	1.07	12	0	0.00
	3	1.01	12	11	0.11
5	1	1.10	10	0	0.00
	2	1.05	12	10	0.50
	3	1.11	12	0	0.00

Copy 3

period	firm	price	qty offered	qty sold	profit
63	1	$ 1.095	12	0	$ 0.00
	2	1.45	12	0	0.00
	3	1.05	12	10	0.50
62	1	1.10	12	4	0.40
	2	1.45	12	0	0.00
	3	1.10	12	5	0.50
61	1	1.01	12	11	0.11
	2	1.45	12	0	0.00
	3	2.00	12	0	0.00
60	1	0.999	12	11	-0.01
	2	1.00	12	0	0.00
	3	2.00	12	0	0.00
59	1	1.00	1	0	0.00
	2	1.00	12	11	0.00
	3	1.10	12	0	0.00
58	1	1.20	12	0	0.00
	2	1.00	12	11	0.00
	3	1.09	12	0	0.00

57	1	1.10	12	9	0.90
	2	1.45	12	0	0.00
	3	1.20	12	0	0.00
56	1	1.00	1	1	0.00
	2	0.00	12	0	0.00
	3	1.25	12	4	1.00
55	1	1.039	12	0	0.00
	2	0.00	12	0	0.00
	3	1.00	12	11	0.00
54	1	1.044	12	10	0.44
	2	1.45	12	0	0.00
	3	1.05	12	0	0.00
50	1	1.00	12	9	0.00
	2	1.05	12	0	0.00
	3	1.00	2	2	0.00
45	1	problem -- no data entered for firm 1			
	2	problem -- no data entered for firm 2			
	3	problem -- no data entered for firm 3			
40	1	1.10	12	9	0.90
	2	1.45	12	0	0.00
	3	1.50	5	0	0.00
35	1	1.04	12	0	0.00
	2	1.00	12	11	0.00
	3	4.00	12	0	0.00
30	1	4.00	2	0	0.00
	2	1.45	12	0	0.00
	3	1.01	12	11	0.11
25	1	problem -- no data entered for firm 1			
	2	problem -- no data entered for firm 2			
	3	problem -- no data entered for firm 3			
20	1	1.10	12	4	0.40
	2	1.45	12	0	0.00
	3	1.10	12	5	0.50
15	1	1.02	12	0	0.00
	2	1.40	12	0	0.00
	3	1.01	12	11	0.11
10	1	1.03	12	0	0.00
	2	1.04	12	0	0.00
	3	1.01	12	11	0.11
5	1	1.24	12	0	0.00
	2	1.18	12	0	0.00
	3	1.10	10	9	0.90

Copy 4

period	firm	price	qty offered	qty sold	profit
71*	1	$ 1.23	12	2	0.46
	2	1.23	12	2	0.46
	3	1.23	12	2	0.46
60	1	1.23	12	2	0.46
	2	1.23	12	2	0.46
	3	1.23	12	2	0.46
55	1	1.23	12	6	1.38
	2	1.28	12	0	0.00
	3	1.28	12	0	0.00
50	1	1.23	12	2	0.46
	2	1.23	12	2	0.46
	3	1.23	12	2	0.46
45	1	1.25	12	1	0.25
	2	1.25	12	2	0.50
	3	1.25	12	2	0.50
40	1	1.23	12	2	0.46
	2	1.23	12	2	0.46
	3	1.23	12	2	0.46
35	1	1.23	12	0	0.00
	2	1.20	12	7	1.40
	3	1.23	12	0	0.00
30	1	1.20	12	0	0.00
	2	1.20	12	0	0.00
	3	1.14	12	8	1.12
25	1	1.10	12	0	0.00
	2	1.15	12	0	0.00
	3	1.05	12	10	0.50
20	1	1.20	12	2	0.40
	2	1.20	12	2	0.40
	3	1.20	12	3	0.60
15	1	1.15	12	2	0.30
	2	1.15	12	3	0.45
	3	1.15	12	3	0.45
10	1	1.15	12	4	0.60
	2	1.18	12	0	0.00
	3	1.15	12	4	0.60
5	1	1.05	12	10	0.50
	2	1.10	12	0	0.00
	3	1.10	12	0	0.00

Copy 5

period	firm	price	qty offered	qty sold	profit
73*	1	$ 1.20	12	2	$ 0.40
	2	1.20	12	2	0.40
	3	1.20	12	3	0.60
60	1	1.20	12	0	0.00
	2	1.20	12	0	0.00
	3	1.18	12	7	1.26
55	1	1.30	12	0	0.00
	2	1.25	12	0	0.00
	3	1.20	12	7	1.40
50	1	1.25	12	1	0.25
	2	1.25	12	2	0.50
	3	1.25	12	2	0.50
45	1	1.20	10	2	0.40
	2	1.20	12	2	0.40
	3	1.20	12	3	0.60
40	1	1.20	4	1	0.20
	2	1.20	12	3	0.60
	3	1.20	12	3	0.60
35	1	1.20	12	2	0.40
	2	1.20	12	2	0.40
	3	1.20	12	3	0.60
30	1	1.24	12	6	1.44
	2	1.25	12	0	0.00
	3	1.25	12	0	0.00
25	1	1.30	12	1	0.30
	2	1.30	12	1	0.30
	3	1.30	12	2	0.60
20	1	1.26	12	0	0.00
	2	1.25	12	2	0.50
	3	1.25	12	3	0.75
15	1	1.25	12	0	0.00
	2	1.25	12	0	0.00
	3	1.25	12	5	1.25
10	1	1.30	10	1	0.30
	2	1.30	12	1	0.30
	3	1.30	12	2	0.60
5	1	1.25	10	0	0.00
	2	1.20	12	7	1.40
	3	1.25	12	0	0.00

Copy 6

period	firm	price	qty offered	qty sold	profit
62	1	1.08	12	0	0.00
	2	1.15	12	0	0.00
	3	1.00	12	0	0.00
61	1	1.20	12	0	0.00
	2	1.15	12	0	0.00
	3	1.09	12	9	0.81
60	1	1.15	12	4	0.60
	2	1.20	12	0	0.00
	3	1.15	12	4	0.60
59	1	1.20	12	0	0.00
	2	1.1899	12	7	1.3293
	3	1.20	12	0	0.00
58	1	1.20	12	2	0.40
	2	1.20	12	2	0.40
	3	1.20	12	3	0.60
57	1	1.20	12	2	0.40
	2	1.20	12	2	0.40
	3	1.20	12	3	0.60
56	1	1.13	12	8	1.04
	2	1.20	12	0	0.00
	3	1.20	12	0	0.00
55	1	1.20	12	0	0.00
	2	1.1999	12	7	1.3993
	3	1.20	12	0	0.00
54	1	1.20	12	2	0.40
	2	1.20	12	2	0.40
	3	1.20	12	3	0.60
53	1	1.20	12	2	0.40
	2	1.20	12	2	0.40
	3	1.20	12	3	0.60
50	1	1.20	12	0	0.00
	2	1.1999	12	7	1.3993
	3	1.20	12	0	0.00
45	1	1.20	12	3	0.60
	2	1.25	12	0	0.00
	3	1.20	12	4	0.80
40	1	1.20	12	0	0.00
	2	1.25	12	0	0.00
	3	1.14	12	8	1.12

35	1	1.15	12	8	1.20
	2	1.20	12	0	0.00
	3	1.20	12	0	0.00
30	1	1.00	12	11	0.00
	2	1.069	12	0	0.00
	3	1.04	12	0	0.00
25	1	1.15	12	0	0.00
	2	1.04	12	11	0.44
	3	1.20	12	0	0.00
20	1	1.16	12	8	1.28
	2	1.20	12	0	0.00
	3	1.19	12	0	0.00
15	1	1.20	12	0	0.00
	2	1.19	12	7	1.33
	3	1.20	12	0	0.00
10	1	1.08	12	10	0.80
	2	1.15	12	0	0.00
	3	1.20	12	0	0.00
5	1	1.50	12	0	0.00
	2	1.09	12	9	0.81
	3	1.20	12	0	0.00

3slrs;mto;d;03 -- a=2, b=.5 (M=\$0.62, PC=\$0.50); 3 sellers; cost for first unit for each seller was \$0.45; market demand information provided

Copy 1 -- experienced

period	firm	price	qty offered	qty sold	profit
72	1	\$ 0.57	12	0	\$ 0.00
	2	0.56	12	9	0.59
	3	0.58	8	0	0.00
71	1	0.59	12	4	0.41
	2	0.60	12	0	0.00
	3	0.59	8	3	0.32
70	1	0.60	12	2	0.25
	2	0.60	12	3	0.35
	3	0.60	5	2	0.25
69	1	0.60	12	0	0.00
	2	0.60	12	0	0.00
	3	0.58	8	8	0.69

68	1	0.60	1	0	0.00
	2	0.60	12	2	0.25
	3	0.57	5	5	0.40
67	1	0.60	12	0	0.00
	2	0.55	12	9	0.50
	3	0.60	5	0	0.00
66	1	0.50	12	5	0.05
	2	0.50	12	6	0.05
	3	0.60	5	0	0.00
65	1	0.51	12	0	0.00
	2	0.50	12	11	0.05
	3	0.53	10	0	0.00
64	1	0.51	12	6	0.11
	2	0.52	12	0	0.00
	3	0.51	10	5	0.10
63	1	0.53	12	0	0.00
	2	0.52	12	11	0.27
	3	0.55	10	0	0.00
60	1	0.62	1	0	0.00
	2	0.53	12	10	0.35
	3	0.54	10	0	0.00
55	1	0.53	12	10	0.35
	2	0.55	12	0	0.00
	3	0.54	10	0	0.00
50	1	0.50	12	11	0.05
	2	0.55	12	0	0.00
	3	0.54	10	0	0.00
45	1	0.53	12	10	0.35
	2	0.55	12	0	0.00
	3	0.54	10	0	0.00
40	1	0.54	12	5	0.25
	2	0.55	12	0	0.00
	3	0.54	10	5	0.25
35	1	0.60	12	0	0.00
	2	0.55	12	9	0.50
	3	0.70	10	0	0.00
30	1	0.60	12	0	0.00
	2	0.50	12	11	0.05
	3	0.60	7	0	0.00
25	1	0.51	12	0	0.00
	2	0.55	12	0	0.00
	3	0.53	11	10	0.35

20	1	0.52	12	11	0.27
	2	0.55	12	0	0.00
	3	0.53	10	0	0.00
15	1	0.51	12	5	0.10
	2	0.51	12	6	0.11
	3	0.55	10	0	0.00
10	1	1.00	12	0	0.00
	2	0.55	12	4	0.25
	3	0.55	12	5	0.30
5	1	0.70	12	0	0.00
	2	0.60	12	7	0.75
	3	0.65	5	0	0.00

Copy 2 -- experienced

period	firm	price	qty offered	qty sold	profit
32*	1	$ 0.62	12	2	$ 0.29
	2	0.62	12	2	0.29
	3	0.62	12	2	0.29
20	1	0.62	12	2	0.29
	2	0.62	12	2	0.29
	3	0.62	12	2	0.29
15	1	0.62	12	2	0.29
	2	0.62	12	2	0.29
	3	0.62	12	2	0.29
10	1	0.65	12	0	0.00
	2	0.62	12	3	0.41
	3	0.62	12	3	0.41
5	1	0.55	12	9	0.50
	2	0.62	12	0	0.00
	3	0.62	12	0	0.00

3slrs;mto;d;04 -- a=1, b=.5 (M=$0.74, PC=$0.50); 3 sellers

Copy 1 -- experienced

period	firm	price	qty offered	qty sold	profit
70*	1	$ 0.62	12	3	$ 0.36
	2	0.62	12	3	0.36
	3	0.62	12	3	0.36

60	1	0.62	12	4	0.48
	2	0.63	12	0	0.00
	3	0.62	12	5	0.60
55	1	0.53	12	11	0.33
	2	0.55	12	0	0.00
	3	0.62	12	0	0.00
50	1	0.55	12	0	0.00
	2	0.55	12	0	0.00
	3	0.53	12	11	0.33
45	1	0.55	12	10	0.50
	2	0.56	12	0	0.00
	3	0.62	12	0	0.00
40	1	0.57	12	5	0.35
	2	0.57	12	5	0.35
	3	0.62	12	0	0.00
35	1	0.60	12	0	0.00
	2	0.57	12	0	0.00
	3	0.55	12	10	0.50
30	1	0.63	12	0	0.00
	2	0.63	12	0	0.00
	3	0.62	12	9	1.08
25	1	0.61	12	9	0.99
	2	0.62	12	0	0.00
	3	0.62	12	0	0.00
20	1	0.60	12	3	0.30
	2	0.60	12	3	0.30
	3	0.60	12	3	0.30
15	1	0.58	12	3	0.24
	2	0.58	12	3	0.24
	3	0.58	12	4	0.32
10	1	0.56	12	3	0.18
	2	0.56	12	3	0.18
	3	0.56	12	4	0.24
5	1	0.55	12	0	0.00
	2	0.54	12	11	0.44
	3	0.55	12	0	0.00

Copy 2

period	firm	price	qty offered	qty sold	profit
29*	1	$ 0.55	12	3	$ 0.15
	2	0.55	12	3	0.15
	3	0.55	12	4	0.20

15	1	0.55	12	3	0.15
	2	0.55	12	3	0.15
	3	0.55	12	4	0.20
10	1	0.55	12	3	0.15
	2	0.55	12	3	0.15
	3	0.55	12	4	0.20
5	1	0.55	12	3	0.15
	2	0.55	12	3	0.15
	3	0.55	12	4	0.20

Copy 3

period	firm	price	qty offered	qty sold	profit
101	1	$ 0.511	12	11	$ 0.121
	2	0.539	12	0	0.00
	3	0.599	12	0	0.00
100	1	9.49	12	0	0.00
	2	0.589	12	0	0.00
	3	0.56	12	10	0.60
99	1	9.49	12	0	0.00
	2	0.56	12	10	0.60
	3	9.49	12	0	0.00
98	1	0.501	12	11	0.011
	2	0.53	12	0	0.00
	3	0.58	12	0	0.00
97	1	0.501	12	11	0.011
	2	0.55	12	0	0.00
	3	0.75	12	0	0.00
96	1	0.501	12	11	0.011
	2	0.532	12	0	0.00
	3	0.538	12	0	0.00
95	1	9.49	12	0	0.00
	2	0.55	12	0	0.00
	3	0.549	12	10	0.49
94	1	9.49	12	0	0.00
	2	0.55	12	0	0.00
	3	0.519	12	11	0.209
93	1	9.49	12	0	0.00
	2	0.539	12	5	0.195
	3	0.539	12	6	0.234
92	1	9.49	12	0	0.00
	2	0.56	12	10	0.60
	3	0.58	12	0	0.00

90	1	0.501	12	11	0.011
	2	0.55	12	0	0.00
	3	0.568	12	0	0.00
85	1	9.49	12	0	0.00
	2	0.57	12	0	0.00
	3	0.538	12	11	0.418
80	1	9.49	12	0	0.00
	2	0.539	11	0	0.00
	3	0.528	12	11	0.308
75	1	0.60	12	0	0.00
	2	0.58	12	0	0.00
	3	0.55	12	10	0.50
70	1	0.60	12	0	0.00
	2	0.579	12	10	0.79
	3	0.59	12	0	0.00
65	1	0.60	12	0	0.00
	2	0.60	12	0	0.00
	3	0.518	12	11	0.198
60	1	0.60	12	5	0.50
	2	0.60	9	4	0.40
	3	0.99	12	0	0.00
55	1	0.53	12	5	0.15
	2	0.53	11	6	0.18
	3	0.54	12	0	0.00
50	1	0.60	12	0	0.00
	2	0.599	12	0	0.00
	3	0.589	12	9	0.801
45	1	0.55	12	3	0.15
	2	0.55	11	3	0.15
	3	0.55	12	4	0.20
40	1	0.501	12	11	0.011
	2	0.529	11	0	0.00
	3	0.53	12	0	0.00
35	1	0.501	12	11	0.011
	2	0.55	11	0	0.00
	3	0.57	12	0	0.00
30	1	0.60	12	0	0.00
	2	0.58	12	10	0.80
	3	0.60	12	0	0.00
25	1	0.60	12	0	0.00
	2	0.55	11	10	0.50
	3	0.60	11	0	0.00

20	1	0.54	12	0	0.00
	2	0.515	11	11	0.165
	3	0.519	12	0	0.00
15	1	0.51	12	11	0.11
	2	0.54	11	0	0.00
	3	0.53	12	0	0.00
10	1	0.53	12	5	0.15
	2	0.54	11	0	0.00
	3	0.53	12	6	0.18
5	1	0.54	12	0	0.00
	2	0.54	11	0	0.00
	3	0.53	12	11	0.33

4slrs;mto;d;01 -- a=2, b=.5 (M=$0.62, PC=$0.50); 4 sellers; cost for first unit for each seller was $0.45

Copy 1

period	firm	price	qty offered	qty sold	profit
73*	1	$ 0.58	12	2	$ 0.21
	2	0.58	12	2	0.21
	3	0.58	12	2	0.21
	4	0.58	12	2	0.21
60	1	0.51	12	11	0.16
	2	0.58	12	0	0.00
	3	0.58	12	0	0.00
	4	0.58	12	0	0.00
55	1	0.52	12	0	0.00
	2	0.50	12	11	0.05
	3	0.58	12	0	0.00
	4	0.58	12	0	0.00
50	1	0.57	12	8	0.61
	2	0.58	12	0	0.00
	3	0.58	12	0	0.00
	4	0.58	12	0	0.00
45	1	0.58	12	2	0.21
	2	0.58	12	2	0.21
	3	0.58	12	2	0.21
	4	0.58	12	2	0.21

40	1	0.58	12	2	0.21
	2	0.58	12	2	0.21
	3	0.58	12	2	0.21
	4	0.58	12	2	0.21
35	1	0.25	12	11	-2.70
	2	0.58	12	0	0.00
	3	0.50	12	0	0.00
	4	0.58	12	0	0.00
30	1	0.60	12	0	0.00
	2	0.58	12	0	0.00
	3	0.57	12	8	0.61
	4	0.58	12	0	0.00
25	1	0.58	12	2	0.21
	2	0.58	12	2	0.21
	3	0.58	12	2	0.21
	4	0.58	12	2	0.21
20	1	0.00	12	0	0.00
	2	0.54	12	0	0.00
	3	0.53	12	10	0.35
	4	0.54	12	0	0.00
15	1	0.75	12	0	0.00
	2	0.54	12	5	0.25
	3	0.58	12	0	0.00
	4	0.54	12	5	0.25
10	1	0.55	12	3	0.20
	2	0.55	12	3	0.20
	3	0.58	12	0	0.00
	4	0.55	12	3	0.20
5	1	0.65	12	0	0.00
	2	0.55	12	4	0.25
	3	0.55	12	5	0.30
	4	0.60	12	0	0.00

4slrs;mto;d;02 -- a=2, b=1 (M=$1.12, PC=$1.00); 4 sellers; market information provided

Copy 1

period	firm	price	qty offered	qty sold	profit
105	1	$ 1.02	12	11	$ 0.22
	2	1.10	12	0	0.00
	3	1.036	12	0	0.00
	4	1.087	12	0	0.00
104	1	1.000001	12	11	0.000010+
	2	1.10	12	0	0.00
	3	1.039	12	0	0.00
	4	1.087	12	0	0.00
103	1	1.004	12	0	0.00
	2	1.10	12	0	0.00
	3	1.000001	12	5	0.000004+
	4	1.000001	12	6	0.000005+
102	1	1.005	12	11	0.055
	2	1.011	12	0	0.00
	3	1.009	12	0	0.00
	4	1.0175	12	0	0.00
101	1	1.02	12	11	0.22
	2	1.027	12	0	0.00
	3	1.027	12	0	0.00
	4	1.375	12	0	0.00
100	1	1.059	12	0	0.00
	2	1.045	12	0	0.00
	3	1.048	12	0	0.00
	4	1.04	12	10	0.40
99	1	1.068	12	0	0.00
	2	1.007	12	11	0.077
	3	1.059	12	0	0.00
	4	13.460736	12	0	0.00
98	1	1.01	12	5	0.05
	2	1.01	12	6	0.06
	3	1.068	12	0	0.00
	4	1.012346	12	0	0.00
97	1	1.02	12	11	0.22
	2	1.10	12	0	0.00
	3	1.024	12	0	0.00
	4	1.023457	12	0	0.00

96	1	1.0498	12	0	0.00
	2	1.10	12	0	0.00
	3	1.047	12	0	0.00
	4	1.04321	12	9	0.388889+
95	1	1.087	12	0	0.00
	2	1.10	12	0	0.00
	3	1.10	12	0	0.00
	4	1.083	12	7	0.581
90	1	1.20	12	0	0.00
	2	1.20	12	0	0.00
	3	1.20	12	0	0.00
	4	1.087	12	7	0.609
85	1	1.03	12	10	0.30
	2	1.12	12	0	0.00
	3	1.12	12	0	0.00
	4	1.06	12	0	0.00
80	1	1.02	12	0	0.00
	2	1.017	12	11	0.187
	3	1.069	12	0	0.00
	4	1.020001	12	0	0.00
75	1	1.10	12	0	0.00
	2	1.035	12	0	0.00
	3	1.026	12	0	0.00
	4	1.023	12	10	0.23
70	1	1.04	12	10	0.40
	2	1.10	12	0	0.00
	3	1.069	12	0	0.00
	4	1.0699	12	0	0.00
65	1	1.04	12	10	0.40
	2	1.10	12	0	0.00
	3	1.088	12	0	0.00
	4	1.10	12	0	0.00
60	1	1.10	12	2	0.20
	2	1.10	12	2	0.20
	3	1.10	12	3	0.30
	4	1.65	12	0	0.00
55	1	1.087	12	0	0.00
	2	1.087	12	0	0.00
	3	1.025	12	10	0.25
	4	1.087	12	0	0.00

50	1	1.068	12	0	0.00
	2	1.10	12	0	0.00
	3	1.087	10	0	0.00
	4	1.059999	12	9	0.53991
45	1	1.07	12	8	0.56
	2	1.10	12	0	0.00
	3	1.10	12	0	0.00
	4	1.08	12	0	0.00
40	1	1.10	12	0	0.00
	2	9.49	12	0	0.00
	3	1.025	12	0	0.00
	4	1.00	12	11	0.00
35	1	1.048	12	0	0.00
	2	1.049	12	0	0.00
	3	1.10	12	0	0.00
	4	1.03	12	10	0.30
30	1	problem -- no data entered for firm 1			
	2	problem -- no data entered for firm 2			
	3	problem -- no data entered for firm 3			
	4	problem -- no data entered for firm 4			
25	1	problem -- no data entered for firm 1			
	2	problem -- no data entered for firm 2			
	3	problem -- no data entered for firm 3			
	4	problem -- no data entered for firm 4			
20	1	problem -- no data entered for firm 1			
	2	problem -- no data entered for firm 2			
	3	problem -- no data entered for firm 3			
	4	problem -- no data entered for firm 4			
15	1	1.00	12	5	0.00
	2	1.09	12	0	0.00
	3	1.079	12	0	0.00
	4	1.00	12	6	0.00
10	1	1.07	12	8	0.56
	2	1.10	12	0	0.00
	3	1.10	12	0	0.00
	4	1.08	12	0	0.00
5	1	1.09	12	0	0.00
	2	1.10	12	0	0.00
	3	1.10	12	0	0.00
	4	1.04	12	10	0.40

Copy 2

period	firm	price	qty offered	qty sold	profit
90	1	$ 1.01	12	0	$ 0.00
	2	1.111111	12	0	0.00
	3	1.0055	12	11	0.0605
	4	1.08	12	0	0.00
89	1	1.01	12	0	0.00
	2	1.01	12	0	0.00
	3	1.009	12	11	0.099
	4	1.01	12	0	0.00
88	1	1.01	12	5	0.05
	2	1.10	12	0	0.00
	3	9.99	12	0	0.00
	4	1.01	12	6	0.06
87	1	1.01	12	0	0.00
	2	1.00	12	11	0.00
	3	1.008	12	0	0.00
	4	1.005	12	0	0.00
86	1	1.01	12	0	0.00
	2	1.01	12	0	0.00
	3	1.009	12	11	0.099
	4	1.01	12	0	0.00
85	1	1.01	12	3	0.03
	2	1.01	12	4	0.04
	3	9.99	12	0	0.00
	4	1.01	12	4	0.04
84	1	1.01	12	3	0.03
	2	1.01	12	4	0.04
	3	9.99	12	0	0.00
	4	1.01	12	4	0.04
83	1	1.01	12	2	0.02
	2	1.01	12	3	0.03
	3	1.01	12	3	0.03
	4	1.01	12	3	0.03
82	1	1.01	12	3	0.03
	2	1.05	12	0	0.00
	3	1.01	12	4	0.04
	4	1.01	12	4	0.04
81	1	1.01	12	0	0.00
	2	1.05	12	0	0.00
	3	1.01	12	0	0.00
	4	1.00	12	11	0.00

80	1	1.01	12	0	0.00
	2	1.01	12	0	0.00
	3	1.00	12	5	0.00
	4	1.00	12	6	0.00
75	1	1.01	12	11	0.11
	2	1.69	12	0	0.00
	3	9.99	12	0	0.00
	4	1.08	12	0	0.00
70	1	1.01	12	3	0.03
	2	1.01	12	4	0.04
	3	1.10	12	0	0.00
	4	1.01	12	4	0.04
65	1	1.02	12	5	0.10
	2	1.25	12	0	0.00
	3	1.25	12	0	0.00
	4	1.02	12	6	0.12
60	1	1.50	12	0	0.00
	2	1.50	12	0	0.00
	3	1.01	12	5	0.05
	4	1.01	12	6	0.06
55	1	1.01	12	3	0.03
	2	1.01	12	4	0.04
	3	1.02	12	0	0.00
	4	1.01	12	4	0.04
50	1	1.01	12	0	0.00
	2	1.10	12	0	0.00
	3	1.10	12	0	0.00
	4	1.00	12	11	0.00
45	1	1.04	12	0	0.00
	2	1.05	12	0	0.00
	3	1.05	12	0	0.00
	4	1.00	12	11	0.00
40	1	1.02	12	11	0.22
	2	1.05	12	0	0.00
	3	1.05	12	0	0.00
	4	1.05	12	0	0.00
35	1	1.01	12	5	0.05
	2	1.01	12	6	0.06
	3	1.03	12	0	0.00
	4	1.05	12	0	0.00

30	1	1.10	12	0	0.00
	2	1.10	12	0	0.00
	3	1.01	12	5	0.05
	4	1.01	12	6	0.06
25	1	1.02	12	0	0.00
	2	1.01	12	5	0.05
	3	1.01	12	6	0.06
	4	1.04	12	0	0.00
20	1	1.03	12	10	0.30
	2	1.08	12	0	0.00
	3	1.08	12	0	0.00
	4	1.08	12	0	0.00
15	1	1.02	12	0	0.00
	2	1.25	12	0	0.00
	3	1.05	12	0	0.00
	4	1.00	12	11	0.00
10	1	1.01	12	11	0.11
	2	1.10	12	0	0.00
	3	1.10	12	0	0.00
	4	1.08	12	0	0.00
5	1	1.03	12	0	0.00
	2	1.05	12	0	0.00
	3	1.05	12	0	0.00
	4	1.01	12	11	0.11

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