COMMON VALUE AND PRIVATE VALUE EXPERIMENTAL ASSET MARKETS WITH INSIDE INFORMATION

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June 1990

Abstract

This paper analyzes economic behavior in nine computerized, double auction asset markets. The markets' ability to disseminate information is compared across several environments. The central focus of the paper is the comparison of common value markets and private value markets in terms of economic efficiency. Of secondary importance is the comparison of fixed and random information environments. These comparisons are analyzed in terms of price error and bid-ask spread as well as time-weighted versions of each. Statistical tests are carried out using the fully revealing rational expectations model as a benchmark. The main findings of the paper are that common value markets have lower price errors on average but a wider bid-ask spread than private value markets. Other findings include lower price errors for fixed information when there are less than three insiders. In terms of the bid-ask spread, random information was found to be more efficient.

* I would like to thank my advisor Daniel Friedman for his guidance and financial support; Mabon Rainsong for computer programing; Bret Carthew and Patrick O'Donnell for their association on this project; and the Economics board at U.C.S.C., Crown College, and the Council of Provosts for financial support.

1. INTRODUCTION

A majority of research on the value of information in experimental assets markets has dealt with securities which have unequal dividends for different groups of traders within the same market. This treatment has been justified on the grounds that traders have diverse opportunity costs and that it provides an incentive for traders to make transactions. Plott and Sunder (1988) and Smith et al. (1988) both deal with common valuation of assets; however it is incidental to both studies. Common valuation is more realistic and easier to apply to real world asset markets. It can also be argued that differing opportunity costs are already present within traders as they have inherently diverse levels of risk aversity. The main focus of this paper will be the comparison of common value markets and private value markets in terms of efficiency. Additionally, I will analyze the effects of fixed and random informational structures.

Most research in experimental markets has concluded that price prediction models that incorporate some form of rational expectations assumptions are the best method of describing market behavior. The extent to which rational expectations assumptions should be embodied in the model is not generally agreed upon and has been difficult to establish empirically. In terms of the efficient markets hypothesis, current field research has led to the belief that securities markets are somewhere between semi-strong and strong form efficient. This means that all public information as well as some degree of private information is disseminated throughout each market in determining the price of an asset. Given that price predictions of rational expectations models have been shown to be reasonably accurate, my analysis will be carried out using fully revealing rational expectations (RE) as a benchmark. The price predictions of fully revealing rational expectations when inside information is given are the actual value of the asset. When no inside information is available, the RE price predictions are the highest midpoint of the ranges of possible values given to traders.

This study analyzes 9 markets organized into 4 series A through D. Series A and B used common valuation while C and D were private value. In those cases where significant results were obtained, the common value markets were found to have been more efficient with respect to price errors. This was particularly evident in instances where there were many traders with superior information about the asset's closing price. Several other treatment variables which will be discussed later were altered and may have affected each market's ability to disseminate information.

The next section includes a discussion of existing literature which is related to the focus of this study. Section 3 contains a more in depth description of the design of the markets as well as the software used to conduct the double auction market. Section 4 gives a brief description of some of the more common price prediction models used in the current literature and outlines the theoretical predictions made for each of the experimental variables that were altered. Section 5 contains the results obtained from all 9 markets and analyzes them with respect to price error and bid-ask spread. Section 6 discusses possible trading strategies and other sources of trader information. The final section reports the overall findings of this study.

2. LITERATURE REVIEW

There are three main characteristics which differ in the literature on experimental assests markets. The first of these is the market mechanism. Several studies have used oral double auction markets in which traders directly interacted to place bids and asks. A number of recent studies have used computerized markets to conduct experiments. Since computerized markets do not allow traders to directly interact, they are less likely to let information leak out. A second difference in the current literature is the life of the asset being traded. Experiments have been conducted using assets with single period as well as multi-period lives. The final major difference in the literature is the markets informational structure. Studies with a fixed informational structure have been found to be more efficient than those with random information given to traders. The remainder of this section will discuss the implications of these different characteristics as well as some of the literature which is related to this study.

In 1982 Charles Plott and Shyam Sunder reported on the ability of two competing models of market behavior to integrate and disseminate information. Their study used an oral double auction in five experimental markets each with several periods. The asset in these markets had a life of one period and paid a dividend determined by one of two randomly drawn states of nature. The dividends were dependent upon which of three possible groups a trader was randomly assigned to. The differences in dividends led to the existence of gains from trade. At the beginning of each trading day subjects were given information about the eventual state of nature which varied from complete knowledge to none at all. The study used a fixed informational structure for all experiments so the traders who received inside information were always the same. The major finding of the study was that the predictions of the fully revealing rational expectations model are relatively accurate. Market prices approached the rational expectations predictions almost immediately and profits of insiders were not significantly different from those of traders without information.

In a 1984 article Daniel Friedman, Glenn Harrison and Jon Salmon study an oral double auction market for an asset with a multi-period life. This study focused on the affects of the presence of futures markets on market efficiency. The six experimental markets used three types of traders with three possible states of nature for each group. In half of the markets futures were available for purchase by the traders. In two of the markets perfect information was given to one trader from each group in a similar fashion to Plott and Sunder (1982). The study concluded that market outcomes evolve over time toward strong-form informationally efficient equilibria (ie. the fully revealing rational expectations model is an accurate representation of market behavior.) This result is statistically significant regardless of the presence of futures markets. In fact, the study found that the inclusion of futures markets actually tends to promote the dissemination of inside information and make markets more informationally efficient.

In 1989, Plott and Sunder published another study using oral double auction markets. A total of 9 markets divided into 3 series were conducted. This paper addressed both the issues of information dissemination as well as aggregation by only giving traders partial knowledge of the assets value in the A series of experiments. This series was designed to test whether diverse information could be pooled to obtain efficient outcomes. The 1989 paper was also the first double auction study to use a common dividend for all traders within a market. This common value treatment was used in the C series experiments which included 3 of the 9 markets studied. The A and B series used 2 and 3 groups of traders respectively. In all experiments there were three possible states of nature relative to the asset's value. The data from each market was tested against three competing models of market behavior including rational expectations (RE), prior information (PI) and maximin (MM), a risk averse model. Experimental markets in which complete information was given to some traders and those for which there was a common dividend were found to be best characterized by the rational expectations model. However, in the markets with partial information given to traders, both PI and MM outperform the RE model.

In 1985, Jeffrey Banks examined potential problems that may have arisen from the fixed informational structure used in the previously mentioned studies. His hypothesis was that the fixed-information structure of Plott and Sunder (1982) and Friedman, Harrison and Salmon (1984) may have allowed uninformed traders to guess the identities of insiders. If this were the case, experimental results would obviously be biased toward acceptance of the fully revealing rational expectations model. Banks attempted to overcome this problem by replicating market 5 of Plott and Sunder (1982) but adding more noise to the trading environment in order to give rational expectations a more stringent test. In the Banks experiment each trader was given perfect information in at least 2 of the 10 trading days. In addition, the periods in which traders received information was randomized. The results indicated that the fixed-informational structure of previous experiments had little to do with price convergence to the rational expectations equilibrium. Furthermore, the ratio of profits of insiders to those of uninformed traders was actually lower on average in the Banks experiment than in market 5 of Plott and Sunder (1982.)

As noted in an M.S. thesis by von Borries (1988), the evidence presented in these studies seems to confirm the predictions of the rational expectations model, but the results may be biased by the chosen market mechanism. The oral double auction market is by nature more informative than its computerized counterpart. This is due to the ability of traders to observe who is actually making transactions and the reactions of other traders. When the double auction is set in a computerized environment, the origin of bids, asks, and transactions is unknown. A replication of two of the markets from Plott and Sunder (1982) by DeJong et al.(1987) indicated that the profits earned by insiders was slightly higher when the market was carried out in a computerized environment. Unfortunately, the limitations of their computer program may have biased the results and make it hard to put much faith in the conclusions of the study.

Also noted by von Borries is the fact that most economists agree that markets are probably only semi-strong form efficient. In order to test this von Borries (also see von Borries and Friedman 1988) implements a partially reveailing rational expectations (PRE) model adapted from Friedman & Copeland (1988) and compares the results to fully revealing rational expectations as well as the private information (PI) model. The findings of the study indicated that in a relatively noiseless enivronment, the rational expectations model was the most accurate description of market behavior. However, when the informational structure became more random, the RE model was outperformed in most cases by the PRE model and even in some cases by the PI model. In the "noisier" market 3 of this study insiders also earned substantially higher profits than uniformed traders.

As previously noted, Friedman and Copeland have also experimented with partially revealing rational expectations models in an attempt to bridge the gap between strong and semi-strong theories of informational efficiency. In Friedman and Copeland (1987,1988, and forthcoming) two different semi-strong form models, ordinary rational expectations (ORE) and the partially revealing rational expectations (PRE) model that the von Borries model was adapted from. These studies use a computerized double auction market with three groups of traders. Perfect knowledge of the asset's value is given to all traders in most of these experiments however, the time of information arrival is quite varied. Friedman and Copeland report that RE is the best method of price prediction with some reservations. Specifically, the semi-strong form models perform better in some cases of noisier environments and tend to predict asset allocation and trading volume better than the fully revealing rational expectations model. In the forthcoming paper, Friedman and Copeland conjecture that more refined versions of PRE could possibly do better than the RE model in all areas.

The 9 markets in this study employ the same double auction market used in Copeland and Friedman (1988) as well as von Borries (1988) and von Borries and Friedman (1988.) All markets use a one-period asset with 24-41 trading days. We experiment with both a fixed informational structure similar to Plott and Sunder (1982) and a somewhat noisier environment in each series. Our fixed information structure differs from Plott and Sunder in that information is only stable for four periods. The number of insiders is varied within each market usually from 0 to 4. Perfect knowledge or probabilities of possible states is given at the beginning of each trading day with no sequential arrival of information. As in Plott and Sunder (1989) both common value and private value series of experiments are conducted. Additionally, we have added a continuous payout schedule in series A and C. Based on past performance and ease of calculation, a fully revealing rational expectations model is used as a benchmark for price predictions in all experiments. Later research on these markets may possibly test the same experiments with a PRE type model.

3. MARKET DESIGN

All experimental markets in this study were carried out using a computerized real-time double auction program. The experimental design of the markets is shown in the four panels of table 1. Each market was organized into several trading days ranging from 24 to 41. Trading days ranged from 90 seconds to 3 minutes in length. At the beginning of every trading day, each trader's endowment is returned to its initial level of $40 and 3 shares. Traders were able to simultaneously enter one bid and ask for a generic asset which we refer to as a share. These bids and asks were then put in order by the program which reported the best (lowest) ask and best (highest) bid. Traders could also transact directly by accepting the best bid or ask. In all markets traders were restricted to buying and selling using only their initial balances of cash and shares, (ie.short-selling and negative cash balances were not allowed.) These constraints were binding if a trader believed that the share would be valued below the current market price and wanted to make profits by selling as many shares as possible. In the case of high valued shares, cash balances were not a restriction since traders were given enough money to purchase all of the shares they wanted at reasonable prices.

The screen display that traders saw during a trading day is shown in figure 1. In the top right corner traders are given the range of possible share values and the probabilities associated with each. The current market bid and ask is shown as well as any bid and ask that the trader may have entered. If a trader's bid or ask is the best in the market, it is marked by an asterisk. The price of each transaction made during a trading day is listed below the bid/ask region in a fasion similar to a ticker tape. Traders are not given information concerning who has the best bid and ask or who they transact with when buying or selling shares. The initial endowment and constantly updated current endowment is shown in the lower middle portion of the screen. The upper right hand corner shows the time remaining in the trading day.

At the end of each trading day the traders were shown an interim screen. This screen gave information on the final value of the share from the previous trading day and the amount of profit (or loss) accumulated for each trader. This information was given both in terms of the previous periods profit/loss and that for all trading days combined. In addition, the interim screen provided time for the traders to relax and think about their strategies for the upcoming trading day.

Traders for our experiments were recruited from a pool of approximately 40 undergraduate students at UCSC. All of the traders had previously participated in similar asset market experiments. However, the abilities and experience of the traders did vary. In order to get traders in the right frame of mind, a few practice rounds preceded each experiment. Aside from a few isolated cases of obvious keypunch errors, it appeared that traders were competent in all of the procedures involved in operating the double auction market program.

All of the markets in this study used eight traders. In the A and B series experiments, all eight traders were given the same range of possible payouts. The C and D series experiments randomly assigned traders to one of two groups of four who were given different payout schedules. In these markets one group was given a wide range and the other was given a somewhat narrower range of possible payouts which was within the endpoints of the first group's. At the end of each experiment traders received a cash payment which represented some fraction of their total trading profits. This fraction was adjusted according to our budgetary constraints. Since the common value markets lead to a zero sum of trading profits traders were given a base payment of \$14 or \$15 dollars from which trading profits/losses were added or subtracted. By definition, the average amount earned by traders in these experiments was \$14 or \$15 dollars. The average amount earned by traders in the C and D series markets was also close to \$15 dollars. In the event that a trader's profits were negative or less than \$5, they were given a minimum payment of \$5 as a compensation for their time.

Traders were informed at the start of each experiment that their payout schedules would remain constant. At the beginning of each trading day, traders were given the probabilities of each payout. For markets in series B and D this consisted of either a 50-50 probability of each state or complete knowledge of the shares eventual value. In series A and C the payout could be anywhere in between the upper and lower boundaries of the given range. For these markets, traders were either given equal probabilities of the shares value or they were given complete knowledge.

The number of traders who received inside information was varied in each experiment. This variable was changed in order to determine how many insiders it takes for information to be disseminated efficiently. In all markets except 5, 7 and 9 there were also days in which no traders received inside information about the shares payout. These days were added to help determine the value of inside information. In at least one experiment from each series there were several "blocks" of four or more days where the same traders received inside information. These days were meant to loosely correspond to the fixed informational structure of Plott and Sunder (1982.)

4. THEORY

There are a number of models that have been used to describe market behavior in the existing literature on experimental asset markets. The first category of models make use of the rational expectations hypothesis to form price predictions. These models have generally taken one of two forms. The first of these is fully revealing or telepathic rational expectations hereafter referred to as RE. This model assumes that traders are risk neutral and behave as if they understand the structure of the market. The RE model also assumes that traders make use of all public information and are able to extract private information through market signals such as price and volume. Therefore, whenever there are insiders in a market, all other traders should be able to determine the assets true price through market signals. These assumptions are consistent with the strong form of the efficient market hypothesis.

The expected payoff for any trader, i, in period t is

$$E_{it} = p_{it}(X)v_i(X) + p_{it}(Y)v_i(Y). \tag{1}$$

where X and Y are the set of possible states of nature and $p(X)$ and $p(Y)$ are the probabilities associated with each. As a general rule, X is the best possible outcome and Y is the worst. For our continuous payout schedules X is above the midpoint and Y is below the midpoint of the range of payouts. The state contingent payoffs are represented by $v(X)$ and $v(Y)$ in the above equation. The expected payoff can be thought of as each trader's reservation price. From the above equation we can determine the RE price prediction.

$$P_t(RE) = \max_i E_{it}. \tag{2}$$

This equation merely states that the rational expectations price prediction $P_t(RE)$ will be the maximum of the

reservation prices E_{it} of traders in the market. In periods when one or more traders have inside information, this prediction converges to the actual value of the asset. When no traders have information, this prediction is merely the midpoint of the range of possible payouts. For the private value market predictions we use the highest midpoint from the possible payout ranges.

Another rational expectations model which has been used to explain market behavior is partially revealing rational expectations or PRE (von Borries & Friedman 1988.) This model is similar to another loosened form of RE called ordinary rational expectations which was used by Copeland and Friedman (see Copeland & Friedman 1988.) Given the similarity of the two models I will describe only the PRE model. The PRE model makes the same assumptions concerning risk neutrality and traders knowledge of market structure as the RE model. It differs in that traders are not assumed to make reliable inferences from market signals. When information is given and the payout is above the midpoint of the given range, the PRE predictions are identical to the RE model. However, for payouts that are below the midpoint of the range traders are not assumed to be able to determine the price as effectively. Under these circumstances, traders with inside information are able to sell all of their shares to uninformed traders at a profit. The assumptions of this model are consistent with the semi-strong form of the rational expectations hypothesis.

In order to determine the price predictions for this model we must consider both information given and the assets actual price. For an outcome X with information given, the PRE prediction is identical to the RE prediction. If the outcome is Y and information is given, the price prediction reverts to the maximum reservation price of the uninformed traders. For both no information cases, the price prediction is the second highest reservation price as determined by equation (1).

Another model which has received much attention in the existing literature is the private information or PI model. This model also makes the assumption that traders will act as if they are risk neutral. Contrary to RE models however, PI assumes that traders will ignore all endogenous information from the market. Traders are assumed to act only on their private information. Price predictions are formed applying Bayes law to the given probabilities of each state. Traders will transact based only on these probabilities regardless of what has taken place in the market. These assumptions are in accordance with the expected utility hypothesis.

For the PI model we use equation (1) to determine the reservation prices of each trader. From this equation we can determine the PI price prediction given by

$$P_t(PI) = \max_i 2\, E_{it}. \qquad (3)$$

In all no information cases all of the previous models give exactly the same price predictions.

The general consensus among the existing literature on experimental asset markets seems to suggest that the RE model is the most accurate representation of market behavior in noiseless environments. In the case of somewhat noisier environments, there is some evidence that the PRE model performs slightly better than RE. The PI model has been all but ruled out in a good portion of the literature to date. Given its proven performance and ease of computation, we decided to use the RE model to form price predictions in our analysis. These price predictions were used as a benchmark to compare the effects of each of the variables in our experimental markets.

4.1. THEORETICAL PREDICTIONS

The RE model was used to make forecasts of the equilibrium price of the asset in each period for all markets. The main comparisons that I will be dealing with concern the common value vs. private value markets and fixed vs. random information. Theory and intuition have led me to make the following predictions.

Common Value vs. Private Value

An important theoretical issue to consider when dealing with common value markets is what has been called the "winner's curse." McAfee and McMillan (1987) discuss this phenomenon in great detail with respect to sealed bid, English and Dutch auctions but the general theory is similar for double auctions. In common value markets when a bidder makes a transaction it means that he or she has shown the highest current valuation for the asset. In other words, no other trader currently believes that the asset is worth as much as the trader who just bought it. When insiders are present this can be particularly dangerous for uninformed traders since they will generally overpay for shares. As a result, traders will adjust their bidding strategies to be more cautious than normal. Thus, traders will attempt to avoid becoming the victim of an insider's superior information. Selling strategies in this type of market will also be adjusted to reflect the different expectations of a common value market. In this case it is in the seller's best interest to set a reservation price that is above his or her own valuation. Theoretically a sellers reservation price should increase with the number of traders.

In the common value markets traders were informed that it would be harder to make profits. We refrained from using the words 'zero-sum' but told the traders that everyone would have the same payout. With all traders having the same payout, the incentive to trade is removed. Given this information, theory and intuition would predict lower trading volumes and a wider bid-ask spread in common value markets. In designing these experiments we were expecting to have several trading days without transactions, however, the bid-ask spread would still give valuable information in these cases. We also expected price errors and trader profits to be lower in these markets.

Fixed vs. Random Information

Within at least one experiment in each series there were several blocks of four periods in which the same traders received inside information. Traders were given no previous information about when this would occur. Previous experimental work has found fixed informational structures to make markets more efficient and easier to describe by the fully revealing rational expectations model. The fixed vs. random comparison was included in order to test these previous results. In addition, we put forth the alternative hypothesis that insiders could learn to exploit their information more efficiently after having it for several periods in a row. Thus, traders having information for fixed periods would earn higher profits than those who were given information randomly. As a result, we would expect that price errors in the fixed information periods would be higher.

Other Variables

Two other treatment variables were altered in our experimental markets. The first of these was the number of traders given inside information. Our hypothesis was that price errors and trader profits would go down as the number of insiders was increased. The final variable that was changed was the number of possible payouts in a trading day. Series A and C had continuous payout structures in which the terminal value of the asset could occur anywhere between the ranges endpoints with equal probability. Series B and D were the more conventional payout structure with two equally likely payouts for each trader. Our hypothesis concerning this variable was that price errors and trader profits would be greater in the continuous payout markets. These final variables will be discussed in greater detail in a forthcoming M.S. thesis by Bret Carthew.

5. RESULTS

This section is devoted to analyzing our experimental markets with respect to price errors and the asset's bid-ask spread. The first section looks at the time graphs for selected days in each market. This is followed by a description of the statistical measures and tests used to analyze the data. Finally, I will provide an analysis of price errors and the bid-ask spread with respect to common value vs. private value markets and fixed vs. random informational periods.

5.1. GRAPHS

Because of the large number of trading days in our study (a total of 321) I have elected not to present all of the graphs from each market. Instead, I have selected 4 graphs from each market which summarize major trends that took place. These graphs are shown in figures 2 through 10. The vertical axis of these graphs represents the price of the asset in cents and the horizontal shows time in seconds. The bids and asks are shown by the solid lines and transactions are indicated by stars. The dashed lines on the graphs depict the RE price prediction for each trading day.

The graphs from the first common value continuous market indicate a less than strong-form efficient market in terms of the RE price prediction. Most transactions when there was no information given took place around the midpoint of the payout range as would be expected. When there is only one insider, the market slowly approaches efficiency but still leaves room for insider profits. With two insiders and a payout above the midpoint, the market approaches an efficient outcome much faster and insiders make less profits. However, when the payout is below the midpoint, it is still possible for insiders to sneak out of the market.

The market 2 graphs show a much more efficient market in nearly all cases. There are two possible causes for these different effects in the same type of market. The first of these is the fact that market 2 uses more insiders which leads to greater efficiency. Another possible cause is the date the experiments were run. Over the course of our study we noticed that traders in later common value markets would bid more cautiously and information would come out much faster. Apparently, the group of traders became aware of the proper strategies for common value markets only after a few experiments had been run. Market 2 was conducted much later during our experimental period than was market 1 which could account for the greater efficiency.

The first common value discrete market appears to be slightly less efficient than the continuous payout schedules. In market 3, the no information periods have transactions at all ranges indicating uninformed traders who were mislead. The 1 and 2 insider periods are very efficient when the payout is above the midpoint. However, this market also provides some opportunity for insiders to sneak out of the market when the state of nature is 'bad'. The market 4 graphs indicate that it is much more efficient than market 3. Once again, this may be caused by the increased number of insiders and the later time period in which it was conducted.

The private value continuous markets appear to be much less efficient than either of the common value markets on average. The market 5 graphs show prices slowly approaching the RE prediction but seldom reaching it when there are less than 3 insiders. A large percentage of transactions in these markets occured at or around the midpoint of the ranges. The market 6 graphs show a slight improvement in efficiency over market 5 once again probably due to increased insiders and being conducted later in the study.

The private value discrete graphs make very apparent the induced incentive for trade. The average volume in these markets appears to be much higher than in all other markets observed. The market 7 graphs indicate that a monopolist insider can make substantial profits if the state is 'good.' For 'bad' states the ability of the market to disseminate information is mixed. It is probable that some traders were better than others at withholding information which caused this result. Market 8 included several no information days in which most trades occurred around the midpoint of the higher range as theory would predict. In all other cases, the market 8 graphs appear to be very similar to those for market 7. Market 9 has several multiple insider days structured in blocks of four. However, even multiple insiders don't seem to disseminate information efficiently when the state is bad. For all good states of nature the market appears to approach the RE prediction price quite well. The overall trend in the graphs is that the markets are much less efficient in bad states of nature. This may suggest that some form of partial rational expectations may better represent market behavior.

5.2. STATISTICAL MEASURES

As already mentioned, the statistical tests for our treatment variables were analyzed with the RE model as a benchmark. Thus, when I refer to a price prediction, I mean the price prediction given by the fully revealing RE model. One parametric and one nonparametric test were used to evaluate the data in terms of mean squared error and bid-ask spread. The forecast errors in prices are measured in terms of the square root of the mean squared error (RMSE) and the time weighted root mean squared error (TWMSE.) These figures were calculated using the following formulas.

$$RMSE = \sqrt{\frac{1}{ntrans} \sum_{i=1}^{i=ntrans} \left(x_i - p\right)^2}$$

where x is the transaction price and *ntrans* is the number of transactions in a period.

This error term can also be time weighted as follows

$$TWRMSE = \sqrt{\frac{1}{T} \sum_{i=1}^{i=ntrvls} \left[\frac{t_i}{2}\left(a_i + b_i - 2p\right)\right]^2}$$

where *ntrvls* is the number of intervals where existing market prices were constant. a and b are the best bid and ask at those times. p is the predicted price of the model. t is the length of the time interval and T is the duration of all time intervals. This statistic shows how far off price predictions were from an imaginary price halfway between the current market bid and ask.

The first measurement of efficiency of the bid-ask spread is the difference between the best bid and ask at the end of the trading day. Unfortunately, there is not always a bid and ask withstanding at the end of a trading day so this statistic is not always observable. Additionally, we have employed a time weighted version of this statistic. The time-weighted spread gives the average distance between market bids and asks. It is calculated by summing the distances between bids and asks and multiplying by the time during which bids and asks existed. This statistic is observable even when the end of period spread is not since it represents an average. The formula for time-weighted spread is shown below.

$$TWSPRD = \frac{1}{T}\sum_{i=1}^{i=ntrvls}\left[t_i\left(a_i-b_i\right)\right]$$

The notation in this equation is identical to that used in the earlier equations.

The first test applied to these statistics used the nonparametric Wilcoxon rank-sum T statistic. This test rank-orders the summary statistics for the price prediction over all periods in which they are different. For the sum of the ranked differences, SR_1, the Wilcoxon rank-sum statistic is computed as follows.

$$T=\frac{SR_1-\mu_{SR\,1}}{\sigma_{SR\,1}}$$

$\mu_{SR\,1}$ represents the mean of the ranked sum and $\sigma_{SR\,1}{}^2$ the variance of SR_1. These figures are calculated using the following formulas. $\mu_{SR\,1}=\frac{n_1(n_1+n_2+1)}{2}$ and $\sigma_{SR\,1}{}^2=\frac{n_1 n_2(n_1+n_2+1)}{n-1}$. The null hypothesis for this test is that the data come from the same distribution. Thus, if we obtain a significant value of T, the differences in the ranking of the errors of the two samples can be assumed to be nonrandom.

The other test applied to the sample statistics was a parametric *pooled t* test. The *pooled t* computes the significance of the difference between summary statitistics for each comparison. The *pooled t* is computed as follows

$$t=\frac{(\bar{X}-\bar{Y})\sqrt{\frac{(n_X n_Y)}{(n_X+n_Y)}}}{\sqrt{\frac{S_X{}^2 n_X+S_Y{}^2 n_Y}{n_X+n_Y-2}}}$$

where n_X and n_Y are the number of observations for each sample and S_X and S_Y are the standard deviations. The significance of both the Wilcoxon T as well as the *pooled* t can be inferred from a standard t distribution.

5.3. Price Errors

Common Value vs. Private Value

The statistical results appear in tables 2 and 3. When all observations are considered, common value (CV) markets have a statistically significant lower RMSE than the private value (PV) markets according to the Wilcoxon T*–test*. This remains significant when only fixed information CV and PV periods are tested but loses its significance when only random information observations are included. The *pooled* t*–test* gives statistics with the same sign for all CV and PV and for all fixed information periods but is only significant for the fixed information observations. The TWRMSE test statistics have the same signs and similar significance. This leads us to conclude that the common value markets are more efficient than the private value markets with respect to price errors. This is particularly true in the fixed informational periods.

The continuous markets comparisons show no significant difference in price efficiency for the CV vs PC comparison. The Wilcoxon test statistics, although insignificant, indicate that the common value markets are slightly more efficient. The *pooled* t results are much less significant and differ in sign when time weighted. There doesn't appear to be any useful information given by this comparison.

The discrete payout comparisons show a significantly lower RMSE for common value as indicated by the Wilcoxon T*–stat*. The *pooled* t stats also show common value to have lower price errors but are not quite as significant. These results imply that with discrete payout schedules, CV markets are more efficient than PV markets and better described by the fully revealing rational expectations model.

The early and late comparisons in the table pertain to the first ten trading days and 'all other' trading days in the market respectively. The early day comparisons yielded no significant results but the signs of the test statistics favored common value. The late day comparisons favor common value when evaluated by both the Wilcoxon test and *pooled* t test although only the Wilcoxon was significant. The overall results of the early vs. late comparison indicate that CV markets maintain their efficiency advantage n both early and later periods.

The comparisons for number of insiders show no significant difference between CV and PV when there are less than two insiders. However, when there are two or three traders with superior information, the Wilcoxon *T−stats* strongly indicate lower RMSE's for CV markets. The *pooled t* stats are not as significant but also favor CV markets with two or three insiders. This outcome is not too surprising considering that two or more insiders with the same payout are directly competing for profits. An environment such as this should disseminate information very quickly and make the market more efficient.

Fixed vs. Random Informational Structure

The comparison of all fixed and random informational periods shows no significant difference in price efficiency. Similarly, most of the comparisons between fixed and random information periods yield insignificant results. Exceptions to this include observations in early periods and those for various numbers of inside traders. Both the Wilcoxon *T−stats* and *pooled t−stats* for early periods show fixed information to have significantly lower RMSE's. These results do not remain significant but have the same sign for TWRMSE. The test statistics for later periods favor random information for price efficiency but are not significant. The early period results are consistent with the results of past research that found fixed information to be more efficient. However, the results of the later period comparison suggest that information is not disseminated as efficiently in fixed information environments. One possible explanation of this is that insiders are in fact able to make better use of their information but only in later periods after 'getting a feel' for the market. A more rigorous test of this hypothesis could compare insider's profits for fixed and random information in later periods of the market. This test will be left for future research.

The comparisons for the number of insiders show several significant figures for TWRMSE and to a lesser degree RMSE. The tests for RMSE with one insider show fixed information periods to have a lower RMSE. This result is consistent with past research in finding fixed information to be more efficient. However, the test statistics turn to favor random information as the number of insiders increases. Intuitively, one would expect that as the number of insiders increased, information would disseminate more efficiently and that fixed information would accelerate this process. A possible explanation of this phenomenon is some form of implicit collusion between insiders. By cooperatively trying to not let their information get out, insiders could extract higher profits from the outsiders in the market. This type of collusion would be most successful with a fixed informational structure.

5.4. Bid-Ask Spread

Common Value vs. Private Value

The end of period spread comparison for all observations favors common value over private value for the Wilcoxon T but not the *pooled* t test. However, the Wilcoxon T is statistically significant, while the *pooled* t is very insignificant. The Wilcoxon T's also significantly favor common value markets for random information periods and for observations with 2 or 3 insiders. The *pooled* t's actually favor private value markets but are not significant for any of the comparisons. On average it appears that common value markets have lower end of period spreads particularly with multiple insiders.

The time-weighted spread test statistics give quite different results however. Both the Wilcoxon T and *pooled* t favor private value when all observations are considered. In fact, private value is favored significantly by most of the comparisons. The results are not as significant for periods with insiders but the signs favor private value in virtually all comparisons.

The fact that most of the end of period spread and time-weighted spread statistics are in disagreement is not as disturbing as one would initially think. The differences in the way these statistics are calculated must be taken into consideration when evaluating the results. The end of period spread is only observed at one point in time (the end of a trading day). The time-weighted spread however, is an average of the spread throughout the entire trading day. Therefore, it makes sense that these statistics may disagree at times. Based on the current results it appears that CV markets have lower end of period spreads while PV markets have lower average spreads. This result may be partially explained by the effects of winner's curse. Early in the trading days of CV markets, traders bid more cautiously producing a wider spread. As information is leaked out later in the trading day the spread becomes narrower. Since common value markets disseminate information more efficiently, it makes sense that the spread would become smaller at the end of the period than in private value markets. Private value markets on the other hand, have a narrower spread initially and a relatively small spread throughout which produces a smaller time-weighted spread.

Fixed vs. Random Information

Virtually all significant test results in the fixed vs. random information comparisons of bid-ask spreads indicate that random information periods have a lower bid-ask spread on average. The TWSPREAD test statistics are significant in a majority of the comparisons. The end of period spread statistics are not significant as often as TWSPREAD but also favor random information periods. These results lead to the conclusion that information is disseminated more efficiently with random information and contradict past research. Taken alone, these results confirm our hypothesis that insiders are able to exploit their information more efficiently when receiving it for consecutive periods. Unfortunately, this conclusion is not supported by the price error comparisons and requires further testing.

6. TRADING STRATEGIES

In this section I will discuss possible trading strategies for informed and uninformed traders. In addition, I will briefly analyze which strategies were apparently used by traders in our experimental markets. The optimal strategy for each trader depends on their expectations of the world and the information they receive.

Friedman and Copeland (1988) propose 3 possible trading strategies that insiders will choose from. Traders following a *risk-neutral* strategy will accept(refuse) offers to sell shares at prices above(below) their predetermined reservation price R_i and refuse(accept) offers to purchase shares at prices at prices above(below) R_i. Traders who follow an *aggressive* strategy will actively undercut(raise) the current best ask(bid) whenever they may do so at a price above(below) their predetermined reservation price. Finally, they consider an *aggressive risk-neutral* strategy followed by traders who posess both of the above characteristics. Traders who use the *aggressive* and *aggressive risk-neutral* strategies will reveal information to the uninformed traders in the market. On the other hand, traders following a pure *risk-averse* strategy are much less likely to disseminate information.

Uninformed traders on the other hand, are quite limited in their choice of trading strategies. A trader without information may try to interpret market signals and act upon them according to his or her reservation price. However, after becoming the victim of superior information, traders may resort to a *withdrawal* strategy. A *withdrawal* strategy is defined by Friedman and Copeland as "the refusal to accept offers to buy or sell, and the setting of her own bid(ask) below the minimum(above the maximum) possible final equilibrium price given current information."

There appear to have been some trends of strategic behavior in our experimental markets. Monopolist insiders are sometimes able to follow a risk-neutral strategy without revealing their superior information. This is particularly true in 'bad' states of nature when they are able to sneak out of the market. When additional insiders are present, bidding strategies become more aggressive as insiders compete for profits. Uninformed traders tend to use risk-neutral strategies in early experiments but resort to withdrawal strategies in later periods. Withdrawal strategies seem to be more prevalent in common value markets where it is easier to become a victim. Additional analysis of trading strategies may provide useful information in the future but is not the focus of the current study.

7. CONCLUSION

The price error comparisons of common value and private value markets lead to the initial conclusion that common valuation of assets is a more efficient treatment in experimental double auction markets. However, there are a few points which must be discussed before making any general assumptions. The first of these is the "winner's curse" phenomenon described earlier. The effects of winner's curse are evidenced by lower trading volumes and an increased time-weighted spread. The combination of these factors alone could lead to lower price errors and the appearence of a more efficient market. One should also consider the significance of the bid-ask spread statistics. As already mentioned, these statistics indicated that private value markets had a smaller bid-ask spread on average. This appears to be inconsistent with the conclusion that common value markets are more efficient. However, higher trading volumes in private value markets may partially cause these results. It is also important to note that the test statistics were computed using fully revealing rational expectations as a benchmark model. This model is not universally accepted and it is possible that a comparison based on some form of partially revealing rational expectations may give different results. Lastly, a complete comparison of private value and common value markets should incorporate an analysis of trader profits and asset allocation.

The comparison of fixed and random informational periods weakly indicates that fixed information is more efficient with respect to price errors when there are less than 2 traders with inside information. This conclusion supports past research that found fixed information structures to be strong form efficient and random information to be only semi-strong form efficient. However, this assumption is also contradicted by the results of the bid-ask spread statistics and is therefore inconclusive. Once again, to obtain a comprehensive test of fixed and random information efficiency, trader profits and allocation of shares should be included.

Further research in this area should incorporate the additional comparisons that I have mentioned above. Unfortunately, the software to efficiently make these comparisons was not readily available at the time our analysis was carried out. Additionally, an analysis of the data using some form of partially revealing rational expectations as a benchmark model may obtain interesting results. It is my eventual goal to carry out this additional research when better endowed with time and resources.

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Table 1a*
Series A
COMMON VALUE CONTINUOUS PAYOUT SCHEDULE

	Market 1 Range \$.40 - \$2.00		Market 2 Range \$.70 - \$2.10	
Day	Informed Traders (ID#)	State	Informed Traders (ID#)	State
1	0	.70	0,4	.87
2	1	1.62	0,4	.77
3	2	.54	0,4	1.68
4	none	.94	0,4	1.96
5	2	1.42	1	1.16
6	0	1.12	1	1.64
7	0	1.68	1	.90
8	3	.43	1	.94
9	0	1.78	2	1.90
10	4	.48	2	1.37
11	5	1.80	2	2.04
12	5	1.63	2	.84
13	0	.45	5	1.67
14	3	.62	5	1.01
15	6	1.46	5	1.51
16	5	1.02	5	1.78
17	0	1.50	3,5,6	1.65
18	1	1.03	3,5,6	1.02
19	7	.67	3,5,6	.78
20	4	.67	3,5,6	2.09
21	0,2	.62	2,3,4,5	.91
22	2,6	.62	0,4	2.03
23	4	1.92	1,4	1.93
24	4	.82	1,5,7	.74
25	1	.58	1,4,5	1.86
26	7	1.47	none	.77
27	3	1.95	0,3,5,6	1.04
28	5	.66	2,4	1.57
29	0	1.57	1,4,6	.71
30	2,3	1.60	1,7	1.85
31	4	.82	0,4	.97
32	5,7	1.42	2,6,7	1.76
33	3,6	.82	0,2,7	1.14
34	1,4	1.79	3,5	.84
35	7	1.94	1,2,6	2.06
36	0,5	1.54	none	1.40
37	6,7	1.12	0,3,7	1.93
38	6	1.68	2,6	1.96
39	0,2	.42	0,3,6	.97
40	1,3	1.79	3,7	1.82

* Note: In all experiments traders were given \$40 and 3 shares at the beginning of each trading day.

Table 1b Series B COMMON VALUE DISCRETE PAYOUT SCHEDULE				
	Market 3 X = $1.90, Y = $.30		**Market 4** X = $1.90, Y = $.50	
Day	Informed Traders (ID#)	State	Informed Traders (ID#)	State
1	0	Y	0,4	Y
2	1	X	0,4	Y
3	2	Y	0,4	X
4	none	Y	0,4	X
5	2	X	1	Y
6	none	Y	1	X
7	none	X	1	Y
8	3	Y	1	X
9	none	X	2	X
10	none	Y	2	Y
11	none	X	2	X
12	none	X	2	Y
13	none	Y	5	X
14	3	Y	5	Y
15	none	X	5	X
16	none	Y	5	X
17	0	X	3,6,7	X
18	1	Y	3,6,7	Y
19	none	Y	3,6,7	Y
20	3	Y	3,6,7	X
21	0,2	X	2,3,4,5	Y
22	2	Y	0,4	X
23	none	X	1,4	X
24	none	Y	1,5,7	Y
25	none	Y	1,4,5	X
26	none	X	none	Y
27	0	X	0,3,5,6	Y
28	none	Y	2,4	X
29	0	X	1,4,6	Y
30	2,3	X	1,7	X
31	5,6	Y	0,7	Y
32	5,7	X	2,6,7	X
33	3,6	Y	0,2,7	Y
34	1,4	X	3,5	Y
35	none	X	1,2,6	X
36	0,5	X	none	Y
37	6,7	Y	0,3,7	X
38	none	X	2,6	Y
39	0,2	Y	0,3,6	X
40	1,2	X	3,7	X

Table 1c
Series C
PRIVATE VALUE CONTINUOUS PAYOUT SCHEDULE

	Market 5 Range I $.60 - $1.90 Range II $.80 - $1.40		**Market 6** Range I $.60 - $2.00 Range II $.90 - $1.60	
Day	Informed Traders (ID#)	State	Informed Traders (ID#)	State
1	7	1.88, 1.39	0,4	.77, .98
2	7	.73, .86	0,4	.67, .94
3	7	1.08, 1.02	0,4	1.58, 1.39
4	7	.70, .85	0,4	1.86, 1.53
5	3	1.55, 1.24	1	1.06, 1.13
6	3	1.70, 1.31	1	1.54, 1.37
7	3	.74, .87	1	.80, 1.00
8	3	1.17, 1.06	1	.84, 1.02
9	0	.65, .83	2	1.80, 1.50
10	0	1.74, 1.33	2	1.27, 1.24
11	0	1.45, 1.19	2	1.94, 1.57
12	0	.90, .94	2	.74, .97
13	5	.60, .80	5	1.57, 1.38
14	5	1.82, 1.36	5	.91, 1.06
15	5	1.60, 1.26	5	1.41, 1.30
16	5	1.01, .99	5	1.68, 1.44
17	2	.81, .90	4,6,7	1.55, 1.38
18	2	.79, .89	4,6,7	.92, 1.06
19	2	1.65, 1.29	4,6,7	.68, .94
20	2	1.87, 1.39	4,6,7	1.99, 1.58
21	6	1.59, 1.26	2,3,4,5	1.00, 1.11
22	6	.91, .94	0,4	1.56, 1.93
23	6	1.82, 1.36	1,4	1.52, 1.83
24	6	1.71, 1.31	1,5,7	.92, .64
25	1	1.38, 1.16	1,4,5	1.48, 1.76
26	3,7	1.67, 1.09	none	.94, .67
27	0,5	1.78, 1.35	0,3,5,6	1.07, .94
28	4	.63, .81	2,4	1.34, 1.47
29	1,2,6	1.39, 1.17	1,4,6	.91, .61
30	3,4	1.30, 1.12	1,7	1.48, 1.75
31	0,7	1.60, 1.26	0,4	1.04, .87
32	2,4,5	.77, .88	2,6,7	1.43, 1.66
33	1	1.81, 1.36	0,2,7	1.12, 1.03
34	2,6	1.72, 1.32	3,5	.97, .74
35	5,7	.83, .71	1,2,6	1.58, 1.96
36	1,3,4	1.46, 1.19	none	1.25, 1.30
37	2,7	1.37, 1.15	0,3,7	1.52, 1.86
38	0,5,6	.61, .81	2,6	1.53, 1.86
39	4	.78, .89	0,3,6	1.04, .87
40	1,7	1.74, 1.32	3,7	1.46, 1.72
41	4	1.89, 1.39		

Table 1d Series D PRIVATE VALUE DISCRETE PAYOUT SCHEDULE						
	Market 7 Type I X=$1.80,Y=$.50 Type II X=$1.30,Y=$.70		Market 8 Type I X=$1.80,Y=$.40 Type II X=$1.20,Y=$.70		Market 9 Type I X=$2.00,Y=$.50 Type II X=$1.40, Y=$.80	
Day	Insiders (ID#)	State	Insiders (ID#)	State	Insiders (ID#)	State
1	7	X	7	X	0,1	X
2	7	Y	1	Y	0,1	X
3	7	Y	6	X	0,1	Y
4	7	Y	4	Y	0,1	Y
5	3	X	none	X	4	X
6	3	X	none	Y	4	X
7	3	Y	4	X	4	X
8	3	Y	3	X	4	Y
9	1	Y	none	Y	6,7	X
10	1	X	7	Y	6,7	Y
11	1	X	3	X	6,7	Y
12	1	Y	none	X	6,7	X
13	6	Y	1	Y	0,3	Y
14	6	X	2	X	0,3	X
15	6	X	none	Y	0,3	Y
16	6	Y	none	Y	0,3	X
17	3	Y	5	X	2	X
18	3	Y	none	Y	2	Y
19	3	X	5	X	2	Y
20	3	X	1	X	2	X
21	6	X	0	X	4,5	Y
22	6	Y	2	Y	4,5	X
23	6	X	none	X	4,5	X
24	6	X	6	X	4,5	Y
25	1,4	X			1,2,6	X
26	1,4	Y			1,2,6	Y
27	1,4	Y			3,5,7	Y
28	1,4	X			3,5,7	X

Table 2* COMMOM VALUE vs. PRIVATE VALUE COMPARISONS					
SAMPLES		PERFORMANCE MEASURES			
X vs. Y	STATISTIC	RMSE	TWRMSE	SPREAD	TWSPREAD
1. All	Wilcoxon	-2.51	-1.94	-2.29	3.68
	t	-1.46	-1.75	.14	4.67
	Means	29.9,34.1	35.8,39.7	27.0,26.2	46.8,36.9
	Nob's	156,160	160,161	153,146	160,161
2. Fixed Information	Wilcoxon	-2.98	-2.70	-.24	4.62
	t	-2.24	-2.81	.28	5.41
	Means	25.8,35.6	32.0,41.5	29.1,27.2	54.9,39.4
	Nob's	47,95	49,96	48,90	49,96
3. Random Information	Wilcoxon	-.93	-.12	-2.38	2.36
	t	-.04	.09	.14	3.23
	Means	31.7,31.9	37.4,37.1	26.0,24.6	43.3,33.1
	Nob's	109,65	111,65	105,56	111,65
4. Continuous	Wilcoxon	-1.01	-1.16	-1.56	0.35
	t	.013	-.81	.59	1.30
	Means	24.6,24.5	28.6,30.8	26.7,20.9	34.5,31.7
	Nob's	77,80	80,81	74,69	80,81
5. Discrete	Wilcoxon	-2.54	-1.85	-1.58	5.15
	t	-1.86	-1.87	-.57	5.70
	Means	35.2,43.6	42.9,48.7	27.3,30.9	59.2,42.1
	Nob's	79,80	80,80	79,77	80,80
6. Early Periods	Wilcoxon	-1.04	-1.65	-1.58	1.75
	t	-.49	-1.16	-1.22	2.20
	Means	34.8,37.4	37.5,43.1	23.6,34.6	44.5,36.7
	Nob's	40,50	40,50	39,46	40,50
7. Late Periods	Wilcoxon	-2.23	-1.04	-1.61	3.22
	t	-1.25	-1.20	.83	4.06
	Means	28.3,32.6	35.2,38.2	28.2,22.3	47.6,37.0
	Nob's	116,110	120,111	114,100	120,111
8. Zero Insiders	Wilcoxon	.36	-1.78	.21	3.39
	t	.54	-1.76	.78	3.56
	Means	54.0,47.0	31.6,47.7	42.1,31.7	67.1,37.6
	Nob's	21,10	23,10	23,9	23,10
9. One Insider	Wilcoxon	-.89	-.39	.17	1.19
	t	-.76	-.20	1.06	1.76
	Means	34.3,37.4	40.2,40.9	35.7,25.0	39.8,35.2
	Nob's	64,88	65,89	62,82	65,89
10. Two Insiders	Wilcoxon	-2.2	-1.91	-2.64	.94
	t	-1.93	-2.00	-1.58	1.51
	Means	22.5,31.5	34.5,42.2	17.7,33.6	48.3,42.6
	Nob's	44,40	44,40	41,36	44,40
11. Three Insiders	Wilcoxon	-3.15	.44	-2.67	1.19
	t	-1.10	.81	-1.00	1.93
	Means	14.0,20.5	31.7,27.8	9.1,14.6	45.4,32.0
	Nob's	23,20	24,20	23,18	24,20

*Note: Positive values favor private value over common value.

Table 3*
FIXED vs. RANDOM INFORMATION COMPARISONS

SAMPLES X vs. Y	STATISTIC	PERFORMANCE MEASURES RMSE	TWRMSE	SPREAD	TWSPREAD
1. All	Wilcoxon	.62	.61	1.61	3.31
	t	.17	.44	.42	2.47
	Means	32.3,31.8	38.3,37.3	27.9,25.2	44.6,39.5
	Nobs	142,174	145,176	138,161	145,176
2. Common Value	Wilcoxon	-.59	-1.16	1.59	3.41
	t	-1.24	-1.58	.29	2.95
	Means	25.8,31.7	32.0,37.4	29.1,26.0	54.9,43.3
	Nobs	47,109	49,111	48,105	49,111
3. Private Value	Wilcoxon	1.05	1.35	-.41	2.72
	t	.96	1.35	.45	3.08
	Means	35.6,31.9	41.5,37.1	27.2,24.6	39.4,33.1
	Nobs	95,65	96,65	90,56	96,65
4. Continuous	Wilcoxon	.03	1.08	-.18	2.38
	t	-.03	.76	-.92	2.02
	Means	24.5,24.6	31.0,28.9	18.5,27.7	35.7,31.3
	Nobs	62,95	64,97	59,84	64,97
5. Discrete	Wilcoxon	-.25	-1.30	1.96	1.28
	t	-.42	-1.12	1.87	.64
	Means	38.5,40.4	44.0,47.6	34.8,23.2	51.7,49.6
	Nobs	80,79	81,79	79,77	81,79
6. Early Periods	Wilcoxon	-2.81	-1.49	.06	1.90
	t	-3.10	-1.77	.73	1.13
	Means	31.0,47.9	37.8,46.9	31.8,24.7	41.5,37.1
	Nobs	62,28	62,28	58,27	62,28
7. Late Periods	Wilcoxon	1.63	1.22	1.21	3.02
	t	1.31	1.23	-.09	2.51
	Means	33.4,28.7	38.7,35.2	25.0,25.7	47.0,40.0
	Nobs	80,146	83,148	80,134	83,148
8. Zero Insiders	Wilcoxon	-1.85	-2.16	2.01	.91
	t	-1.70	-2.03	1.88	.45
	Means	36.3,58.0	22.9,41.7	56.4,32.4	61.5,57.0
	Nobs	9,22	9,24	9,23	9,24
9. One Insider	Wilcoxon	-2.55	-2.05	-1.40	3.44
	t	-2.26	-2.07	-1.19	3.57
	Means	32.4,41.5	37.7,44.8	24.7,36.8	40.8,31.7
	Nobs	90,62	92,62	86,58	92,62
10. Two Insiders	Wilcoxon	1.71	2.26	.55	1.40
	t	1.89	2.42	.95	.25
	Means	32.4,23.3	44.1,34.6	31.0,21.1	46.2,45.2
	Nobs	32,52	32,52	31,46	32,52
11. Three Insiders	Wilcoxon	1.88	1.54	2.03	3.07
	t	2.42	2.45	2.26	3.53
	Means	28.7,13.0	39.0,26.6	20.8,7.7	57.6,32.4
	Nobs	11,32	12,32	12,29	12,32

*Note: Positive values favor fixed information structure

```
Double Auction Market 2.0          Trader Name                Time left:  1:05
Experiment test:  Day #1           (Trader #0)

  Prob.  Worth
  .50    $1.90
  .50    $0.30


      Your  Mkt
      Price Price
Asks: 1.80  1.60
Bids:*1.00  1.00

Ticker Tape:  1.76  1.35  .98  1.22

===>
+-------+ +-------+ +-------+ Holdings:                          +-------+ +-------+ +-------+
|   Q   | |   E   | |   R   |                                    |   U   | |   I   | |   P   |
|       | |Accept | |       | Start:   25.00    0.00             |       | |Accept | |       |
|  Ask  | | Best  | |Cancel | Change:   0.00    0.00             |Cancel | | Best  | |  Bid  |
|       | |  Bid  | |  Ask  | Now:     25.00    0.00             |  Bid  | |  Ask  | |       |
+-------+ +-------+ +-------+                                    +-------+ +-------+ +-------+
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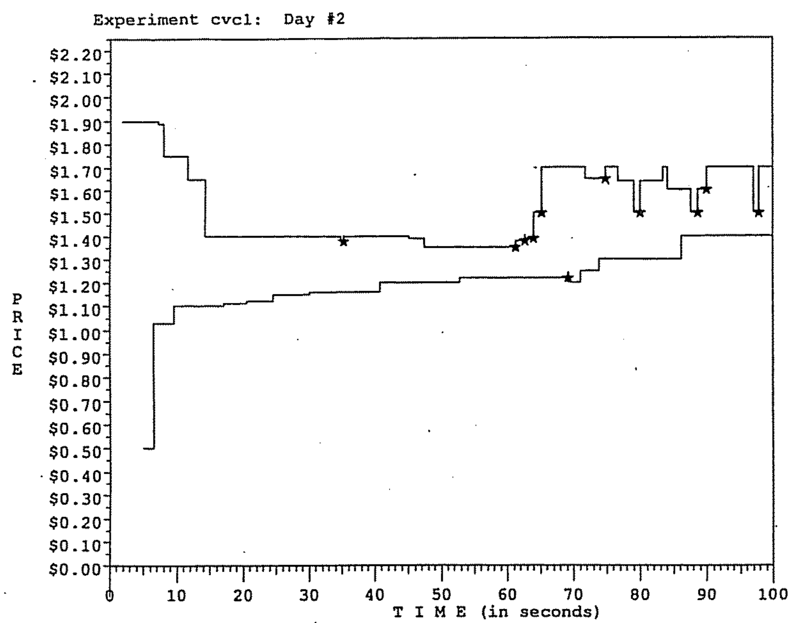
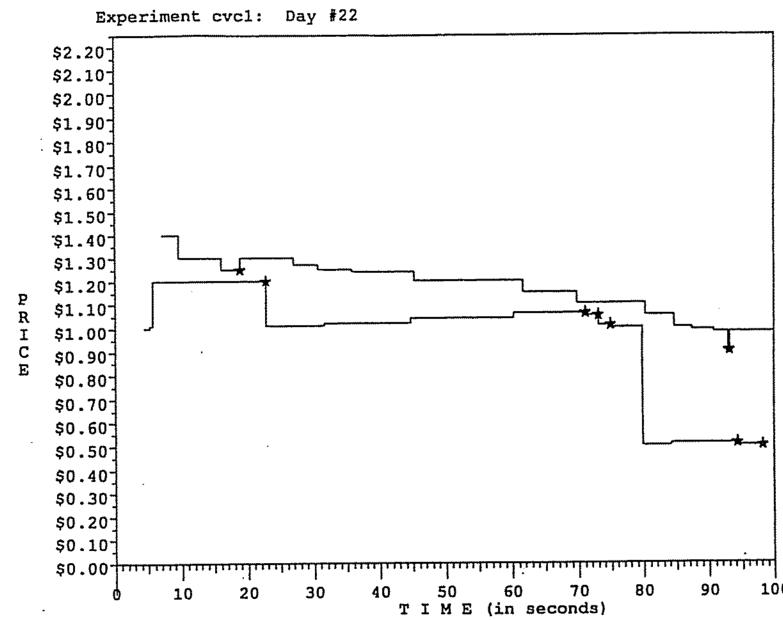

Experiment cvcl: Day #2
PRICE
TIME (in seconds)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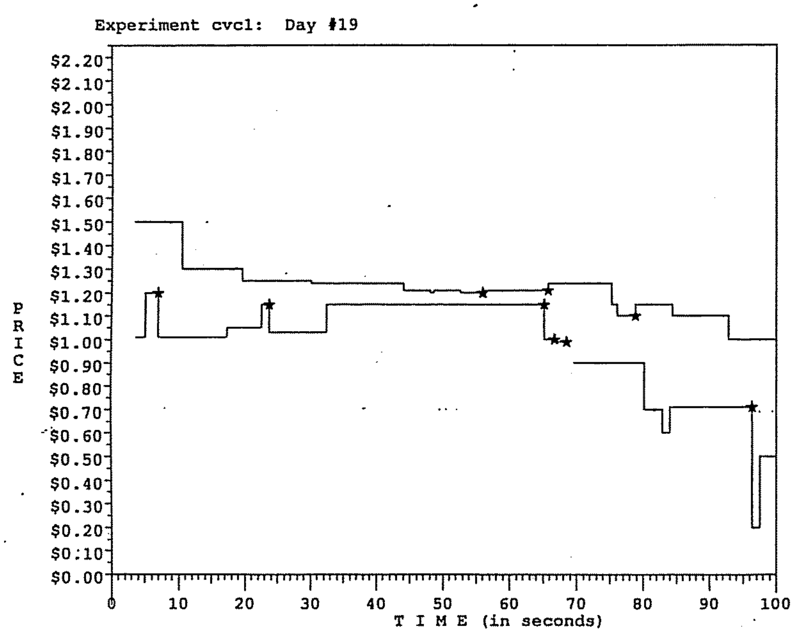
PRICE
TIME (in seconds)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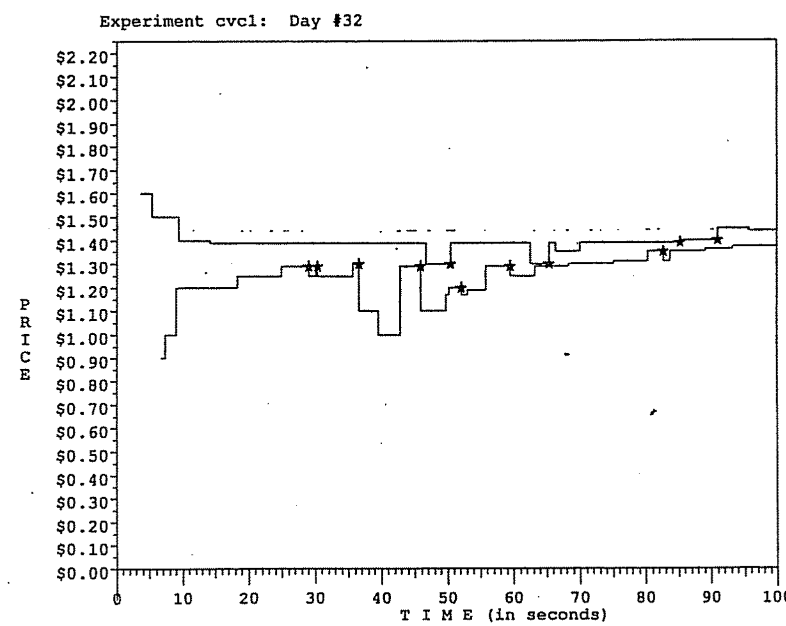
PRICE
TIME (in seconds)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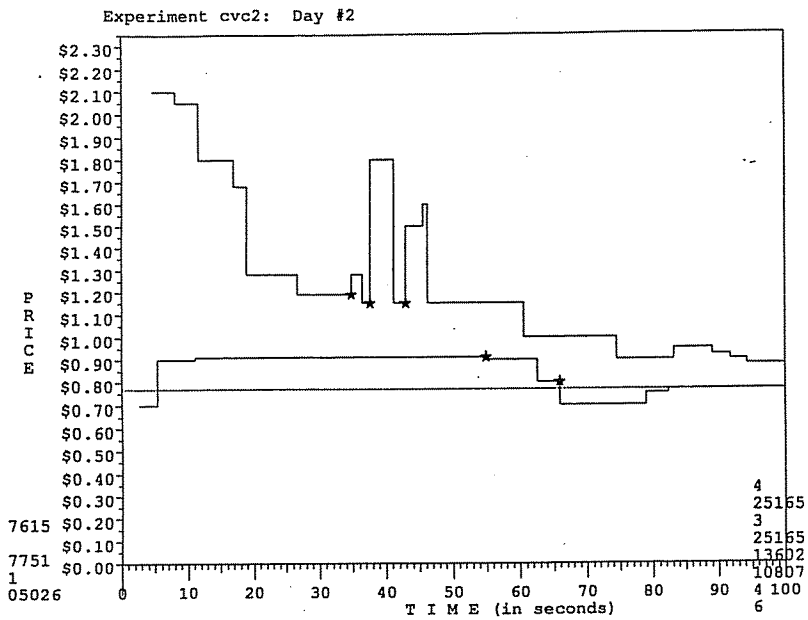
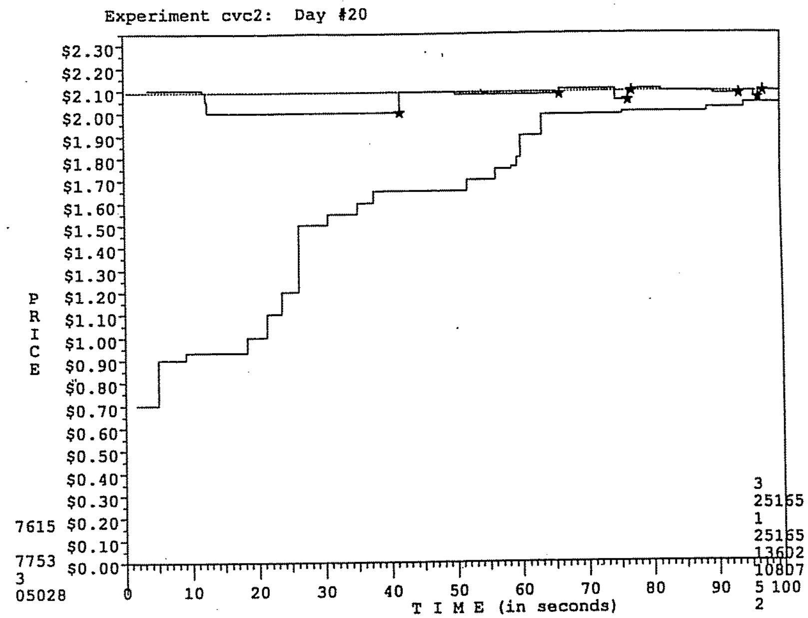
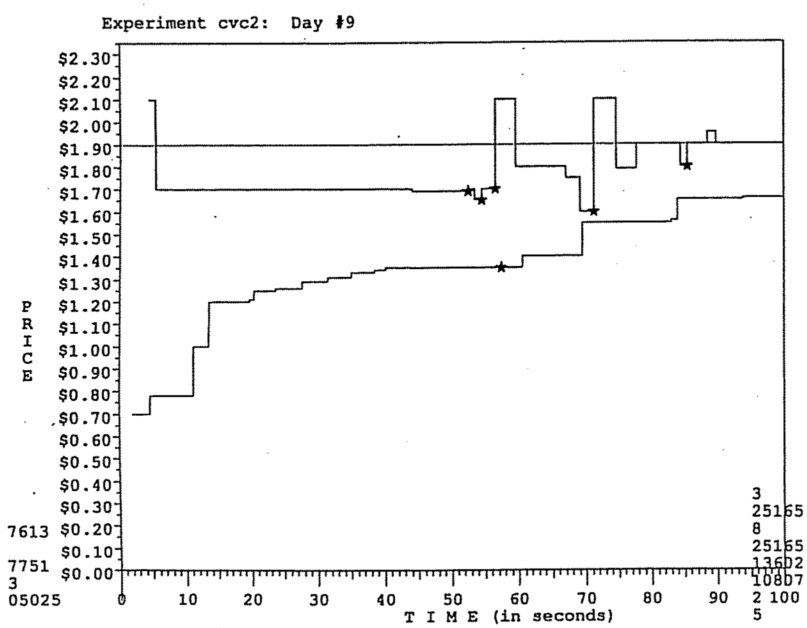
PRICE
TIME (in seconds)


Experiment cvc2: Day #2
PRICE
TIME (in seconds)


Experiment cvc2: Day #20
PRICE
TIME (in seconds)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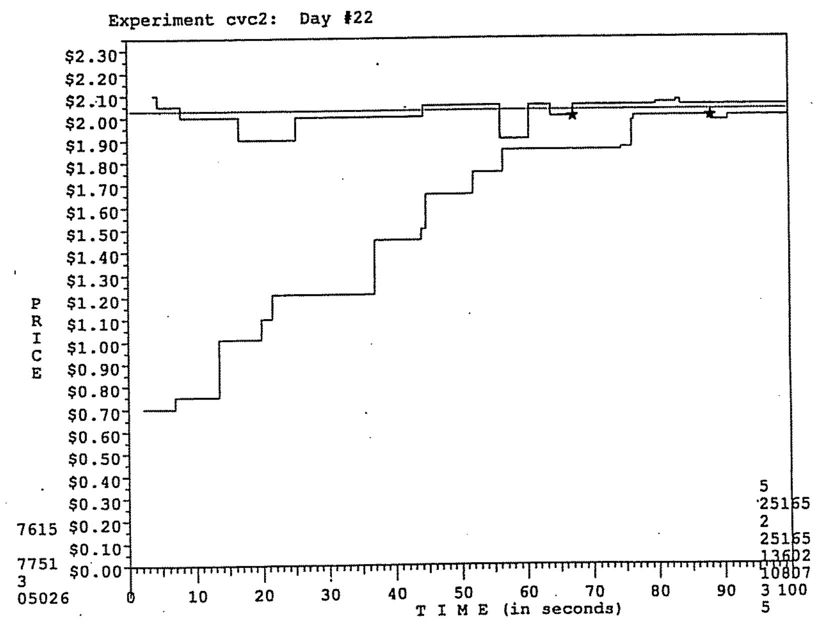
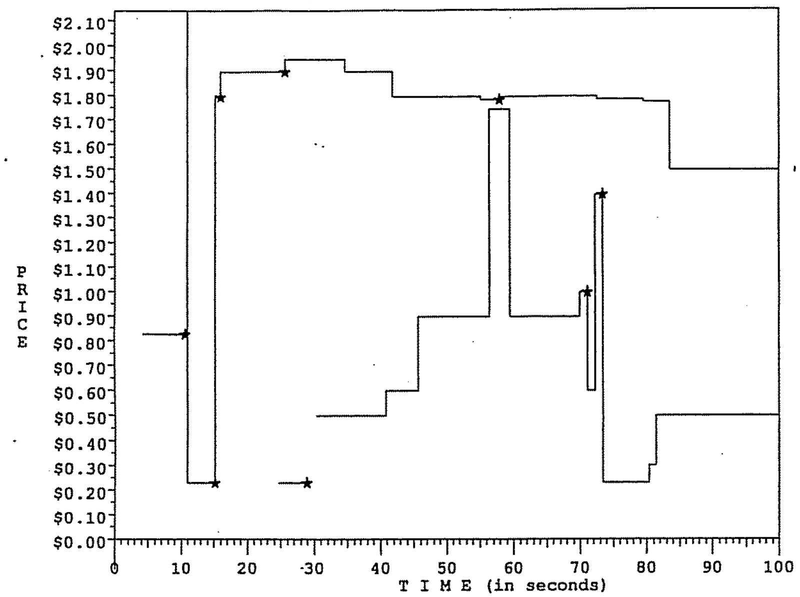
PRICE
TIME (in seconds)


Experiment cvc2: Day #22
PRICE
TIME (in seconds)

Experiment cvdl: Day #4



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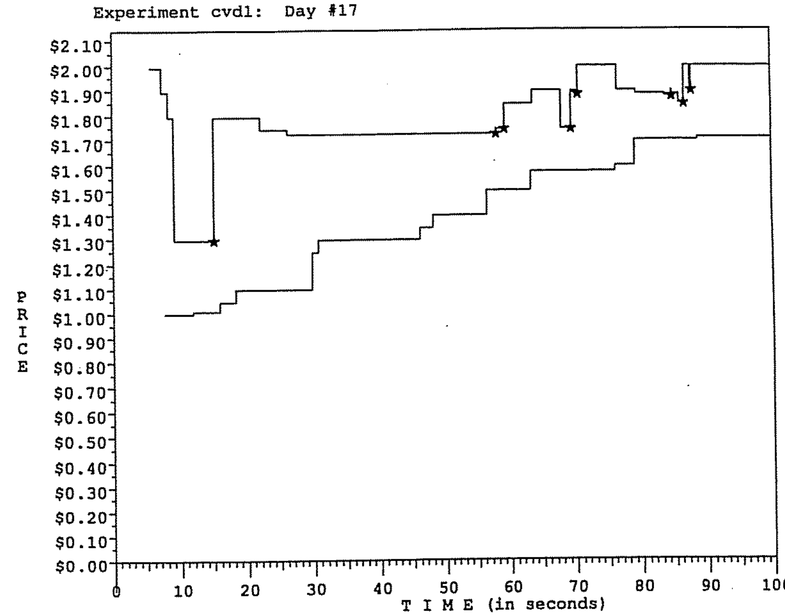

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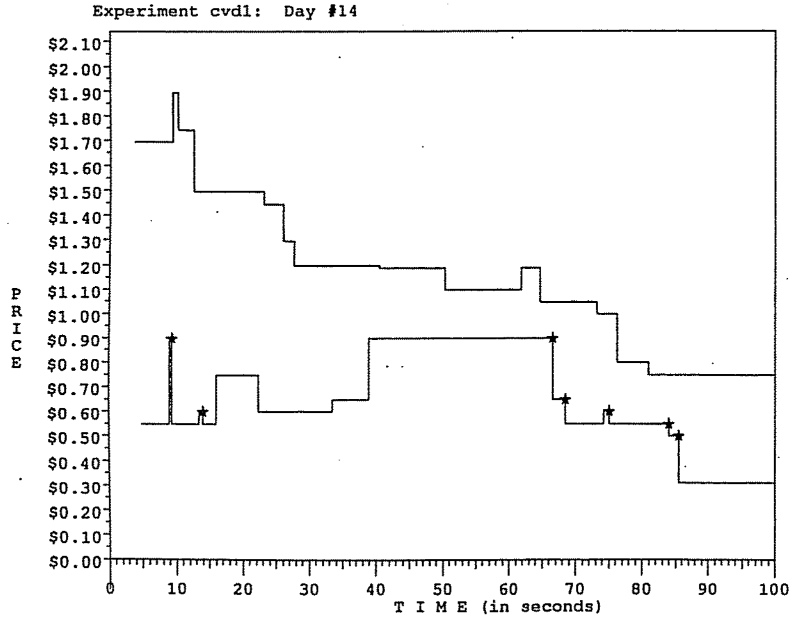

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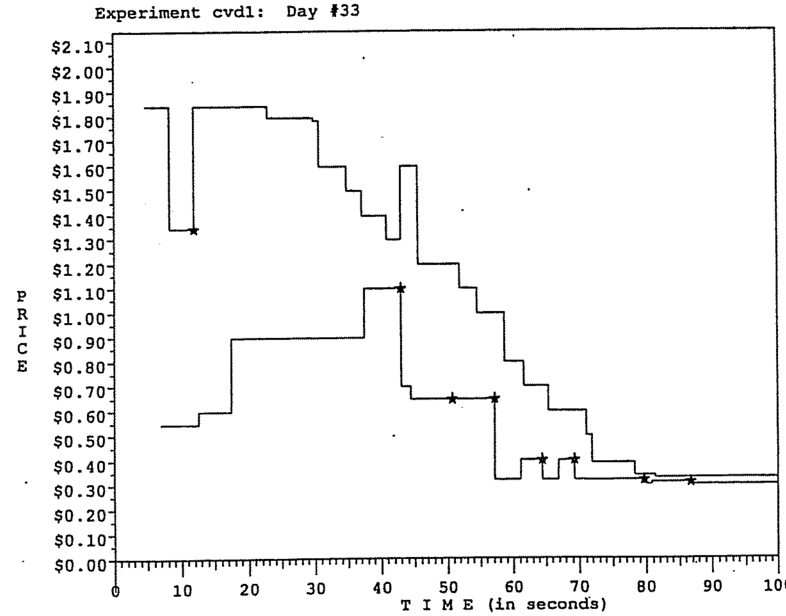

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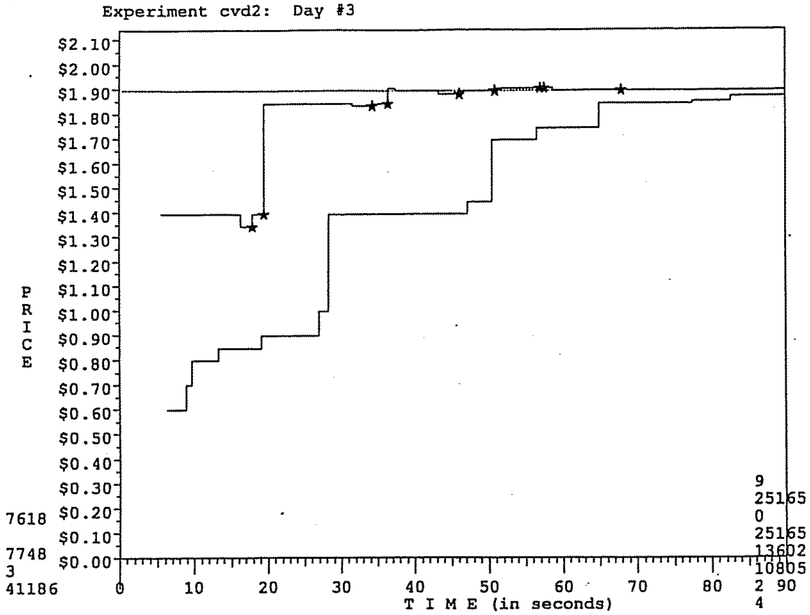

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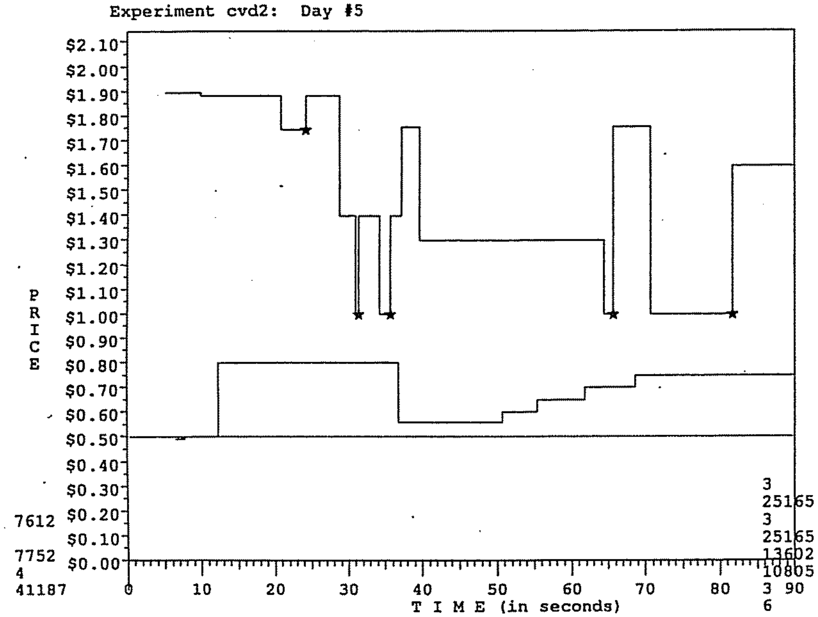

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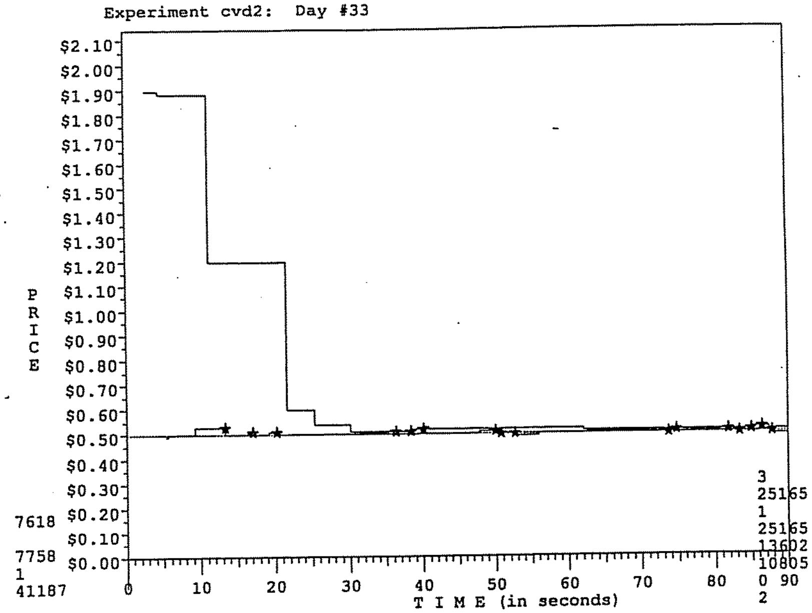
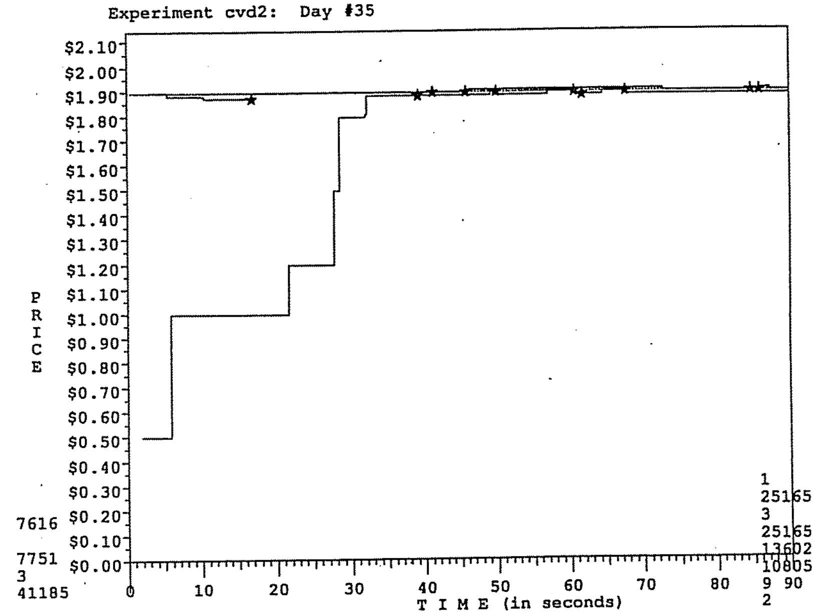
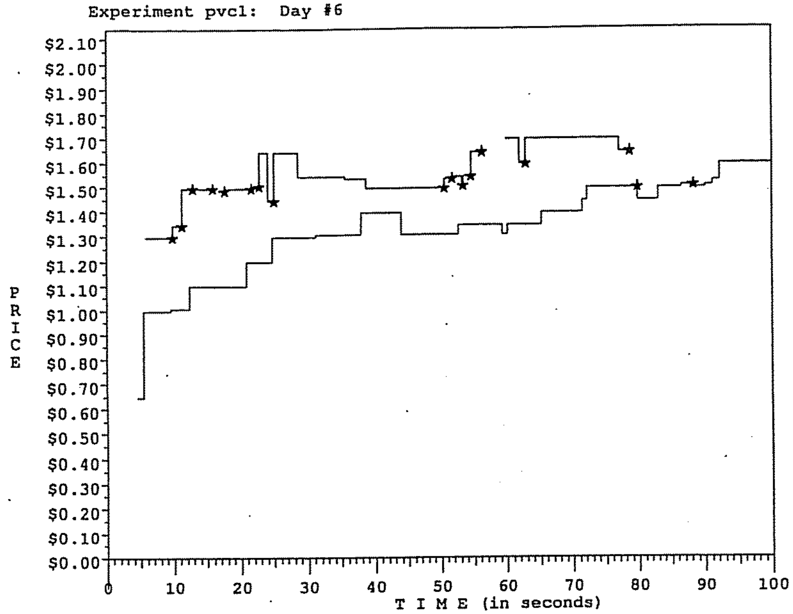


Experiment cvd2: Day #35



Experiment pvcl: Day #6



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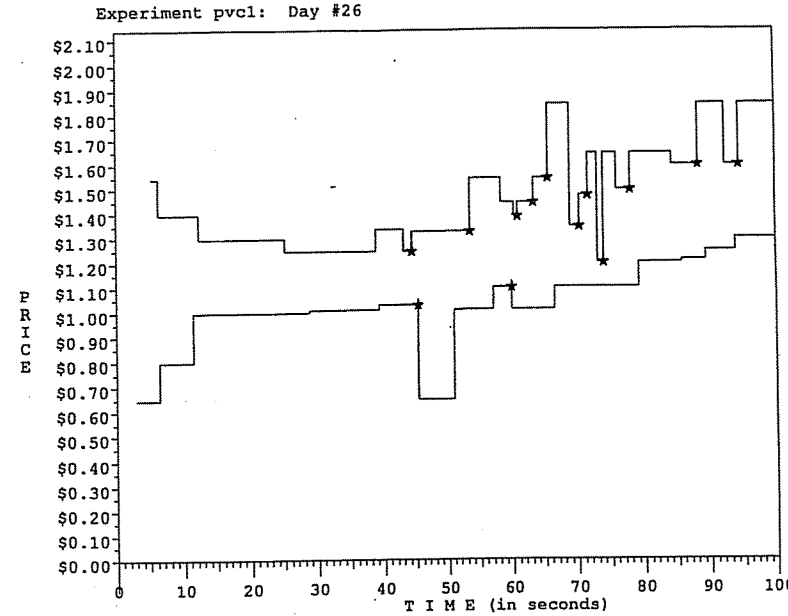
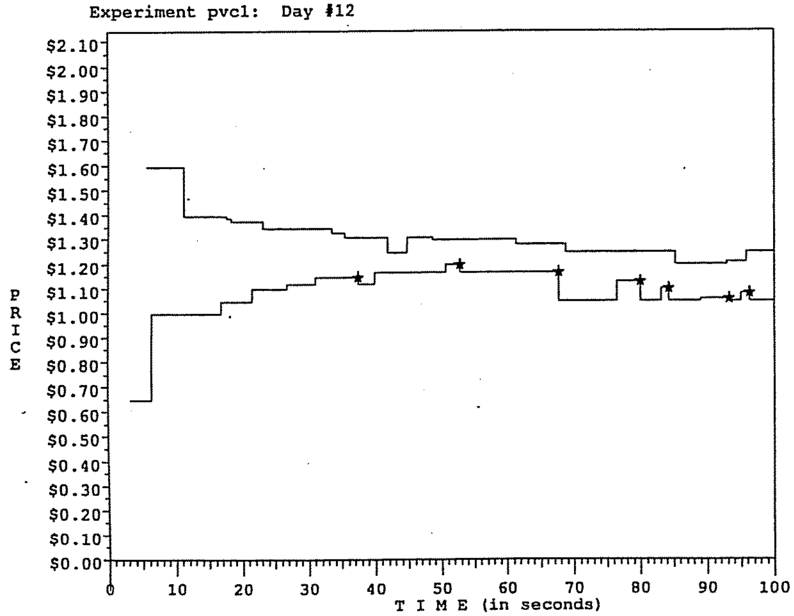
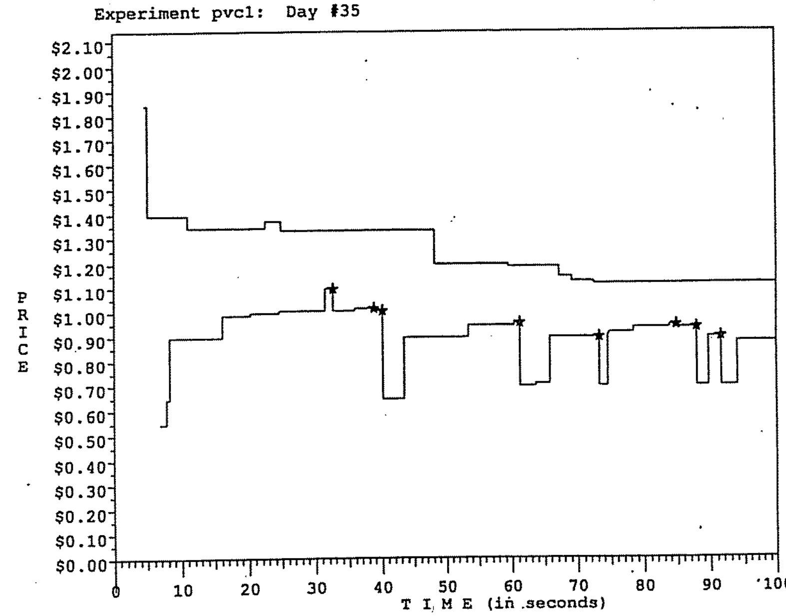


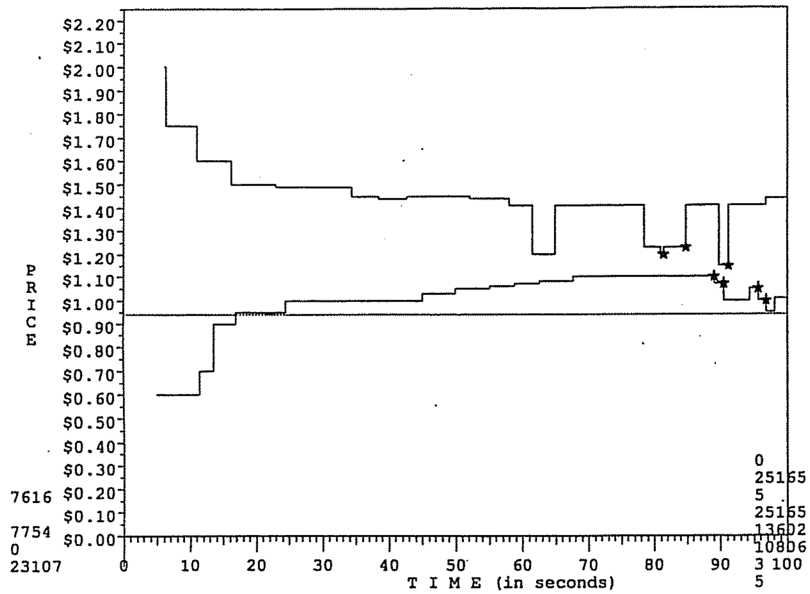
Experiment pvcl: Day #12



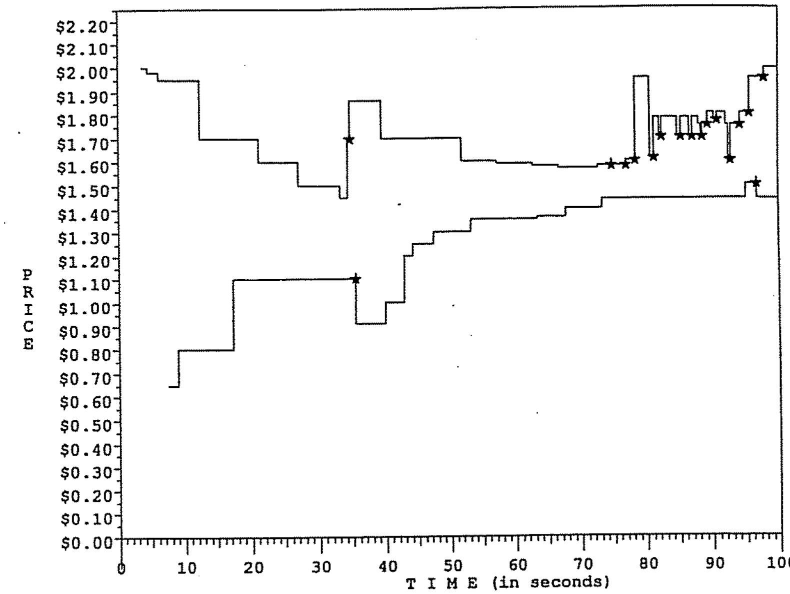
Experiment pvcl: Day #35



Experiment pvc2: Day #2



Experiment pvc2: Day #20



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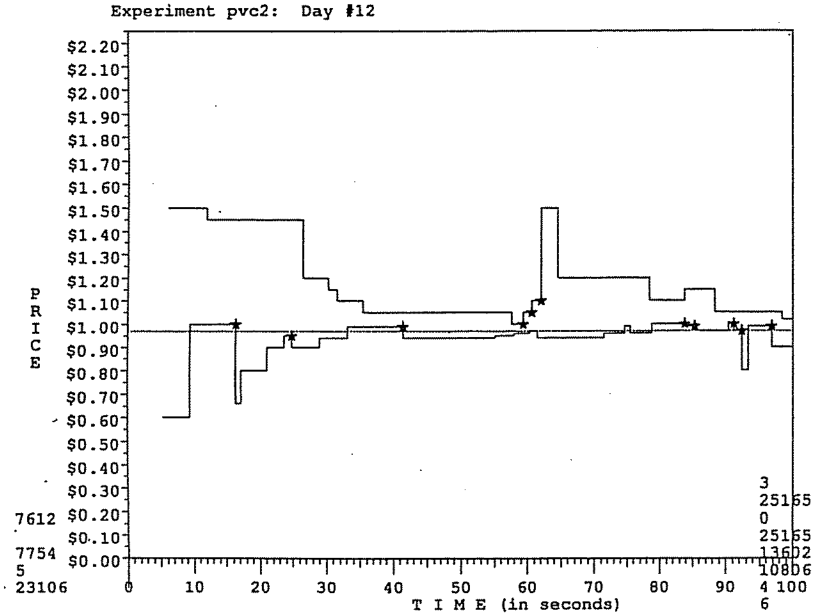

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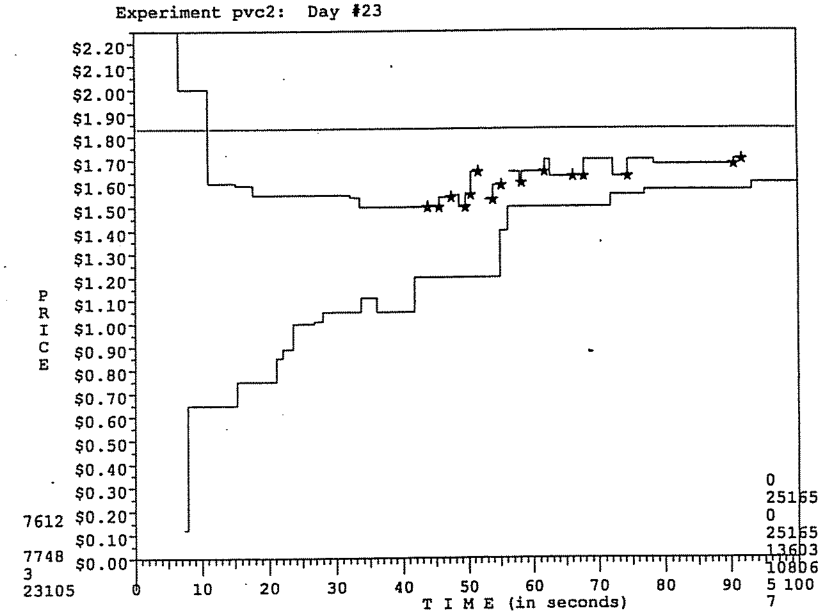

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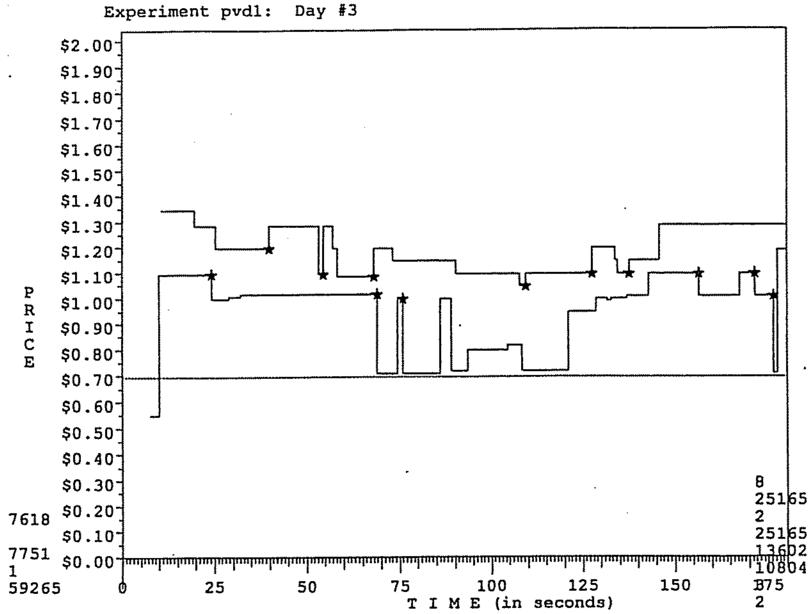

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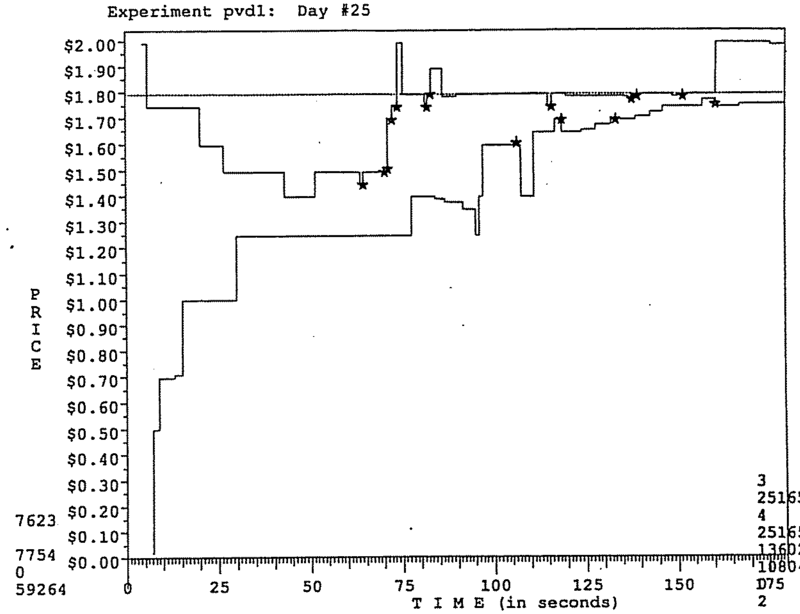

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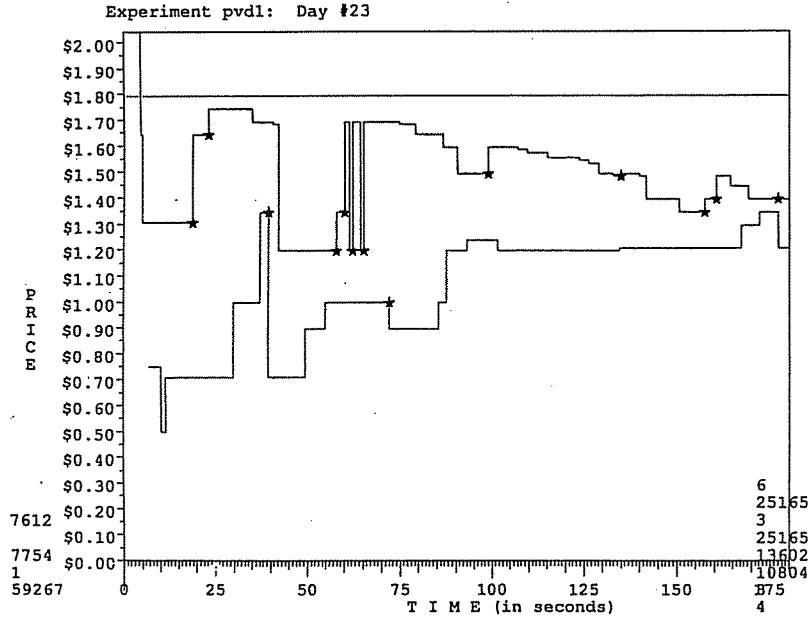

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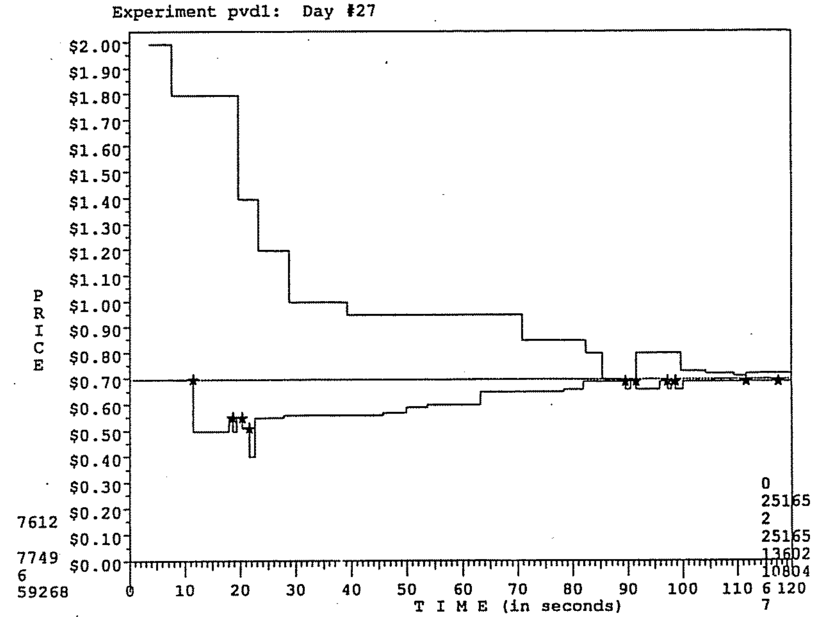

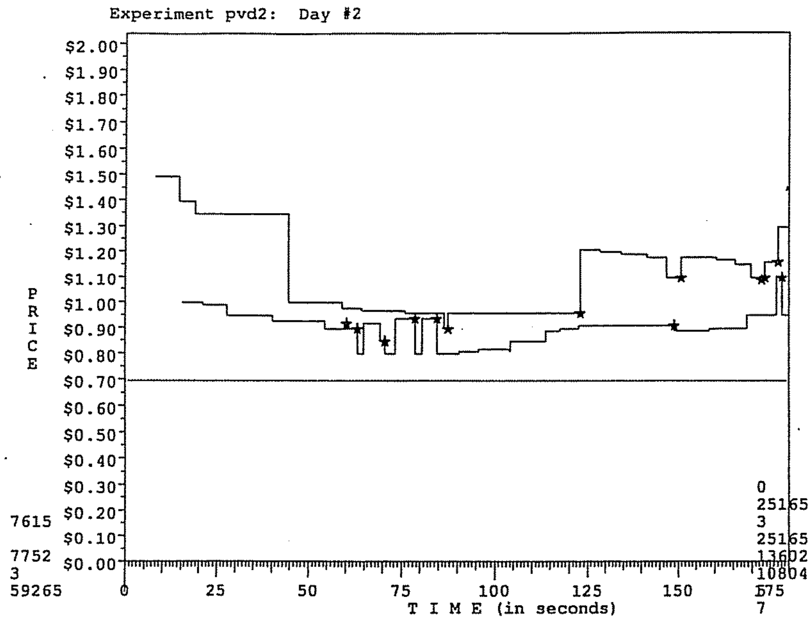
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TIME (in seconds)
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25165
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10804
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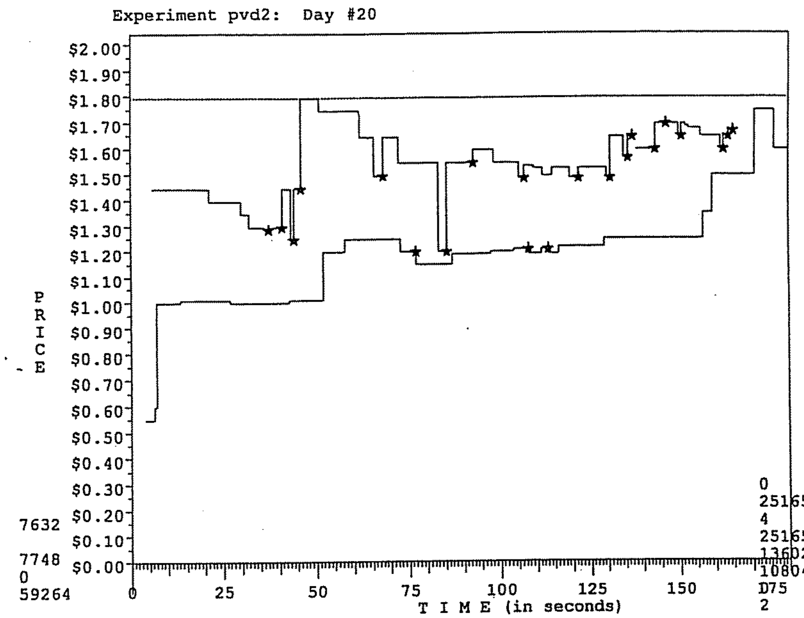
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$0.00
7632
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TIME (in seconds)
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25165
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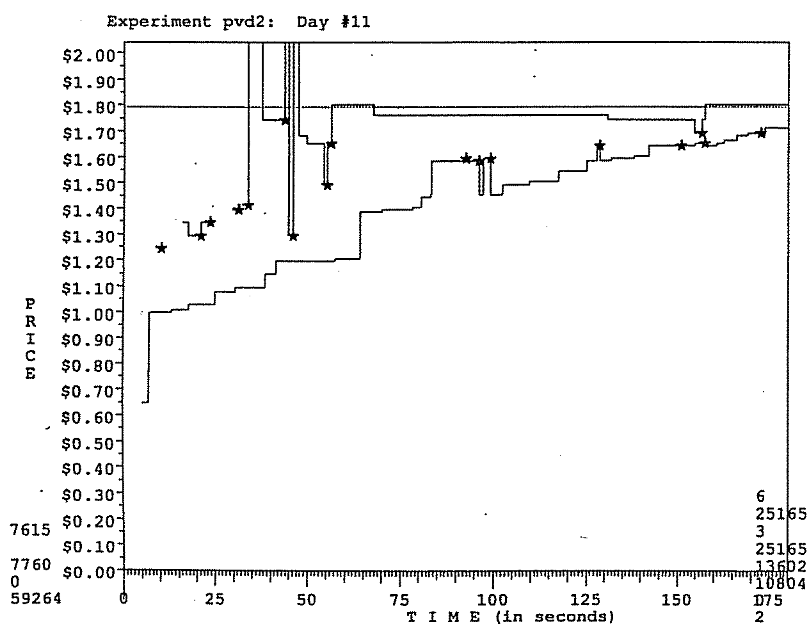
10804
2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TIME (in seconds)
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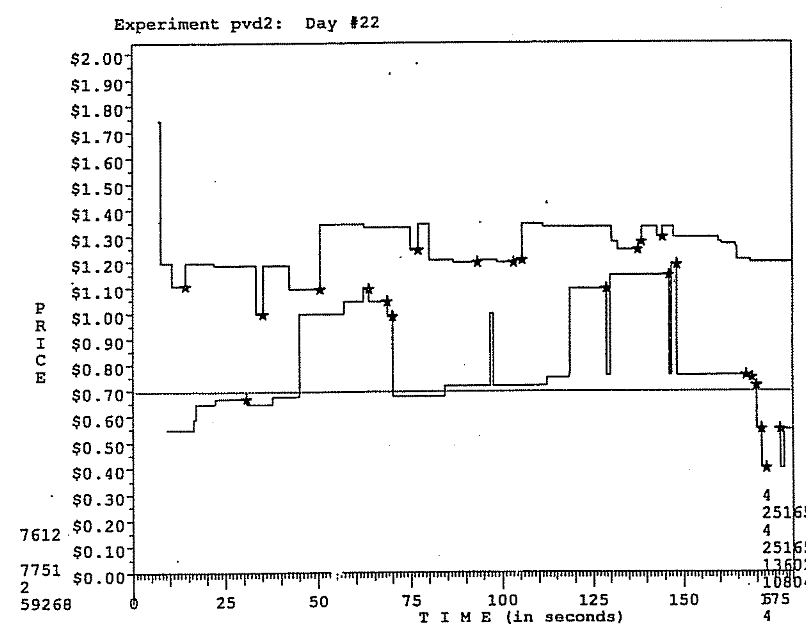
2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7612
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59268
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25
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75
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175
TIME (in seconds)
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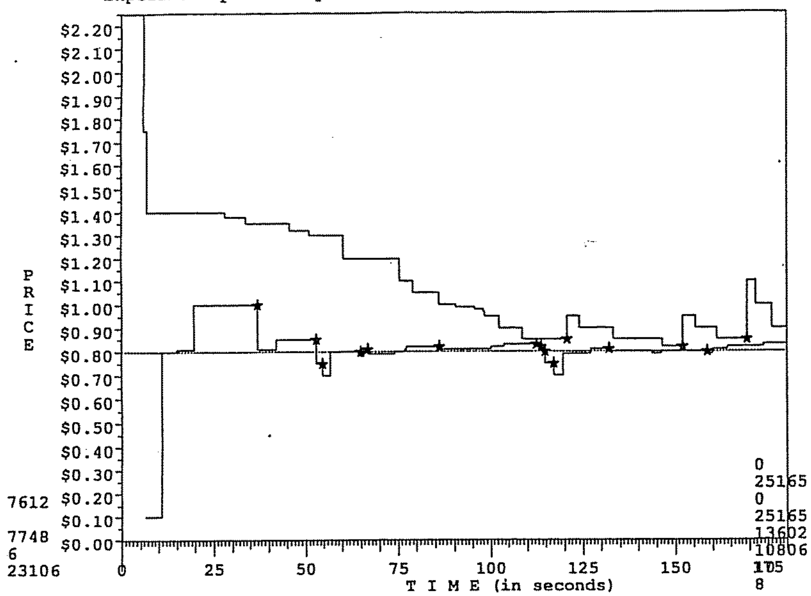
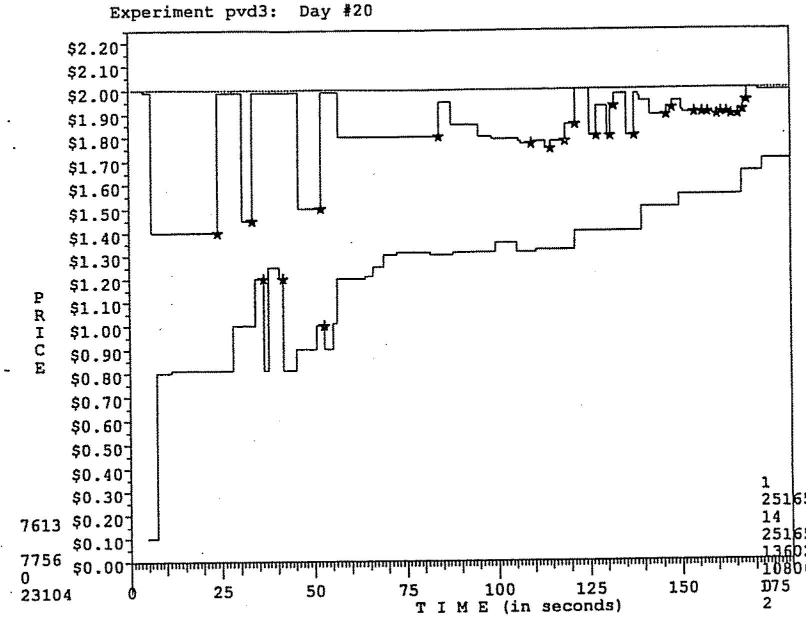
25165
4
25165
13602
10804
4

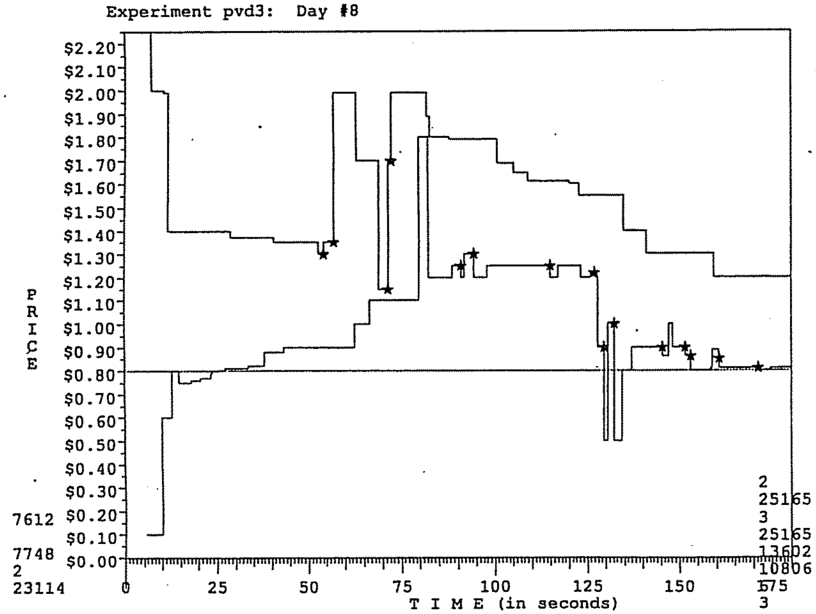
Experiment pvd3: Day #4



Experiment pvd3: Day #20



Experiment pvd3: Day #8



Experiment pvd3: Day #25