Undergraduate Economic Review

Volume 7 | Issue 1 Article 9

2011

An Exploration of Market Efficiency and the Marginal Trader Hypothesis

Thomas Clay McManus
College of Charleston, TCMcManus@gmail.com

Calvin Blackwell
College of Charleston, blackwellc@cofc.edu

Follow this and additional works at: https://digitalcommons.iwu.edu/uer

Recommended Citation
McManus, Thomas Clay and Blackwell, Calvin (2011) "An Exploration of Market Efficiency and the Marginal Trader Hypothesis," *Undergraduate Economic Review*: Vol. 7 : Iss. 1 , Article 9.
Available at: https://digitalcommons.iwu.edu/uer/vol7/iss1/9

This Article is protected by copyright and/or related rights. It has been brought to you by Digital Commons @ IWU with permission from the rights-holder(s). You are free to use this material in any way that is permitted by the copyright and related rights legislation that applies to your use. For other uses you need to obtain permission from the rights-holder(s) directly, unless additional rights are indicated by a Creative Commons license in the record and/ or on the work itself. This material has been accepted for inclusion by faculty at Illinois Wesleyan University. For more information, please contact digitalcommons@iwu.edu.
©Copyright is owned by the author of this document.

An Exploration of Market Efficiency and the Marginal Trader Hypothesis

Abstract

This research explores one possible explanation for market efficiency, the Marginal Trader Hypothesis (MTH), which holds that a small group of active and well-informed traders are responsible for steering market price to efficient levels. We test the appropriateness of the MTH by conducting a series of experimental asset markets; information regarding the asset's value was introduced to the markets so as to evaluate the impact on market efficiency and the role of the "insider" in steering market price. The results indicate that traders conformed to the median of three possible values, though prices failed to converge to a Rational Expectations equilibrium.

Keywords

Experimental Economics, Laboratory Asset Markets, Marginal Trader Hypothesis, Market Efficiency, Rational Expectations, Price Formation, Information Aggregation

Cover Page Footnote

Many thanks most especially to Dr. Calvin Blackwell for his expertise, direction and advice with respect to both this material and my development as a student of economics; thanks also to the professors in the College of Charleston's Department of Economics and Finance, notably to Dr. Betsy Jane Clary for first instilling in me a passion for economics.

This article is available in Undergraduate Economic Review: https://digitalcommons.iwu.edu/uer/vol7/iss1/9

Introduction

Discussion on the subject of market efficiency and the accuracy of the world's financial markets, and indeed the capacities of the market mechanism as a whole, has grown in the past twenty years with advances in the study of experimental economics and finance and changes in the dynamics of the financial market system. The recent global recession, stemming largely from the so-called "Subprime Mortgage Crisis," led to a collapse in the global financial markets which has further fueled debate over the accuracy of prices in the financial markets relative the true intrinsic value of the stocks being traded. The Dow Jones Industrial Average closed at its highest-ever price of over 14,164 on October 9, 2007, and lost over half that value over the following seventeen months, closing at a price of 6,547 on March 9, 2009. While the bear market has since turned bull, the question remains as to how accurately price levels within the security markets reflect the true value of the stocks being traded. An application of experimental economics, a discipline which studies economic theories by applying experimental methods, affords an opportunity to test the accuracy of a market for securities under parameterized conditions. More specifically, the operation of experimental asset markets allows economists to explore the potential accuracy of the market instrument and to investigate conditions which foster accurate pricing within a security market; market conditions discovered to improve market efficiency in the laboratory can then be applied to real financial markets as a means of building more accurate markets which are less-susceptible to volatile shifts such as the recent collapse.

Efficient prices within the financial market reflect the future earnings for a security, discounted for risk and the time value of money. For example, a share of common stock traded on the New York Stock Exchange would be correctly priced if the current price in the market was equal to future dividends and capital gains on the security, adjusted for risk and with future cash flows discounted accordingly. A single-period security, paying only one dividend at the end of the holding period and with no other re-sale value, would be efficiently priced in a market if the price at which it is trading is equal to the dividend which is later paid for it.

This paper investigates the potential of the market mechanism with regards to efficient price formation and the underlying drivers of such a convergence. Security markets have been known to operate at efficient price levels amidst diverse private information and despite the inclusion of poorly-informed or "market-ignorant" traders. Furthermore, the studies in experimental economics (Forsythe, Palfrey, and Plott 1982; and Plott and Sunder 1982, 1988) have established that markets are able to both aggregate diverse private information held by individual traders and disseminate this information to all traders through price signals and other endogenous variables. Specifically, this

research explores one possible explanation for market efficiency, the Marginal Trader Hypothesis (MTH), as well as market efficiency amidst partial information; the MTH suggests that a small proportion of the trader population, having either superior information or market intellect, are responsible for steering market price to efficient levels by exploiting mispricings in the market and correct price level as a by-product of this action.

We test the appropriateness of the MTH by conducting three sessions of experimental asset markets, comprised of two stages. The first stage was a prediction contest designed to teach participants about the state-selection mechanism and disproportionate state structure. The second stage was comprised of eight consecutive rounds of computerized asset markets, in which six or twelve participants traded securities in a double-oral auction. Information regarding the true price of the artificial securities was injected into the markets in varying degrees so as to evaluate the impact of insider information on market efficiency and the role of the "insider," defined herein as the (imposed) marginal trader, in steering market price. The results of this study indicate that traders within the security markets studied were able to conform to prices consistent with the expected value of the security based on no information other than the dividend and state-selection structure, though the prices fail to adjust to the introduction of insider information to a proportion of participants. Some shifts in price level reflect a lower or higher true value, though the shifts are inconsistent and insufficient in size so as to support the notion of a perfectly efficient market.

This paper begins by summarizing the pertinent body of literature surrounding experimental asset markets and the MTH. The second section describes the methodology of the study with regards to the market design and to the models which are tested. The results of the study are presented in the next section, and thereafter discussed. The final section is the conclusion.

Literature Review

The late economist Friedrich Hayek famously asserted what has since come to be called the *Hayek hypothesis*; it holds that holds that despite traders' limited knowledge about their environment and other traders, markets can work correctly. (Forsythe et al. 1992) While the theory carries undeniable weight coming from a Nobel laureate, Hayek and those who have followed him have provided little explanation as to what enables markets to operate at efficient levels and continue to do so even with large numbers of participants of varying degrees of market competence. While many explanations for this observation have been tested, the process of efficient price formation itself and the contributing factors remain largely a mystery to economists.

The Efficient Markets Hypothesis (EMH) broadly holds that markets are efficient based upon the information held by the traders within them. The

supposition is divided into three forms which account for various levels of information disclosure: strong form, semi-strong form, and weak form. The strong form of the EMH asserts that the market is efficient based upon publicly held information, both current and that held in the past, and also private or "insider" information which is held by some trader(s) but has not been publicly disclosed. The semi-strong version of the EMH asserts that the market is efficient based solely upon the body of publicly available information, both at the current time and that which has been made available in the past. Lastly, the weak form of the EMH asserts only that markets are efficient based upon all public information which has been made available in the past.

Within an experimental asset market in which some portion of traders are given insider information regarding the true value of a security, the various forms of the EMH explain varying levels of market efficiency with regards to that true value. Under the strong form specifically, the price in the market will equal the true value provided the collective body of private and public information contains that value. For example, if even one trader is told that the true price is not one of three possible values and another is told the same information about another of the three values, then the collective body of information "knows" that the true price is the remaining of the three values and a market adhering to the strong form of the EMH would trade the securities at that efficient price.

This research into the Hayek hypothesis on market efficiency and potential explanatory models is founded on the research in two fields: the methodology and research design stems primarily from the field of experimental economics, while the marginal trader hypothesis (which comprises a central target of the study) has been developed in field experiment research on political stock markets. Therefore, each field will be separately explored through the contributions, methodology, and results presented by previous research selected for its prominence and/or relevance to the focus of this research. In conjunction, the research into experimental economics and political stock markets suggests the following: markets can, under the proper conditions, aggregate and disseminate asymmetrical information to the ends of achieving rational expectations equilibrium; and the marginal trader hypothesis represents a plausible explanation of the mechanisms which steer a market to efficiency even in the presence of non-rational trader behavior.

The study of experimental asset markets truly came into its own in the 1970's. Researchers such as Vernon Smith began to promulgate the potential benefits of operating economic markets in a closed laboratory setting as a means of testing hypotheses on observed market behavior; Smith (1976) observed that all the defining characteristics which underpin market activity, such as the pursuit of self-interest and diverse trader information, inevitably can be simulated in an experimental setting. Launching from this intrinsic link between laboratory

controlled markets and "real world" markets, the study of experimental economics has grown and developed over the past three decades.

While much of the research in the field has been centered on testing economic theory in an experimental market, research into the design of experimental markets themselves and the effects of various parameters has been an underlying theme in much of the prominent research. Establishing the implications of various market restrictions and trader conditions in a laboratory setting has been particularly important to the study of market behavior, most notably price formation. Various models of price formation have been studied in experimental markets in an attempt to explain observed market behavior and isolate the relevant causes of market efficiency, the most prominent of these being the Rational Expectations (RE) model. The RE model holds that individual traders form expectations about the true state of nature based upon endogenous variables observed in the marketplace, and act upon both their own personal information and their inferences based on these observations. In an experimental market with insider information, the model suggests that non-insiders will behave the same as insiders because the price in the market is fully revealing. While research into market behavior has proven that experimental markets operating under certain conditions behave in accordance with the RE model, it has failed to yield a formal model explaining the process of price equilibration. (Forsythe and Lundholm 1990)

Although the RE model and strong form of the EMH would predict the same market price levels under the application of insider information, that is to say they both explain that the market price will equal the true intrinsic price, the former explains this observation in a slightly different manner than does the latter. While the strong form of the EMH holds simply that prices will be an accurate reflection of all publicly and privately held information, the RE model explains that this will happen in equilibrium as each trader behaves as if they were aware of the entire body of private information; the strong form of the EMH does not posit this condition. Within the context of this paper, efficient prices are defined as prices which reflect the body of privately held information and therefore, because the body of insider information as a whole contains the true value, are equal to the price of the security at the end of the round. This definition is congruent with both the RE model and the strong form of the EMH.

Robert Forsythe and his colleagues have developed a model for this process in their study of political stock markets, a unique and nonconventional application of experimental economic theory. The Iowa Political Stock Market (IPSM), which has since come to be called the Iowa Election Market (IEM), is an experimental futures market which allows participants to trade securities which pay dividends relative the results of an upcoming election. In their research, Forsythe and others have found that market efficiency is achieved through the

actions of marginal traders, identified broadly as well-informed and active traders more capable of inferring true price and willing to act on those inferences. The impressive accuracy of past markets lends significant weight to their theory.

Experimental Economics

Through the 1960's and early 1970's, future Nobel Prize winning economist Vernon L. Smith laid the foundation for the field of experimental economics. Smith (1976) represents a summary of his findings and an examination of Induced Value Theory; many characteristics of experimental markets which now are intuitively familiar to economists were first published in the work. Smith (1976) asserts that all the defining characteristics of market structure and individual behavior which underpin market activity, such as the pursuit of self-interest and trader information diversity, inevitably occur in an experimental setting. Observations of market phenomena such as price formation, Smith (1976) reports, can be formulated into hypotheses and tested in controlled experiments.

Smith's Theory of Induced Valuation holds that control, which is the foundation of experimentation, can be exerted by the experimenter by using a monetary award structure. The theory is built upon the postulate of non-satiation, which states that an individual faced with a costless choice between two options, the first yielding more reward than the second, will always choose the first. (Smith 1976)

Plott and Sunder

Charles Plott and Shyam Sunder, through a series of studies conducted together and separately with other co-researchers, laid much of the foundation used to design this application of experimental economics. In two studies in particular (1982, 1988), the pair design and operate a series of experimental asset markets with insider information. The researchers explored the implications on market efficiency made by adjusting various parameters within their market design. As a result, they have both proven various capacities of the market mechanism and also established conditions within the design of experimental asset markets which are, and are not, necessary in order to achieve efficient pricing.

In Charles Plott and Shyam Sunder's 1982 publication, *Efficiency of Experimental Security Markets with Insider Information: An Application of Rational Expectations Models,* five double-oral auction markets were run for several periods in which securities with one-period lives were traded. The five markets were comprised of between eleven and fifteen periods, which lasted for seven minutes; each security paid a single dividend to the owner at the end of the trading period. There were a total of eighteen certificates for securities traded in the first market and the supply was increased to twenty-four certificates for the remaining four markets. The amounts each security paid were unique to each individual, an element the market designers liken to the effects of different risk

preferences or tax brackets among traders. There were three groups of traders in each market which were given different dividend structures; each group contained three traders in market 1 with a total of nine participants, and each group in markets 1 through 4 contained four traders with a total of twelve participants.

Payouts were also dependent on which state of nature was randomly selected; in four markets there were two possible states from which the true state was chosen at random, and in the last market there were three possible states. In markets 1 and 2, the probabilities of choosing state X or state Y were 1/3 and 2/3, respectively. In markets 3 and 4, the disparity was decreased and these probabilities were set at 2/5 for state X and 3/5 for state Y. In market 5, there was a 35% chance of state X being selected, a 25% chance of state Y being selected, and a 40% chance of state Z being selected.

In order to assess the efficiency of markets with insider information relative those without, the experimenters provided some participants with information on the true state of nature. So as to not reveal "insiders" to other participants, the experimenters gave each participant a card which was either blank or contained insider information. In control periods all cards were blank. In thirty-two of the fifty total periods operated in markets 2 through 5, two traders from each of the three groups were given perfect information as to the true state. In other words, one-half of the twelve traders were given a clue card providing them with the true state of nature. In four periods, two each in both markets 2 and 3, all traders were given this perfect information. In seventeen periods, no information was given. In seven of these rounds, blank cards were given to every trader so as to illicit uncertainty as to the presence of insiders; in the other ten of these periods, no cards were given out and therefore traders were aware that no insider information had been distributed.

Market 1 was unique amongst the others in that the information given to insiders was less than certain, rather than perfect; this information was a sample of 10 clues which were randomly chosen for each period. This treatment was used in four periods with three insiders (one from each trader group) and in three periods in which all traders were given information. Of these three periods with all traders receiving inconclusive information, the traders in the final period were aware that all participants had been selected as insiders.

The operation of the markets was broken down to three stages. First, participants were trained with the mechanism which was used to draw the state of nature: a bingo-ball machine with 40 numbered balls which were each respectively linked to one of the possible states of nature. In order to familiarize participants with the process, the experimenters conducted a short exercise in which traders were told the odds of selecting one of two states from the machine and asked to predict which would be drawn. They were given $0.25 for a correct guess and penalized $0.10 for an incorrect guess. In the second stage, the general

instructions and an explanation of the market process was read aloud to all participants. The third stage was the operation of the experimental markets for single-term securities.

Plott and Sunder (1982) is centered on evaluating two models which explain price behavior in the market: the Prior Information (PI) model and the Rational Expectations (RE) model. The PI model asserts that traders are acting upon the information they were given going into a market round. Within this study in which there were multiple trader types with heterogeneous dividend structures, this amounted to a trader knowing only the public information and their own private information. As the model does not account for a trader inferring current information from price behavior in the market, the PI model is consistent with the weak form of the Efficient Markets Hypothesis (EMH). The study observed non-insiders acting in the market based on the endogenous information they gathered, a finding which supports the RE model. Furthermore, the performance of the RE model was found to strengthen after time and replication of market periods. Plott and Sunder (1982) concluded that endogenous variables could serve to convey the true state to the non-insiders and these non-insiders then act on their observations. Additionally, the study found that the number of possible states from which the true state of nature was drawn, be it two or three, did not affect the applicability of the RE model.

Having established with Plott and Sunder (1982) that markets were able to disseminate information in a manner congruent with the RE model, the pair next addressed a market's capacity to accomplish the inverse; Plott and Sunder (1988) was designed to test the ability of markets to aggregate private information from individual traders and then disseminate that information in a manner similar to that which they observed earlier.

Eleven double-oral markets were run in the study, the first two of which were run using state-contingent claims followed by periods allowing only a single compound security to be traded. The remaining nine were single-asset markets, with six of the markets offering traders diverse dividends and the others structured with uniform dividends among all traders.

Subjects in every market, who were undergraduate and graduate students, received two or more single-period assets which paid dividends depending on the realized state of nature. While the true state of nature was only publicly revealed at the end of the period, every trader was given diverse, imperfect information regarding the state (which was randomly selected before the experiments began). No participant was aware of the dividend structure of any other trader. After one of the three possible states of nature (X, Y, or Z) was drawn, each trader was given information that it was not one of the two remaining states. For example if state X was drawn, one-half of traders were told that the state was "not Y" and the other half was told that the state was "not Z."

The operation of markets was again divided into stages, though the experimenters added a fourth stage in which traders were familiarized with the mechanism used to distribute information. This additional process was done after traders were taught the state selection process.

Both the RE model and the PI model were tested, along with the Maximin model, in which traders are assumed to act only on prior information which they know to be certain. In other words, they will only purchase a security if they are certain the true value is higher than the asking price and likewise sell only when they are sure the price offered is greater than the true value. Markets described by this model thus settle at the greatest price perceived amongst all traders to be the minimum possible true value of the asset.

Based on the performance in their contingent claims markets and uniform dividends markets, Plott and Sunder (1988) conclude that markets do have the capacity to aggregate diverse information as the RE model holds. The research did conversely find that not all markets behave in a manner congruent with the RE model; they observed markets with a diverse dividend structure could not aggregate information successfully. The study represents an extension of Plott and Sunder (1982), researching more into the capacity of the market mechanism as an aggregator of information.

Further Experimental Work

The findings of Plott and Sunder (1988), specifically the contrasting results they observed in markets yielding uniform dividends and those paying diverse dividends, were further explored by Forsythe and Lundholm (1990). Their study represents an examination of this disparity and an attempt to discover what specific market parameters would enable a market to aggregate information despite differences in trader preferences. Forsythe and Lundholm (1990) likewise explore the validity of the Maximin, PI and RE models. They argue that the RE model arguably demands too much from traders' ability to forecast, especially the need to predict the equilibrium price of a security in multiple possible future states; while the RE model seemingly expects too much from traders, the Prior Information (PI) model appears to do the opposite.

Forsythe and Lundholm (1990) ran nineteen markets, each of which was conducted over two nights. The first eight, labeled BC (better chance) markets, were structured so as to give the markets the best chance of reaching an efficient equilibrium under the RE model. Twelve traders were evenly divided into two groups and asked to trade a fixed supply of a single-period asset which paid diverse dividends depending on which of three possible states of nature were drawn. Each group of six traders was given their own unique dividend payoff structure, though both structures were publicly disclosed. Traders switched groups for the second night, so that Type I traders on the first night became Type II on the second and vice versa. One half of each trader type was told one payoff

state that would not occur, so that the market as a whole "knew" the true state which would occur but no single trader was explicitly informed. If information aggregation did occur, the researchers assert, traders could determine the true market state with absolute certainty. The remaining markets were designed to include a partial set of the BC market parameters, allowing the experimenters to isolate the relevant components to achieving RE equilibrium given the condition of diverse trader preferences.

After establishing that the BC markets would achieve RE equilibrium, Forsythe and Lundholm (1990) altered the parameters for the subsequent markets. They manipulated several components of the BC markets, specifically isolating the effects of removing several components they identified as potential impacts on a market's ability to aggregate information. In four CT (constant type) markets, the experimenters held a trader's dividend payout schedule constant over both nights. The following four markets, labeled NCK (no common knowledge), retained most of the conditions of the CT markets with the exception that dividend payout structures were not publicly disclosed. The final three markets, coded ERT (experience and random type) were unique in that they were conducted on a single night by agents who had already participated in the BC markets; also, each trader was randomly assigned to a group and the results of these assignments was kept undisclosed.

Among their conclusions, Forsythe and Lundholm found that rotating trader types for the second night was unnecessary to achieve RE equilibrium, indeed operating markets over two nights was found to be unnecessary altogether as proven by the success of the ERT models in achieving REE. Observing the experimental markets heavy dependency on replication and experience as foundations for achieving REE, the authors note that traders with previous experience in double oral auctions (such as the subjects in the ERT models who had already participated in an earlier BC market) were able to infer endogenous information and act on these observations. The rapidity with which the ERT models achieved REE stands in contrast to the BC markets, which required a large number of replicate periods.

The researchers posit a learning model in which individuals act first based only on their private information and later infer information based on market data. Forsythe and Lundholm (1990) notably report that existing models fail to yield a formal model explaining the process of achieving RE equilibrium, as they do not afford the experimenter sufficient control over key factors such as traders' information sets and sequences of market action. Arguably the most significant contribution of Forsythe and Lundholm (1990) is their discovery that a market was capable of information aggregation despite heterogeneous preferences amongst individual traders, given that all agents possessed both experience gained from market repetition and knowledge of all existing dividend payoff structures.

Sunder (1992) augmented his study of laboratory asset markets by complimenting them with markets for insider information about the asset dividends. Seven markets were studied, participants were undergraduate and graduate-level business students; subjects in 4 markets were inexperienced, while those comprising the other three had previously participated in a laboratory market. Two or three states of nature determined the dividend payout for the single-period security. One was drawn randomly before trading began and while the odds of which type would be chosen were made known to all traders, the true state of nature was not. In two markets, all participants were asked to submit a sealed bid in an information market for the true state. In these markets, the top four bidders each paid the amount of the fifth highest bid and were consequently provided the actual state of nature and therefore the true value of the security. The identity of these buyers was not revealed, although the price paid for the information was. In five markets, the price of this information was fixed and all those willing to buy it were allowed to do so. The number of traders having chosen to pay was announced, though their identities were again kept undisclosed. In five of the seven markets, traders were randomly and evenly divided into two groups with different dividend structures and one of two possible states of nature was drawn. In the other two markets, there were three possible states of nature and all traders were given identical dividend structures.

Sunder (1992) found that when the supply of information was fixed to only the highest bidders, both the asset markets and markets for information each behaved in a manner consistent with the rational expectations model and simultaneously approach a fully revealing state of equilibrium. The study alternately revealed that when price as opposed to quantity is fixed in the information markets, the asset market's behavior is congruent with the noisy rational expectations model.

The research supports Plott and Sunder's (1982) conclusion that the rational expectations model is capable of explaining asset markets with asymmetric information, though the key finding of Sunder (1992) was the establishment that the REE model was able to accomplish this for both asset markets and information markets, and do so simultaneously.

Approaching the turn of the millennium, the study of experimental economics had established that laboratory markets were quite capable of information aggregation/dissemination, although the limitations of this mechanism were relatively unexplored. Nöth, Camerer, Plott and Weber (1999) followed the task of discovering the limits of a market's ability to aggregate and disseminate information in the presence of asymmetric information.

In their study of 14 market sessions, Nöth, Camerer, Plott and Weber (1999) observe periods of market inefficiency resulting from misaligned beliefs among traders. These "information traps," as the researchers refer to them, are

indicative of individual non-rational behavior in the market. The researchers note that similar market behavior was observed by Sunder (1992), as markets converged to an altogether wrong price.

Among its conclusions, Nöth et al. (1999) found several market conditions minimized the occurrence of information traps and fostered convergence to a fully revealing rational expectations equilibrium. Primarily, a full set of Arrow-Debreu conditions contribute to a market's ability to reach efficiency. Participants with prior experience in experimental markets were found to be more able to identify potential non-rational behavior by other traders and the formation of information traps in the market; traders familiar with the market structure and general information are able to more effectively evaluate price movement and harvest information from market behavior and endogenous signals. (Nöth et al. 1999) It follows from this conclusion that conducting practice trading rounds would increase the chances of a market reaching rational expectations equilibrium by decreasing the sample group's susceptibility to information traps.

Table 1: Summary of Parameters and Conclusions within Similar Experimental Security Market Research

Summary of Experimental Market Research						
Author(s)	Year	Title	Type of Information	Trader Experience	Dividend Structure Across Traders	Conclusion
Charles Plott and Shyam Sunder	1982	Efficiency of Experimental Asset Markets with Insider Information: An Application of Rational-Expectations Models	Complete and Incomplete, given to one-half the traders	Inexperienced	Asymmetrical	Markets are able to disseminate information, consistent with the rational expectations model
Charles Plott and Shyam Sunder	1988	Rational Expectations and the Aggregation of Diverse Information in a Laboratory Security Markets	Incomplete, given to all traders	Inexperienced, Experienced	Asymmetrical	Markets are able to aggregate private information held by traders and disseminate it through price sign
Robert Forsythe and Russell Lundholm	1990	Information Aggregation in an Experimental Market	Incomplete, given to all traders	Inexperienced, Experienced	Asymmetrical	Achievement of rational expectations equilibrium is dependent on trader experience and experiment replication
Shyam Sunder	1992	Market for Information: Experimental Evidence	Complete, given only to portion of traders who bid highest in info. market	Inexperienced, Experienced	Asymmetrical, Symmetrical	A market for a fixed supply of insider information, when that information was supplied only to the highest bidder, achieved RE equilibrium along with the asset market in which the information was used
Markus Noth, Colin F. Camerer, Charles Plott, and Martin Weber	1999	Information Aggregation in an Experimental Markets: Traps and Misaligned Beliefs	Complete to one-third, Incomplete to remaining two-thirds	Inexperienced, Experienced	Symmetrical	A full set of Arrow-Debreu conditions foster achievement of RE Equilibrium; individual non-rational behavior in a security market can lead to convergence within the market to an altogether incorrect price

Political Stock Markets and the Marginal Trader Hypothesis

The Iowa Political Stock Market (IPSM), which would later become known as the Iowa Electronic Market (IEM), was created in 1988 in a nonconventional application of experimental economics. While a market-decision mechanism had previously been used for predicting political election outcomes, the IPSM was the first to do so strictly in the interest of research.

The market allowed participants to trade securities for candidates in upcoming elections in an experimental market; each security pays dividends according to the percentage of votes the candidate received. (Forsythe et al. 1992) The 1988 IPSM for the presidential election was a double-auction market allowing participants to trade futures over the Internet using their own money and do so in real-time. There were 192 voluntary participants in the market, who between them held 1,462 shares in each candidate. Share portfolios and cash reserves among all traders were a combined $4,967; the average individual invested just over $25. (Forsythe et al. 1992) At close, the 1988 IPSM was trading shares in George Bush at 53.2 and shares of his opponent Michael Dukakis at 45.2; the election on November 8th gave Bush 53.2% of the votes and Dukakis 45.4%. The market outperformed essentially every major national poll including Gallup in predicting each candidate's relative percentage of the vote and also the marginalized lead. (Forsythe et al. 1992)

Forsythe and his colleagues explore three possible explanations for the market's success. The first and most basic theory they posit is the possible role of pure and random luck in the observed results, though they conclude the sample size is large enough to refute this suggestion. Secondly, they evaluate the possibility that the IPSM was accurate in predicting election results because the sample group was representative of the population in their presidential preferences and therefore naturally produced results similar to those observed in the election as they acted on personal biases. The dismiss this possibility by citing research into the 1988 U.S. presidential election which found that more traders in their market switched bias towards candidate Michael Dukakis and were in fact not sufficiently biased towards the winner George H. W. Bush. (Forsythe et. al 1992) The researchers endorse the third, the MTH: it purports that price is actually dictated by a fraction of the overall trader population who, recognizing the opportunity to profit from apparent mispricings in the market, buy or sell a stock accordingly and in doing so steer the price to the correct level. In layman's terms, marginal traders are able to profit from other less-knowledgeable trader's mistakes and prices are corrected as a by-product of this process. For example, a marginal trader who identified that a market price of $0.48 for a Bush (reflecting that the market anticipated Bush would receive 48% of the votes) was too low and instead believed Bush would receive 51% of the vote and the

security's true value was $0.51, would buy at all prices below $0.51 and steer the market to an efficient price through the shift in demand. Traders in the 1988 IPSM were formally identified as "marginal traders" if, on three days during the three weeks prior to the election, they had submitted limit orders which were either accepted that day or were within two cents of the price at the end of the trading day. Noting that the exact definition of such a trader is fairly vague, Forsythe et al. (1992) varied the requirements on both the necessary number of days meeting the criteria and also on the limit order's proximity to closing price; they found that adjusting the parameters produced essentially the same results.
The research found that those participants identified as marginal traders on average invested more than double the amount of the non-marginal traders and earned a median rate of return of 9.6 percent (the median ROR for the non-marginal traders was 0). Also, marginal traders in the study traded a higher volume of shares than their counterparts and were active in the market on a greater number of days. (Forsythe et al. 1992)

In conclusion, Forsythe et al. (1992) contributed to the study of the Hayek hypothesis by providing contributing evidence from a broader application. They found that even despite apparent barriers such as uninformed traders and non-rational market behavior, a market was able to achieve efficiency; they assert that this efficiency, and market prices in general, are the result of marginal trader behavior.

Oliven and Rietz (2004) further explore the Iowa Electronic Market (IEM) and the application of the MTH; in particular, they research the presence of non-rational trader behavior and outright mistakes in the market and their implications on market efficiency. The data they use in their study is from IEM's 1992 presidential election market, which was the most accurate IEM market to date, had the greatest volume of any IEM market, and also contained a relatively large number of active traders. There were 1000 participants in the market who were each limited to a maximum investment of $500, though the average investment per person was around $83 as the total investment was approximately $83,000. (Oliven and Rietz 2004) The study segregated market participants much like Forsythe et al. (1992), although they refer to marginal traders as *market makers* and the other market participants as *price takers*; traders who set a limit order on their futures were classified as market makers and the price takers were identified as traders who submitted market orders and in doing so accepted the limit orders. In practice, the market makers set a limit order either above or below the current market price depending on which direction they believe it will move and when a price taker accepts that order the stock price adjusts accordingly.

A central focus of Oliven and Rietz (2004) is the study of the behavioral anomalies found in the 1992 IEM data. They identify two distinct "violations of individual rationality:" market-making violations and price-taking violations. A

market-making violation occurs when a trader posts a best bid or ask (acting as a market-maker) which is either respectively above or below market price and creates the opportunity for an arbitrageur to make an immediate and risk-free profit. Conversely, a price-taking violation occurs when a trader either buys above or sells below a better and readily-available market price. Oliven and Rietz (2004) found these violations were quite prolific in the 1992 IEM, despite the market's efficiency. They contribute this success to the role of market-makers (marginal traders). Furthermore, the study concludes that a lower ratio of market-makers relative price-takers increases the frequency of violations and a market containing a larger proportion of market-makers produces fewer violations.

Oliven and Rietz (2004) yields a number of contributions to the study of experimental economics and market efficiency as a whole. Their research demonstrates that a market can function efficiently despite frequent violations in rational trader behavior. They report that market-makers compete with one another in an effort to profit from others' mistakes and simultaneously set efficient prices. Oliven and Rietz (2004) conclude that an efficient prediction market does not depend on the trader sample being representative of the population, but rather a prediction market can achieve an efficient outcome given a proportion of the sample traders are willing to fill market-making capacities and are presented with the opportunity to profit from others' mistakes and violations in rational behavior.

Methods

The field of experimental economics has established that experimental markets operated within the laboratory function in the same manner as all market instruments, including the financial markets, given that the traders are properly incentivized. This is because all rational and self-interested people exhibit profit maximizing behavior whether the market is "real" or constructed as an experiment. (Smith 1976) This connection allows researchers to study trader actions and market behavior within a controlled experimental environment and apply their conclusions to markets which exist outside the laboratory, such as the financial security markets. Accordingly, three sessions were operated as a means of studying price formation within an experimental asset market with insider information, particularly with the intention to examine the role of insiders in the market and the implications of their actions on market efficiency. Session 1 and Session 2 had six participants, and Session 3 had twelve participants. Participants were undergraduate students studying economics at the School of Business and Economics at the College of Charleston. Subjects had some previous experience with experimental laboratory markets; they had previously participated in a basic double-oral auction in a principles of economics class.

All market sessions were comprised of two different stages. Stage 1 was a prediction contest designed to familiarize participants with the state-selection mechanism which was used to determine the dividend payouts of securities traded in eight concurrently-ran computerized markets in Stage 2.

Incentives

All participant compensation in Stage 1 and market activity in Stage 2 was done using the fiat currency, guldens; this was seen as most conducive to avoiding logistical problems associated with using dollar amounts and allowed flexibility in the choice of parameters. Fiat currency has historically been employed in such a capacity in other experiments (Forsythe et al. 1982) and explicitly to accomplish the above conditions in Plott and Sunder 1982. Students earned extra credit in their undergraduate economics class based upon their earnings in guldens relative the earnings of the others in their session; points were awarded proportionately by ranking, so that the student earning the most guldens received the most extra credit points and the student earning the least guldens in a round received the least extra credit points. All participants earned at least one point.

Stage 1

In Stage 1, traders were asked to predict which of three possible states would be randomly selected by rolling two ten-sided dice, one with sides 0-9 and the other with sides 00, 10, 20…90. It was explained to the participants that the two numbers rolled would be added together to derive a two digit number between 00-99 and that each number had an equal chance of being rolled. The following chart of number ranges and their corresponding states was given to the participants:

Number Range	Corresponding State
00-34	X
35-79	Y
80-99	Z

Participants submitted their predictions into a public chat window, which they were logged into by a randomly assigned ID number, so that they could see others' predictions; after all participants had submitted their predictions, the dice were rolled in plain view of the participants and the true state was published in the chat window by the experimenter. Traders were awarded 10 guldens for each correct prediction and awarded none for an incorrect prediction. This process was repeated for twenty rounds. The intention of this stage is to impose on participants an understanding of the relative odds assigned to each state so that the dividend structure can be properly interpreted.

Stage 2

In Stage 2, participants traded single-period securities in each round which paid the owner a one-time dividend at the end of the trading period. The amount of these dividends was kept homogenous for all traders, though the true amount depended upon which of two possible states of nature were randomly drawn. The dice mechanism for state-selection and the number ranges which correspond to them were the same in Stage 2 as in Stage 1; the following chart describing the states and dividends in guldens was given to the participants:

Number Range	Corresponding State	Dividend Paid
00-34	X	50 Guldens
35-79	Y	240 Guldens
80-99	Z	490 Guldens

Differences in individual expectations as to this true state of nature provided traders incentive to interact in the market in an attempt to maximize their earnings at the end of the period. Markets were set up as double-oral auctions in which participants acted as both buyers and sellers; these conditions imitate those of many financial markets, including the New York Stock Exchange.

In accordance with the field's accepted means for inducing value (Smith 1976, Plott 1979, Plott and Sunder 1982), individuals were compensated according to the following redemption function of the form

$$M_i^t = d(\theta)a_i^t + \Sigma_s P_s^{it} - \Sigma_c P_c^{it} + C_i^t,\ d(\theta)>0,\ a_i^t \geq 0,\ \text{where}$$

M_i^t = gulden earnings of individual i in period t
$d(\theta)$ = dividend rate in terms of fiat money, expressed as a function of the state of nature θ
a_i^t = units held by individual i at the end of period t
$\Sigma_s P_s^{it}$ = revenue from sales of securities during period t
$\Sigma_c P_c^{it}$ = expenses from purchase of securities during period t
C_i^t = initial endowment of fiat money

In congruence with Induced Value Theory, subjects are motivated to maximize M_i^t through market activity. The values induced on these securities are therefore deemed appropriate to test the market models. Restrictions on the exogenous variables are: $d(\theta)$ is strictly greater than zero as all dividends are constructed to be positive and a_i^t is nonnegative as individuals are prohibited from short-selling, or simply from selling a certificate which they do not currently possess so that they can never own a negative amount of certificates.

At the beginning of each period, each subject was given an initial amount of fiat money (C_i^t) which was sufficiently large so as to eliminate any budget constraints which may otherwise have retarded market activity. For Stage 2, the fiat currency used was again guldens; each trader was given a bank of 10,000 guldens in each period with which to trade. Similarly, each individual was given an initial amount of four securities at the start of each period (a_i^t) with which to trade in the market. There was a fixed supply of securities, $\Sigma_i a_i^t$; the total supply of certificates in Sessions 1 and 2 was 24 securities among the six traders, and the total supply of certificates in Session 3 was 48 among the twelve traders.

Before the first trading period began, all participants were thoroughly briefed on the laboratory market process and specifically on the state-of-nature mechanism which would ultimately determine the securities' dividend yield at the end of each period.

Prior to the beginning of each round, a portion of randomly selected participants were selected as insiders or "marginal traders." These marginal traders were given a clue as to the true realized state which would determine the dividend payout, and therefore the true market price, of a security. This clue was transmitted to the traders in the chat room through a private message sent by the experimenter. These traders can be referred to as imposed marginal traders, as information was given to them by the experimenter so that they were more knowledgeable of the true price than their counterparts. To protect the anonymity of the marginal traders, blank messages were simultaneously distributed to the remaining subjects.

Each round was operated for five minutes as an independent market, with its own independently selected state and a unique set of traders selected to receive hints. There were no limits on re-sale so traders were limited only in that there was no short-selling allowed: a trader could only sell certificates which were in his or her possession at the time of the transaction.

Each individual trader was responsible for recording their predictions in Stage 1 and transactions in Stage 2. This was done using a Microsoft Excel Workbook for each trader which was programmed with macros such that traders only needed to enter their prediction and the selected state in Stage 1 and only needed to enter the price of any transactions conducted in Stage 2, and their earnings and remaining banks of guldens and certificates were automatically calculated and displayed in real time; this allowed traders to track the profitability of their decisions and presumably make informed decisions in later rounds so as to maximize their earnings.

Table 2: Design of Markets

Design of Markets														
	Number of Traders		Initial Endowment		Dividends			Probabilities			Expected Dividends			
Session	Total	No. Given Hints	Certificates	Guldens	X	Y	Z	X	Y	Z	No Hint	"Not X"	Not Y"	"Not Z"
1	6	3	4	10,000	50	240	490	0.35	0.45	0.20	223.5	317	210	157
2	6	2	4	10,000	50	240	490	0.35	0.45	0.20	223.5	317	210	157
3	12	4	4	10,000	50	240	490	0.35	0.45	0.20	223.5	317	210	157

Hypotheses

Three models are used to form the hypotheses for this study: the Rational Expectations (RE) Model, the Prior Information Model, and what may be called the Naïve Model. Table 3 provides the price predictions based upon each of these models.

A security market behaves in a manner congruent with the rational expectations (RE) model if, at equilibrium, all traders make decisions as if they were aware of the private information of all other traders. The model holds that this can be accomplished without any direct communication between traders and despite the fact that traders are not incentivized to divulge their private information, either directly or indirectly. (Plott and Sunder 1988) In the context of these sessions, a market round behaving in accordance with the RE model would converge to a price equal to the true state's dividend; this would happen as information was aggregated by the market instrument and disseminated through price signals to all traders. The predictions made by the RE model are the same as those made by the strong form of the Efficient Markets Hypothesis (EMH), where efficient markets are defined such that the market price is reflective of both public information and all private or hidden information; since the collective body of private information contains hints which eliminate two of the three possible states, the strong form of the EMH likewise would predict prices in the market to converge to a price equal to the true dividend which will be paid for the security.

The PI Model explains that traders make decisions based on the information which they are given before the start of a round, and accordingly this body of information will not be changed by price signals in the market; within these markets, the PI model predicts that prices will be dependent upon the expected value for each trader based upon the dividend structure which is made publicly available and upon the hint which they are given, if any. Prices behaving in a manner congruent with the PI model will converge within the range of expected values held by all traders, though the exact price will be dependent on individual trader activity.

The so-called Naïve Model defines that traders will fail to adjust their expectations to account for both hints which they are given and to price signals sent within the market. Evidence in support of the Naïve Model would accordingly be found in markets where the price rested at the expected value for traders receiving no hints; in other words, price expectations are based solely upon the dividend structure and state-selection probabilities and the equilibrium price will equal the expected value derived from these. This model can be correlated to the weak form of the EMH, where prices are a reflection of all past publicly available information; the weak form of the EMH would likewise predict prices to converge to the expected value for the security based solely upon the

dividend structure and state-selection odds, and would not account for current information which is made publicly available, such as price signals in the market.

Traders' expected values, defined statistically as the weighted average of the possible dividends relative their probability of selection, serves as an appropriate measure of their performance as it supports the PI model and semi-strong form of the EMH as these values reflect only the public and private information which has been directly given to a trader. For example, a trader given the hint "Not X" would be certain that the dividend for the round is either 240 or 490 guldens, which have probabilities of 45% and 20% of being selected from the three possible states. The particular trader's expected value, because state X has been eliminated, is calculated as follows:

240 (.45/.65) + 490 (.20/.65) = 316.92 guldens

This trader, acting only on the information made publicly available and the hint directly given him/her, should sell at prices above 316.92 guldens and buy at prices below this value.

Hypothesis 1: Prices will converge to an equilibrium price explained by one of the following models: the RE model, the PI Model, and the Naïve Model.

The Marginal Trader Hypothesis (MTH) explains market efficiency through the actions of superior traders who capitalize on mispricings in the market so as to maximize their own profits, and correct the price in the process. (Forsythe et al. 1992) A market round within this study would be evidence in support of the MTH if the traders given information hints as to the true state of nature, referred to as imposed marginal traders, capitalized on their superior information and exploited mispricings in the market as a means of earning profits and price adjusted accordingly to a more accurate level. For example, a trader given the hint "Not X," can be certain that the true price should not be less than 240 as the only two possible states after X has been eliminated pay 240 and 490 guldens; the trader would buy any securities for sale at a price of less than 240 and the price in the market adjusts accordingly. Inversely, a trader given the hint "Not Z," can be certain that the true price should not be more than 240 as the only two possible states after Z has been eliminated pay 50 and 240 guldens and would accordingly sell at all prices greater than 240. The price signals sent by the marginal traders would presumably occur early in a market round, as those without information wait for signals to be sent in the form of the early transaction prices and marginal traders act on their information.

Hypothesis 1b: This convergence will be the result of marginal trader activity, defined as signals sent by those traders given insider information regarding the true state for the round.

One alternate way of defining marginal traders according to Forsythe et al. (1992) is by their role in a given transaction, as either the trader responsible for

posting an offer or the trader who accepts it; they define the former as the "price-maker" and attribute this characteristic to marginal traders, who are more knowledgeable of the true price and have the active role of setting appropriate price level rather than accepting the current offer. Our results showed little correlation between participants' roles in transactions and their statuses as either imposed marginal traders or uninformed traders. A second type of marginal trader may accordingly be identified and referred to as an endogenous marginal trader, defined as traders within these parameters who exploit mispricings in the market and correct price level in the process but do so irrespective of their having received insider information. These intuitive investors are defined within this study by their performance in the Stage 1 Prediction Contest: an intelligent participant acting on rationality and not emotionality would select State Y in each round of Stage 1, as it has the highest probability of being selected regardless the past rounds' states. Such a participant would conceivably act according to the values of their own expected outcome and be more attentive to price signals sent in the market. These endogenous marginal traders can be evaluated as a separately defined group as a means of satisfying an alternate definition of marginal traders.

Hypothesis 2: Traders submitting Stage 1 predictions with greater probabilities of being selected, identified as more intuitive than their counterparts, will earn greater profits in Stage 2 of the experiment.

Plott and Sunder (1988) found that non-marginal trader earnings in later rounds of the experiments were equal to the earnings of those who were given information. They explain this through the behavior of the uninformed traders, who wait for price signals to be sent by the marginal traders early in the market round and are able to discern the true price as a result; this finding was evidence in support of the RE Model.

Hypothesis 3: Uninformed trader earnings will equal the earnings of informed traders in later rounds.

Table 3: Model Predictions for Price Equilibrium

State	Rational Expectations (RE) Model	Naïve Model	Prior Information (PI) Model	
X	50	223.5	Received Hint "Not Y" Received Hint "Not Z" Received No Hint	210 156.9 223.5
Y	240	223.5	Received Hint "Not X" Received Hint "Not Z" Received No Hint	316.9 156.9 223.5
Z	490	223.5	Received Hint "Not X" Received Hint "Not Y" Received No Hint	316.9 210 223.5

Results

A good summary of the results is provided in Figures 2-4. The results for Session 1 were relatively insignificant. The eight rounds comprising Session 1 were mostly inundated with noise-trading, marked by transactions sending false signals, perhaps because traders had a poor understanding of market signals; traders properly utilizing hints with regards to their expected value were unable to communicate their information through price signals because others with hints and those not given hints were consistently making bids and asks which were inconsistent with their expected values based on the potential dividends and relative odds. Table 4 shows the percentages of informed and uninformed traders involved in the first three trades of each round. In Session 1, marginal traders represented 54% of the traders involved in the first three trades of each round; the trader population was composed of 50% marginal traders. While the induced marginal traders were generally involved in the early transactions in a round which would otherwise serve to send signals to the uninformed as to the true state and therefore the correct price, these prices were almost exclusively below the expected values for all traders, even those receiving the hint "Not Z" and certain that the dividend was either 50 or 240 guldens. With marginal traders comprising 54% of those involved in the first three trades of each round, this means that 46% of the traders involved in the early transactions received no information and had no private information which needed to be communicated through the market; the high levels of activity on the part of the uninformed likely contributed to the failure of these markets at achieving RE equilibrium.

There was an apparent disconnect between traders understanding of appropriate prices and their observation of realized dividends: after the second round of Session 1 paid dividends of 490 guldens per certificate with the realized state of Z, the first transaction in round three was for 50 guldens. While the underlying cause of the underpricing is unclear, it seems likely to be a combination of trader emotionality or risk-aversion and improper calculation of expected values. Several traders consistently made outright violations such as posting an asking price of 48 guldens for a security, whilst the least dividends the security would yield them should they hold it was 50 guldens. Only one transaction in the first five rounds of Session 1 exceeded 100 guldens, which was less than half of the expected value for a trader not receiving a hint.

The average opening transaction within Session 1 rounds was 73.25 guldens and the average of the last transactions in the eight rounds was 93.875 guldens. Both are considerably below the expected value for the half of participants who received no hint in a round and are even below the lowest expected values of any trader. No rational trader acting on the body of publicly available information and their own hints should have sold for a price of less than their expected value, assuming that the true state could not be inferred from the

market. In none of the transactions conducted in the first six rounds of Session 1 did the seller act in a manner accordant with his/her own expected values; in other words, a rational trader would not have sold at any of the transaction prices in the first six rounds because the price was below their expected value for the round's dividend. It is possible that this decision error would have been corrected by some traders should the experiment have continued for a number of additional rounds, though the majority of traders would have to adjust their behavior because a proportion of traders continuing to sell at unreasonably low prices can only be corrected by the intuitive or informed traders by buying at those prices. Failure to adjust for the increase in demand at these prices on the part of some traders would indefinitely restrict market prices from achieving efficient levels.

Table 4: Marginal Trader Representation in Early Transactions

Percentage of Induced Marginal Traders Involved in the First Three Transactions				
	Session			
Round	**1**	**2**	**3**	**Average**
1	67%	50%	50%	56%
2	33%	33%	50%	39%
3	50%	33%	17%	33%
4	50%	50%	17%	39%
5	67%	33%	67%	56%
6	83%	33%	33%	50%
7	33%	67%	17%	39%
8	50%	17%	17%	28%
Average	54%	40%	33%	42%

Sessions 2 and 3

Conversely, the results for Sessions 2 and 3 gave some insight into the validity of the rational expectations model and the Marginal Trader Hypothesis. Markets in both sessions, after the initial rounds were conducted and the participants became familiar with the trading mechanism and dividend structure, converged to prices near the expected value for traders not receiving any hints at 233 guldens; the apparent price to which both markets converged was in fact closer to the median dividend of 240 guldens for State Y. Two-thirds of the traders in these sessions did not receive hints in a given round so this is not an unlikely outcome, though it is not in direct accordance with our models.

Figure 1: Session 1 Transaction Prices

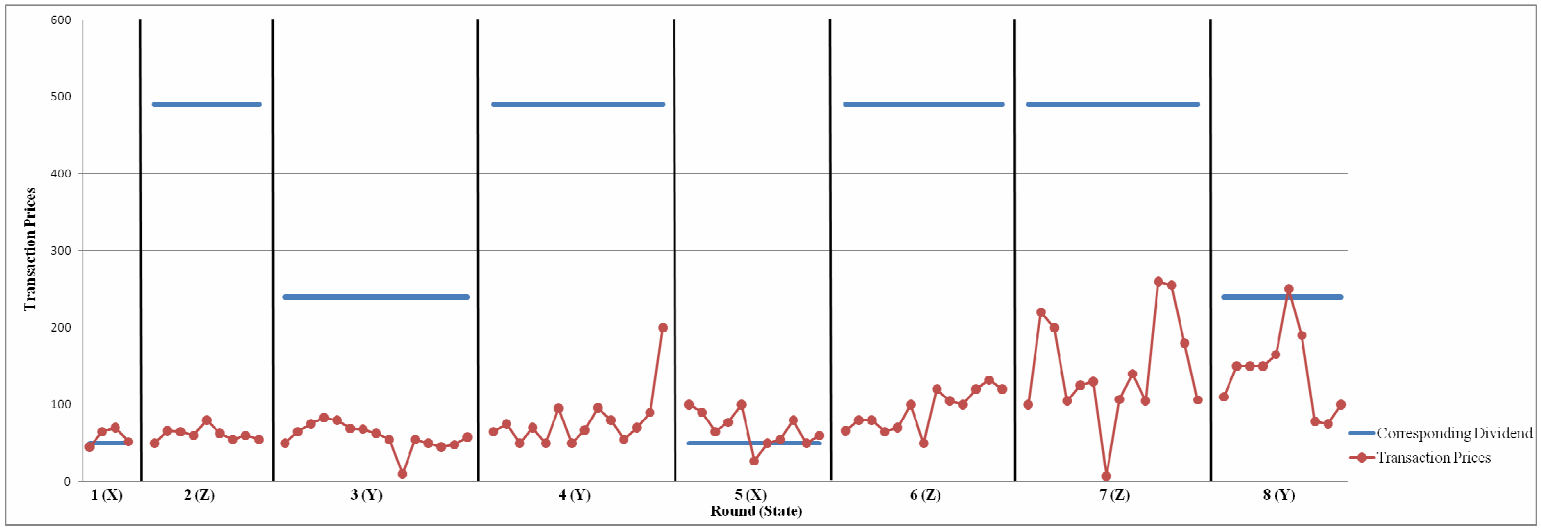


Figure 2: Session 2 Transaction Prices

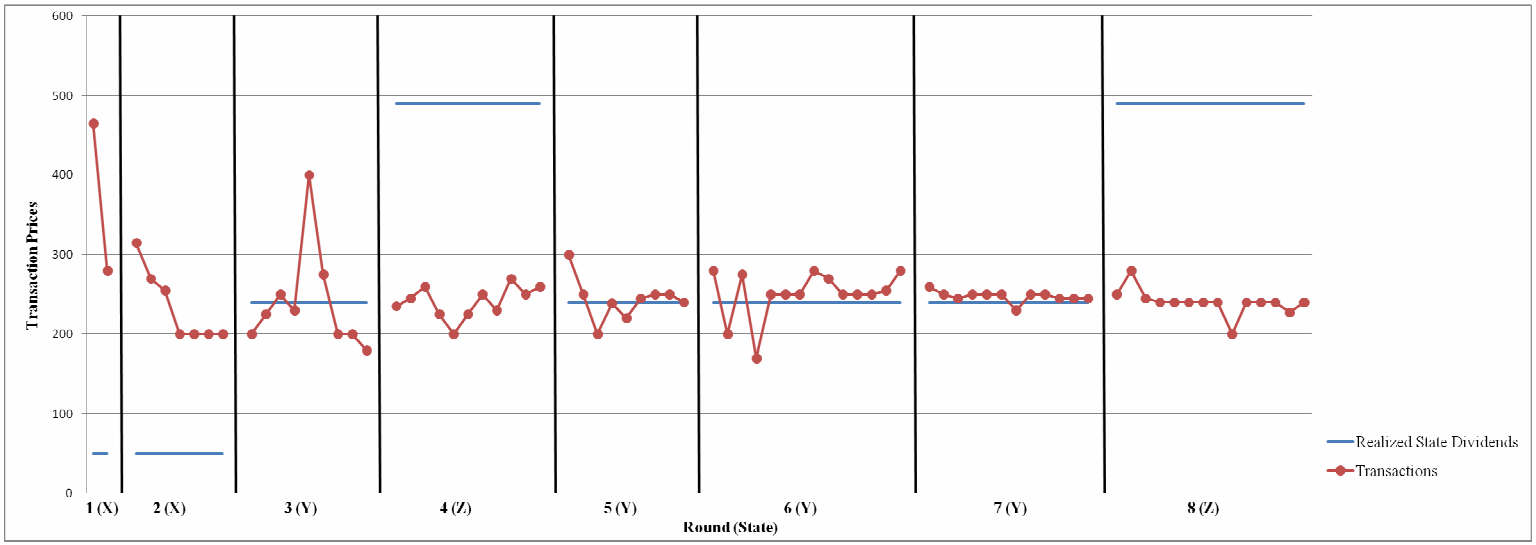
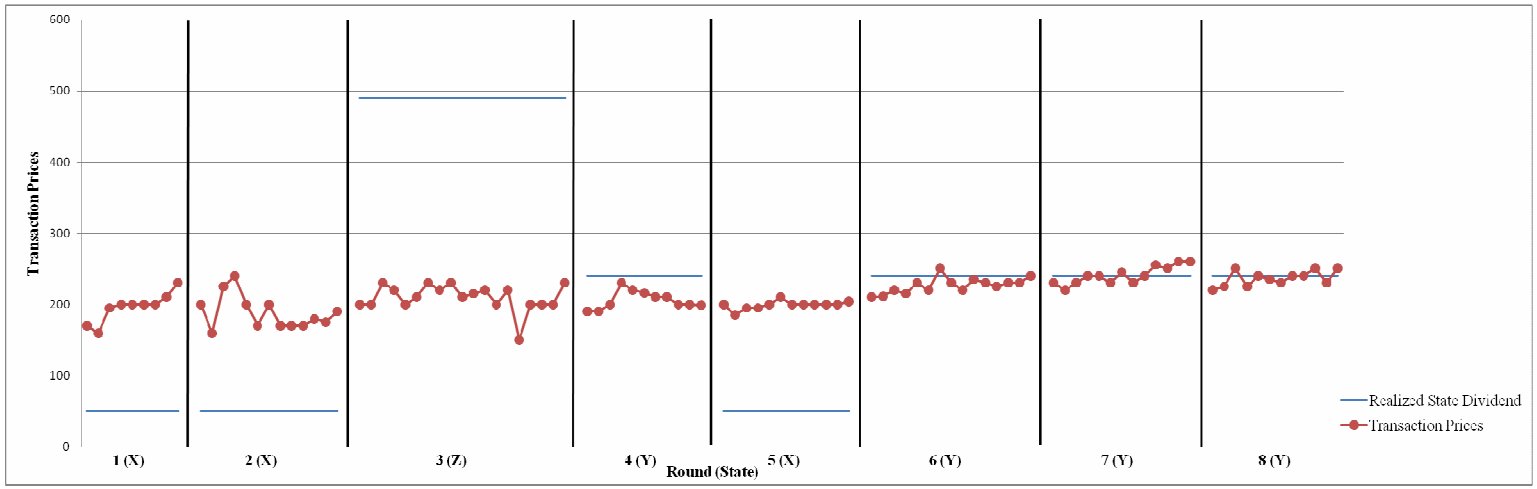


Figure 3: Session 3 Transaction Prices



The introduction of insider information did little to shift prices from the median dividend value after traders had settled there, despite signals being sent by the imposed marginal traders reflecting the information which had been given to them at the start of the round. There were price-correcting trends observed in Session 2 when prices were driven down in rounds 1 and 2 when the state was X and the dividend was 50, though the market struggled to adjust to the higher rational expectations equilibrium price of 490 in rounds 4 and 8 when the state was Z. Price levels in Session 3 were appropriately lower when the state was X in rounds 1, 2 and 5 and the rational expectations equilibrium price and realized dividend were 50, though the lack of discernible trends in price changes indicate this may be the result of undervaluing the expected value with no information introduced or the result of price signals sent by the imposed marginal traders not being assimilated into the market amidst noise-trading. Transaction prices never exceeded 230 in round 3 of Session 3 of Session 3, the only round in which Z was the selected state and the realized dividends were 490 guldens.

Marginal traders were on the "winning" side, defined where a transaction ultimately benefitted the trader once the round's dividend was realized (a trader in a round paying a 240 gulden dividend was defined as winning if he/she bought a certificate in the round for less than 240 guldens or sold a certificate for more than 240 guldens, and vice versa; trades made at the exact price of the round's dividend were not counted), of 58.2% and 53.6% of their aggregate transactions in Sessions 2 and 3, respectively; conversely, those traders not given hints were defined as winning on 45.5% of their transactions in Session 2 and 48% of their transactions in Session 3.

The average profits in Stage 2 of imposed marginal traders exceeded those of their counterparts in five of the eight rounds in Session 2 and in four of the eight rounds in Session 3. It was often the case that traders receiving one type of hint profited based on the disparity between their expected value and the realized dividend, while those receiving the opposite type of hint suffered losses for the same reason. This is because traders acting solely on their own private information (the hint they received) and the public information (dividend structure) while failing to infer the private information of others through market signals cannot be certain of the true state and must act only on their expected value, which is not the efficient or correct price.

Table 5: Correlation of Performance Factors for Session 2 Participants

		Stage 1 Predictions		Transaction Activity			Profits	
		Y-Guesses	*Avg. Probability*	*Total No.*	*No. "Price Making"*	*%"Price Making"*	*Stage 1*	*Stage 2*
Stage 1 Predictions	Y-Guesses	1						
	Avg. Probability	0.974272469	1					
Transaction Activity	Total No.	-0.693068591	-0.670101145	1				
	No. "Price Making"	-0.406711127	-0.391586699	0.912505873	1			
	%"Price Making"	0.146049919	0.109989925	0.516184258	0.808131606	1		
Profits	Stage 1	0.87530155	0.924028547	-0.840381095	-0.679507738	-0.263572605	1	
	Stage 2	-0.621851211	-0.554477289	0.637293332	0.643548808	0.297703581	-0.660595925	1

Table 6: Correlation of Performance Factors for Session 3 Participants

		Stage 1 Predictions		Transaction Activities			Profits	
		Y-Guesses	*Avg. Probability*	*Total No.*	*No. "Price Making"*	*%"Price Making"*	*Stage 1*	*Stage 2*
Stage 1 Predictions	Y-Guesses	1						
	Avg. Probability	0.88006356	1					
Transaction Activities	Total No.	0.190170695	0.250872191	1				
	No. "Price Making"	0.06453473	0.060404723	0.545557757	1			
	%"Price Making"	-0.059498443	-0.148068603	-0.222360593	0.625166201	1		
Profits	Stage 1	0.218943511	0.270159575	0.588718904	0.48980509	0.068653505	1	
	Stage 2	0.148452673	0.285907451	0.233730904	0.358251895	0.173749609	0.054759748	1

Above, tables 2 and 3 show that there were few discernible correlations among measurements of participant performance in both stages of Sessions 2 and 3. The average probability of a participant's prediction in the Stage 1 contest is unsurprisingly correlated to both the number of times they predicted the state to be Y (which had the highest probability of selection) and their earnings in Stage 1.

Several measurements describing characteristics of activity levels and market intelligence used to categorize marginal traders are shown in correlation to trader profitability. The number of Y-guesses, identified above as a marker for endogenous marginal traders in congruence with the definition of Forsythe et al. (1992), was surprisingly not well correlated to earnings in the Stage 2 market in Session 3 and was negatively correlated to the same measure in Session 2. This finding can be explained, however, by the correlation between Stage 1 earnings and Stage 2 profits, which was negative in Session 2 and near-zero in Session 3; trader success in the prediction contest did not correspond to success in the security markets, so the measurement of endogenous marginal traders by their success in Stage 1 is either inappropriate or those classified as endogenous marginal traders performed poorly in the markets.

A higher number of transactions per round made by a trader, another identifier of marginal traders described by Forsythe et al. (1992), was positively correlated to Stage 2 earnings; the correlation coefficient was 0.637 in Session 2 and 0.234 in Session 3. A higher number of "price-making" transactions was likewise positively correlated to Stage 2 earnings in both Sessions 2 and 3, with correlation coefficients of 0.643 in Session 2 and 0.358 in Session 3.

Marginal traders represented only 40% of those involved in the first three transactions in Session 2, and 33% of those in Session 3. This means that 60% and 67% of the traders involved in the early transactions of Sessions 2 and 3, respectively, were acting without having received information.

Discussion

Session 1 notwithstanding, the traders in the experimental security markets of this study were able to conform to prices near the expected value in later rounds; Sessions 2 and 3 support Hypothesis 2, while Session 1 fails to support it.

Traders in all Sessions were unable to steer prices away from the median dividend with different states despite the introduction of partial information. Consequently, the markets failed to approach rational expectations equilibrium in all rounds except those in which the state was Y and the corresponding dividend was 240, though there is apparently no reason to infer that traders are not still trading in the range of the expected value for those not given information of 223.5 and the median dividend of 240. This conclusion is supported by the last round of Session 2: after trading at accurate levels for three consecutive rounds in which

the state was Y and the dividend was 240, transaction prices remained in the same range for the eighth round in which the State was Z and the dividend was 490. This result is consistent with the Prior Information (PI) model: traders made decisions based upon the information which they were given prior to beginning a trading round and did not adjust their behavior based on newly revealed information in the form of price signals. Similarly, the results in Sessions 2 and 3 are in line with the semi-strong form of the EMH: in equilibrium, the market price was a reflection of all past and currently-available public information. The results fail to support the strong form of the EMH, as the market price did not reflect private information in addition to public.

The market price did not reflect the distributed information, as the traders were unable to transmit and respond to signals in price formation. While the imposed marginal traders in Sessions 2 and 3 were almost exclusively acting in accordance with their own expected values, particularly in later rounds, these indications that the market price was over or under the true price were not identified as such and the following transactions apparently failed to incorporate the information produced by the early trades. This occurred despite the fact that imposed marginal traders were consistently involved in the early trades of each round.

The failure of these markets to achieve an efficient equilibrium in accordance with the RE model and strong form of the EMH is likely the result of several contributing factors. Firstly, participants were undergraduate students with minimal experience interacting in such a double-oral auction market; there were significant struggles in the early rounds to explain the logistical operation of the market to participants, and the experimenters refrained from explaining profit-maximizing strategy and proper information inference to the participants in order to avoid corrupting the results. This study struggled to replicate the success observed by Plott and Sunder (1982, 1988), whose participants were recruited from graduate school at the University of Chicago and the California Institute of Technology, with less-sophisticated traders. Secondly, the excessive amount of noise-trading by uninformed or irrationally behaving traders flooded the market with false information so that even the most observant traders, the endogenous marginal traders, were unable to infer accurate price signals. A third explanation for the failure to achieve rational expectations equilibrium is a matter of market design. The convergence in transaction prices to the true dividend value observed by Plott and Sunder (1988) was strengthened in later rounds after the traders had greater experience interacting in the market and observing price signals; the markets in their study generally consisted of 14 rounds lasting seven minutes each. At the time of their last transaction, subjects in their study had participated in over an hour and a half of trading and seen 14 different state selections; our markets combined for 40 minutes of trading with 8 different state selections. It is

likely that greater accuracy would have been observed were the experiments longer in duration, however this would conceivably be the result of imposed marginal traders learning to maximize profits using their hints, rather than a shift in general market behavior or a discernible change in the markets' ability to relay accurate information and have that information properly interpreted and acted upon by all traders.

These results support the finding of Forsythe and Lundholm (1990) that market efficiency is highly dependent on trader experience. The results seem to explain the first half of the model for trader behavior with regards to information assimilation formed in Forsythe and Lundholm (1990), which is that traders in an experiment begin by acting only on the information they are directly given and later learn to act on information they infer from the market. The shift to inferring information from price movements in the market may have been observed in later rounds should the experiment have been lengthened, though this is a speculative deduction.

While the imposed marginal traders in Sessions 2 and 3 did largely act in accordance with their hints and the corresponding changes in their expected values, the signals which would have otherwise been sent by these decisions in the market were lost amidst the excessive amount of noise-trading. It was observed that traders receiving no information often participated in the first transactions of the round, rather than wait to observe the actions of their co-traders who were imparted with a hint. The Marginal Trader Hypothesis, while it does account for noise-trading and irrational investors, cannot account for traders behaving as if they do have information and sending excessive false signals into the market; in this way the non-marginal traders are behaving as if they have information and others in the market interpret their actions as if they were founded on relevant information.

Trader familiarity with price moving behavior, presumably honed over a longer series of rounds, appears to be a necessity for achieving efficient levels in such a market experiment. A better Stage 1 training mechanism may be designed to also train participants how to exploit mispricings in the market and how to infer signals as to the true state based upon price movements in the market, as the Stage 1 training process used in this study and others in the past (Plott and Sunder 1982, 1988) serves only to teach traders how the states are selected and not how to interpret the other intricacies of the Stage 2 security markets.

Restricting the number of certificates may have hindered an informed trader's ability to push price level down by selling their quantity of certificates if he/she believes the market price to be too high; an increase in the number of certificates allocated to traders each round would provide more liquidity and not affect adjusted profits, which account for earnings on a set of untraded certificates. Evidence supporting this as a potential retarding factor to achieving

efficiency can be found in the results of Sessions 2 and 3. Four of six traders in Session 2 sold all of their certificates at one point in time, with a total of six occurrences reported; in four of these six times in which traders could no longer sell certificates and therefore lower price levels, the constrained party was an imposed marginal trader. Two of twelve traders sold all of their certificates in Session 3, each doing so in only one round; in one of the two instances, the constrained individual was a marginal trader. The number of participants in Session 2 relative Session 3 likely explains the higher frequency of occurrences in the former in which a trader was incapable of sending the signal that the market price was too high based upon their information and inferences.

This study reveals one set of limits to traders conforming to accurate price levels with the introduction of partial insider information. Our participants were unable to create and respond to price signals in the market and accordingly price levels failed to adjust to the realized states for each round. It is possible that there was an insufficient amount of insider information distributed and the RE model's prediction was not met for this reason, and further research is merited as to the required amount of information necessary to achieve RE equilibrium under such conditions.

Conclusion

At a broad level, the results do not support the EMH or MTH, although there is some positive evidence of both models. It is clear that in a market with unsophisticated traders, a substantial amount of learning must take place in order for the market to achieve efficient price levels, and that outcome may well never be reached. These results are inconclusive as a means of evaluating the MTH as an explanation for market efficiency, and there is a need for further research on the topic. The study of experimental economics has established that markets can function at rational expectations equilibrium, though the Marginal Trader Hypothesis may be a more valid explanation if that price is achieved not as every trader acts as if in possession of the collective market intelligence, but rather is achieved as a smaller proportion of intelligent and active traders serve their own interests by exploiting mispricings in the market and steer prices to RE equilibrium levels in the process.

Appendix A: Instruction Distributed to Participants for Stage 1 of the Experiment

Welcome to the Experiment!

We are conducting an experiment that helps us understand how people make economic decisions. Experimental economics is an important and interesting way for us to learn about how people make economic decisions, but in order for these experiments to be successful we must follow some simple yet very **important rules**.

- We will be using computers for the experiments. Please do not touch anything until you are told to do so
- Please do not speak out loud
- Do not communicate with anyone in the room but the coordinator
- If you have a question, **raise your hand** and a coordinator will visit your station.

Experimental Overview:

This is an experiment in the economics of decision making. There will be two separate experiment stages. The first will be a prediction game in which you will become familiar with a random selection method for determining one of three possible states. In the second stage, we will ask you to participate in a market for trading certificates. Instructions for both will be fully explained to you when the time comes.

This experiment will last approximately one and a half hours; if you are unable or unwilling to participate for the duration of the experiment, please raise your hand to notify the coordinator at this time.

For your participation today, you will earn extra credit in Professor Blackwell's class. In the experiment, you will have the opportunity to earn a fiat (mock) currency, guldens. The more guldens you earn in these experiments, the more extra credit you will receive in his class. You should therefore try to earn as many guldens as possible and behave in the same manner you would as if these were dollars in your pocket. Follow the rules, relax, and above all have fun!

Operation of Chat Window:

Your portal into the experiment will be a chat room which is opened in a browser window on the screen in front of you. This will be defined as your station; you are not to leave your station during a round. Please raise your hand to notify the coordinator if you need to be excused between rounds, but these breaks will prolong the experiment for everyone involved and are discouraged.

In the chat window, you will enter one of the appropriate entry options in the submission box at the bottom of the window and hit "Enter." These entry options will be explained for each stage, and you must limit your submissions to these options. Do not exit the chat room for any reason or engage in any activities other than submitting these entries to the general chat and recording the appropriate notes on your record sheets.

Operation of Excel Workbook

In addition to using the chat window to participate in the market, you will use Recording Sheets in the form of Microsoft Excel worksheets to keep track of your actions. Specific instructions will be given for using the Sheets in each stage. Note that you can only enter information into cells which are highlighted yellow. All other information will be automatically calculated for you, provided you properly enter information according to the instructions below.

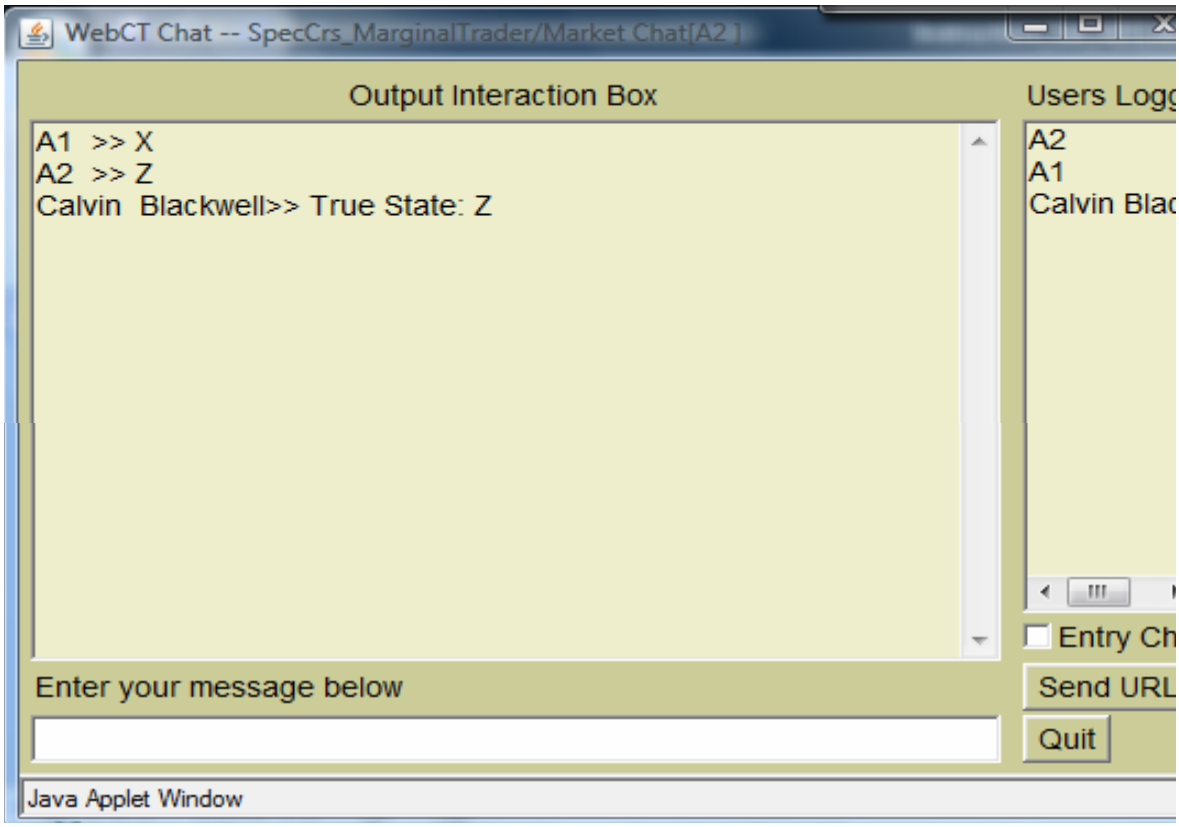
Each of you has a student ID. This can be found in brackets at the top of the chat window. For example, if your window reads "WebCT Chat—SpecCrs_MarginalStudent/Market Chat [student**a13**]," your ID would be "**A13**."

Instructions for Stage 1:

Each session, we will roll two ten-sided dice. One die has faces numbered 0-9, and the other has ten sides reading 00, 10, 20, 30, 40, 50, 60, 70, 80, and 90. The two rolls will be added together to derive a two digit number. Thus there are 100 possible numerical outcomes, each with an equal probability of being selected. The range of these numbers is 00-99. The number rolled determines a state, which can be either X, Y, or Z. If the rolled number is between 00 and 34, the state will be X. If the rolled number is between 35 and 79, the state will be Y. And if the rolled number is between 80 and 99, the state will be Z. A table describing this is given below:

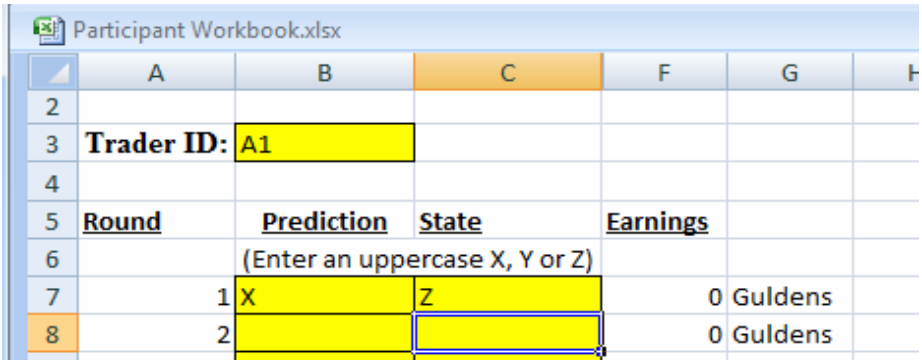
Number Range	Corresponding State
00-34	X
35-79	Y
80-99	Z

You have to predict the state of each roll before it is announced. Before each roll is made, submit your prediction (either X, Y or Z) in the chat room window; you may only submit one prediction per round. If you believe the state will be state X, for example, enter "X" in the chat window and hit "Enter" on the keyboard. An example of a proper submission is given below:

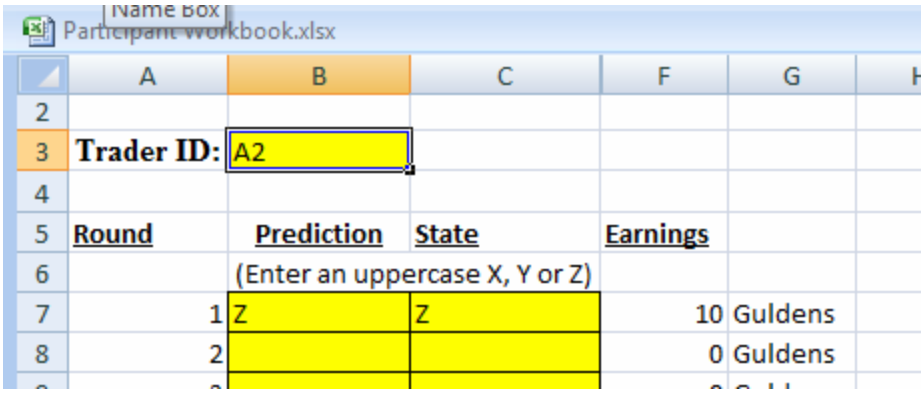


In the screenshot above, student A1 predicted the state to be X and student A2 predicted the state to be Z. The coordinator then reported the true state in the window. Both students must now record their prediction and the actual state in their "Stage 1 Record Sheet."

Each student's proper entry is shown below:



	A	B	C	F	G
2					
3	**Trader ID:**	A1			
4					
5	**Round**	**Prediction**	**State**	**Earnings**	
6		(Enter an uppercase X, Y or Z)			
7	1	X	Z	0	Guldens
8	2			0	Guldens



Notice that because student A2 correctly predicted the state, his/her earnings for Round 1 changed to 10 Guldens.

Record your prediction on the proper row of your Record Sheet by entering the corresponding letter in the "Prediction" column. After each student has submitted their prediction, the state will be announced. Record the true state on your Stage 1 Record Sheet in the "State" column. You will be awarded 10 Guldens for each correct prediction and will not be penalized for an incorrect prediction. We will do a number of rounds. At the end of the stage, your earnings will be given to you at the bottom of the Record Sheet beside "Total earnings from Stage 1."

Are there any questions? Let's begin…

Appendix B: Instructions Distributed to Participants for Stage 2 of the Experiment

Instructions for Stage 2:

In this experiment, we are going to simulate a market in which you will be able to buy and sell certificates in a sequence of market rounds. In your Excel Workbook, click on the tab "Stage 2"; this is your Stage 2 Record Sheet. This sheet is to record your transactions for the second stage and to help you determine the value of any decisions you may make.

The type of currency used in this experiment will be guldens. Like in Stage 1, your objective is to earn as many guldens as possible in order to maximize the amount of extra credit you receive in Dr. Blackwell's class. All market prices and transactions will be in terms of guldens. At the end of the experiment, you and the other students will be ranked in terms of earnings and each of you will be given an amount of extra credit proportionate to your earnings. Those with higher earnings will be compensated with more extra credit points and those with lower earnings will receive less extra credit points. The more guldens you earn, the more extra credit points you receive.

Your profits come from two sources: (i) from collecting certificates and receiving dividends on those held at the end of the round and (ii) from buying and selling certificates. During each market round, you are free to buy and sell as many certificates as you wish, provided you adhere to the rules below. For each certificate you hold at the end of the round, you will be given one of the three dividend amounts listed on your Dividend Sheet. Note that these amounts are dependent on the randomly selected state; this process is explained further later in the instructions.

Your total earnings for a round will be computed by multiplying the number of certificates held by the amount paid per certificate given the realized state (either X, Y or Z). For example, if you held three certificates and the realized state was X, which pays 50 guldens in dividends for each certificate, your Total Earnings on Certificates for the round would be 150 guldens (3 certificates x 50 guldens).

Sales from your certificate holdings increase your bank of guldens by the selling price. Conversely, purchasing certificates decreases your guldens on hand by the purchase amount. In this manner you can gain or lose guldens by purchasing and reselling certificates. At the end of each round, all certificates are automatically sold to the experimenter at a price of 0, so that the only value of a certificate at the end of a trading round is equal to the dividend paid.

At the beginning of each round, you are provided with 4 certificates and 10,000 guldens. Note that you may keep the certificates for the entire round and you can earn at least the dividends paid when a particular state is rolled. Similarly, you can retain your entire bank of guldens or you may use it to buy certificates. You are free to buy and sell certificates as you wish, subject to the rules below. Your guldens on hand at the end of a market round are determined by your initial endowment of guldens, earnings paid on certificates you hold at the end of a round, and any profits from buying and selling certificates during the market round.

Information about Dividends:

Whether a certificate pays the X-dividend, Y-dividend, or Z-dividend is determined by the experimenter at the beginning of each round by rolling two ten-sided dice. One die has ten sides with the digits 0-9 and the other has ten sides reading 00, 10, 20, 30, 40, 50, 60, 70, 80, and 90. The two numbers will be added together to derive a two-digit number; in this way there are 100 possible numerical outcomes (numbers 00-99), each with an equal probability of being rolled. If the number rolled is between 00 and 34, then the state for the round will be X and certificates will pay the X-dividend. If the number is between 35 and 79, the state for the round will be Y and certificates will pay the Y-dividend. If the number is between 80 and 99, then the state for the round will be Z and certificates will pay the Z dividend. This information is provided in the table below.

Number Range	Corresponding State	Dividend Paid
00-34	X	50 Guldens
35-79	Y	240 Guldens
80-99	Z	490 Guldens

At the beginning of each market round, each student will receive a private message in the chat room which will contain one of the following pieces of information: (i) Not X, (ii) Not Y, (iii) Not Z, (iv) Blank. If your clue contains "Not X," the true state which has been randomly chosen for the round will not be X, leaving states Y and Z as the only possibilities. If your clue card contains "Not Y" then you can be certain the state is not state Y, and the same is true for the clue "Not Z." A "Blank" message tells you no information about the state. In any given round there may be a number of clues as to the true state and a number of blank clue messages; this includes rounds in which only blank messages are distributed. You can only be certain that everyone receives a message, and that between all and none of the students have been given a useful clue message. Note that any information sent to you is private and it is in your best interest not to share that information with anyone else, as they may have received different information or none at all.

Trading and Recording Rules:

1. All transactions are for one certificate at a time. After making a trade, you must record the transaction price on your Stage 2 Record Sheet under the appropriate column (be it "Sell" or "Purchase," depending on your role in the trade). The first transaction is recorded on Row 1 and subsequent trades are to be recorded on the rows below.
2. You record the price in the appropriate cell, your new holdings of certificates and guldens on hand will be automatically calculated for you and displayed in the same row in which you enter the price. Note that your number of certificates and of guldens on hand may never go below zero.
3. At the end of the market round, the state will be announced. Record the appropriate letter in your Stage 2 Record Sheet beside "Selected State."
4. Your Total Earnings for Round 1 will be displayed below the Market Round 1 table.

5. Scroll down to the table for Market Round 2 and the experiment will be repeated. Remember that you will receive a new piece of information about the dividends in a private message in the chat window each round. Each round is independent, and information given in one round may not be applicable for other rounds. For example, if you receive the hint "Not X" in Round 1, you can be certain the state in Round 1 is not going to be X; the state in Round 2 or any other round may still be X (or Y or Z). The market will be operated for a number of rounds.

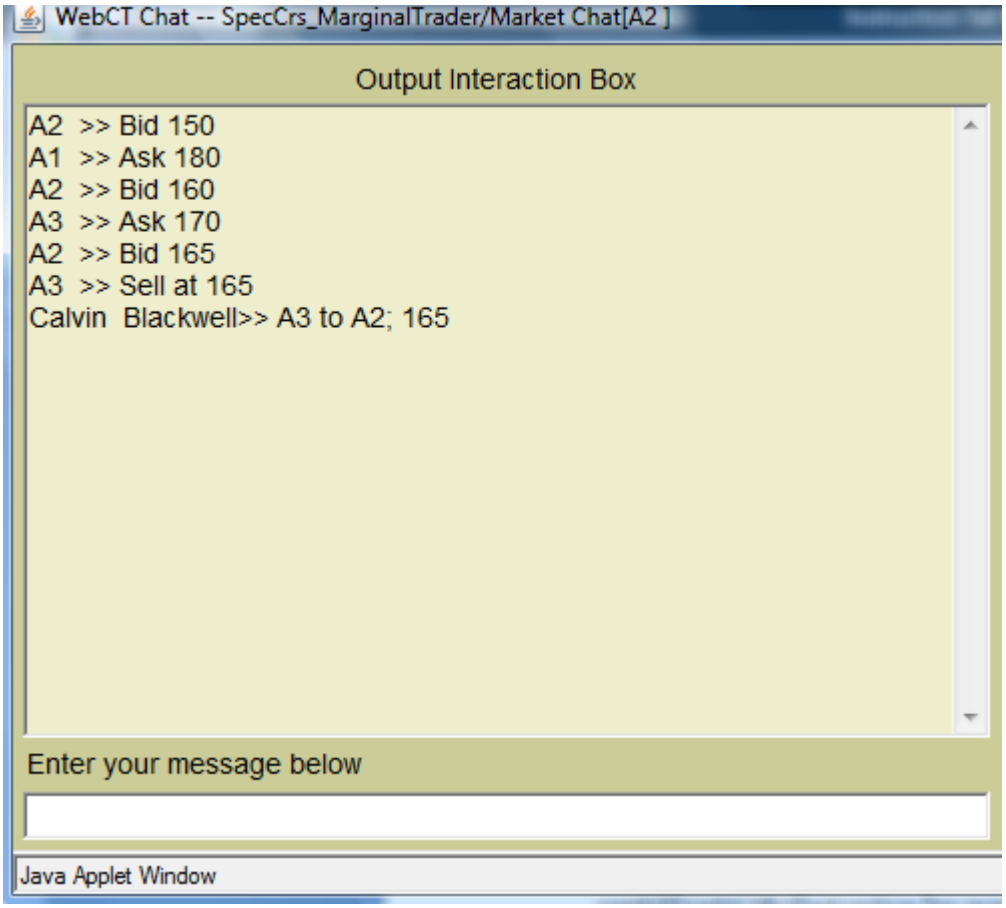
Market Organization:

The market for these security certificates is organized as follows. The market will be conducted for a series of sessions or rounds, each lasting five minutes. Anyone wishing to buy a certificate may post a bid in the Chat Room to purchase one certificate at a specific price, and everyone is free to accept the bid there by posting in the room. A student may make a bid to purchase one certificate by posting "Bid *amount*" and another student may accept by posting "Sell at *amount*." The first student to post their acceptance enters into a contracted sale. The coordinator will indicate when a trade has occurred and send a corresponding message: "A1 to A3; *amount*."

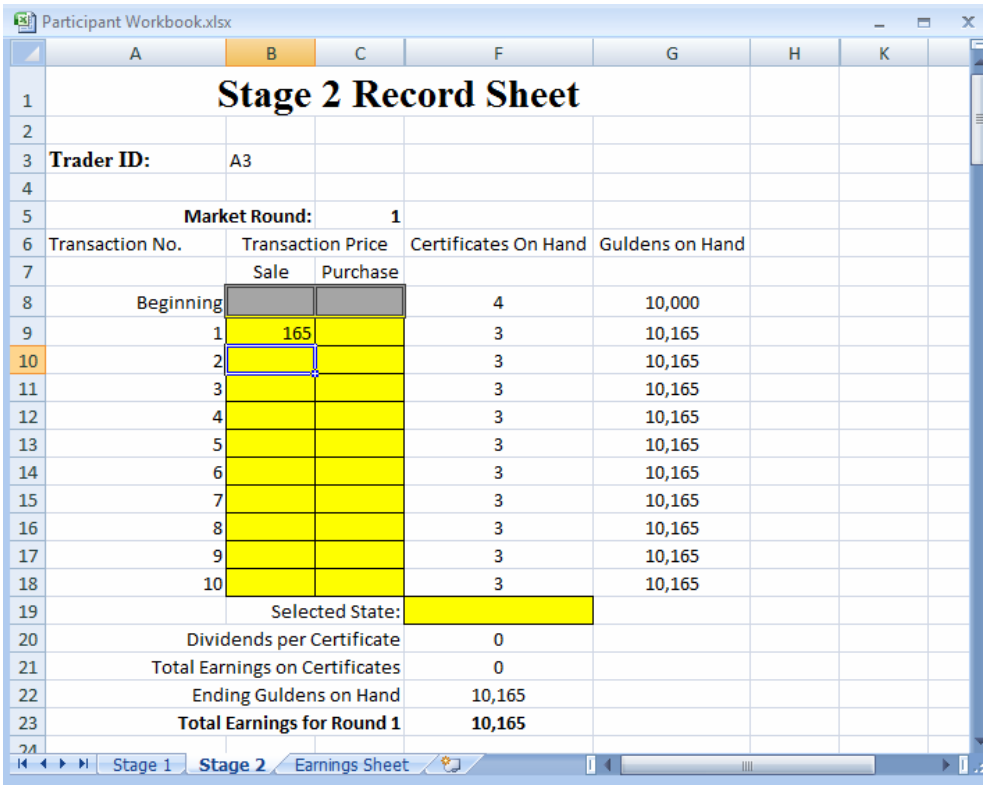
Both parties must then record the transaction price on their Stage 2 Record Sheet under the appropriate column (either "Sale" or "Purchase," depending on your role in the trade). Your updated amounts of certificates and guldens on hand will be calculated and displayed in the same row for that trade. Similarly, anyone wishing to sell one certificate by posting an asking price may do so in the Chat Room by posting "Ask *amount*." A student may agree to buy the certificate at that price by posting "Buy at *amount*."

You must adhere to a bid-ask improvement rule: any newly submitted bid to purchase a certificate must be a higher offer than existing open bids, and conversely any newly submitted asking price for selling a certificate must be lower than any existing offer. In other words, you may not bid to buy a certificate for 150 guldens if there is an open offer in the market to buy a certificate for 160 guldens. Likewise, you may not ask a price of 180 guldens to sell a certificate when there is an open offer in the market to sell at 170 guldens.

With the exception of bids and their acceptance, you are not to talk or nonverbally communicate with any other students. You are free to make as much profit as you can, keeping in mind that your profit in guldens relative the other students will determine the amount of extra credit you earn for class.



In the above example, trader A2 begins the round by offering to buy one certificate for 150 guldens by posting "Bid 150" in the chat window. Trader A1 counters the offer by asking for 180 guldens to sell one certificate. After trader A2 increases his bid to 160 guldens, trader A3 enters the market and she asks for 170 guldens to sell a certificate. Trader A2 increases his bid to 165 guldens and trader A3 agrees to sell a certificate at this price by posting "Sell at 165." The moderator, Calvin Blackwell, officially verifies the sale, posting the seller (A3), the buyer (A2) and the price (165). Notice that all traders adhered to the bid-ask improvement rule by only posting improvements to the outstanding offers. Traders A2 and A3 must now make the appropriate entries into their Stage 2 Record Sheet. Trader A3's Record Sheet is shown below:



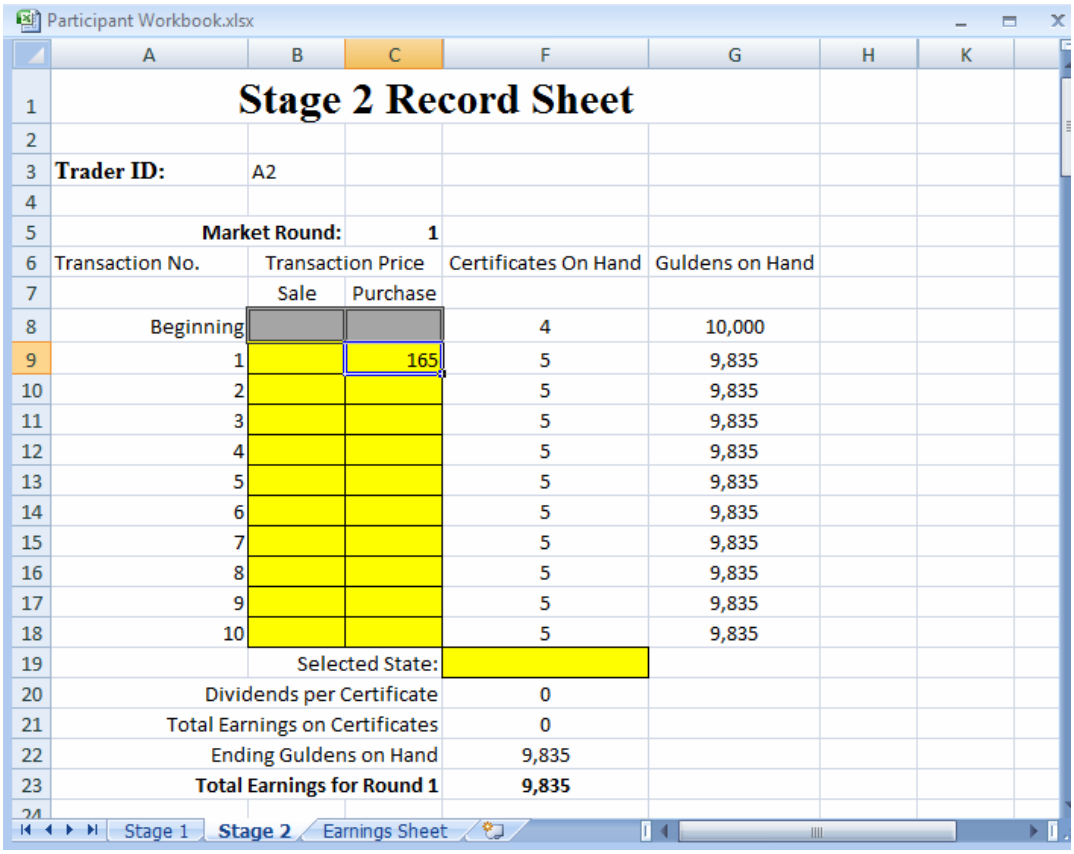
Participant Workbook.xlsx

Stage 2 Record Sheet

Trader ID:	A3			
	Market Round:	**1**		
Transaction No.	Transaction Price		Certificates On Hand	Guldens on Hand
	Sale	Purchase		
Beginning			4	10,000
1	165		3	10,165
2			3	10,165
3			3	10,165
4			3	10,165
5			3	10,165
6			3	10,165
7			3	10,165
8			3	10,165
9			3	10,165
10			3	10,165
	Selected State:			
	Dividends per Certificate		0	
	Total Earnings on Certificates		0	
	Ending Guldens on Hand		10,165	
	Total Earnings for Round 1		**10,165**	

Stage 1 | Stage 2 | Earnings Sheet

As the seller of the certificate, trader A3 enters the selling price of 165 guldens under "Sale" on the row for Transaction No. 1. After entering the transaction price in the appropriate cell, the amount of certificates and guldens on hand automatically change. Trader A3 has sold one of her certificates, so her number of certificates on hand decreases from 4 to 3; likewise, the amount of guldens on hand has increased in the amount of guldens the trader earned from the sale. The appropriate recordings for trader A2 are depicted below:



Participant Workbook.xlsx

Stage 2 Record Sheet

Trader ID: A2

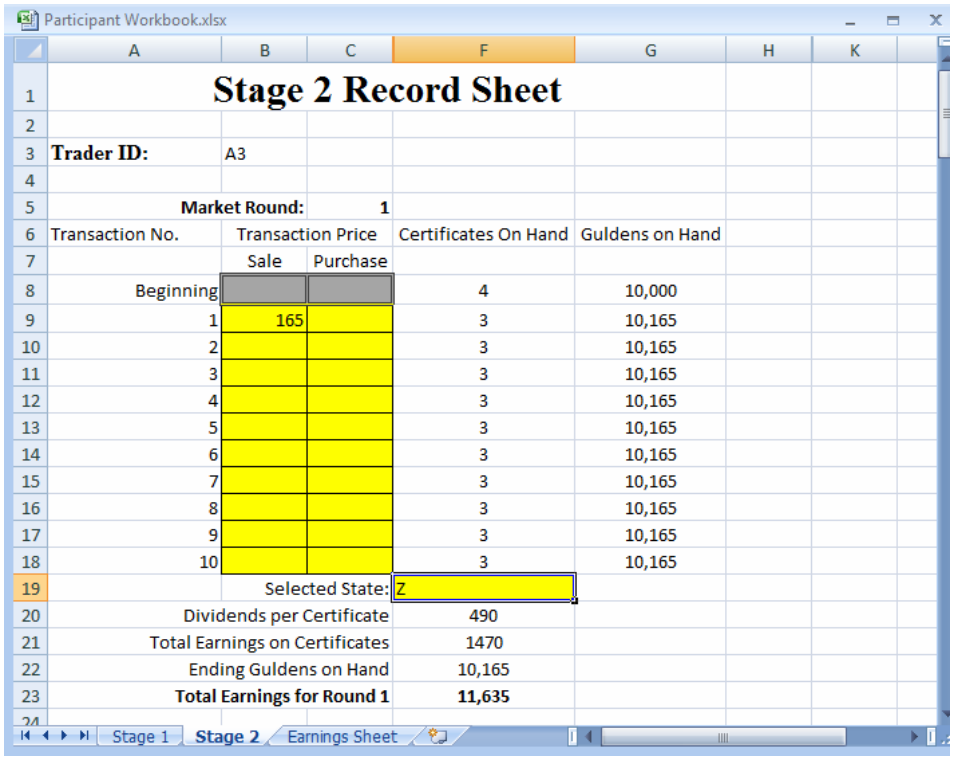
Market Round: 1

Transaction No.	Transaction Price		Certificates On Hand	Guldens on Hand
	Sale	Purchase		
Beginning			4	10,000
1		165	5	9,835
2			5	9,835
3			5	9,835
4			5	9,835
5			5	9,835
6			5	9,835
7			5	9,835
8			5	9,835
9			5	9,835
10			5	9,835
		Selected State:		
		Dividends per Certificate	0	
		Total Earnings on Certificates	0	
		Ending Guldens on Hand	9,835	
		Total Earnings for Round 1	**9,835**	

Stage 1 | Stage 2 | Earnings Sheet

As the buyer, trader A2 has appropriately entered the transaction price of 165 guldens under "Purchase." Accordingly, his number of certificates on hand has automatically increased to 5 and his amount of guldens on hand has decreased by the 165 guldens the trader paid for the certificate.

For simplicity's sake, we will assume that these were the only two trades in the round. The randomly selected number was 81, which corresponds to a state of Z. Each trader must then enter "Z" in the highlighted cell beside "Selected State" at the bottom of this round. Dividend earnings and Total Earnings for Round 1 will be automatically calculated and displayed at the bottom of the round's table. Trader A3's Stage 2 Record Sheet with the appropriate entries is shown below, as it should appear at the end of the round:



Participant Workbook.xlsx

Stage 2 Record Sheet

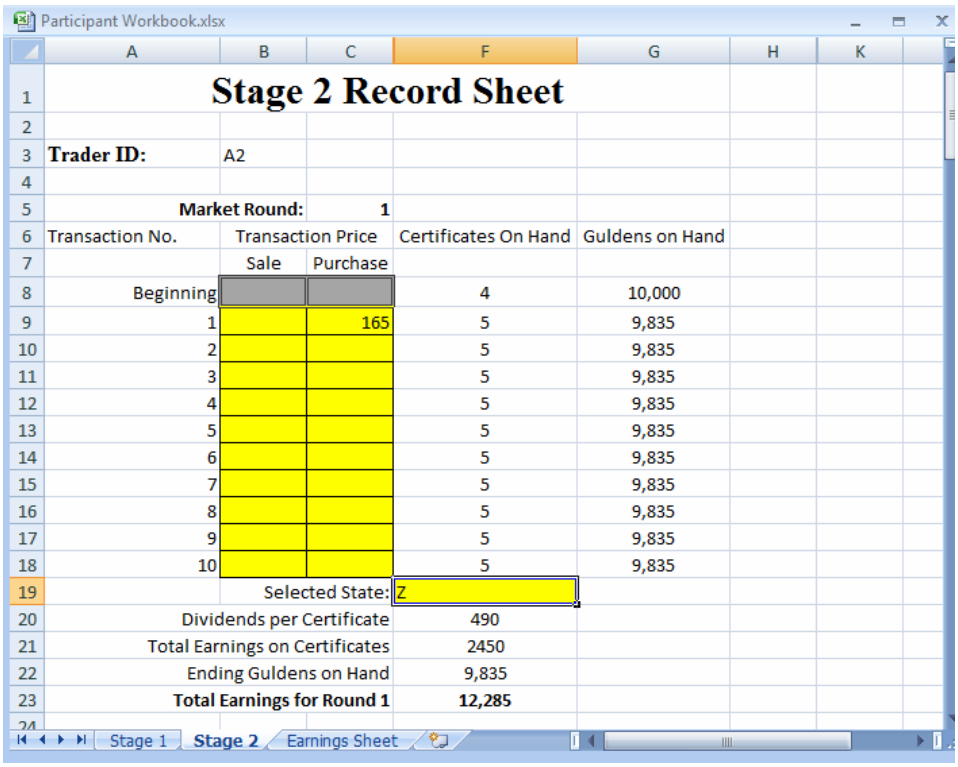
Trader ID:	A3
Market Round:	1

Transaction No.	Transaction Price		Certificates On Hand	Guldens on Hand
	Sale	Purchase		
Beginning			4	10,000
1	165		3	10,165
2			3	10,165
3			3	10,165
4			3	10,165
5			3	10,165
6			3	10,165
7			3	10,165
8			3	10,165
9			3	10,165
10			3	10,165

Selected State:	Z
Dividends per Certificate	490
Total Earnings on Certificates	1470
Ending Guldens on Hand	10,165
Total Earnings for Round 1	**11,635**

Stage 1 | Stage 2 | Earnings Sheet

Trader A2's completed sheet is shown below:



Participant Workbook.xlsx

Stage 2 Record Sheet

Trader ID:	A2
Market Round:	1

Transaction No.	Transaction Price		Certificates On Hand	Guldens on Hand
	Sale	Purchase		
Beginning			4	10,000
1		165	5	9,835
2			5	9,835
3			5	9,835
4			5	9,835
5			5	9,835
6			5	9,835
7			5	9,835
8			5	9,835
9			5	9,835
10			5	9,835

Selected State:	Z
Dividends per Certificate	490
Total Earnings on Certificates	2450
Ending Guldens on Hand	9,835
Total Earnings for Round 1	**12,285**

Stage 1 | Stage 2 | Earnings Sheet

Are there any questions? Let's begin…

Appendix C: Recruitment Announcement

Students,

You have the opportunity to participate in an upcoming economics experiment; participants in the experiment will be trading dividend-bearing assets in a computerized market as a means of studying market behavior and trader decision making. For your participation, you will earn at least one point extra credit added to your next test, and as many as five points, depending on your performance in the markets. There are no negative consequences should you choose not to participate. There are three sessions which will be operated:

Tuesday March 16, 3:30-5:00 pm
Thursday March 18, 3:30-5:00 pm
Friday March 19, 3:00-4:30 pm

If you are willing to participate, please email Dr. Blackwell at blackwellc@cofc.edu to confirm your available times, and he will send you a confirmation email. Your participation is entirely optional, but if you confirm one of the below times you will be expected to arrive on time and remain for the duration of the experiment; this experiment will last approximately one and a half hours.

Thank you for your interest.

Appendix D: Consent Form

INFORMED CONSENT AGREEMENT TO PARTICIPATE IN RESEARCH

The following information describes the research study in which you are being asked to participate. Please read the information carefully. Afterwards, you will be asked to sign if you agree to participate.

A. INVESTIGATORS: Calvin Blackwell and Clay McManus, Department of Economics & Finance, College of Charleston.
B. PURPOSE: This study involves research. Its purpose is to examine markets and market performance.
C. EXPECTED DURATION: The length of time you are expected to participate in the study is one and a half hours.
D. PROCEDURES: We will be conducting two stages of the experiment; each will be preceded by 10-15 minute explanation of the rules and procedures. You will be rewarded with extra credit in Dr. Blackwell's class based upon your decisions.
E. POSSIBLE DISCOMFORTS AND/OR RISKS: We know of no significant risks or discomforts associated with this study.
F. POSSIBLE BENEFITS: Benefits that you may experience through participation in this study include a better understanding of your own decision-making processes, as well as compensation in the form of extra credit in Dr. Blackwell's class for your time. There are no negative consequences should you choose not to participate; your grade cannot be harmed, either by participating or not participating. Regardless your choice to participate and any choices you make in the experiment, your grade will only be affected by an increase in the amount of extra credit earned, there will be no other consequences affecting your grade or treatment in the class.
G. CONFIDENTIALITY: The results of your decisions will be kept entirely confidential. Only the aggregate results (for example, the average decision made by all participants today) of this experiment will be published; no individual identifying information will be released. As much as is possible, identifying information will be kept separate from data collected during the experiment. The researchers will keep two databases – one with your name and extra credit earned; and a second database with the records of your actions during the experiment. During and after the experiment you will be identified only by your participant number. At no time will your name be linked to the record of your actions today. Dr. Blackwell will not be shown the results of your decisions today until the end of the semester when he will allocate the appropriate amount of extra credit; this will protect you against any possible discrimination in his class.
H. COMPENSATION: You will be given extra credit for both your participation and your decisions. These decisions involve uncertainty, and so we cannot guarantee a particular amount; however, we can guarantee you will earn a minimum of one point on your next test in Dr. Blackwell's class, and you could earn up to five points. The better decisions you make, the more extra credit you will earn. It is highly unlikely that more than half of you will earn all five points.
I. VOLUNTARINESS: Your participation is completely voluntary. Refusal to participate in this study will not result in any penalty or loss of benefits to which you are otherwise entitled. You may likewise discontinue participation in the study at any time without penalty or loss of benefits.
J. CONTACT INFORMATION: Calvin Blackwell (843-953-7836) will gladly answer any questions you may have concerning the purpose, procedures, and outcome of this project. You may also contact the College of Charleston Institutional Review Board (IRB) through the Office of Research & Grants Administration (843-953-5673) to convey any questions or concerns you may have about the rights of study participants. (The IRB is a college committee concerned with the protection of human subjects in research.)

I have read and understand the information in this consent form and agree to participate in this study. Although the investigator will make every effort to maintain confidentiality, I understand that research records must be made available to the College's Institutional Review Board, if for any reason they should be requested. I will receive a copy of this form after it has been read and signed.

_____ _____
Printed Name of Participant/Parent/Legal Guardian Date

_____
Signature of Participant/Parent/Legal Guardian

References

Cason, Timothy N. and Friedman, Daniel. 1992. "An Empirical Analysis of Price Formation in Double Auction Markets." In The Double Auction Market: Institutions, Theories, and Evidence, edited by Daniel Friedman and John Rust. Santa Fe Inst. Studies in the Sciences of the Complexity. New York: Addison-Wesley.

Copeland, Thomas, and Daniel Friedman. 1991. "Partial Revelation of Information in Experimental Asset Markets." *Journal of Finance* 46.1: 265-95.

Copeland, Thomas, and Daniel Friedman. 1992. "The Market Value of Information: Some Experimental Results." *Journal of Business* 65.2: 241-66.

Forsythe, Robert, and Russell Lundholm. 1990. "Information Aggregation in an Experimental Market." *Econometrica* 58.2: 309-47.

Forsythe, Robert, Forrest Nelson, George R. Neumann, and Jack Wright. 1992. "Anatomy of an Experimental Political Stock Market." *American Economic Association.* 82.5: 1142-61.

Forsythe, Robert, Thomas R. Palfrey and Charles R. Plott. 1982. "Asset Valuation in an Experimental Market." *Econometrica* 50.3: 537-67.

Forsythe, Robert, Thomas A. Rietz and Thomas W. Ross. 1999. "Wishes, Expectations and Actions: A Survey on Price Formation in Election Stock Markets." *Journal of Economic Behavior & Organization* 39: 83-110.

Friedman, Daniel, Glenn W. Harrison and John W. Salmon. 1984. "The Informational Efficiency of Experimental Asset Markets." *The Journal of Political Economy* 92.3: 349-408

Gode, Dhananjay K. and Shyam Sunder. 1993. "Allocative Efficiency of Markets with Zero-Intelligence Traders: Market as a Partial Substitute for Individual Rationality." *The Journal of Political Economy* 101.1: 119-37.

Gode, Dhananjay K. and Shyam Sunder. 1997. "What Makes Markets Allocationally Efficient." *The Quarterly Journal of Economics* 112.2: 603-30.

Malkiel, Burton G. 2003. *A Random Walk Down Wall Street*. 8 ed. New York: W. W. Norton & Company.

Malkiel, Burton G. 2003. "The Efficient Market Hypothesis and Its Critics." *The Journal of Economic Perspectives* 17.1: 59-82

Miller, Ross M. 2002. *Experimental Economics: How We Can Build Better Financial Markets*. Hoboken: John Wiley & Sons, Inc.

Nöth, Markus, Colin F. Camerer, Charles R. Plott and Martin Weber. 1999. "Information Aggregation in an Experimental Asset Markets: Traps and Misaligned Beliefs." California Institute of Technology, Social Sciences Working Paper.

Oliven, Kenneth and Thomas A. Rietz. 2004. "Suckers Are Born but Markets Are Made: Individual Rationality, Arbitrage, and Market Efficiency on an Electronic Futures Market." *Management Science* 50.3: 336-51.

Plott, Charles R. 2000. "Markets as Information Gathering Tools," *Southern Economic Journal* 67.1: 2-15.

Plott, Charles R. 1967. "A Notion of Equilibrium and Its Possibility Under Majority Rule." *The American Economic Review* 57.4: 787-806.

Plott, Charles R. and Shyam Sunder. 1982. "Efficiency of Experimental Security Markets with Insider Information: An Application of Rational-Expectations Models." *The Journal of Political Economy* 90.4: 663-98.

Plott, Charles R., and Shyam Sunder. 1988. "Rational Expectations and the Aggregation of Diverse Information in a Laboratory Security Markets." *Econometrica* 56: 1085-118.

Plott, Charles R. and Dean V. Williamson. 2000. “Markets for Contracts: Experiments Exploring the Compatibility of Games and Markets for Games.” *Economic Theory* 16.3: 639-60.

Plott, Charles R. and Vernon L. Smith. 1978 “An Experimental Examination of Two Exchange Institutions. *The Review of Economic Studies* 45.1: 133-53.

Shiller, Robert J. 2003. "From Efficient Markets Theory to Behavioral Finance." *The Journal of Economic Perspectives* 17.1: 83-104

Shiller, Robert J. 2005. *Irrational Exuberance*. 2 ed. New York: Doubleday.

Smith, Vernon L. 1962. "An Experimental Study of Competitive Market Behavior." *The Journal of Political Economy* 70: 111-37.

Smith, Vernon L. 1976. "Experimental Economics: Induced Value Theory." *American Economic Review* 66.2: 274-79.

Smith, Vernon L. 1982. "Macroeconomic Systems as an Experimental Science." *American Economic Review* 72.5: 923-55.

Sunder, Shyam. 1992. “Market for Information: Experimental Evidence.” *Econometrica* 60.3: 667-95.

Sunder, Shyam. 1995. “Experimental asset markets: A Survey.” In *Handbook of Experimental Economics*, edited by John H. Kagel and Alvin E. Roth. Princeton, NJ: Princeton University Press. 445-500.

Surowiecki, James. 2004. *The Wisdom of Crowds: Why the Many Are Smarter than the Few and How Collective Wisdom Shapes Business, Economies, Societies, and Nations*. New York: Doubleday.