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Version of attached file:

Published Version

Peer-review status of attached file:

Peer-reviewed

Citation for published item:

Damianova, E. and Damianov, D. (2018) 'Teaching futures markets with the "ZIP Code" trading game.', *Journal of financial education*, 44 (1). pp. 79-99.

Further information on publisher's website:

<https://doi.org/10.2307/26573537>

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Teaching Futures Markets with the “ZIP-Code” Trading Game

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Source: *Journal of Financial Education*, Vol. 44, No. 1 (SPRING 2018), pp. 79-99

Published by: Financial Education Association

Stable URL: <https://www.jstor.org/stable/10.2307/26573537>

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Teaching Futures Markets with the “ZIP-Code” Trading Game

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The price dynamics of futures markets and the spot-futures convergence are among the hardest concepts for students to fully understand in a traditional lecture. In this paper we present a classroom exercise designed to enable students to better grasp the intricacies of futures market trading. The simulation mirrors trading on an electronic market exchange in that students can freely submit bids and offers or enter into contracts at pre-existing quotes. We present questions and problems related to transaction data generated during the experiment to aid instructors in explaining: the mechanics of opening and closing position, the calculation of gains and losses, the daily settlement process, the futures-spot price convergence, the behavior of arbitrageurs and speculators, as well as the concepts of market efficiency and insider trading. Finally, we present experimental results from a large cohort of students in a Masters of Finance program.

Keywords: *Futures markets, margin accounts, daily settlement, futures-spot convergence, arbitrage*

INTRODUCTION

Anyone involved in teaching a derivatives course is aware of the challenges that students face in grasping the mechanics of the futures market. Among the hardest concepts to master are the spot and futures price convergence and the differences in the trading strategies for hedgers, arbitrageurs and speculators. Even the mechanics of closing positions and the operation of margin accounts pose difficulties for some students. Because of these hurdles a discussion of more advanced topics such as the transmission of information into prices, market efficiency and insider trading often remains off limits in traditional lectures.

The main approach to these challenges has been in organizing and presenting this material in a logical, coherent way, and in assigning numerous end-of-chapter problems. Although endorsed by long use and tradition, and supposedly effective

in aiding understanding, the standard lecture mode creates some misconceptions. Liebler (2000) aptly illustrates them by posing the following question: when asked what they do in the classroom, why do finance students say that they “study financial theory and solve countless problems” while psychology students respond that they “learn about people’s behavior?” Liebler’s explanation is that in the minds of students finance is abstract because it is based on mathematical theory while psychology is tangible because it is based on experiments. Liebler also points to the common challenge faced by finance instructors in facilitating classroom engagement and interaction in lectures in which key concepts, e.g. arbitrage relationships, are conveyed in the form of formulae and equations.

In this paper we present an interactive classroom approach to teaching futures markets to impart the idea that finance is about understanding human behavior. We simulate a futures market in which students participate as traders. Trading in this market resembles trading on an electronic futures exchange in that market participants can make bids and offers and enter into contracts at preexisting quotes. The uncertainty regarding the delivery price is gradually resolved over time while students attempt to make a profit by trading with each other in the pit.

The simulation allows for the use of a variety of trading strategies and creates rich experimental market data which students summarize and explore upon the completion of trading. The opportunity for students to analyze the data they created themselves reinforces the idea that finance is about people making choices on financial markets. This point is further strengthened when the experimental data is used to create measures such as trading volume and open interest in the experimental market. A discussion of trading strategies after the experiment further helps reduce the level of abstraction for students and make mathematical concepts such as the futures-spot arbitrage relationship easier to grasp.

We call this experiment the “ZIP-Code” trading game because the delivery price of the underlying asset is determined by the sum of the digits of a secret ZIP code. An initial idea for such a trading exercise, with some modifications, can be found in the notes to instructors to Hull’s (2012a) textbook (see Hull 2012b, Chapter 2) as explained in more detail in next section. In addition to creating an Excel-based system for collecting and recording quotes that mirrors trading on an electronic exchange, we develop a number of additional exercises and extensions from which instructors can pick and choose to help students understand the mechanics of futures trading.

Trading in the simulated futures market proceeds in rounds and after each round we reveal to traders one of the secret numbers that will determine the delivery price. This new information allows market participants to update the possible outcomes for the delivery price and to formulate and pursue new trading strategies. This trading environment helps students develop more intuitive understanding of

financial concepts. In addition to being an effective tool for engaging students, the “ZIP-Code” trading exercise helps students better grasp a number of futures market concepts including:

- the mechanics of trading (making bids, offers, and entering into long and short positions on exchanges),
- trading strategies for hedgers, speculators, and arbitrageurs,
- the process of opening and closing out positions,
- the calculation of profits and losses for traders,
- the determination of trading volume and open interest,
- the use of margin accounts and the marking to market process,
- the spot-futures arbitrage relationship and convergence, and
- trader (ir)rationality, market (in)efficiency and insider trading.

Presenting these concepts and their relationships is aided by the use of an Excel spreadsheet we developed to simulate this market environment. The functionality of the spreadsheet aids the instructor in several ways. Probably most importantly, the spreadsheet is programmed to function as an electronic market exchange: it automatically highlights the current highest bid and lowest offer, and helps the instructor to fill contracts in the appropriate order so that higher bids and lower offers have priority, and in the case of ties, earlier submitted bids and offers are filled first. Another advantage of this approach is that it allows the instructor to face the audience and to quickly and accurately record and aggregate information on the order flow from students. Further, the spreadsheet serves as a generator of uncertainty in the market: the ZIP code is determined by random draws between 0 and 9 and is visible to all traders. Finally, it generates the open interest and trading volume from the information recorded during each round of trading allowing students to check the accuracy of their own calculations.

The rest of the paper is organized as follows. In the next section we briefly discuss the related literature and review the learning objectives. Section 3 presents the experimental design, provides guidance on the initial preparation needed, and offers suggestions on how to conduct of the experiment. Section 4 presents exercises from which instructors can pick and choose to discuss in the classroom. Section 5 presents the data collected from a large number of sessions in which the experiment was conducted, and Section 6 contains the concluding remarks. Student instructions for the experiment are presented in the Appendix.

RELATED CLASSROOM EXPERIMENTS

Classroom experiments have become increasingly popular and widely accepted in finance education. The effectiveness of classroom simulations as an active learning tool is due to their ability to capture students' interest (Simkins, 1999) and their potential to help explain complex concepts in a way that is accessible to students (Bergstrom and Kwok, 2005). Classroom games also serve to enhance student confidence and engagement, to remove barriers between the instructor and students, thus leading to a better student-teacher relationship (Butler, 1988). Further benefits of interactive classroom exercises is that they help students develop strategic, reflective, and critical thinking skills and provide a much needed connection between classroom and professional environments (Roden, 2013).

The main category of finance experiments, to which the current experiment also belongs, is related to trading on financial markets. Among the most popular experiments is Bell's (1993) "Asset Trading Game" which uses an idea initially proposed by Williams and Walker (1993) and which, similarly to the present setting, generates uncertainty by using random draws from a uniform distribution. Unlike the present experiment, the uncertainty is related to the dividends that an asset pays in each period and students are trading an asset instead of a derivative. Traders can buy and sell this asset at the spot market using a double sealed bid auction and trading proceeds in rounds as in the present setting. The main objectives for students are to learn how to apply formal analysis for asset valuation and to assess the profitability of investment strategies.

Interesting patterns that the experiments can potentially create are bubbles or, more generally, price deviations from fundamental values. In the present experiment, the trading protocol can best be described as an electronic exchange instead of sealed bid double auction, yet deviations from fundamental values can also be observed and will be a central point of discussion. Further, while the main decision students make in Bell's experiment is to determine the appropriate value of the spot price, in the current experiment students estimate the futures price. In both experiments, however, asset prices change over time and are subject to uncertainty.

Bell's experiment has been subsequently used by Cebula and Toma in Banking and Finance courses over a number of years (see Cebula & Toma, 2002). The collected data on student learning over a fairly long time period affords an assessment of the teaching effectiveness of the experiment. By using control groups of students not being exposed to the experiment and accounting for other relevant factors such as grade expectation and number of absences, Cebula and Toma (2002) find that the "Asset Trading Game" has a positive and statistically significant effect on student motivation and satisfaction. Further studies to establish that market games have a positive effect on student learning outcomes include Emerson and Taylor (2004) and Ball, Eckel, and Rojas (2006).

Perhaps most closely related to the present simulation are the market experiments by Holt (1996) and Hunsander, Mitchell, and Parker (2011). Unlike the present game, uncertainty in Holt (1996) is generated by using playing cards to induce supply and demand functions. As some cards are removed from the decks, supply and demand, and therefore equilibrium price, are not observable to students. In Hunsander et al. (2011) uncertainty is created by the flip of a coin and by the rolling of a dice which determine direction and magnitude of change in the spot price. In our setting, uncertainty is created by a random number which is automatically generated in an Excel spreadsheet and displayed at the end of each trading period. This straightforward way to create uncertainty allows more time for students to develop their trading strategies. Another key difference between these experiments and our setting consists in the market mechanism used. Holt (1996) and Hunsander et al. (2011) implement a decentralized trading environment according to which students are looking for trading partners in the classroom and prices are determined in bilateral negotiations. We, in contrast, use a centralized trading environment by operating a simulated electronic market exchange.

Alternative pedagogical approaches for teaching courses on derivative markets include exercises in which students have real stake in the game. Root and Lien (2005) present an exercise in which students trade a futures contract based on the average grade they received in the class. Thus, the gains and losses that they realize from trading have a direct bearing on their final grades. Similarly, Smolira and Travis (2011) give students the opportunity to purchase a call or a put option on their final exam score in a derivatives markets course. By exposing students to this tangible and very real opportunity for a gain or a loss, they encourage students to fully analyze the aspects of valuation and risk exposure. Further simulations of options markets are developed by Pavlik and Nienhouse (2004), and Cooper and Grindler (1997).

There are several key design features that make classroom experiments effective. As an alternative to lectures, these pedagogical innovations impose an opportunity cost due to the additional classroom time required (Bell, 1993). Thus, simple design, clear rules, and the leveraging of technology to facilitate student interaction can help keep the time needed low. Our experiment takes about an hour to complete—including debriefing and exercises—due to its simple rules and the spreadsheet simulated electronic exchange. Similarly to a traditional lecture format, a good design should allow instructors to test the effectiveness of their exercise in fulfilling learning objectives. Standard approaches are the use of questionnaires after the classroom activity (see e.g. Gotsias & Tompkins, 2013) or even the use of control groups not exposed to the treatment and statistical analyses to measure student satisfaction (Cebula & Toma, 2002). To assess student learning and understanding we rely on observed behavior during the later stages of the experiment and student testimonials.

A preliminary description of the “ZIP Code” trading game can be found in the notes to instructors that accompany Hull’s (2012a) textbook (see Hull 2012b, Chapter 2). Hull (2012b) writes that this game was suggested to him by a Wall Street training manager and calls it the “telephone number” game as it consists of seven rounds of trading. Hull (2012b) relies on student volunteers to record the trades on the blackboard. To allow more time for debriefing we adjusted the duration of the game to five rounds and extended the experiment along several new dimensions.

First, we designed an Excel spreadsheet that functions as an electronic exchange. The spreadsheet facilitates trading by highlighting the highest bid and lowest offer currently available in the market and automatically keeps track of the open interest and trading volume in each round. In addition, it transforms the data on trading in a format that is convenient for analysis after the experiment. Using the spreadsheet, instructors can face the audience and record bids, offers, and transactions quickly and accurately and without the need for volunteers allowing all students to participate in the trading. In the next section we provide guidance on how to prepare the spreadsheet.

Second, we developed a set of problems and exercises that are directly related to the data that students generated by trading in the experiment. These problems provide a discussion on opening and closing positions, an illustration of the arbitrage relationship between the spot and futures price based on the cost of carry model, and an explanation of the daily settlement process.

Third, our design allows us to incorporate in the discussion more advanced topic such as informational efficiency, insider trading, and trader rationality. The benefit of the present design is that it places the experimental subjects in a setting in which the instructor can control aspects related to the information that traders receive during trading. This is not possible with the commercially available and widely used trading simulators such as Stock Trak or Stocknavigator. While students using these trading simulators try to “beat the market,” students in our experiment directly interact with each other. This creates a more stimulating and engaging learning environment. Further, controlling the “news” that students receive regarding the fundamental value of the asset traded allows us to observe, for instance, whether and to what extent information on fundamental values is impounded into transaction prices, and quite generally, how students react to new market information.

Finally, we conducted the present experiment in a large Masters course in Derivative Markets and analyzed the trading data. We discuss here several phenomena related to trading such as the formation of price bubbles and the reaction of traders to the arrival of new information. It is our hope that this article will lead to new studies in which the behavioral phenomena we document here are further explored.

PREPARATION FOR THE EXPERIMENT

As the experiment entails a choice of trading strategies, it is recommended to pair students in teams so as to enhance interaction and keep the process of trading manageable. Our classroom sizes ranged between 16 and 24 students, so we had between 8 and 12 teams participating in the trading. While the experiment can be conducted in smaller or larger classes, a smaller number of traders might result in the market being thin with potentially only few or no trades occurring in some rounds. A larger number of traders, on the other hand, might pose some difficulty for the instructor in recording bids and offers and keeping track of transactions especially when the order flow is fast. In larger or smaller classes a different grouping can be considered so that the number of teams remains within reasonable bounds.

Instructions for the experiment (presented in Appendix A) were distributed in advance of the experimental session (handed out in the lecture prior to the experiment and posted on Blackboard). As some students might still arrive to class without knowledge of the trading rules, we provided a five minute verbal explanation of the trading rules, along with a simple example of how the gains and losses of traders are determined before starting the actual trading.

Once teams were formed, each team was given an identifier (A, B, C, etc.) to be used for the duration of the trading game. There were 5 rounds (or days) of trading, and each round lasted 3 minutes. During each round we used an Excel spreadsheet to simulate an electronic trading system (instructions on how to create the spreadsheet are presented in Appendix B). According to the trading rules, teams can freely make bids and offers which are entered in an Excel spreadsheet and displayed to all traders. The spreadsheet automatically highlights the current highest bid and current lowest offer in a distinct color. Teams trade by entering into futures contracts at the already preexisting quotes. In the case of several identical bids or offers, the earlier submitted quotes are filled first. The spreadsheet aids this process by automatically highlighting these quotes.

Each team can assume both long and short positions in the futures contracts. For simplicity, bids, offers, and transactions are allowed for one futures contract at a time and only integer prices are admissible for bids and offers. Each team can also withdraw a bid or an offer before this bid or offer has been accepted. All futures contracts have a delivery date at the end of the fifth (and last) trading period. The delivery price for the outstanding contracts at the end of the game is determined by the sum of the 5 digits of a secret zip code. After each trading period one digit is randomly generated with the spreadsheet and revealed to traders.

To explain the process of trading and the payoffs we use a hypothetical example presented in following two tables. Table 1 presents a scenario according to which teams C and D made offers and E and B made bids. The spreadsheet highlights the

best bids and offers available. The table also indicates that team A wants to accept the \$25 bid of team B. The way the instructor records the contract is given in Table 2. The instructor notes that the \$25 bid of team B has led to a transaction with team A as shown in the Table 2.

Table 1. Bids and offers.

Long	Team	Bid	Offer	Team	Short
			\$35	C	
			\$38	D	\$30
	E	\$20			
	B	\$25			
				A	\$25

The spreadsheet automatically updates the best bid and offer available and highlights the transaction.

Table 2. Example of a trade.

Long	Team	Bid	Offer	Team	Short
			\$35	C	
			\$38	D	\$30
	E	\$20			
\$25	B				
				A	\$25

To check whether students understand the consequences of such trades we ask the following questions.

- Assume that both teams A and B keep this contract till maturity and the delivery price turns out to be \$30. Calculate the gain or loss for team A and team B.
- Assume that in the next round team A enters into a long contract for the price of \$28 while team B enters into a short contract for the price of \$29. Calculate the gains and losses of the two teams.

DEBRIEFING AND EXERCISES

Upon completion of trading we use the board to record only the transactions and the delivery price in each round. We start with the following exercise.

Exercise 1. (Trading volume and open interest). Record all transactions. Determine the trading volume and open interest after each round of trading.

To illustrate how to structure the debriefing we present the results for one of the sessions. The bids, offers, and transactions for this group are presented in Table 3 below.

Table 3. Teams and transaction prices.

Random ZIP code #	Round	Closed position	Long position	Transaction price (\$)	Short position	Closed position
	1	X	I	15	D	X
		X	I	20	A	X
4						
	2	X	A	30	I	X
			C	20	F	
			C	26	I	X
		X	D	25	H	
7						
	3		F	25	A	
			B	26	I	
5						
	4		E	25	B	
			D	26	H	
0						
	5		D	22	H	
			E	25	I	
2						

In Round 1 trader I opened two long positions by trading with traders D and A, and in Round 2 this trader closed these two positions. After each round we cross the positions that have been closed. The closing of positions for the first two rounds is illustrated in Table 3. The open interest is two contracts in Round 1 and two contracts in Round 2. Using the same technique students calculate the open interest in the remaining rounds. The results for all rounds are presented in Table 4 below.

Table 4. Trading volume and open interest.

Round #	Trading volume	Long positions opened	Long positions closed	Open interest	Settlement price
1	2	2	0	2	\$20
2	4	4	4	2	\$25
3	2	2	1	3	\$26
4	2	2	1	4	\$26
5	2	2	0	6	\$25

We next calculate the gains and losses of traders. For the current example the delivery price is $4+7+5+0+2=\$18$.

Exercise 2. (Gains and losses) *Trader “I” has entered into a long position at a price of \$20 in Round 1 and closed this position in Round 2 at a price of \$30. Determine the profit or loss of this trader.*

Trader “I” acts as an arbitrageur by entering into a long contract below the expected delivery price and holding this position just for one round. Trader “I” is able to earn a profit of $\$30-\$20=\$10$ by engaging in this trade.

For the next exercise we choose a trader who signed a contract for which the settlement price went into an unfavorable direction. This gives an opportunity to demonstrate the mechanics of the daily account settlement.

Exercise 3. (Marking to market) *Trader “A” has entered into a short position at a price of \$20 in Round 1. Suppose that this contract was held until the delivery date. Create a table to reflect the daily settlement process assuming that the initial margin is \$10 for this contract and the maintenance margin is \$8.*

The results are presented in Table 5. In the second column we record the settlement prices which are the prices for the last transaction in each round.

Table 5. Marking to market for a long position of a contract with a delivery price of \$24.

Day	Settlement price	Daily gain (\$)	Cumulative gain (\$)	Margin account balance (\$)	Margin call (\$)
1	\$20	0	0	10	
2	\$25	-5	-5	5	5
3	\$26	-1	-6	9	
4	\$26	0	-6	9	
5	\$25	1	-5	10	
Delivery	\$18	7	2	17	

We next ask students about the strategies they followed during the simulation. In particular, we discuss the behavior of arbitrageurs and speculators.

Exercise 4. (Arbitrageurs and speculators). *Discuss the difference in the trading strategies of arbitrageurs and speculators. Were you an arbitrageur or a speculator during the experiment? Determine the expected delivery price in each round of trading. How would risk neutral traders behave during the experiment?*

In Table 3 we observed that most of the traders open and close positions in each round. Open positions are held in the majority of cases for one or two rounds only. Thus, most of the students behave as arbitrageurs seeking to predict and exploit short term mispricing. This exercise provides an opportunity to discuss the definition of arbitrage and to clarify that this is a trading strategy intended to take into account the mispricing of assets relative to each other. In some sessions we observed traders that open a position early in the game and hold this position until delivery in line with the behavior of speculators who are trying to exploit longer term trends.

For the following exercise we create a table with the expected delivery price. This price is determined by the sum of the revealed digits plus the expected value of each round (4.5) times the number of the remaining rounds. For the current simulation, the expected delivery price is adjusted upwards in round 2 and 3 in response to “good news” after the realizations of 7 and 5 respectively (see Table 3). The delivery price is adjusted downwards after “bad news” in round 1 and 4 when the realizations were 4 and 0, respectively.

Exercise 5. (Futures-spot arbitrage relationship) Assume that in each round a parallel spot market exists and traders can borrow and lend at the interest rate of $r=0.1$ (expressed with continuous compounding). Use the cost of carry model to determine the arbitrage-free spot price in the market by assuming that you trade an investment asset that pays no dividends. Explain the arbitrage opportunities that would exist if traders can trade the asset at the spot price of \$20 in each round.

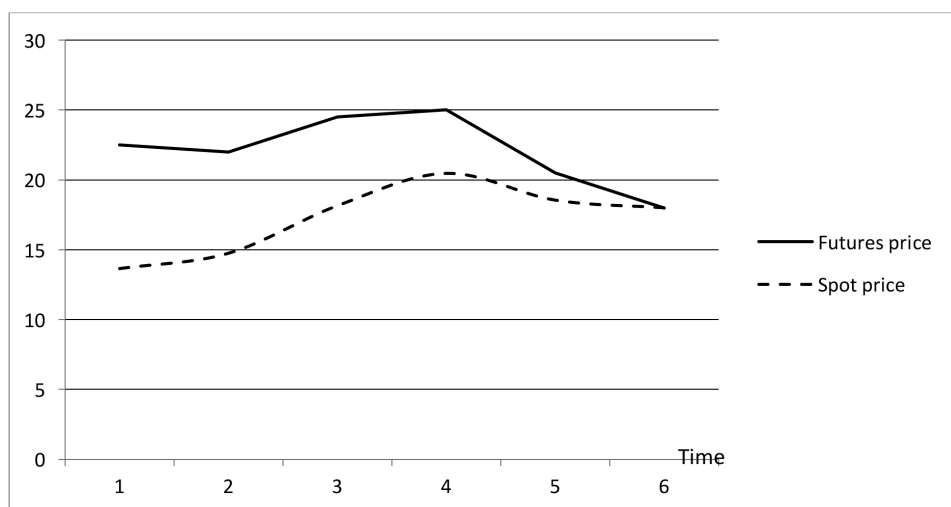
Using the arbitrage relationship $F_t = S_t \cdot e^{r(T-t)}$ we calculate for each round $t = 1, 2, 3, 4, 5$ the spot prices $F_t = S_t \cdot e^{-r(T-t)}$ where $r = 0.1$ and $T = 6$.

Table 6. Expected delivery price at the beginning of each round and the arbitrage free spot price calculated using the cost of carry model.

Round	Expected delivery price	Arbitrage free spot price
1	22.5	13.6
2	22.0	14.7
3	24.5	18.2
4	25.0	20.5
5	20.5	18.5
Delivery	18.0	18.0

Table 6 illustrates the spot-futures price convergence. For the given example, the spot price of \$20 is above the arbitrage-free spot price for rounds 1, 2, 3 and 5. In these rounds the arbitrage strategy entails short selling the asset at the spot price of \$20 and entering into a long position in the futures contract. To illustrate the theoretical futures-spot price convergence we plot in Figure 1 the relationship presented in the table.

Figure 1. Futures-spot price convergence



In the following exercise we show how to use the current experiment to develop a test for market efficiency.

Exercise 6. (Market efficiency) *Explain the concept of market efficiency. How would you examine whether the experimental market impounds the arrival of new information into transaction prices? Do traders behave rationally during the experiment? How would “market insiders” trade in this experiment?*

The present exercise creates transaction data that allows student to discuss whether the experimental market is efficient. This is possible due to the clear interpretation of “good” and “bad” news in the current market setting. The instructor can begin by asking what good and bad news is (for instance, identify whether the realization of the random number is above 4.5 or below 4.5). It is easy to see that a realization of 5 and above would lead to an update of the expected delivery price upwards while a realization of 4 and below would lead to an update downwards. We then ask whether market prices react to good and bad news. One way to answer this question is to examine whether transaction prices indeed increase after good news and decrease after bad news. For the current simulation there is mixed evidence of market efficiency. Prices do not appear to drop as traders move from the first to the second round (note that bad news arrives as the realization of the random number is 4), neither do they increase significantly in the third round upon the realization of the number 7. In the next section we analyze the data from all the sessions we conducted.

EXPERIMENTAL RESULTS

The experiment was conducted during the 2014-2015 academic year in a large

elective course in Derivative markets taken by MSc in Finance students. There were a total of 218 students enrolled in the course of which 200 participated in the experiment. The trading simulation was run independently with 13 groups of students whereby in each groups there were between 7 and 10 trading teams. Each trading team, which we refer to as a “trader” consisted of two participants allowing students to consult with each other as they choose trading strategies. There were a total of 100 traders in all 13 groups. We thus analyze the trading data generated by those 100 traders who signed a total of 156 futures contract in the 13 market simulations. In Table 9 we present the number of transactions completed in each round and session. As can be observed in the first round teams are cautious in making bids and offers and entering into trades.

Yet, in some sessions transactions were completed already in the first round, and the total number of transactions exceeded the number of traders in 9 out of the 13 sessions. Given that each transaction has two sides this shows that a large number of traders were engaged in some stage of the game rather than passively observing. As the experiment progresses, teams learn the rules of the experiment and gain more confidence. The largest number of contracts were signed in Round 4 followed by Round 5 in which many traders close their positions.

Table 7. Number of transactions per round and session.

Session	Number of traders	Number of transactions					Total
		R1	R2	R3	R4	R5	
1	8	0	4	2	5	2	13
2	9	2	4	2	2	2	12
3	7	0	2	1	4	1	8
4	7	1	1	1	1	2	6
5	9	0	1	0	4	2	7
6	8	0	1	3	2	4	10
7	9	2	4	5	5	4	20
8	8	3	4	5	5	3	20
9	7	1	1	1	3	4	10
10	6	0	1	1	1	1	4
11	8	2	5	8	5	9	29
12	7	0	3	1	2	1	7
13	7	3	2	2	2	1	10
Total	100	14	33	32	41	36	156

We next explore the formation of market bubbles and deviations from fundamental values. As the uncertainty is gradually resolved during the experiment, traders need to adjust their quotes so as to reflect the arrival of new information.

The optimal strategy for risk neutral agents in this experiment involves accepting bids at prices above the expected delivery price and offers at prices below that price. If we denote by z_t the realization of the random number in round t , the expected delivery price in round k can be calculated as follows

$$\begin{aligned}
 E(P_k) &= \sum_{t=1}^k z_t + (6 - k) \cdot E(z_t) \\
 &= \sum_{t=1}^k z_t + (6 - k) \cdot 4.5
 \end{aligned}$$

The last equality applies because the expected price in each round is

$$E(z_t) = \frac{0+1+2+\dots+9}{10} = 4.5$$

For all trading groups the expected delivery price is 22.5 in the first round, and then varies in the individual groups of traders depending on the realization of the random draws. These random draws create variation in the fundamental price, and consequently in the optimal trading strategies of traders. We exploit this variation to conduct statistical tests in order to analyze whether teams behave rationally during the experiment. We focus on two measures of deviations from rationality based on the relationship between transaction prices and expected values. We denote the transaction price of transaction number l of session i in round k by $P_{i,k,l}$. We observe a “bubble” if the discrepancy between transaction prices and fundamental values

$$B_{i,k,l} = P_{i,k,l} - E(P_{i,k,l})$$

is statistically different from zero. Figure 2 below presents a scatterplot of all deviations from the fundamental value resulting from all transactions in each round. As can be seen, the majority of the observations in particular in rounds 2, 3 and 4 are more scattered and below zero indicating that transaction prices are below their respective fundamental values.

We examine this phenomenon more closely in Figure 3 by plotting the average deviation per round along with confidence intervals.

Figure 3 shows the means of the deviation from the expected delivery price along with the 95% confidence intervals for each round. The figure provides evidence of a bubble formation in period 2, 3 and 4. In these periods transaction prices are below fundamental values of average of, respectively, \$4.93, \$5.59, and \$3.24. A standard one-sided t-test with the alternative hypothesis that the transaction price is below the expected delivery price as well as a two-sided t-test reject the null of no significant difference between fundamental values and transaction prices at 1% significance level for round 2, 3, and 4. In round 5 all the

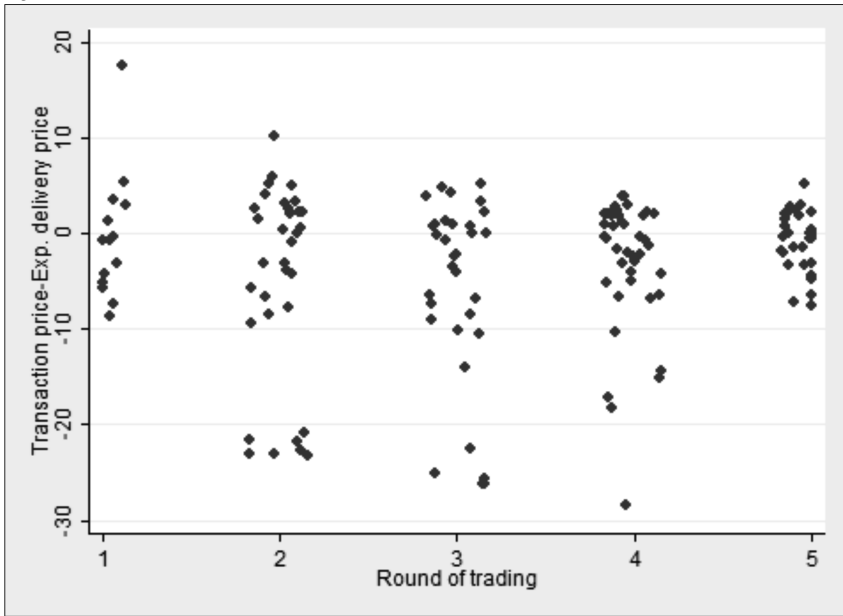


Figure 2. Deviation from fundamental values.

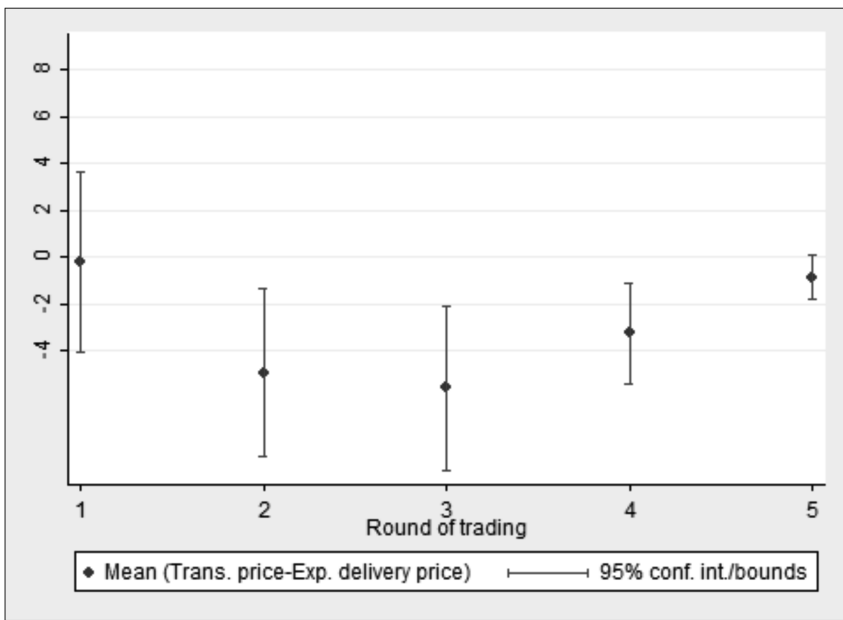


Figure 3. Confidence intervals for deviations from fundamental values.

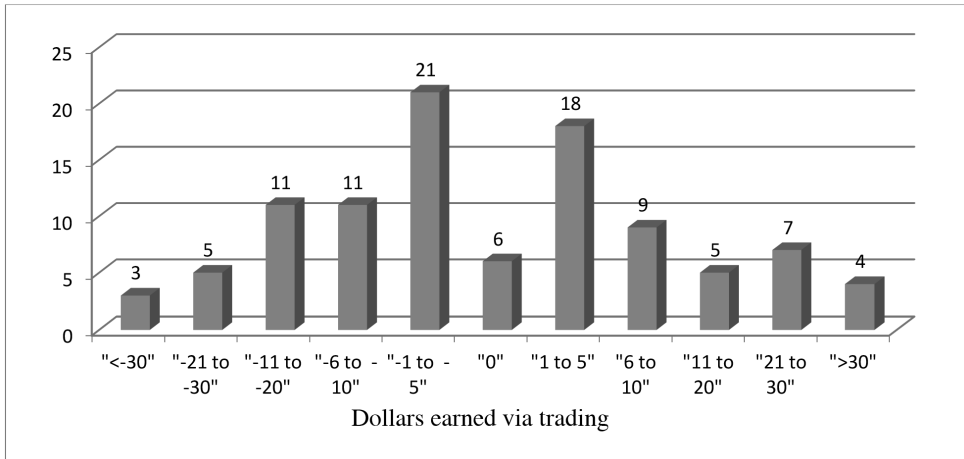


Figure 4. Distribution of dollars earned in the experiment.

transactions are very closely clustered together and not significantly different from the fundamental value.

Figure 4 below presents the gains and losses of students during the experiment.

The majority of the teams (65 out of 100) realized a gain or loss in the range of \$10. The largest gain by a group was \$58 and the largest loss was \$40. Overall Figure 4 lets us draw conclusions about the level of participation in the game. The vast majority of traders (94 out of the 100 traders in the game) experienced gains and losses demonstrating that nearly all traders across all sessions completed transactions. At most 6% of the participants did not participate in the game given that only 6 teams registered no gains or losses. This does not necessarily indicate they were completely passive throughout the entire game as they may have opened and closed positions resulting in zero gains or losses or submitted quotes that were not acted upon by any of the other participants. Thus the game achieved high level of engagement and student interaction.

CONCLUSION

The mechanics of futures markets is among the hardest concepts to explain in a derivatives market lecture. In this paper we show how a lecture can be augmented by a learning-by-doing classroom exercise in which students trade futures contracts with each other on a simulated electronic exchange. The market rules are relatively simple and the trading simulation is automated (using an Excel spreadsheet), so that the exercise confers a variety of benefits to students at a low opportunity cost. In addition to introducing basic concepts, such as the opening and closing of positions, the calculations of profits and losses, and the process of

daily settlement, the exercise affords a discussion of more advanced topics such as futures-spot price convergence, market efficiency, and insider trading. Main aspect of the trading exercise is that students get the opportunity to analyze and interpret the market data that they create by trading with each other. Exploring data from independently conducted sessions with 13 student groups, we find evidence of increased student engagement and learning.

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APPENDIX A (INSTRUCTIONS)

In this classroom trading game you will participate in a simulated futures market. The instructor will pair you with a partner in a trading team and your team will receive an identifier (A, B, C, etc.). Please remember your trading identifier as it will be used to record your trades.

Trading will proceed in 3-minute rounds (trading days). In each trading day, your team can make bids and offers or trade at already pre-existing quotes. All futures contracts traded are for delivery of one unit of an asset with a delivery date the end of the 5th trading period. Bids and offers allowed are integers, e.g. bid of \$25, offer of \$38. Each trader can withdraw their bid or offer before it is accepted by another trader. New futures positions can be opened and existing futures position can be closed in each trading round.

The delivery price of the asset at the end of the 5th round will be the sum of the digits of a secret ZIP-Code. At the end of each trading period the instructor will generate one digit in an Excel spreadsheet. If the randomly generated numbers are, for instance, 2,5,6,3, and 7 in the five rounds, the delivery price of the asset will be $2+5+6+3+7=23$. The difference between the futures price and the delivery price will determine your gains and losses during the experiment depending on your trading positions (short or long). To illustrate the gains and losses from trading consider the futures contract between the traders A and B shown in the table below.

Table A1. Example of a trade.

Long	Team	Bid	Offer	Team	Short
	A	\$30			
\$30				B accepts	\$30

The table shows that trader A made a bid of \$30, trader B accepted this bid, and the two parties entered into a futures contract. Assume that this contract remained open till maturity. According to the futures contract, trader A made a commitment to buy (assumed a long position) and trader B made a commitment to sell (assumed a short position in) one unit of the asset for \$30. As trader B receives \$30 for the delivery of an asset whose value is \$23, this trader realizes a gain of $\$30-\$23=\$7$. Trader A, on the other hand, incurs a loss of $\$23-\$30=-\$7$ by entering into a long position.

APPENDIX B (PREPARATION OF THE EXCEL SPREADSHEET)

We use the conditional formatting feature in Excel to make sure bids, offers, and trades are accurately represented. In addition, the spreadsheet automatically summarizes the long and short contracts and calculates open interest, trading volume, and the bid ask spread. For the color coding of the bids we use the conditional formatting capability in Excel presented in Table B1 below.

Table B1. Preparation of the spreadsheet.

	A	B	C	D	E	F	G	H
1	Long	Team	Bid	Offer	Team	Short		Random #
2								
3								
4								
5								
6								

Column C:

We click on C2, go to “conditional formatting”, “new rule”, and “Use formula to determine which cell to format” and write the following

`=AND($C2>MAX($C$1:$C1),$C2<=MAX($C3:C100))`

This automatically tracks and highlights the highest bid (we use a yellow color). For the color coding of the offers we need an intermediate step because all empty cells are automatically given the value of zero in Excel. To make sure that they are not highlighted, we first use the following formula for the entire column G giving the value of 1000 for all empty cells and making sure they are not highlighted.

Column G:

`G1=1000,`

`G2=IF(D2=""",1000,D2)`

Column G can subsequently be hidden so that changes to the cells occur in the background and are not visible students. We then use the following conditional formatting for the offers.

Column D:

`=AND($G2<MIN($G$1:$G1),$G2<=MIN($G3:G100))`

This makes sure that the lowest offer is highlighted (we also use a yellow color). To highlight also the signed contract (we use green color for the contracts) we enter the following formatting for the columns A and B:

`=(A2<>"")`

and for the columns E and F:

`=(F2<>"")`

while applying a green color for the signed contracts.

To automatically record open interest and trading volume we first count the number of long and short positions traders have entered into. In the columns I, J, K, and L we enter, respectively, the following formulas

Table B2. Long and short contracts, open interest and trading volume.

	I	J	K	K
1	Team	Long contracts	Short contracts	Outstanding long
2	A	<code>=COUNTIF(B2:B100,"A")</code>	<code>=COUNTIF(F2:F100,"A")</code>	<code>=MAX(J2-K2,0)</code>
3	B	<code>=COUNTIF(B2:B100,"B")</code>	<code>=COUNTIF(F2:F100,"B")</code>	<code>=MAX(J3-K3,0)</code>
4	etc.
10	I	<code>=COUNTIF(B2:B100,"I")</code>	<code>=COUNTIF(F2:f100,"I")</code>	<code>=MAX(J10K10,0)</code>
11			Trading volume:	<code>=SUM(J2:J10)</code>
			Open interest:	<code>=SUM(L2:L10)</code>

In this design every round is developed on a different Excel tab. After each round of trading we move on to the next tab and use the formula "`=RANDBETWEEN(0,9)`" to generate the next random ZIP code number. To account for previous round of trading we add results from previous round as follows. For Round 2 we apply the following formula for cell J2:

`J2=Period1!J2+COUNTIF(B2:B100,"A")` to take into account the positions trader A has entered into in the previous round. The same approach is followed for all traders and rounds 2 through 5. This ensures that the entire history of contracts and positions each trader has entered into in previous rounds are considered in the current round.