Classroom Games

Speculation and Bubbles in an Asset Market

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Abstract: This exercise puts students into a classroom market in which the assets being traded pay a fixed cash dividend each period. Discounting is induced by the fact that each asset unit has a one-sixth probability of failing and becoming worthless, which produces a "flat" fundamental value. Student traders earn money from dividends and capital gains (losses). The trading prices often rise above the fundamental value in a bubble, which is usually followed by a crash. The exercise stimulates a discussion of present value and market trading strategies.

Introduction

   The standard theory of stock valuation is that an asset should sell for the discounted present value of the stream of future returns. Trade occurs because traders have divergent attitudes about risk or expectations about future returns. In the *General Theory*, Keynes (1936) argued persuasively that asset prices are frequently not determined by long-term market fundamentals, but rather, that professional investors are "concerned, not with what an investment is really worth to a man who buys it 'for keeps', but with what the market will value it at, under the influence of mass psychology, three months or a year hence."

   This paper describes a classroom market that permits a comparison of the trading prices for an asset with its fundamental value. The exercise provides an interactive framework to facilitate discussion of rational expectations, discounting, backward induction and speculative price bubbles. We have found this exercise to be useful in a wide variety of undergraduate and MBA classes: principles, money and banking, macroeconomics, finance, and investments.

Setting Up the Asset Market

In this exercise, students trade assets of uncertain value in a sequence of market periods. It takes about 40 minutes to read the instructions and go through a number of trading periods, and you should allow 10-15 minutes for discussion. If you run short of time, you can cut the number of trading periods or leave students with some questions that will start the discussion at the beginning of the following class.

There should be at least five students in the class to serve as traders, but it is possible to involve much larger classes (up to 50 or 60 students) by letting traders be represented by teams of three to five students and using the other students as data recorders, time keepers, and so on. You can use 15 sheets of colored paper to represent assets. Each trader begins the game with three colored sheets (assets), which can be bought or sold during 10 trading periods, and some capital -- we suggest (a hypothetical) $20 -- to finance trading.

Traders can earn money from assets in three ways. First, each asset held by a team at the end of a trading period will pay a $1 dividend. Second, they can earn profits from buying and selling assets. Third, any asset that still exists at the end of 10th trading period will pay $6.

However, not every asset will survive until the last period, and this part of the game's structure is primarily what promotes the differences of opinion over underlying value that make traders willing to buy or sell the asset. After the $1 dividend is paid at the end of each trading period, there is a 1/6 chance that any individual asset will be destroyed, in which case the paper representing that asset is torn in half. We use a six-sided die to determine whether the asset is destroyed. The die should be tossed separately for each of the remaining assets.[1] It is expected that the overall number of assets will drop by about two during each of the first three or four trading periods, and then will diminish by one in each of the later periods. Some of the original 15 assets will typically remain in the final period. To repeat, only those assets that last the entire ten periods without destruction can be cashed in for $6. In a fifty-minute class, the final period should be period 6, with surviving assets redeemed for $6, which will save time and will not alter

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[1] If one follows an approach where, say, each team of traders has all of its assets at risk for a given toss of the die, it is possible that many assets are wiped out quickly, which diminishes the value of the experiment.

the discussion of asset valuation in any significant way.[2]

In economic terms, the purpose of introducing a risk that an asset will be destroyed is to simulate discounting. The key analytical ingredient of discounting is that returns received in the future should be valued less than returns received in the present. The game accomplishes that purpose in this way: once the dividend is paid at the end of a trading period, there is a fixed probability that the asset will be destroyed, which makes it worth less in the future.

The trading teams keep track of their earnings on forms provided in the appendix, which allow them to list separately the cash and number of assets on hand on hand along with the sale and/or purchase price(s) of assets in each period, which allows them to keep a running total of how they are doing. Our approach is to tell traders that all earnings are hypothetical, although it adds interest to promise small rewards -- like candy bars -- to successful trader(s).[3]

The instructions in the Appendix describe the general setup and the way in which assets are bought and sold. Trading is conducted as an explicit double auction, moderated by the instructor as Walrasian auctioneer, in which buyers' bids increase and sellers' asks decrease until one trader accepts the terms of another. Each team is designated by a letter, A through E, and a single member of the team is designated as the trader for that team. To "bid" to buy or "ask" to sell, a trader must raise his or her hand and be recognized before speaking. The bid/ask terminology will be strange to many students, and you may distribute the instructions to them in the previous class period, although we have not found this to be necessary.

As auctioneer, the instructor should state that the traders must speak by first identifying their team and then stating whether they wish offer a bid or an ask, or to accept the most recent bid or ask of another team. It is useful for bids and asks to be stated in terms of number of cents. The instructor must begin by soliciting an opening bid and ask: a first statement might be, for

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[2] If you run out of time and have to stop before preannounced final period, pay the dividend for the period just completed, throw the dice, and cash in the surviving assets for $6. Using the $6 value together with the 1/6 probability of the asset being destroyed helps facilitate discussions of fundamental value, as discussed below.

[3] In theory, offering a prize for the highest earnings may transform the incentive structure in such a way as to produce indifference or extreme risk-seeking behavior on the part of traders who know that they are behind in terms of earnings. This would be a serious problem in a research experiment. To mitigate this effect, we prefer to be a little vague about the numbers of prizes and to keep the prizes small. Another alternative is to pay everyone some fraction of their earnings, with the fraction chosen to fit the instructor's budget constraint.

example, that "Team A bids 700 for one asset." There is no reason to solicit a bid or ask from each team; some teams will be more active than others. The instructor/auctioneer repeats each bid and ask aloud and record them in two separate columns on the blackboard or overhead projector. There is a "bid/ask improvement rule"; each bid after the first must exceed the highest outstanding bid, and each ask after the first must be lower than the lowest outstanding offer. This rule is easily enforced by recording each bid and ask on the board, and students can watch the convergence of the bids and asks occur. At some point, a team will accept either the highest outstanding bid or the lowest outstanding ask. A team will state, for example, "Team C accepts B's ask." After a contract is accepted, the price should be circled, as a reminder that all previous unaccepted bids and asks are now cancelled, and a fresh cycle of bids and asks follows. (In other words, the bid/ask improvement rule does not constrain the first bid of a new cycle, and this can be emphasized by using a fresh transparency or erasing all previous bids and asks after each trade.)

Some questions may come up during the first trading period, any you can allow extra trading time. All subsequent rounds of trading can be limited to two minutes in length. This means that there may be only time for two or three deals to be completed in a given round, depending on how students briskly step forward and bid. Do not become frustrated if buyers and sellers do not trade during a given period; this may happen, especially after a price "crash".

Students who are not assigned to trading teams can assist in recording data, keeping time, plotting the price path, and (especially in larger classes) checking the earnings calculations of the teams. The person recording the data should be reminded, as necessary, to write the identities of the traders next to the bids and asks as they occur and to circle any completed contract. A timekeeper should give a warning 30 seconds before the end of the period.

To prepare the materials, you will need a six-sided die, 15 cards or colored sheets of paper to serve as assets, and about 15 copies of the instructions: five for the trading teams, five for the shadow teams if they are being used, and five for the assistants who keep time, record data, etc.) Each team should have a recording sheet for each of the 10 periods (6 periods in shorter classes). The format of these recording sheets is shown in the Appendix. Finally, a transparency formatted for recording the data and preparing for class discussion can be set up as in Figure 1 below.

Classroom Discussion

This exercise can be used as the basis for a class discussion of asset valuation. A good way to begin is to put up a transparency that shows the trades made in each period and the associated prices. If you prepare a transparency with labeled axes in advance, you can have a student or teaching assistant plot the trades as they occur, so that it will be ready as soon as the auction is completed.

Start the discussion with a review of prices in the first period. Ask students about what the expected value of the asset was in this period, and how to calculate this value. Also, ask them to assess the degree of agreement between trading teams about the initial value of the asset. Their answers will likely reflect a great deal of disagreement about how to calculate the fundamental value.

To clarify the discussion, it is typically useful to shift the focus of discussion to the end of the experiment. You should be able to find ready agreement that the asset is worth $6 at the end of the final period if it survives a tenth roll of the die. Then ask what the value will be at the *beginning* of trading in period 10. Many of them will probably value the asset correctly in the final period at $6, but you should help them formalize their thinking. The value at the beginning of the 10th period the final $1 dividend plus the expected value of being able to cash in the asset if it survives the toss of the die. Thus, the total value is 1.00 + [5/6]*6.00, which is $6.00. Notice how the 5/6 works like a discount factor that affects the present (beginning-of-period) value of an asset facing a 1/6 chance of subsequent failure. Of course, this expected value calculation assumes that traders are neutral to risk; risk aversion could reduce current prices.

Now work backwards to asking about the ninth period, drawing students out by asking them questions. If $6 is the asset value at the start of period 10, then it is the same at the end of period 9. Working backward to the beginning of period 9, the expected value in period 9 is calculated in the same way: 1.00 + [5/6]*6.00 = 6.00. It may be necessary to work back into period 8, but at some point is should become intuitively clear that the value should be $6 in all periods. At this point, it may be useful to write the following general formula on the board:

Price (t) = 1.00 + [5/6] x Expected Price (t+1)

This formula opens up the question of how present prices are affected by expectations of future prices. For example, someone may be willing to pay more than $6 for the asset in period 9 if they expect that they can sell it for more than $6 in the final period, but these expectations are not rational, since the actual price in period 10 must equal the dividend plus the expected redemption value, which is exactly $6. In this manner, rational expectations about future prices requires a flat price path for all periods under this setup. This flat path also has the convenient property that the valuation discussion is not significantly different if you plan to run the market for fewer periods, or if you run short of time and end the experiment before the pre-announced number of rounds.[4]

The trajectories of transactions prices in the experiment can be compared with the rational expectations prediction. In particular, students should recognize that there is a potential circularity when current prices depend on expectations about future prices, but those expectations are being affected by the levels and trends in current prices. A typical price bubble pattern from an undergraduate class at Virginia Tech is shown in Figure 1. Prices are measured along the vertical axis in pennies, and the 10 trading periods are shown on the horizontal axis. Prices in the two trades in the first period are represented by the two adjacent dots on the far left side of the figure, just below a level of 600 (six dollars). Prices surge past $6 in periods three and four, which were the also show the highest trading volume. Then prices and volume level off and eventually decline. There is no trade in the final two periods.

If market bubbles are not consistent with rational expectations, then why is this pattern of boom and bust so common in the classroom experiments? One answer lies in a type of competitive irrationality, by which we mean a case where agents act in a way that is clearly irrational in terms of the expected outcome of an economic environment, but when it is difficult to identify any particular action as being irrational. In these markets, traders often anticipate that the prices of the assets might increase because other traders might have higher valuations of the asset or because other agents might speculate. Because of these beliefs, agents will purchase

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[4] This setup can be related to standard discussions of present value by considering a case of an infinite horizon, with no final period. Then the expected dividend payments are: $1 + (5/6) + (5/6)^2 + (5/6)^3 + ... = 1/[1-(5/6)] = 6$. Note that the (5/6) discount factor corresponds to $1/(1+r)$ where r represents the relevant rate of interest. Since the present value is 6 dollars, the setup in the classroom game implements a flat price path by redeeming the asset in period 10 for its present value at that time.
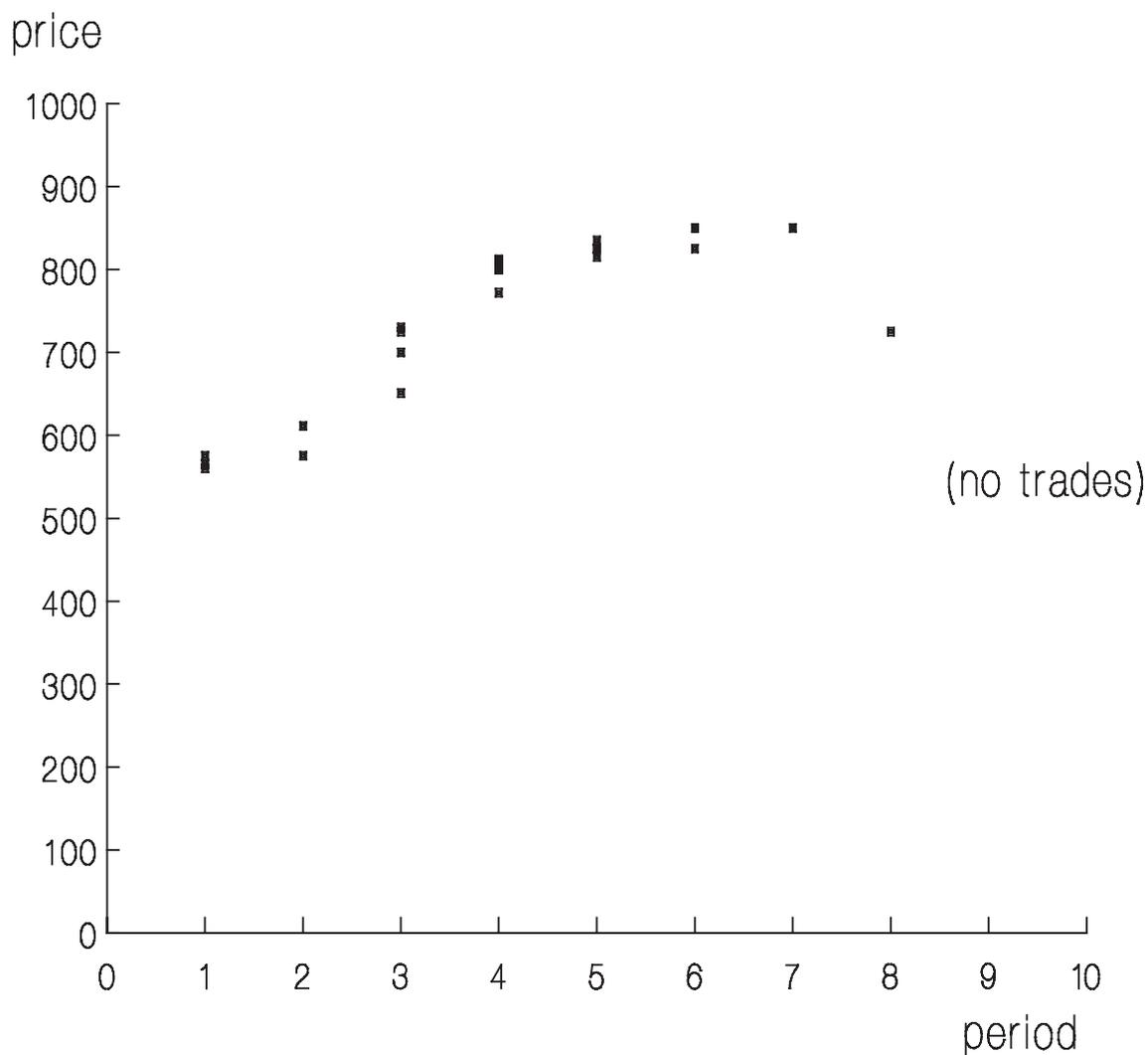
Figure 1. A Price Bubble

assets at low prices in an attempt to earn capital gains. If these beliefs are shared by several traders, then the conjecture about future prices becomes self-fulfilling. In this manner, Keynes' argument about asset prices being determined by short-term predictions about future prices is confirmed. In fact, this type of optimistic expectation about asset prices is very common. The result is that market bubbles are likely to occur. Pessimistic beliefs, that the asset is likely to be destroyed before it is redeemed, for example, are much less common. An initial price decline may be prevented as pessimists sell their assets to optimists in initial rounds. By the end of the

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exercise, increased consensus on valuation and decreased scope for speculation result in a decline in trading volume. Ask students what strategies they used and how their strategies changed in the final periods, to stimulate discussion of these issues.

The exercise produces bubble in some classes, but not others. A six-period market in one class showed prices going from $5.90 in period 1 to $9.99 in period 5, and back down to $6.75 in the sixth and final period. Traders who bought in early rounds stated that they planned to sell at higher prices, although they were not always able to do so before the price decline. In another class, however, prices started and stayed a little above $7 for the first nine periods, with no trade in the final period. If a bubble does not occur, you can bring to class a transparency (like Figure 1) of a case where a bubble occurred, and point out that market swings can be unpredictable. Students are very interested in speculation and asset valuation issues, even if a bubble does not occur.

Further Reading

Experiments motivated by issues in finance are usually conducted with some variant of the double auction used here. In fact, Smith (1964) designed double auction rules to approximate the trading environment of a centralized stock exchange, like the New York Stock Exchange. He argued that the public display of all bids and asks makes this a highly centralized institution, which tends to promote efficient allocations. Double auction experiments are discussed in Davis and Holt (1993, chapters 1, 3, and 7); in particular, the appendix to chapter 1 lists a number of useful hints for running double-auction experiments.

Smith, Suchanek, and Williams (1988) first documented the prevalence of price bubbles in asset market experiments. Their setup was somewhat similar to the one used here, except that dividends were random and there was no final cash-in value in most cases. When the asset is worthless after the final period, the only earnings are the dividends, and total expected earnings decline linearly with time. This causes the fundamental value of the asset to decline linearly toward zero throughout the sequence of trading periods. Significant bubbles were observed in about half of their sessions, including one in which subjects were recruited from the professional business community in the Tucson area. However, all experiments show a general tendency for price to converge to the fundamental value by the final period. Also, trading volume tends to be

high during the "boom" phase and may decline to zero in the final periods as differences in expected valuations diminish. Sunder (1995) offers a recent survey of experimental research on related issues in financial economics.

References

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Appendix: Auction Instructions

This game will set up a financial market. Traders are given both cash and paper assets that pay future dividends. Traders need to make decisions as to what their paper assets are worth, so that they can decide at what prices they would be willing to buy or sell assets. The detailed structure of the game is as follows:

Players and Assets

TRADING TEAMS: There are 5 trading teams: A, B, C, D, and E. In addition to the people assigned to each of these teams, some of you will help with keeping time, recording prices, etc.

ASSETS: Each team starts with:
> 1) Three "assets," each of which is represented by a sheet of colored   paper; and
> 2) a $20 cash account that can be used for buying other assets.

EARNINGS: Trading teams make money from:
> 1) collecting a $1 dividend paid on each asset held at the end of each trading period;
> 2) buying and selling assets; and
> 3) cashing in for $6 any assets that survive until end of the tenth trading   period.

FAILURES: There is a 1/6 chance that the asset will fail after each dividend payment. Once an asset fails, it is worthless, and I will tear up the sheet of paper that represents that asset. To determine failures, I will come to all trading teams that own assets at the end of each trading period, after the $1 dividend for that period has been paid, and throw a 6-sided die once for each asset. A throw of "1" will result in the destruction of that asset, while throws of any other number will allow the owner to keep or trade that asset in the next period. As already noted, any asset that is not destroyed after the die is thrown in period 10 will be redeemed for $6 at the end of period 10.

Trading Rules

TRADERS: Each team will have one person designated as the representative or "trader" for that team. Once the trading period begins, each trader is free at any time to rise a hand, and when called on, to make one of several statements: a BID that expresses a commitment to buy an asset at a certain price; and ASK that expresses a commitment to sell an asset at a certain price; accepting the BID price given by another trader, and thus making a transaction to sell; or the acceptance of an ASK price given by another trader, and thus making a transaction to buy.

BIDS: If team A wishes to BUY an asset at 758 cents, the trader for team A should place a BID at 758 cents. The bid tells all others that team A is willing to buy one asset from any of them at a price of 758 cents.

ASKS: If trader B wishes to SELL an asset at 981 cents, trader B should place an ASK at 981 cents. The ask tells all other traders that trader B is willing to sell one asset to any of them at a price of 981 cents.

TRADES: Suppose that the highest bid is 758, from trader A, and the lowest ask is 981, from trader B. Any of the traders who own assets can then decide whether or not they want sell an asset to trader A in exchange for 758 cents. If some trader wishes to sell, they must raise their hand, and when called on, say "I hit A's bid of 758." Similarly, any of the other traders with sufficient cash on hand can decide whether or not they want to buy from trader B in exchange for 981 cents. If some trader wishes to buy, they must raise their hand, and when called on, say "I take B's offering at 981." Instead of accepting someone else's bid or ask, a trader may simply enter a new bid or ask.

BID/ASK IMPROVEMENT RULE: I will record bids and asks as follows:

BIDS	ASKS
A 758	B 981
C 759	D 979
A 762	

A new bid must be higher than the highest outstanding (untaken) bid, and a new ask must be lower than the lowest outstanding (untaken) ask. In the example, the next bid must be above A's bid of 762, and the next ask must be below 979.

TRADES: A trade occurs only when one trader accepts another's bid or ask. When this occurs, someone from the seller's team should immediately deliver the sheet of paper representing the asset to the buyer's team, and both teams should adjust their cash positions: the buyer's cash goes down by the amount of the price, and the seller's cash goes up by the amount of the price. Once a trade is made, I will circle the price and erase all outstanding bids and asks, which are automatically cancelled. You are free to reenter previous bids and or asks, however.

RULES: Any trader may make both bids and asks during a period, but to make a bid you must have enough cash on hand, and to make an ask you must have at least one asset, i.e. one sheet of colored paper (no short sales). All bids and asks are for a single asset, although you may buy or sell more than one asset during a period.

CLOSING BELL: The period will end after 2 minutes, regardless of whether the traders have completed all of the trades that they wish to make.

SUMMARY:
    BID to buy and ASK to sell.
    You may sell an asset by:
        (1) announcing an ask that someone else accepts, or
        (2) accepting someone else's bid price.
    You may buy an asset by:
        (1) announcing a bid that someone else accepts, or

(2) accepting someone else's asking price.
You cannot sell an asset that you do not have.
You cannot purchase an asset with money that you do not have.

RECORD KEEPING
(1) There is a recording table for each trading period. Please see the samples for periods 1 and 2 on the next page. Always make sure that you are using the recording table for the correct trading period.
(2) Your trader letter is listed on the top left corner. The sample is for trader E.
(3) Refer to the sample table for period 1. On line (0) notice that you have "Assets on Hand" of 3 and a "Cash Balance" of 2000. Everyone begins period 1 with the same number of assets and the same cash balance.
(4) Line (1) shows that trader E's first move in period 1 was to sell 1 asset for 625. Trader E immediately records this amount in the Sale Price column of line 1. The Assets on Hand decrease from 3 to 2, and the cash balance increases to 2000 to 2625.
(5) Line (2) shows that trader E's second move was to buy 1 asset for 650. This price is immediately recorded in the Purchase Price column of line 2. The Assets on Hand increase from 2 to 3, and the cash balance decreases by the amount of the purchase price, from 2625 down to 1975.
(6) Line (3) shows that the trader's third move in the period was to buy a fourth asset.
(7) Once the period is over, the trader records his/her final cash balance (the bottom number in the Cash Balance column) on line A near the bottom of the table. The number of assets is multiplied by the dividend amount of 100 pennies per asset to obtain the total dividends for the period. In this case, $4*100 = 400$, which is entered in the right column of line B. The end-of-period Cash Balance is obtained by adding the amounts in lines A and B and entering the sum ($1325 + 400 = 1725$) in the right column of line C.
(8) After dividends are paid, we will come to each team holding assets, and we will throw a 6-sided die once for each asset. If the outcome is "1", the asset will be torn up. Then the number of remaining assets is entered in the Assets-on-Hand column of the table for the next trading period. The end-of-period cash balance is also transferred to the top of the Cash Balance column for the next period. There will be 10 periods.
(9) There will be 10 trading periods, and any asset that has not been torn up after dividend payments in period 10 will be redeemed for $6. All cash earnings are hypothetical.
(10) Please keep track of your team's earnings carefully, and raise your hand if you have any questions during the trading process. All earnings are hypothetical.

Are there any questions?

Now please find your recording table for period 1. The market is now open for bids and asks. Please do not call out a price until you are recognized.

Trader E   Sample Recording Sheet:
                                    Trading Period 1

	Sale Price	Purchase Price	Assets on Hand	Cash Balance
0			3	2000
1	625		2	2625
2		650	3	1975
3		650	4	1325
4				
5				
A			last cash balance	1325
B			# assets * 100	400
C			end-of-period cash	1725

Trader E   Sample Recording Sheet:
                                    Trading Period 2

	Sale Price	Purchase Price	Assets on Hand	Cash Balance
0			4	1725
1				

Trader ___   Trading Period 1

	Sale Price	Purchase Price	Assets on Hand	Cash Balance
0			3	2000
1				
2				
3				
4				
5				
A			last cash balance	
B			# assets * 100	
C			end-of-period cash	

Trader ___   Trading Period 2

	Sale Price	Purchase Price	Assets on Hand	Cash Balance
0				
1				
2				
3				
4				
5				
A			last cash balance	
B			# assets * 100	
C			end-of-period cash	

Trader ___   Trading Period 3

	Sale Price	Purchase Price	Assets on Hand	Cash Balance
0				
1				
2				
3				
4				
5				
A			last cash balance	
B			# assets * 100	
C			end-of-period cash	

Trader ___   Trading Period 4

	Sale Price	Purchase Price	Assets on Hand	Cash Balance
0				
1				
2				
3				
4				
5				
A			last cash balance	
B			# assets * 100	
C			end-of-period cash	

Trader ___   Trading Period 5

	Sale Price	Purchase Price	Assets on Hand	Cash Balance
0				
1				
2				
3				
4				
5				
A			last cash balance	
B			# assets * 100	
C			end-of-period cash	

Trader ___   Trading Period 6

	Sale Price	Purchase Price	Assets on Hand	Cash Balance
0				
1				
2				
3				
4				
5				
A			last cash balance	
B			# assets * 100	
C			end-of-period cash	

Trader ___   Trading Period 7

	Sale Price	Purchase Price	Assets on Hand	Cash Balance
0				
1				
2				
3				
4				
5				
A			last cash balance	
B			# assets * 100	
C			end-of-period cash	

Trader ___   Trading Period 8

	Sale Price	Purchase Price	Assets on Hand	Cash Balance
0				
1				
2				
3				
4				
5				
A			last cash balance	
B			# assets * 100	
C			end-of-period cash	

Trader ___   Trading Period 9

	Sale Price	Purchase Price	Assets on Hand	Cash Balance
0				
1				
2				
3				
4				
5				
A			last cash balance	
B			# assets * 100	
C			end-of-period cash	

Trader ___   Trading Period 10

	Sale Price	Purchase Price	Assets on Hand	Cash Balance
0				
1				
2				
3				
4				
5				
A			last cash balance	
B			# assets * 100	
C			end-of-period cash	