Stock Market Simulation

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Contents

ABSTRACT

Introductory microeconomics classes can be enhanced by including a simulated market experience for the students. This paper illustrates the stock market system used at Seattle Pacific University, where students post offers to buy or sell on a computer network, where they become available so all students can see the current market prices.

I. Introduction

A challenge in teaching introductory microeconomics is making the idea of supply and demand come alive to the students. A good way to do this is to let the students experience a market where buyers and sellers try to find each other and reach mutually agreeable prices. This paper describes a market simulation that has been used in introductory microeconomics courses at Seattle Pacific University since 1993. In 1997 part of the simulation was transferred to a computer network.

II. Description of simulation

In order for a market to have reason for being, there must be reason for people to buy and sell. In the real world, people's preferences towards goods and services determine their willingness to buy and sell; in a simulation, some other mechanism is needed. Some possibilities are:

- give the students an artificial utility function for commodities (R. Williams, 1993);
- give the students different artificial reservation prices that determine their willingness to buy and sell (DeYoung, 1993, Wells, 1991)

- use real stocks, and let the actual market value determine the value in the simulation (Wood, 1992);
- introduce a random process, such as a computer random number generator, that determines the value (A. Williams, 1993, and Bell, 1993);
- let the class vote and then use the vote to determine the value of the stocks.

Each approach has advantages and disadvantages. The first two provide good opportunities to observe the adjustment process as the market approaches equilibrium, but the students do not experience the reason why the artificial preferences they are given apply.

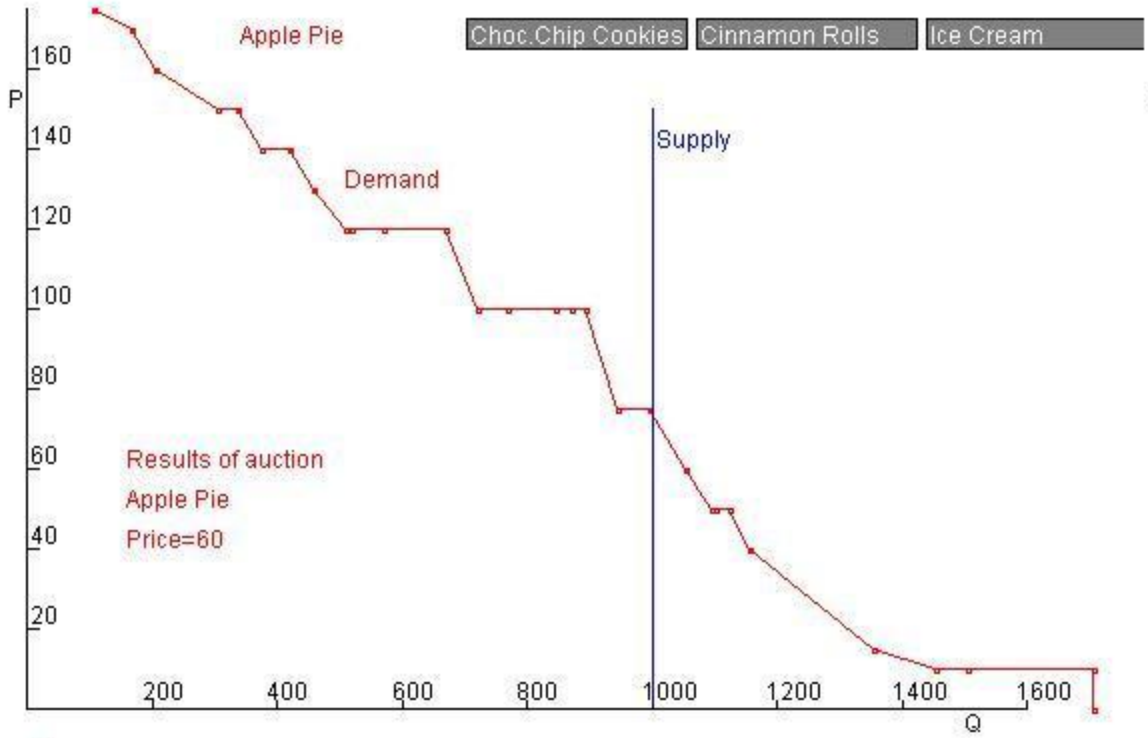
In order for a stock market to have reason for being, there needs to be uncertainty about the future value of the stock, which could be achieved by either of the last three approaches. The use of real stock prices encourages students to pay attention to actual news events but the students do not actually experience the supply/demand interaction that determines the prices. The use of a random number generator allows the students to use methods of financial analysis that apply to a known random variable distribution, but the actual values come from a mysterious process. The SPU simulation uses the class vote approach, which illustrates the concept of consumer sovereignty. No individual consumer has much power over the stock values, but consumers collectively determine which companies are successful and which are not.
The SPU simulation involves four companies:

- AP: apple pie
- CC: chocolate chip cookies
- CR: cinnamon rolls
- IC: ice cream

In order to succeed at this simulation, it helps to be good at predicting which of the four treats the people in the class will vote for, since that is what determines the final value of the shares of stock. In reality, a company that is better able to predict the demands of consumers will be more successful.

The first stage is the initial auction for the stocks. At that time students bid for stocks; those who bid the highest prices will receive shares of stock until the supply of each stock is used up. This is a sealed-bid single auction. (See DeYoung, 1993, p349, for descriptions of different trading institutions.) There are 1,000 shares of each stock; each person starts with $15,000 worth of cash available to be used at the initial auction. The auction is similar to the initial public offering of the stock.

Demand curves are constructed from the bids in the auction and are made available to the students on the internet. The supply curve for each stock is vertical.


Apple Pie
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Cinnamon Rolls
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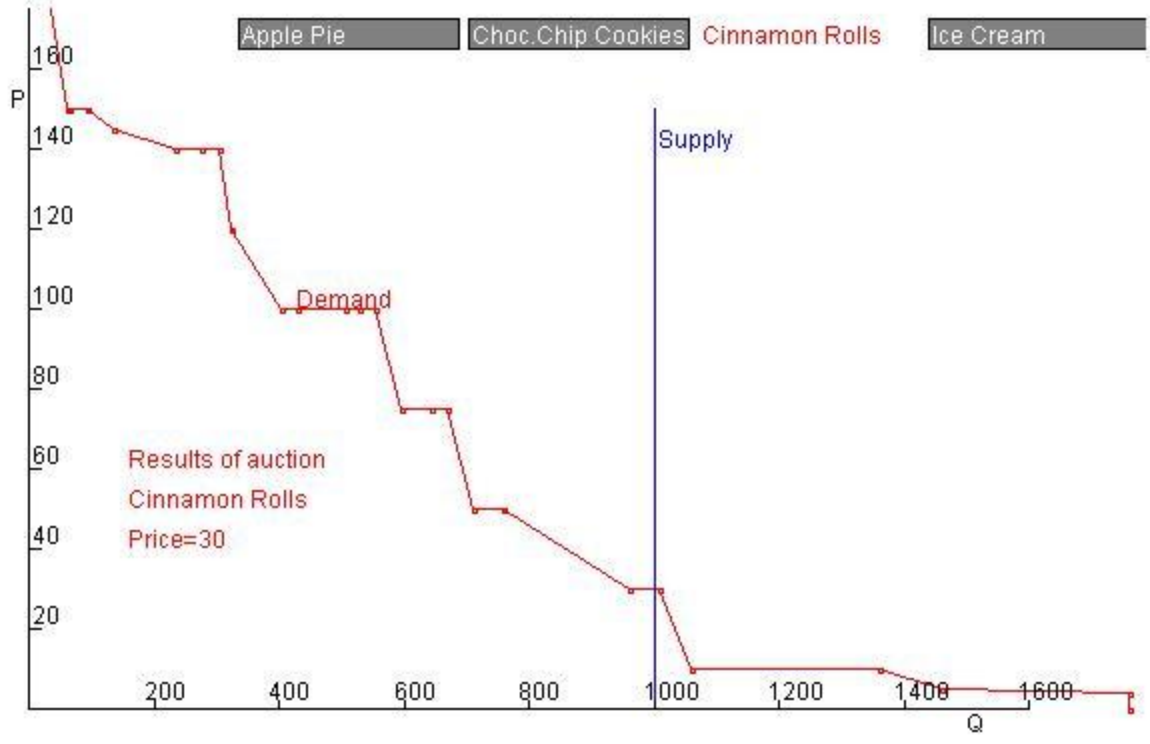
Apple Pie
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Results of auction
Cinnamon Rolls
Price=30
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800
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1200
1400
1600
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In the initial auction, students can bid on one stock, or on all four, or two or three; however, the rule is that the total dollar value of the bid must be less than or equal to $15,000. If you bid a higher price, you are more likely to receive that stock; but if you bid a higher price, you must bid for a smaller quantity.

After the initial auction there is a secondary market, similar to a market such as the New York Stock Exchange or NASDAQ. Students are able to trade shares of stock with other members of the class, at whatever price is mutually agreeable.

Following the end of stock trading, the class will take a vote between the four treats. The class will actually receive the treat that receives the most votes. Therefore, students have an incentive to vote their true preferences (although understandably when the final vote arrives students may vote in the way that is best for their portfolio).

The final value of the shares of stock will be determined after the vote:

- 1st place: pays $100 plus percent of vote per share
- 2nd place: pays $60 plus percent of vote per share
- 3rd place: pays $40 plus percent of vote per share
- 4th place: pays $20 plus percent of vote per share

The final standings are ranked by the highest value portfolio. For example:

- suppose stock A is 1st with 30% of vote; it will be worth $130
- suppose stock B is 3rd with 25% of vote; it will be worth $65
- suppose you have $12,000 cash, 30 shares A, 10 shares B
- total value: 12,000+30*130+10*65=16,550

In order to be effective, the simulation needs to award prizes based on portfolio value. Obviously it is not feasible to pay them the value of their portfolio with real dollars, but prizes are awarded for finishing in first place, finishing in the top 5, finishing in the top quarter, and finishing in the top half of the class. However, these prizes need to be modest enough so as not to put too much pressure on the students, since this is supposed to be an educational (and hopefully fun) experience. In practice, it also helps to give extra points based on the number of other students that a person trades with, to encourage more activity in the secondary market.

Once the in-class trading starts, it is always advantageous to buy a share of stock if you can buy it at a price that you think will be less than the final value of that stock. It is advantageous to sell a share of stock if you can sell it at a price you think is higher than what the final value of that stock will be.

One important feature of the simulation is to give the students the opportunity to experience both a disorganized market and an organized market. The first day of the secondary market is low-tech, where people record transactions on slips of paper whenever two people agree. Signatures are used to authenticate transactions. Each student is given an account number that they use to

interact with the system. This is a negotiated market, as opposed to an auction market. No effort is made to systematically match buyers and sellers. This type of market does provide opportunities for alert students to make profits. For example, if apple pie shares are being sold for $40 in one corner of the room, but they are being purchased for $80 in another corner, there is opportunity to profit for a student who moves around the room and listens carefully to the transactions being made.

The second day of the secondary market involves an organized system to match offers to buy and sell a particular stock. Previously, this system consisted of poster boards on the four corners of the room, one for each stock. Students wrote their offers on the board where all other students could see them. A transaction was completed when another student signed their name on that line indicating they wished to accept the offer. This is a continuous open outcry double auction market. This approach is vaguely similar to the New York stock exchange where different stocks are traded at different locations on the trading floor.

However, the rapid evolution of technology made it clear that the stock trading system should become an electronic system, which is what is described next.

III. Computerized Trading System

Here is the general structure of the computerized trading system:

- The student observes market data.
- The student makes an offer.
- The system processes the offer and returns data.

Here are the specific details of how these steps work:

- (1) The student observes market data. This consists of two types of information: current offers and completed transactions. Here is an example of a screen showing current offers:

Chocolate Chip Cookies: Offers to BUY

Buyer#	Price	Quant
22	146	5
1	145	5
11	100	10
20	70	9
20	70	10

Chocolate Chip Cookies: Offers to SELL

Seller#	Price	Quant
8	150	5
15	155	3
20	180	12

Offers to buy are arranged in descending order by price, since higher price offers have greater priority. Offers to sell are arranged in ascending order, since lower price offers have greater priority. The lowest offer to sell will always be greater than the highest offer to buy (if it wasn't, then the two offers would already have been matched to form a completed transaction). In other words, there will be a bid-ask spread.

Here is an example of a screen showing completed transactions:
Apple Pie Completed Transactions

	Stock	Buyer	Seller	Price	Quant
1	AP	28	7	72	20
2	AP	10	16	47	2
3	AP	20	16	42	10
4	AP	10	28	127	1
5	AP	10	28	125	1
6	AP	10	1	92	1
7	AP	11	1	60	19
8	AP	18	16	20	73
9	AP	18	10	20	1

Total volume: 128 Max Price: 127 Min Price: 20 Avg. Price: 38.42

- (2) The student makes an offer. Each offer consists of this information:
    - the type of stock
    - whether this is a buy or sell offer (actually, there are two other options: cancel a buy offer, or cancel a sell offer. A student may cancel one of their own offers, provided that it has not yet been matched to form a completed transaction.)
    - the price of the offer
    - the quantity of shares in the offer

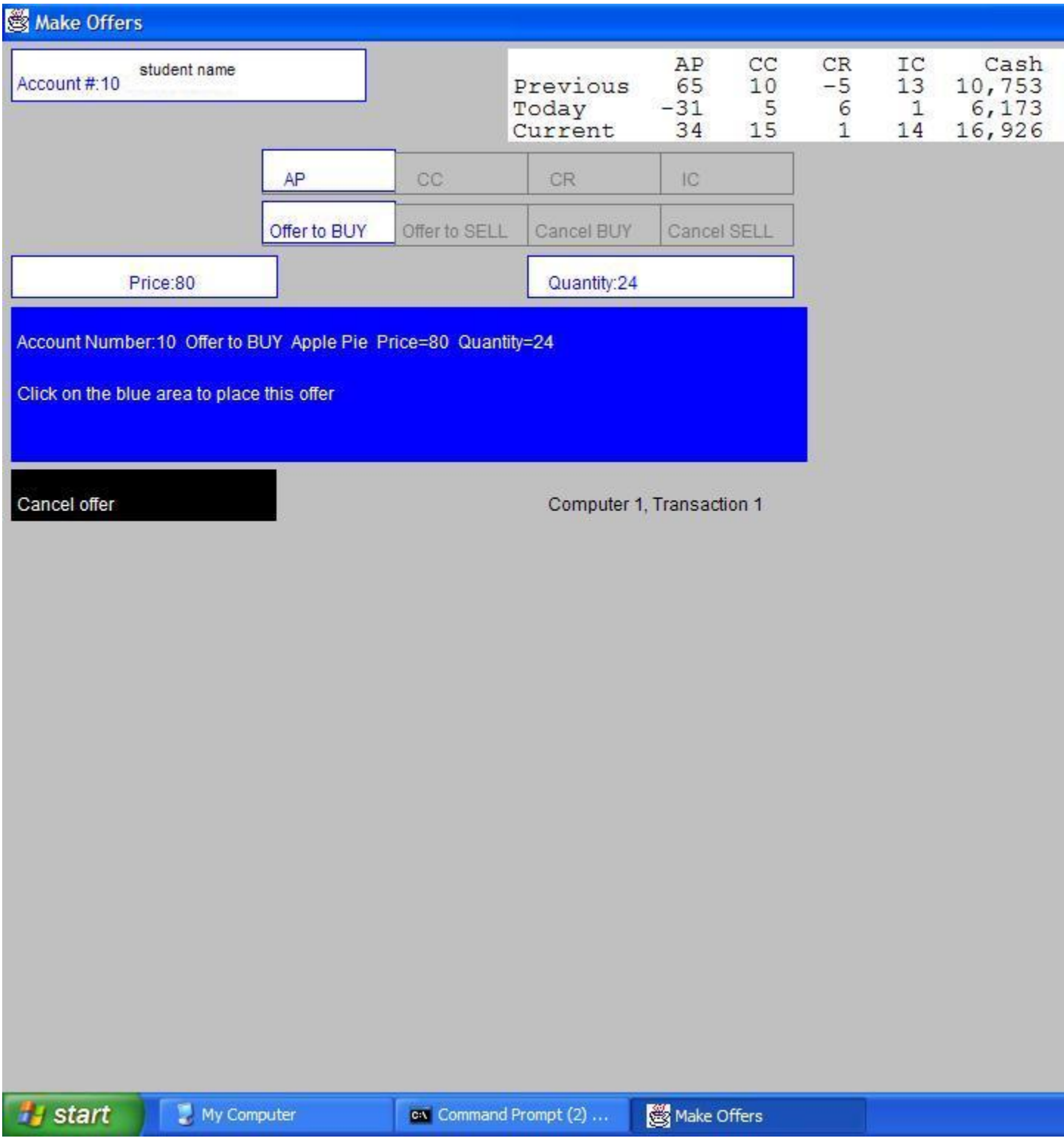
An offer may match an existing offer (for example, if you observe an existing offer to sell 5 shares at $150, and you make an offer to buy 5 shares at $150, then these two offers will be immediately matched to form a completed transaction). Otherwise, your offer becomes added to the board where it will wait to see if somebody else matches it.

- (3) The system processes the offer and returns data. The procedure for updating offers is this: if the lowest-priced offer to sell is less than or equal to the highest-priced offer to buy, these offers are matched. If the prices are not equal, then the midpoint price will be used (for example, if an offer to sell 10 shares at $80 is matched with an offer to buy 10 shares at $90, then a transaction will be recorded for 10 shares at $85. If students are alert, this will not happen often because the second student would not make an offer worse than the already existing offer.) However, two offers at different prices may arise almost simultaneously. Both buyer and seller should be happy in a situation such as this where they both get better prices than they originally offered. If the quantities of the two offers are different, then the transaction is recorded for the smaller quantity, and the offer with the higher quantity remains on the board with whatever quantity is left. For example, if an offer to sell 20 shares at $80 is matched with an offer to buy 30 shares at $80, then these will be matched to form a completed transaction (20 shares at $80), and there will remain on the board an offer to buy 10 shares at $80.

In processing offers, two basic rules apply: (1) priority goes to best-price offers (that is, higher price buy offers and lower price sell offers); (2) two offers with the same price are processed in the order received by the system. Each offer is sent to the system as a separate file which contains a time stamp showing when that file was created.

IV. Technology for Implementation

Students enter offers using client machines connected to a local-area- network (LAN). These machines read from and write to a file on a server machine. Once offers are posted to the server, they are removed from the server and copied to an administrative client that does the processing.



As in any real electronic trading system, a method for authenticating offers is needed that works in the absence of signatures. The system requires a password; hopefully the small scale and short duration of the simulation will reduce the incentive for anyone to try to defeat the password

system. After entering the password, a second dialog box appears in which the student enters the price, quantity, and buy or sell information. Then the offer is processed. The system also provides buttons to view all transactions in a particular stock, and all of your own transactions. It requires your password to view your transactions, so you cannot view a table showing the transactions for another student. However, you can view all the transactions sorted by stock, so if you are diligent enough you can see if someone is trying to corner` the market for a particular stock. (The trades from the day of disorganized trading are not made public, so a student can never know for sure what another student's balances are.)

Offers are only briefly stored on the server before they are copied to the administrative client. Students do not have the ability to read or write files on the administrative client, so the system is more secure than if processing was done on the server. After the offers have been processed the updated HTML page is uploaded from the administrative client to the web server, where it is available for students to see the updated trade results.

The details for the most recent market simulations are available on the internet at
http://myhome.spu.edu/ddowning/ecn2101/micgame.html
The source code for the program is available by email from ddowning@spu.edu.

V. Conclusion: Economic Lessons

Students who experience the simulation will be able to see some of these economic principles in action:

- If you offer a price that is high enough, you should find a seller; if you offer a price that is low enough, you should find a buyer (these are the basic ideas of supply and demand).
- Expectations about the uncertain future determine stock prices.
- Stock market prices reflect information about future (for example, if many student expect one stock will come in first in the vote, then the price of that stock will rise); also, prices provide information about expectations (if students observe that the price of a stock is going up, they can tell that the class in general is expecting that stock to finish high in the voting).
- Different trading mechanisms lead to different results; in particular, in markets where information is not readily available to all participants, those who have an informational advantage are able to profit.
- Consumers collectively determine the value of companies by exercising their preferences (in the simulation, by their vote; in the real world, by their decisions about what to buy).
- These are ways in which the real stock market is different from the simulation: (a) people do not start off equally; (b) the real stock market does not end; (c) funds raised in the real stock market are used for productive purposes.
- Changes in technology are leading to big changes in the way markets work; in this respect the SPU simulation is both following current trends and indicating the direction of future developments of markets.

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