

**Jeremy's Market:**  
**An Internet-Based Simulated Economy for**  
**Principles of Microeconomics**

**Draft**

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**<http://www.as.yzu.edu/~tsporter/MarketsimHome.htm>**

## **Introduction**

Jeremy's Market is an Internet-based simulation designed to help students in microeconomics classes better understand how markets work by taking on the roles of households in a barter economy. The program is intended to give students a better understanding of the concepts of utility maximization, decreasing marginal product, and gains from specialization and trade.

In the simulation students are assigned different production and utility functions, creating the potential for gains from trade. Students can trade goods by posting and accepting offers to trade, so that the exchange rates for the good are set by the trades made by the students. By creating a simulated economy that can be accessed via the Internet Jeremy's Market makes it possible for faculty to give their students an "active learning" experience that can be conducted outside of class and is sophisticated enough to illustrate a variety of economic phenomena.

Jeremy's Market is the first of two simulations being developed by the authors for principles of microeconomics. The second part, titled Adam's Market, is a monetary economy in which students take on the roles of managers of firms. Our intent is that Jeremy's Market would be used in the first half of a typical principles of microeconomics course, and Adam's Market would be used in the second half.

The authors have had the opportunity to use Jeremy's Market twice, an extended beta test in the summer of 2001 and full implementation of the software in the fall semester of 2001 (Adam's Market is still under development). The remainder of the paper provides a brief summary of the use of microeconomic simulations, describes the

characteristics of the program, and the experiences of the authors in using the software in two principles sections at an open-enrollment public university.

### **Literature Review on the Use of Simulations in Economics Instruction**

Since the 1970's articles in the economics education literature have discussed both the advantages of the use of economic simulations and the lack of controlled studies of their effectiveness (see Soper, 1974). Surveys by Yoho and Walstad (1990), Grimes and Ray (1993), P. Davies (1994), and Walstad et al (1998) concluded that simulations running on personal computers were valuable because they give students an opportunity to actively apply the concepts they are learning in the course. Those articles also noted that the use of simulations was still limited, and their effectiveness still unproven. P. Davies (1994) emphasized that there must be a clear relationship between the students' experiences with the simulation and the course material.

Among the few empirical studies that have been undertaken, three studies were conducted on the effectiveness of Smithtown, a "discovery environment," in which students learn economic principles by changing income and prices in a simulated economy. In two studies, Shute, Glaser and Raghavan (1989) and Shute and Glaser (1990), found that students using just Smithtown learned as much as students who attended lectures but did not use the program. Katz and Oaks (1993) found that the intensity with which students used the program was positively related to the student's grade.

Another approach to teaching students about market dynamics is to have them participate as buyers and sellers in a market. Examples of this approach include the Iowa Electronic Markets (see <http://www.biz.uiowa.edu/iem/>) and the exercises designed by

Charles Plott of the California Institute of Technology.

Raehsler, Haggerty, and Caroppeso (1996) evaluated a simulation sharing some of the characteristics of Adam's Market. Students took on the roles of producers and consumers and prices and output levels were set by the students' buy and sell orders (however, students could not participate in that simulation through the Internet). The authors found that the classes that used the simulation had a more favorable opinion of the course and higher grades, but the difference in the grades was not statistically significant.

This project builds on the concepts used in a simulated economy developed by Antony Davies entitled EcoSim (Davies, 1995). In EcoSim participants took on the roles of both households and firms, making decisions about: their reservation wage, how much labor to supply, what products they will choose to produce, how much they will produce, and which inputs they will purchase to produce the products. The prices and quantities, rather than being determined by a formula, are set through the exchanges made between students. Davies, conducted an informal, unpublished survey of 50 principles of micro students. A high percentage of the students reported that EcoSim increased their understanding of economic theory and made the course more interesting.

### **Description of Jeremy's Market**

The simulation is hosted through a system of Active Server Pages (ASP). The ASP technology, which is used in many commercial web sites, links web pages with a database hosted on a server. The pages are hosted on a server running Microsoft Windows 2000. Students browsing the pages must use Microsoft Internet Explorer. Microsoft Access was used as the database to record user selections.

Jeremy's Market has two modes: "Robinson Crusoe" and barter mode. As the names imply, in the Robinson Crusoe mode students are limited to consuming their own output and in barter mode they are able to trade their production. The primary purpose of the Robinson Crusoe mode is to be able to demonstrate how utility increases when trade is possible.

The simulation is divided into a maximum of ten periods, with the length of the periods set by the instructor. At the start of a period each student is allocated some number of hours. Students can use the hours four different ways:

- Consume the hours as leisure time
- Use the time to produce bread
- Use the time to produce wine
- Work for another participant in exchange for bread or wine (in barter mode)

The students are instructed to try to use their time so as to maximize their lifetime utility. Their lifetime utility is the sum of their utilities over all the periods. In setting up the simulation the instructor creates some number of "attributes" which specify utility and production functions. For each attribute instructors can choose between three types of utility functions, and specify different constants for the functions. Instructors also can specify different constants for the production functions of each attribute. Participants in the simulation are then assigned one of the attributes.

The interface of the program consists of three web pages: the Worksheet, Actions, and View Functions and Graphs pages. Since relatively few principles students would be comfortable working directly with the utility and production functions, the Worksheet page is provided to help the students in devising their strategies (see picture 1). Students

can specify different consumption bundles and the Worksheet will calculate the resulting level of utility. The Worksheet also calculates different ways to get some specified amount of a good. On the Actions page students can allocate time to producing goods, make offers to trade, and accept the offers of other students (see picture 2). On the View Functions and Graphs page the utility and production functions of the current user are shown. The user can also view graphs that display summary information about the simulation (see picture 3).

To illustrate how a student would participate in the simulation, the following section describes how a hypothetical student, Matthew, might participate in the simulation. Matthew's class is working with Jeremy's Market, the barter component of the program. Like all players, Matthew's utility is a function of two goods (in his case bread and wine) and leisure time. After he logs in, the program displays the Worksheet page.

The Worksheet page contains information about recently accepted trades. Matthew checks the exchange rates for bread and wine and notes that an offer of 10 units of bread for 5 units of wine was accepted, all previous trades had been one for one. From the exchange rates the program calculates implicit prices for goods, and calculates the marginal utility per dollar. Matthew knows that to increase his utility he needs to buy more of the good with the highest marginal utility per dollar.

After plugging the new exchange rate into the worksheet, Matthew notes that his marginal utility per dollar for bread is now higher than the values for wine and leisure time. Matthew now needs to decide how to get the additional bread he wants. The Worksheet page also calculates the different ways to get a given amount of a good. From

the results of the Worksheet, Matthew decides to dedicate an additional 10 hours to wine production and post an offer to trade wine for bread.

Switching to the Actions page, Matthew types 10 into the box labeled "Hours for production of wine" and pushes the Produce Goods button. He is informed that the 10 hours of labor will produce 15 units of wine. Further down on the Actions page he indicates he is offering 15 units of wine for 30 units of bread and pushes the button labeled Submit Offer.

Matthew then exits the simulation and goes out for lunch. When he logs into the simulation later that evening he finds that his offer had been accepted, and the program had subtracted 15 units from his stock of wine and added 30 units to his stock of bread. If the offer had not been accepted he would have cancelled it and then posted a new offer that asked for less bread.

In his last decision before the end of the period (as usual he had procrastinated until the last day of the period to do his trading) Matthew has to choose how much bread he wants to consume this period, and how much he wants to leave in reserve for next period. He knows he wants to try to spread his consumption relatively evenly over time. He again opens the Actions page, indicates that he wants to increase bread consumption by 20 units, and clicks on the Consume Goods button. Finally, Matthew decides to take a quick look at the View Functions and Graphs page to see how his utility compares with the other participants.

Participating in the simulation has prompted Matthew to think more deeply about opportunity costs, gains from trade, production tradeoffs, and utility maximization. He plans to go over his numbers one more time before the end of the period because he

really wants to have a higher utility than his roommate this round.

### **Outcomes from the Use of Jeremy's Market**

Jeremy's Market was used for the first time in a six-week summer principles of microeconomics class taught by Teresa Riley. The simulation was introduced to coincide with the chapter on utility maximization (the text used in the class was *Economics Principles and Applications, 2nd edition* by Robert Hall and Marc Lieberman).

The students participated in four periods of the simulation over a 10-day period (June 1-11). Because of the limited time available in the summer course this use of the software was more of an extensive beta test as opposed to a full implementation of the simulation into the course. Students in the class were surveyed for their views on the simulation (see the appendix for the survey results).

The outcomes from the initial usage can be summarized as follows:

- Of the 46 students who finished the class 34 participated in the simulation.
- The students who did participate in the simulation were fairly active; a total of 315 trade offers were made, 691 production decisions were made, and 810 consumption choices were made.
- According to the survey results, three-fourths of the students felt that the software was easy to use.
- Approximately three-fourths of the students responding to the survey said they felt the simulation made the class more interesting
- Approximately three-fourths of the students responding recommended that the software be used in future classes

- Slightly over half of the students indicated that software improved their understanding of the material.

The most likely explanation for the low rate of participation is that a number of students simply had difficulty making time for the simulation in the accelerated pace of a summer course. A high percentage of the students also failed to hand in traditional homework assignments.

The results also point up the need to tie in the outcomes of the simulation with the class material. Dr. Riley had relatively little time to prepare for using the simulation. The lack of preparation time, combined with the fast pace of the summer course, meant that she was not able to draw on the simulation for examples and exercises. In open-ended questions several students indicated that they would have liked more information on how the simulation related to the course.

Jeremy's Market was used for the second time in two sections of principles of microeconomics in the fall of 2001 taught by Tod Porter. The students participated in five periods of the simulation from September 26 to October 16. The textbook was again *Economics Principles and Applications, 2nd edition* by Robert Hall and Marc Lieberman and the simulation was again introduced to coincide with the chapter on consumer choice.

Differences from the first use of the simulation included:

- The class participated for one more period (five versus four) and each period was spread over a longer period of time. In the fall semester the periods lasted three to five days, as opposed to two to three days in the summer class.
- The "Robinson Crusoe" option was added and was used for the first two periods.

- Participation in the simulation was explicitly factored into the student's grade. Students were able to earn a total of 550 points in the course, with the simulation accounting for 40 points. Of the 40 points, up to 20 points were given for regularly participating in the simulation and up to 20 points were assigned according to the student's performance. A student's performance was evaluated by comparing their utility against the average of the highest four utility values of students with the same attribute.

Sixty students were originally enrolled in both sections at the start of the semester. At the end of the drop/add period, 93 students were still enrolled in the two sections. YSU is an open-admissions institution and we frequently have high withdrawal rates in principles classes. The second section was atypical because it included a cohort of 15 students taking the class for honors credit.

The level of participation in the simulation was higher than in the first usage, either because students had more time or because participation in the simulation was explicitly included in the calculation of the students' grades, or both. Of the 93 students remaining in the class after the withdrawal date, 84 had participated in the simulation. The students in the class logged in over 2,000 times, made over 1,200 production decisions, and posted slightly over 700 offers to trade (see the appendix for a detailed description of the students' participation).

Students in the classes were given the same survey administered to the students who participated in the simulation in the summer and the results were very similar. About three-fourths of the students characterized the user interface as easy or very easy to use, and the same proportion agreed or strongly agreed with the statement that the

simulation made the material more interesting. Over 80 percent of the students recommended or strongly recommended that the simulation be used in future classes.

The weakest results again dealt with the question as to whether the program increased understanding. Of the students responding 57 percent agreed or strongly agreed with the statement that the program gave them a better understanding of the material. One possible reason for this is that we have not yet developed class materials relating the simulation to the material covered in class.

During the semester the instructor was working on Adam's Market and converting his notes into PowerPoint. As a result, very little time was dedicated to integrating the simulation into the class. In the survey's narrative questions one of the most common comments made by students was that they wished there had been more discussion of the program in the class.

We also evaluated whether the outcomes of the simulation were consistent with economic theory. The participants were split into six equally-sized groups. A Cobb-Douglas utility function was assigned to each group. The exponents of the utility functions were assigned so that one good was more heavily weighted than the other two goods in the function. The production functions were assigned such that each group was much more productive in producing one of the two goods.

From the assignments of the attributes the following outcomes would be expected:

- The exchange rate of wine for bread should be close to 1.
- The variation in the exchange rate should decline as the simulation continues.

- The utility of the participants should rise when trading is allowed
- The groups 3 and 4, who prefer to consume goods that they have an absolute disadvantage in producing, would have the greatest gains from trade.

The results from the simulation closely matched the predictions (see the appendix for a summary of the results). The exchange rate of wine for bread did move towards 1 as the simulation continued. The weighted mean for that exchange rate was 1.19 in period 3, 1.05 in period 4, and 1.00 in period 6 (the weight used in the calculation of the mean was the sum of the units of bread and wine involved in the trade).

The variation in exchange rates did decrease as the simulation continued, demonstrating movement toward equilibrium in the market (see Chart 1). The weighted standard deviation of the exchange rate of wine for bread fell from 0.83 in period 3, to 0.64 in period 4, and to 0.62 in period 5. The variation in the two other exchange rates, bread for time and wine for time, declined as well.

In general, the utility of all six groups was higher when it was possible to trade. Not surprisingly, the smallest increase in utility was for the two groups that had the strongest preference for leisure. As expected, groups 3 and 4 did have the biggest gains (see Chart 2).

## **Conclusion**

The outcomes of the simulation demonstrate that it is a practical means of giving students in large classes an “active learning” experience. The loss of class time was minimal; one hour was dedicated to introducing students to the software. The instructor did spend additional time outside of class responding to student questions. Selecting the

settings for the simulation requires less than an hour. Once the simulation starts, the instructor needs to check the outcomes to discuss the progress of the simulation in class, but no intervention is required.

The survey results indicated most students enjoyed using the program, and the outcomes of the markets were consistent with economic theory. While a majority of the students indicated the simulation increased their understanding of the material, many students also indicated that they would have liked to have spent more time in class discussing the simulation. We interpret these comments as an indication that more work needs to be done to incorporate examples from the simulation into the classroom to make better use of the simulation as a teaching tool.

# Picture 1 Worksheet Page

## Current Values

Hours available for leisure or production: 90

	Bread	Wine
In Stock	44.84	27
Consumed	0	0
Hours for production	13	0

## Possible Production Combinations

Division of Hours Between Leisure and Work		Division of Hours Worked Between Bread and Wine		
Leisure 70 hours, Work 30 hours Leisure 60 hours, Work 40 hours Leisure 50 hours, Work 50 hours Leisure 40 hours, Work 60 hours Leisure 30 hours, Work 70 hours		Bread 80%, Wine 20% Bread 70%, Wine 30% Bread 60%, Wine 40% Bread 50%, Wine 50% Bread 40%, Wine 60%		
Hours of Leisure	Hours worked, Bread	Output, Bread	Hours worked, Wine	Output, Wine
50	35	171.89	15	17.19

## Set Exchange Rates

Exchange Rates		Exchange rates for last five trades:				
Units of wine for one unit of bread:	1	N/A	0.83	1.17	1.25	1
Units of bread for one hour of leisure:	2	N/A	N/A	N/A	N/A	2.33
Units of wine for one hour of leisure:	2	N/A	N/A	N/A	N/A	N/A

## Utility Calculations

### Amounts Consumed

Bread	<input type="text" value="171"/>
Wine	<input type="text" value="17"/>
Leisure:	<input type="text" value="50"/>

**Calculate Utility Values**

**Indifference Curves, Budget Line**

### Utility Values

Utility:	50.39
MU of bread:	0.15
MU of wine:	0.59
MU of leisure:	0.2
MU/P, bread:	0.15
MU/P, wine:	0.59
MU/P, leisure:	0.1

The price of bread is fixed at \$1. The other prices are fixed by the exchange rates.

## Production Options

### Good you want more of:

Bread  Wine

Number of additional units desired:

**Calculate Options**

*Caution: The values for options that include trades will only be accurate if you are actually able to trade at the exchange rates you specified!*

Ways of getting 20 units of wine given the specified exchange rates and the number of hours already spent producing wine and bread:

### Sacrifice time

1. Spend 32 hours producing wine
2. Spend 4.3 hours producing bread and trade the output for wine
3. Trade away 10 hours of time for wine

### Sacrifice bread in stock

4. Trade 20 units of bread for wine
5. Trade 64 units of bread for time to produce wine
6. Trade 8.6 units of bread for time to produce bread, then trade the resulting bread for wine

### Sacrifice wine in stock

7. Trade 64 units of wine for time to produce wine

## Picture 2 Actions Page

### Production and Consumption

Hours available for leisure or production: 90

	Bread	Wine
In Stock	14.84	7
Consumed	30	20
Hours for production	13	0
Additional consumption	<input type="text"/>	<input type="text"/>
<b>Consume</b>		
Additional hours for production	<input type="text"/>	<input type="text"/>
<b>Produce</b>		

### Accept Offers

Offers of bread

Offer Date	Good Offered	Amount Offered	Good Asked	Amount Asked

**Accept Offer**

### Post Offers

<b>Good Offered:</b>	<b>Good Asked:</b>
<input checked="" type="radio"/> Bread <input type="radio"/> Wine <input type="radio"/> Time	<input checked="" type="radio"/> Bread <input type="radio"/> Wine <input type="radio"/> Time, produce Bread <input type="radio"/> Time, produce Wine
Amount Offered: <input type="text"/>	Amount Asked: <input type="text"/>

**Submit Offer**

### Cancel Offers

Your current offers:

Date Posted	Good Offered	Amount Offered	Good Asked	Amount Asked
11/29/2001	Bread	5	Wine	7

**Cancel Offer**

Picture 3  
View Functions and Graphs Page

## User Functions

### Utility Function

$$U = (\text{Bread}^{0.5}) (\text{Wine}^{0.2}) (\text{Time}^{0.2})$$

### Production Functions

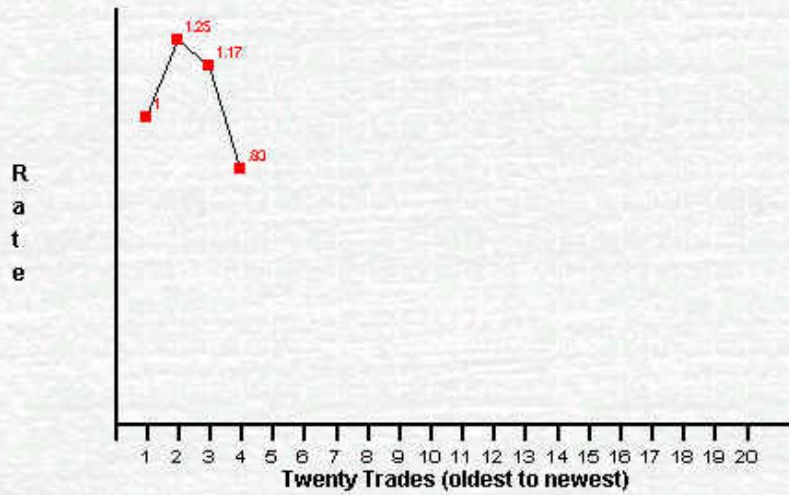
$$\text{Bread} = 10(\text{Hours}^{0.8})$$

$$\text{Wine} = 10(\text{Hours}^{0.2})$$

## Graphs

Exchange rate bread and wine

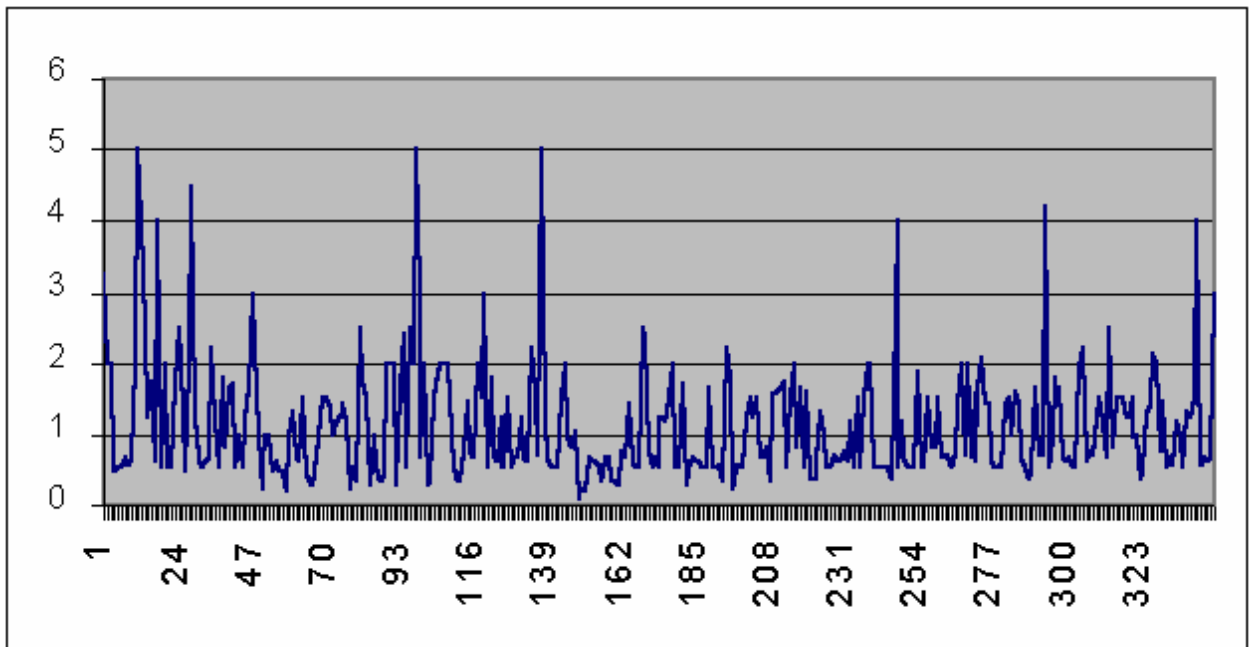
Exchange Rates: wine for bread



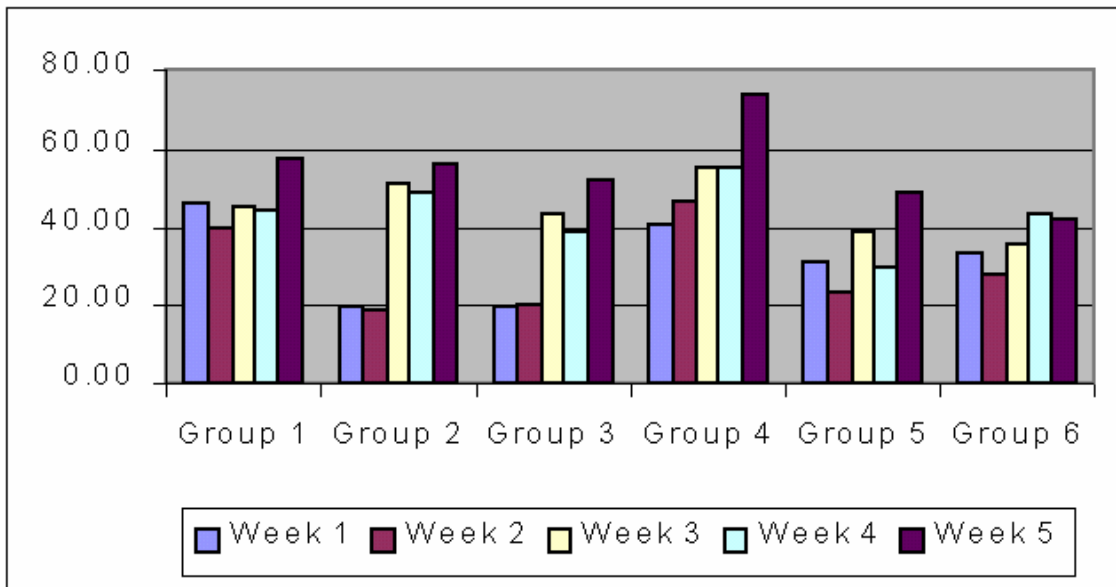
**Table 1**  
**Utility and Production Functions by Group**

Group	Utility Function	Production Function, Bread	Production Function, Wine
1	$\text{Bread}^{0.5}\text{Wine}^{0.2}\text{Leisure}^{0.2}$	$10(\text{Hours}^{0.8})$	$10(\text{Hours}^{0.2})$
2	$\text{Bread}^{0.5}\text{Wine}^{0.2}\text{Leisure}^{0.2}$	$10(\text{Hours}^{0.2})$	$10(\text{Hours}^{0.8})$
3	$\text{Bread}^{0.2}\text{Wine}^{0.5}\text{Leisure}^{0.2}$	$10(\text{Hours}^{0.8})$	$10(\text{Hours}^{0.2})$
4	$\text{Bread}^{0.2}\text{Wine}^{0.5}\text{Leisure}^{0.2}$	$10(\text{Hours}^{0.2})$	$10(\text{Hours}^{0.8})$
5	$\text{Bread}^{0.2}\text{Wine}^{0.2}\text{Leisure}^{0.5}$	$10(\text{Hours}^{0.8})$	$10(\text{Hours}^{0.2})$
6	$\text{Bread}^{0.2}\text{Wine}^{0.2}\text{Leisure}^{0.5}$	$10(\text{Hours}^{0.2})$	$10(\text{Hours}^{0.8})$

**Chart 1**  
**Exchange Rates by Accepted Offer,**  
**Units of Wine per One Unit of Bread, Fall**



**Chart 2**  
**Average Utility by Attribute Group and Period**



## Appendix

### Survey Results

How would you rate the organization of the user interface?

	Summer		Fall	
	Number	Percentage	Number	Percentage
Very difficult to use	0	0	1	1
Difficult to use	9	24	15	21
Easy to use	22	59	44	63
Very easy to use	6	16	10	14

Would you agree or disagree with the statement “The program gave me a better understanding of the material in the course.”

	Summer		Fall	
	Number	Percentage	Number	Percentage
Strongly disagree	2	5	4	6
Disagree	15	41	26	37
Agree	19	51	36	51
Strongly agree	1	3	4	6

Would you agree or disagree that the simulation made the material more interesting?

	Summer		Fall	
	Number	Percentage	Number	Percentage
Strongly disagree	1	3	2	3
Disagree	6	21	15	21
Agree	21	72	42	59
Strongly agree	1	3	12	17

Would you recommend or discourage using the simulation in future classes in principles of microeconomics?

	Summer		Fall	
	Number	Percentage	Number	Percentage
Strongly discourage	1	4	2	3
Discourage	6	21	10	14
Recommend	17	61	41	59
Strongly Recommend	4	14	16	23

Roughly, how often did you log onto the simulation **each period**?

	Summer	Fall, Robinson Crusoe Periods	Fall, Barter Periods
0 times	1	0	2
1-3 times	21	62	29
4-7 times	5	9	30
More than 7 times	3	0	10

Note: For the summer response rates on the last three questions were lower because some students did not realize there were questions on the back of the one-sheet survey.

**Actions Taken by Students, Fall Sections Only**

Total number of students after drop date	93
Total number of students with utility above zero	84
Total number of logins	2,099
Number of production decisions, bread	649
Number of production decisions, wine	635
Hours spent producing bread	11,208
Hours spent producing wine	11,551
Total output, bread	41,065
Total output, wine	42,172
Consumption decisions	1,559
Total number of offers to trade	706
Accepted offers	427
Bad offers (user unable to honor offer)	48
Offers cancelled by user	205
Offers expired at end of period	26

### Exchange Rate Summary, Fall Only

	Period 3	Period 4	Period 5
<b>Number of Trades</b>			
Wine for Bread	102	123	119
Bread for Time	16	13	21
Wine for Time	8	16	9
<b>Exchange Rate, Average</b>			
Wine for Bread	1.31	0.99	1.11
Wine for Bread, Weighted by Units of Bread and Wine	1.19	1.05	1.00
Bread for Time	3.87	3.12	3.35
Wine for Time	4.82	4.23	2.89
<b>Exchange rate, Standard Deviation</b>			
Wine for Bread	1.04	0.71	0.73
Wine for Bread, Weighted by Units of Bread and Wine	0.83	0.64	0.62
Bread for Time	2.33	2.08	2.18
Wine for Time	4.39	2.58	2.30

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