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A Comprehensive Experiment for an Introductory Course in Microeconomics

Charles de Bartolome

University of Colorado

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Department of Economics

University of Colorado at Boulder
Boulder, Colorado 80309

A COMPREHENSIVE EXPERIMENT FOR AN INTRODUCTORY COURSE IN MICROECONOMICS

by

Charles de Bartolome
University of Colorado

ABSTRACT

I present a classroom experiment designed to help students learn (1) decision-making using marginal analysis; (2) the prediction of the price; (3) the decentralized determination of a price by the market; (4) specialization; (5) the gains from trade; and (6) the ability of a competitive market to create a Pareto-efficient outcome. The innovation of the experiment lies in its comprehensiveness and in the identical opportunities faced by all students.

The experiment has two parts. There is a warm-up which is assigned as homework and the experiment proper which takes two 50-minute class sessions. I have run it in classes at the undergraduate introductory level, at the undergraduate intermediate level and at the MA introductory level; these classes have varied in size from 20 to 200 students.

Keywords: Market, Experiment.

JEL Classification: A22, C92, D41.

1. INTRODUCTION

Experiments are now recognized as being a useful tool to assist students learn the material presented in the classroom: the benefit is confirmed by Gremmen and Potters (1997). It is supposed that this learning advantage comes about because the experiments integrate class material with the student's own experience. I present below an experiment which I use in my classes to help students master six important ideas taught in an introductory class in microeconomic principles, viz. (1) decision-making using marginal analysis; (2) the prediction of the price; (3) the decentralized determination of a price by the market; (4) specialization; (5) the gains from trade; and (6) the ability of a competitive market to create a Pareto-efficient outcome.

My experiment adds to the literature by its comprehensiveness. There are many experiments which focus on the determination of the competitive price and on the ability of the competitive market to create a Pareto-efficient outcome. They are well described in all textbooks which use experiments (e.g. Bergstrom and Miller (2000) and Holt (2007)); in addition, the web-based interactive learning system Aplia includes a market experiment in its current package of exercises.[1] There are also many experiments which focus on specialization and the gains from trade (e.g. Bergstrom and Miller (2000), Anderson et al. (2005) and Chiang (2007)). In my experiment the two ideas are combined in a single experiment. Its comprehensiveness makes it a useful tool if an instructor wants to use an experiment at the end of an introductory course to summarize some of the main points of the course.

In addition to its comprehensiveness, the experiment has the advantage that all students face identical opportunities, which enables the instructor to run the experiment "for credit" if she desires.[2] Finally, the experiment allows the calculation of the competitive price by each student

before the experiment starts, enabling students to see the usefulness of using theoretical models to make predictions.

Market experiments were pioneered by Chamberlin (1948) and Smith (1962, 1964). In their design, which is still widely followed, students are divided between buyers and sellers; each buyer is dealt a card marked with a value and each seller is dealt a card marked with a cost. Students are encouraged to trade. Each buyer may buy one unit: if he buys, he earns the difference between the value which he was dealt and the price which he pays. Similarly, each seller may sell up to one unit: if she sells, she earns the difference between the price which she receives and the cost which she was dealt. Because different buyers receive different values, a market demand curve may be constructed by ranking individual buyer values from highest to lowest; the market demand at a given price is the number of buyers with a value at or above the given price. Similarly, because sellers receive different costs, a market supply schedule may be constructed by ranking individual seller costs from lowest to highest, and the market supply at any given price is the number of sellers with a cost at or below the given price.[3] The competitive price and quantity occurs at the intersection of the constructed market demand and supply curves.

My experiment differs from the traditional design described above in two important ways. First, the traditional design favors a buyer being dealt a high value or a seller receiving a low cost. This asymmetry in opportunity makes it difficult to make the student's pay-off be points earned towards the student's final grade. In my design, all students have similar opportunities. In particular, all students have the same pay-off function; the pay-off of each student depends on his consumption of the numeraire good and on his consumption of three

additional goods (described as "clothes", "food" and "housing"). Trade is induced because each student is assigned one of three symmetrical technologies. A student with Technology A can manufacture "clothes" at a cost of 1 (unit of numeraire per unit of clothes), can manufacture "food" at a cost of 2 (units of numeraire per unit of food) and can manufacture "housing" at a cost of 3 (units of numeraire per unit of housing). Similarly, a student with Technology B can manufacture "food" at a cost of 1, "housing" at a cost of 2 and "clothes" at a cost of 3; and a student with Technology C can manufacture "housing" at a cost of 1, "clothes" at a cost of 2 and "food" at a cost of 3. The difference in technologies means that a student who can manufacture one good at low cost finds it advantageous to trade with a student who can manufacture another good at low cost. However, because of the symmetry, their opportunities are the same.

The second way in which my experiment differs from the traditional design is that, in the traditional design, each buyer knows only his own value and each seller knows only her own cost: with information being private, it is not possible for either party to calculate "the equilibrium price" before trading starts.[4] In my design , all students know the three production technologies before trading starts, so that they can calculate the competitive price before trading starts. This is useful because, in the debrief following the completion of the experiment, I discuss how the student could have used the theory presented in class to her advantage or, more generally, the usefulness of using theoretical models to make predictions.[5] Using the competitive price as the predicted price, a wise student's strategy is to buy only at prices "close to but above" or below the predicted price.[6]

My overall design uses a warm-up before the experiment proper. In the Warm-Up, each student is given her pay-off function and her production technology, and she is asked to choose

the quantities of "clothes", "food" and "housing" she wishes to produce. This part is autarkic: a student can only acquire goods by manufacture (i.e. trading between students is not allowed). The warm-up has three objectives - one objective is to familiarize the students with the pay-off function and the technologies, another objective is to demonstrate the power of marginal analysis and the final objective is to provide students with the reference point of "no trade" so that, in the experiment proper, the students can experience the gain from being allowed to trade.

The experiment proper allows students to acquire goods either by manufacture (as in the Warm-Up) or by trading with other students. Students quickly realize that they can experience the "gains from trade" by selling the product they can manufacture at a cost of unity and by buying the other products from students who can manufacture those products at a cost of unity. The traditional market experiments use one of two institutions to establish trading prices. Either a "trading pit" is used in which students roam the classroom seeking a trading partner, form pairs and then bargain over a bilateral trade.[7] Or a "double auction" is used. Although the experiment could be run using a double auction, I use a trading pit partly because I think it allows students to see better the decentralized process by which prices are established, and partly because Bergstrom and Miller (2000, p. viii) report that "[the] trading-pit procedure is faster and more easily administered in a classroom than a double oral auction."

In order to motivate students,[8] I set the student's pay-off to be points earned towards the student's final grade.[9] Because students usually prefer their grade to be based on many different forms of evaluation (e.g. midterm and final exams, term papers, class participation), I find that most students welcome the use of their experimental score as an input to their grade. However, letting the pay-off of the experiment be points earned towards a student's grade requires that

issues of fairness are addressed. First, all students must have similar opportunities. This aspect is present in my experimental design but, as noted earlier, is not present in the traditional design in which students start with different values and costs. Second, it is important that the experiment is given *after* the relevant theory has been discussed in class, so that a student feels that his/her performance is related to his/her mastery of the material presented in the classroom. This aspect means that I use the experiment to validate the theory and not to motivate the theory.

The Warm-Up is assigned to students to be done as homework outside the classroom. The experiment proper requires that students interact with each other to trade, and this is facilitated by putting aside two back-to-back fifty-minute class sessions: at the end of the second session, no student has indicated a wish to continue to seek trades. I have held the experiment in class sizes from 20 to 200 students. Although the experiment is designed for an introductory class in microeconomic principles, I also use the experiment in my intermediate microeconomic theory class and I have used it in my MA class: in the more advanced courses, there tends to be less variance in behavior and the outcomes more closely resemble the competitive outcome.[10]

This paper is organized as follows. Section 2 describes the Warm-Up and Section 3 describes the Experiment. In each section I show the results from my Principles of Microeconomics class in Fall 2005 (180 students participating in the Warm-Up and 184 students participating in the Experiment), and provide a discussion. Section 4 provides some questions which I use to motivate discussion in the debrief but which could be used in an exam. Section 5 concludes.

2. WARM-UP: MARGINAL ANALYSIS

2.1 Description Of The Warm-Up

The formal instructions for the Warm-Up are attached as Appendices A, B and C. Each student obtains "total benefit" *TB* from consuming *c* units of clothes, *f* units of food, *h* units of housing and *x* units of "other things" as[12]

$$TB = 10\sqrt{c} + 10\sqrt{f} + 10\sqrt{h} + x \ . \tag{1}$$

TB is converted into a score which goes towards the student's final grade.

Each student is given 100 units of "resources" which he can use to manufacture the four goods, "clothes", "food," "housing" and "other things."[13] "Other Things" are the numeraire good and to manufacture one unit of "other things" uses up one unit of resources. A student given Technology A uses up 1 unit of resources to manufacture one unit of clothes, uses up 2 units of resources to manufacture one unit of food and uses up 3 units of resources to manufacture one unit of housing. Each student has to choose how to divide his "resources" between the manufacture of clothes, food, housing and "other things".

Two complexities are introduced into the design so that, in doing the Warm-Up, the student becomes familiar with the design of the experiment proper. The first complexity is that *TB* is converted into a score S_1 which goes towards the student's final grade.[14] The student's score S_1 in the Warm-Up is derived from *TB* as

$$S_1 = \tfrac{1}{6}\max[0\ , TB - 126].$$

The floor of zero is imposed to ensure that a student who performs poorly in the experiment does not do worse than a student who does not participate.

The second complexity concerns the technology. In the experiment proper, trade is induced by assigning each student one of the three different manufacturing technologies. In order for the basic structure to be the same in the Warm-Up and in the Experiment (enabling the gains from trade to be readily apparent) and for students to familiarize themselves with the technologies, the three technologies are introduced in the Warm-Up. Table 1 describes the amount of "resources" which must be used to produce one unit of each type of good using each technology:

		Units of "resources" used to manufacture 1 unit of output using technology:		
		A	B	C
Output	clothes	1	3	2
	food	2	1	3
	housing	3	2	1
	"other things"	1	1	1

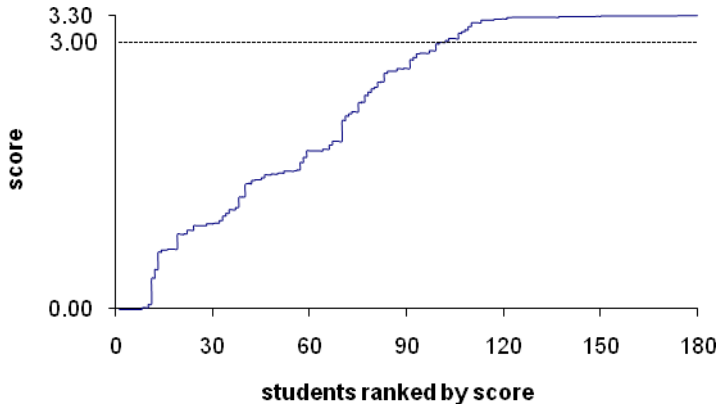
Table 1: the three technologies

One-third of the students are assigned Technology *A*, one-third of students are assigned Technology *B* and the remaining-third are assigned Technology *C*.

The experiment's instructions include a table giving values of $10\sqrt{i}$ for different values of i.[15]

2.2 Results

The maximum value of *TB* achievable in the Warm-Up is 145.8 which translates into a score of 3.3. The actual distribution of scores for the Warm-Up is shown in Chart 1.



Mean score: 2.3; Median score: 2.8; Standard deviation: 1.0

Chart 1: Warm-Up scores

45% of students achieved a score of 3.0 or above, and 17% achieved the maximum score.

2.3 Discussion

Chart 1 shows that most students make choices so that they score at or close to the maximum. However, on discussion, 80% of students spent more than two hours making the decision, and most students used trial and error or used a spreadsheet program such as Microsfot Excel. How can marginal analysis help?

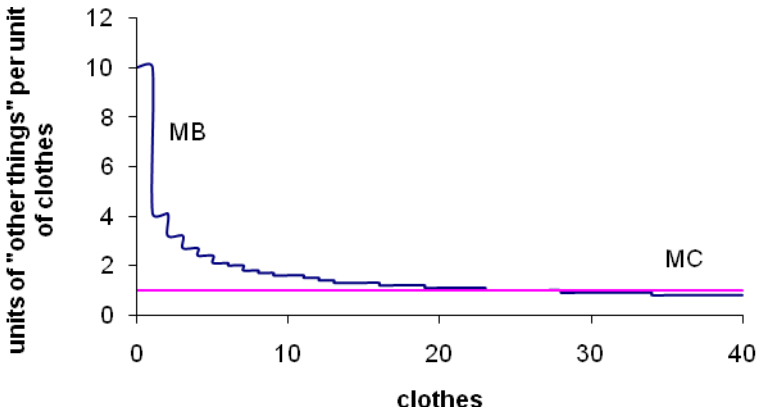


Figure 1: marginal benefit/marginal cost analysis

In the class debrief, all students confirmed that they were choosing the quantities of clothes, food, housing and "other things" in order to maximize their total score, and that they realized that maximizing their total score is equivalent to maximizing their total benefit *TB* . For ease of presentation, I consider a student with Technology *A*. The student starts with 100 units of "resources" and 0 units of clothes, food, housing and "other things"; she must decide how many units of clothes to manufacture. Marginal analysis stresses that she does this by steadily increasing her production provided marginal benefit exceeds marginal cost. The marginal benefit of the *i*th unit is calculated as $10\sqrt{i} - 10\sqrt{i-1}$ using the values of $10\sqrt{i}$ shown in the appendix of the Warm-Up's instructions; these values are shown as the curve *MB* in Figure 1. The marginal cost is the benefit foregone because one unit of resources is shifted from manufacturing a unit of "other things" into manufacturing a unit of clothes. For a student with Technology A, this cost is unity and it is shown as the curve *MC* in Figure 1.[16] [17] When the student has manufactured 23 units, an additional unit has a marginal benefit of 1 and a marginal cost of 1 - "total benefit" is unchanged if an additional clothes is manufactured (Law of Marginal

Indifference). The analysis is then repeated for food (marginal cost of 2: optimal choice 6 or 7) and housing (marginal cost of 3: optimal choice 3). "Total benefit" is then 145.8 and the individual's highest achievable score is 3.3.

For courses which use indifference curves, indifference curves can be constructed. If an individual consumes *c* units of clothes, *f* units of food, *h* units of housing and *x* units of "other things", he achieves "total benefit" *TB* :

$$TB = 10\sqrt{c} + 10\sqrt{f} + 10\sqrt{h} + x \ .$$

Holding *f* and *h* constant, the "utility" achieved from clothes and "other things" is:

$$U(c, x \mid f, h) \stackrel{\text{def}}{=} TB - 10\sqrt{f} - 10\sqrt{h} = 10\sqrt{c} + x$$

Hence combinations of clothes *c* and "other things" *x* which gave the same utility *U* are:

$$x = U - 10\sqrt{c}.$$

Combinations of *c* and *x* which give utility levels *U = 100*, *U = 125* and *U = 150* are plotted as the three "indifference curves" in Figure 2:

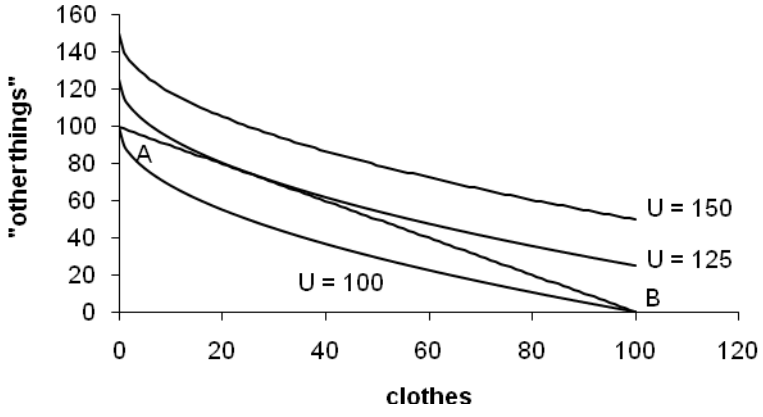


Figure 2: indifference curve analysis

Figure 2 represents the traditional optimization diagram. *AB* is the possibility frontier and the curved lines are lines of constant utility. Starting at *A*, moving down the budget line moves the student onto a higher indifference curve or increases the utility of the student until 23 units of clothes are manufactured. Because the score is rounded to one decimal place, the indifference curve is flat between 23 and 28 units, and lies on the possibility frontier: this illustrates the general idea that small movements along the possibility frontier, around the point of tangency of the budget line and the indifference curve, give no change in utility (Law of Marginal Indifference).

Repeating the analysis for food (opportunity cost is 2 units of "other things" per unit of food) and housing (opportunity cost is 3 units of "other things" per unit of housing) shows that the utility maximizing level of food is 6 or 7, and of housing is 3.

2.4 Tips On Running The Warm-Up

1. I assign the Warm-Up after consumer optimization has been covered in class.
2. I do not hold the Warm-Up during class. Instead I assign it as homework.
3. In order to reduce the class time taken up, I do not read the instructions through with the students. Instead, I talk the students informally through the instructions - pointing out that their score depends on the quantities they choose - and direct the students to read the instructions carefully in their own time.
4. In the experiment proper, I assign a number to each student and each student is required to use her number. In order to get each student to be familiar with her number, I require that each student use her number in the Warm-Up. I post a list with student names, their numbers and assigned technologies on the course web-page.
5. For 20% of students, the score as calculated by the student in his Production Plan which he hands in differs from the score I calculate using his chosen quantities of clothes, food and housing. Therefore, because this is part of the student's class grade and to ensure that the student understands the calculations prior to taking part in the experiment proper, I calculate each student's score using his chosen quantities of clothes, food and housing using a spreadsheet program.

3. EXPERIMENT: TRADE

3.1 Description

The Experiment's structure is similar to that of the Warm-up, and the formal instructions are shown in Appendices D, E and F. Each student achieves a "total benefit" *TB* from his consumption of clothes *c*, food *f*, housing *h* and "other things" *x* as in Equation (1) and he has an endowment of 100 units of "resources" which he can use to manufacture the goods using the same technology as in the Warm-Up. The difference between the Warm-Up and the Experiment is that, in the Experiment, the student is allowed to trade with other students. As noted in the Introduction, each student can gain if he manufactures and sells the good which he can manufacture at a unit opportunity cost (units of "other things" per unit of good) , and buys the other goods from students with technologies which enable them to manufacture these goods at unit opportunity cost (units of "other things" per unit of good). The experiment uses a trading pit to facilitate trading: students roam the classroom seeking buyers and sellers, and prices are not centrally posted.

Each student's "total benefit" *TB* achieved in the experiment is converted into a score S_2 which goes towards the student's final grade as:

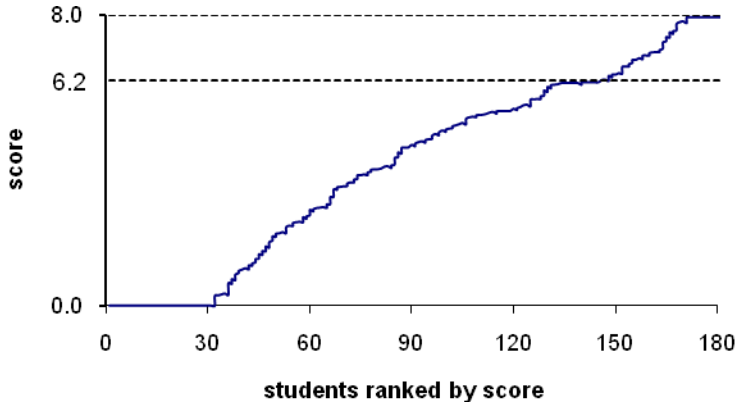
if	$TB < 138$,	$S_2 = 0$;
if	$138 \leq TB \leq 186$,	$S_2 = \frac{1}{6}(TB - 138)$;
if	$186 < TB$,	$S_2 = 8$.

Note that, in order to prevent the influence of the experiment on the student's grade becoming excessive, a ceiling as well as a floor is imposed on the score. In addition, in order to better

balance the influence of S_1 and S_2 in the contribution to the student's grade, 138 is subtracted from *TB* in the Experiment whereas 126 is subtracted in the Warm-Up.[19]

3.2 Results

Under perfect competition, students with the least cost technology supply unlimited amounts at any price exceeding unity (units of resources per unit of good) , or the supply curve *S* for each good is perfectly elastic at a price of unity. The competitive equilibrium price is therefore unity. At the unit price, students consume between 23 and 28 units of clothes, food and housing. Students manufacturing goods make no profits and hence consume between 31 and 16 units of "other things". Hence, under perfect competition, each student would obtain a score of $S_2 = 6.2$. In fact, actual trades occur at various prices and students achieve lower or higher scores. The distribution of scores is shown in Chart 2.



Mean score: 4.1; Median score: 4.6; Standard deviation: 2.7

Chart 2: Experiment scores

The median score is 4.6 but that there is considerable variation around the median. 18% of students actually achieved a lower value of *TB* in the Experiment than in the Warm-Up.

3.3 Discussion

3.3.1 Power Of Prediction

Students often ask: "How can I know whether to buy or sell at the start of the experiment?" In the debrief a student is usually able to tell me that he would have known what to do if he had known what the price is likely to settle at - he would "sell high" or sell aggressively to any student willing to buy at a price exceeding his marginal cost and he would "buy low" or buy from any student willing to sell at a price equal or below the predicted future price. If the price initially exceeds the predicted future price, he would delay his purchases until the price fell to close to the predicted price. At this point I explain that he is able to predict the price using the framework of demand and supply![20]

The demand curve for each good is constructed using the method of marginal analysis discussed in Section 2.3: with 184 students taking part in the experiment, the demand curve for each good is shown as curve *D* in Figure 3.

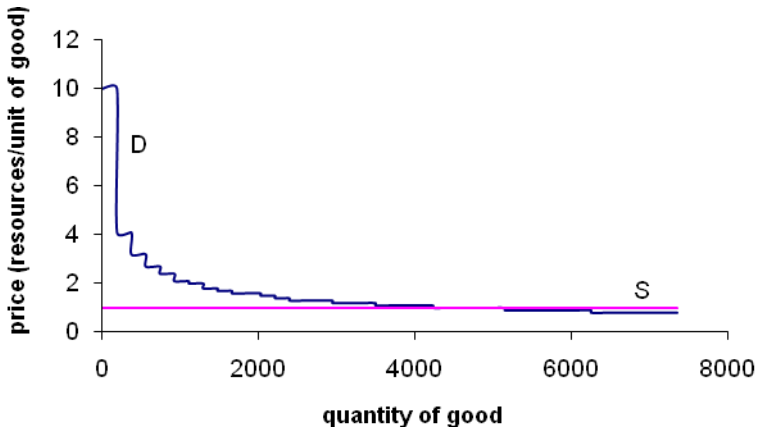
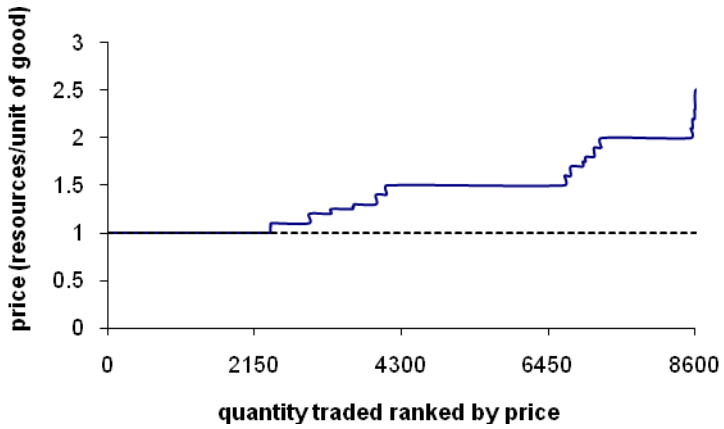


Figure 3: the competitive prediction

Under perfect competition, students with the least cost technology supply unlimited amounts at any price exceeding unity (units of resources per unit of good) , or the supply curve *S* for each good is perfectly elastic at a price of unity. The competitive equilibrium price is therefore unity. I believe that this ability of the economist to make predictions is an important but often overlooked component of an introductory course in microeconomics.

How well does our prediction match with what happened? The actual distribution of prices is shown in Chart 3.



Mean price: 1.4 ; Median Price: 1.5 ; Standard Deviation: 0.37.

Chart 3: distribution of actual prices

The quantity of product which is traded at the competitive price of unity as a fraction of the total quantity traded is .27; the quantity of product which is traded at a price between 1 and 1.5 as a fraction of the total quantity traded is .75. Casual observation suggests that most of the high-priced trades are made early on the first day and that the price "settles" at unity by the end of the experiment. I stress to students that most trades being made at a price exceeding the competitive price does not invalidate the prediction *per se*: the competitive model is an approximation. And

the competitive price is a good prediction for the price of most trades in the second class put aside for trading, when students have become experienced.

3.3.2 Decentralized Determination Of The Price

At the end of the experiment, trades are being made at a price of unity. In the debrief I ask students to reflect on how this price is not established by anybody but by everybody, or by the twin forces of demand and supply.

3.3.3 Specialization

Competitive theory predicts that specialization occurs with each good being made by the firms or individuals with the least cost technology. The least cost method of producing clothes, food or housing involves the use of 1 unit of resources per unit of output. This involves clothes being manufactured by students with Technology *A*, food being manufactured by students with Technology *B* and housing being manufactured by students with Technology *C*. Chart 4 shows that 95% of production is carried out at least cost.

Mean cost: 1.08; Median Cost: 1.00; Standard Deviation: 0.33

Chart 4: product specialization

3.3.4 Gains From Trade:

In the experiment trade enables a student to increase his value of *TB* by being able to obtain product which is manufactured at a cost which is lower than the cost at which he can produce it.

Predicted "Total Benefit" - if trade allowed:	175
- if no trade allowed:	145.8
Predicted gain from trade:	29.2
Average of actual "Total Benefits" - if trade allowed:	158.9
- if no trade allowed:	138.6
Average actual gain from trade:	20.3
Standard deviation of actual gains:	28.4

Table 2: gains from trade.

Table 2 shows the gains from trade by comparing the "Total Benefit" obtained in the Experiment (trade allowed) with the "Total Benefit" obtained in the Warm-Up (no trade allowed). There is a large increase in the students' predicted and actual "Total Benefit" as a consequence of trade.

3.3.5 Ability Of The Competitive Market To Create A Pareto-Efficient Outcome.

Probably the most important idea in an introductory economics class is Adam Smith's Invisible Hand. At the Pareto-efficient outcome there is specialization in production with each good being manufactured by the students who have the technology with least cost. The output is distributed so that each student consumes between 23 and 28 units of clothes, food and housing. Therefore, at the Pareto-efficient outcome between 69 and 84 units of clothes, food and housing are produced per student. Units not consumed are exchanged, or between 46 and 56 units are traded per student.[21] Table 3 shows that the actual quantities manufactured and the actual quantities traded are approximately the efficient quantities. In consequence, although the actual level of surplus gained is less than the efficient level, a large part of the potential surplus is gained.

Production: units of clothes, food and housing manufactured per student:	
At the Pareto-efficient outcome	69-84
Actual average:	67
Exchange: units of clothes, food and housing exchanged per student:	
At the Pareto-efficient outcome	46-56
Actual average:	47
"Total Benefit":	
At the Pareto-efficient outcome	175
Actual average:	145.8

Table 3: the partial achievement of Pareto-efficiency.

3.4 Tips On Running The Experiment

1. I run the Experiment close to the end of term after all the topics - decision-making by the individual, decision-making by the competitive firm, competitive markets, specialization and the market attainment of Pareto-efficiency have been discussed in class.
2. As noted in the Introduction I put aside two back-to-back fifty-minute class periods for trading. I have found that about half-way through the second period all students feel that they have made all the trades they want.
3. Because the instructions are so long, I do not read them through with the students. Instead, at the start of the class preceding the first class put aside for trading, I stress that each student's decisions in the experiment will affect their score. Then I show the

students how the slips and log are completed for a fictional sequence of transactions, using production slips, trade slips and the log which have been copied onto transparencies for overhead projection. E.g. "I have number 250 and Technology A. I manufacture 10 units of food. I meet a student whose number is 420 and agree to buy 17 units of clothes at a price of 1.3 (units of resources per unit of clothes). I meet another student whose number is 370 and agree to sell 5 units of food at a price of 2.1 (units of resources per unit of food). I manufacture 5 units of housing. I meet a student whose number is 372 and agree to buy 13 units of housing at a price of 1.6 (units of resources per unit of housing)." After reading each transaction I complete the entries on the overhead transparencies which show a production or trade slip and the log. Then I add: "If I stopped now, I would use the quantities in my log (clothes =17, food = 5, housing = 18 and "other things" = 32.6) to calculate my "Total Benefit" as 138.6 and my score as .1." Finally I add: "Now that you have got an overview of the experiment, I strongly encourage you to read the instructions carefully and make a plan for the trading period in class."

4. All production and trade must be done in the assigned class-times. I do this because the competitive process requires that buyers and sellers can readily find alternative sellers and buyers with whom to trade, and this is facilitated by all students being in the same room.

5. The two errors I have found students to make when recording a trade is (1) recording the total resources transferred in Part (5) of the trade slip instead of the price (units of resources per unit of good); and (2) the buyer and seller each completing a trade slip instead of only one trade slip being completed by them together. When showing how the

trade slip is to be completed (see Point (3) above), I therefore stress that Part (5) of the trade slip records the price and that only one trade slip is to be completed.

6. I bring a list of the students' numbers and technologies to the class periods. At the start of each class period I stress that everybody must use their assigned numbers and that any student who has mislaid his number must see me. I also bring in a large quantity of extra logs, production slips and trade slips.[22]

7. Many students make mistakes in recording their logs. I therefore recreate the production and trade flows by entering the data from the production and trade slips into a spreadsheet. Using the spreadsheet, I compute each student's score. For a class of 200 students, this aspect of the experiment takes about 15 hours (it is much quicker for smaller classes). My algorithm is described in Appendix G.

4. POSSIBLE EXAM QUESTIONS

I show below some questions which I have used to promote discussion in the debriefs but which could be used on an exam:

1. What is marginal analysis? How did you use it or could you have used it in the Warm-Up to simplify your choice of quantities?

2. What information did you have at the end of the experiment that you would have liked to have had at the start of the experiment.

3. Why do you think that, by the end of the experiment, almost all trades were taking place at a price of unity?

4. In the experiment no trades were made at a price below the competitive price, but some trades were made at prices above the competitive price. Can you rationalize this?
5. Were you acting as a price-taker?
6. What factors affected the price at which you agreed to buy or sell product?
7. Why do you think that almost all students specialized by making only one product?
8. What feature of trade enabled students to achieve higher "total benefit" (*TB*) in the Experiment than in the Warm-Up.
9. If a planner were to decide that all students should get the same "total benefit" (*TB*), what would be the highest "total benefit" that the typical student could attain?

5. CONCLUSION

The paper provides an experiment to illustrate six important principles of microeconomics. The experiment, when used near the end of an introductory economics course, is well suited to solidify a student's understanding of markets. Each student is required to work on parts of the experiment on her own, making her responsible for learning the experiment and related concepts. The experiment could be modified to allow computer technology to facilitate production and trading; the necessary program would have the advantage that it could be written to automatically keep track of students' logs and trades.

I find that students enjoy the experiment and the feedback I receive confirms that it is a useful learning experience. At the end of each course, instructors at the University of Colorado distribute a Course Evaluation Questionnaire. Question 1 of the Questionnaire asks: "What are the most effective aspects of this course." In Fall 2005 30% of students replied to this question

with: “The experiment.” Although the principal benefit of the experiment is that it provides the students with the possibility of learning by experience, the correlations suggest that the experiment functions weakly as an exam with the implied motivation for learning: in Fall 2005 the correlation between a student’s total score (warm-up plus experiment) from the experiment and his course score was 0.47 which is similar to the correlation of 0.77 between his score in the first midterm and his course score.

LIST OF APPENDICES

APPENDIX A

WARM-UP: INSTRUCTIONS FOR STUDENTS WITH TECHNOLOGY A

These instructions are for students with Technology A. If you have Technology B or C, please read the correct instructions.

This is an experiment in economic decision-making. The instructions are simple and, if you follow them carefully, you may earn points towards your grade.

Out of the 100 possible points used to calculate your final grade, 90 points come from your scores in the midterm and final exams, and 10 points come from your scores in this warm-up and in the experiment proper. You cannot earn a negative score in this warm-up, and hence participating in the warm-up cannot cause your score to be lower than if you do not participate.

Your "total benefit" *TB* depends on the goods you own as

$$TB = 10\sqrt{clothes} + 10\sqrt{food} + 10\sqrt{housing} + \text{"other things"},$$

where the labels "clothes", "food", "housing" and "other things" denote the units of these goods you own. Your score from this experiment depends on your "total benefit" as:

if $TB \leq 126$, your score is *0*.

if $126 \leq TB$, your score is $\frac{1}{6}(TB - 126)$.

You start with 100 units of "resources". You can acquire clothes, food, housing and "other things" by manufacture, but not by trade with somebody else. There are 3 technologies of manufacturing - technologies *A, B* and *C*. Each technology uses different quantities of "resources" as inputs to manufacture a unit of clothes, food and housing. In particular, the "resources" used up to produce a unit of clothes, food or housing using the different technologies are described as:

		Units of "resources" used to manufacture 1 unit of output using technology:		
		A	B	C
Output	clothes	1	3	2
	food	2	1	3
	housing	3	2	1
	"other things"	1	1	1

One third of students are using Technology *A*, one third of students are using Technology *B* and one third of students are using Technology *C*. *You can only use Technology A.*

You may only manufacture integer units of clothes, food, housing and "other things". Scores are rounded to 1 decimal point. For different values of *x*, the values of $10\sqrt{x}$ which you are to use to calculate your score are shown in the Appendix.

At the start of class on _____ or earlier, you must return your Production Plan of clothes, food and housing. "Resources" not used to produce clothes, food and housing are assumed to be used to produce "other things". The Production Plan form is shown at the end of these instructions. Production Plans handed in late will not be accepted.

EXAMPLES OF CALCULATING THE CONTRIBUTION TO YOUR GRADE

EXAMPLE 1: Your production is:

Clothes:	15	units
Food:	23	units
Housing:	9	units

To produce these outputs, you use up (15x1) + (23x2) + (9x3) = 88 "resources". Therefore, you have remaining 100-88 = 12 "resources" which you use to produce 12 “other things”.

TB is calculated as

$$TB = 10\sqrt{15} + 10\sqrt{23} + 10\sqrt{9} + 12 = 128.7$$

Your score is

$$\frac{1}{6}(128.7 - 126) = 0.45.$$

EXAMPLE 2: Your production is:

Clothes:	3	units
Food:	21	units
Housing:	15	units

To produce these outputs, you use up (3x1) + (21x2) + (15x3) = 90 "resources". Therefore, you have remaining 100-90 = 10 "resources" which you use to produce 10 “other things”.

TB is calculated as

$$TB = 10\sqrt{3} + 10\sqrt{21} + 10\sqrt{15} + 10 = 111.8$$

Because $TB \leq 126$, your score is *0* .

APPENDIX: VALUES OF x AND $10\sqrt{x}$

x	$10\sqrt{x}$
1	10.0
2	14.1
3	17.3
4	20.0
5	22.4
6	24.5
7	26.5
8	28.3
9	30.0
10	31.6
11	33.2
12	34.7
13	36.1
14	37.4
15	38.7
16	40.0
17	41.2
18	42.4
19	43.6
20	44.7
21	45.8
22	46.9
23	48.0
24	49.0
25	50.0
26	51.0
27	52.0
28	53.0
29	53.9
30	54.8
31	55.7
32	56.6
33	57.5
34	58.4
35	59.2
36	60.0
37	60.8
38	61.6
39	62.4
40	63.2

PRODUCTION PLAN: TO BE HANDED IN

YOUR #: _____

TECHNOLOGY: _____

YOUR NAME: _____

My production plan is:

Clothes : ____ units.

Food : ____ units.

Housing : ____ units.

I am using the “resources” left over after the manufacture of the above quantities of clothes, food and housing to manufacture “other things”.

I calculate my "total benefit" as: _____ .

I calculate my score in this experiment as: _____ .

APPENDIX B

WARM-UP: INSTRUCTIONS FOR STUDENTS WITH TECHNOLOGY B

These instructions are for students with Technology B. If you have Technology A or C, please read the correct instructions.

This is an experiment in economic decision-making. The instructions are simple and, if you follow them carefully, you may earn points towards your grade.

Out of the 100 possible points used to calculate your final grade, 90 points come from your scores in the midterm and final exams, and 10 points come from your scores in this warm-up and in the experiment proper. You cannot earn a negative score in this warm-up, and hence participating in the warm-up cannot cause your score to be lower than if you do not participate.

Your "total benefit" *TB* depends on the goods you own as

$$TB = 10\sqrt{food} + 10\sqrt{housing} + 10\sqrt{clothes} + \text{"other things"},$$

where the labels “food”, “housing”, “clothes” and “other things” denote the units of these goods you own. Your score from this experiment depends on your “total benefit” as:

if $TB \leq 126$, your score is 0.

if $126 \leq TB$, your score is $\frac{1}{6}(TB - 126)$

You start with 100 units of "resources". You can acquire food, housing, clothes and "other things" by manufacture, but not by trade with somebody else. There are 3 technologies of manufacturing - technologies *B, C* and *A*. Each technology uses different quantities of “resources” as inputs to manufacture a unit of food, housing and clothes. In particular, the “resources” used up to produce a unit of food, housing and clothes using the different technologies are described as:

		Units of "resources" used to manufacture 1 unit of output using technology:		
		B	C	A
Output	food	1	3	2
	housing	2	1	3
	clothes	3	2	1
	"other things"	1	1	1

One third of students are using Technology *B*, one third of students are using Technology *C* and one third of students are using Technology *A. You can only use Technology B.*

You may only manufacture integer units of food, housing, clothes and "other things". Scores are rounded to 1 decimal point. For different values of *x*, the values of $10\sqrt{x}$ which you are to use to calculate your score are shown in the Appendix.

At the start of class on _____ or earlier, you must return your Production Plan of food, housing and clothes. "Inputs" not used to produce food, housing and clothes are assumed to be used to produce "other things". The Production Plan form is shown at the end of these instructions. Production Plans handed in late will not be accepted.

EXAMPLES OF CALCULATING THE CONTRIBUTION TO YOUR GRADE

EXAMPLE 1: Your production is:

Food:	15	units
Housing:	23	units
Clothes:	9	units

To produce these outputs, you use up (15x1) + (23x2) + (9x3) = 88 "resources". Therefore, you have remaining 100-88 = 12 "resources" which you use to produce 12 “other things”.

TB is calculated as

$$TB = 10\sqrt{15} + 10\sqrt{23} + 10\sqrt{9} + 12 = 128.7$$

Your score is

$$\frac{1}{6}(128.7 - 126) = 0.45\,.$$

EXAMPLE 2: Your production is:

Food:	3	units
Housing:	21	units
Clothes:	15	units

To produce these outputs, you use up (3x1) + (21x2) + (15x3) = 90 "resources". Therefore, you have remaining 100-90 = 10 "resources" which you use to produce 10 “other things”.

TB is calculated as

$$TB = 10\sqrt{3} + 10\sqrt{21} + 10\sqrt{15} + 10 = 111.8$$

Because $TB \leq 126$, your score is 0 .

APPENDIX: VALUES OF x AND $10\sqrt{x}$

x	$10\sqrt{x}$
1	10.0
2	14.1
3	17.3
4	20.0
5	22.4
6	24.5
7	26.5
8	28.3
9	30.0
10	31.6
11	33.2
12	34.7
13	36.1
14	37.4
15	38.7
16	40.0
17	41.2
18	42.4
19	43.6
20	44.7
21	45.8
22	46.9
23	48.0
24	49.0
25	50.0
26	51.0
27	52.0
28	53.0
29	53.9
30	54.8
31	55.7
32	56.6
33	57.5
34	58.4
35	59.2
36	60.0
37	60.8
38	61.6
39	62.4
40	63.2

PRODUCTION PLAN: TO BE HANDED IN

YOUR #: _____

TECHNOLOGY: _____

YOUR NAME: _____

My production plan is:

Food : ___ units.

Housing : ___ units.

Clothes: ___ units.

I am using the “resources” left over after the manufacture of the above quantities of food, housing and clothes to manufacture “other things”.

I calculate my "total benefit" as: _____ .

I calculate my score in this experiment is: _____ .

APPENDIX C

WARM-UP: INSTRUCTIONS FOR STUDENTS WITH TECHNOLOGY C

These instructions are for students with Technology C. If you have Technology A or B, please read the correct instructions.

This is an experiment in economic decision-making. The instructions are simple and, if you follow them carefully, you may earn points towards your grade.

Out of the 100 possible points used to calculate your final grade, 90 points come from your scores in the midterm and final exams, and 10 points come from your scores in this warm-up and in the experiment proper. You cannot earn a negative score in this warm-up, and hence participating in the warm-up cannot cause your score to be lower than if you do not participate.

Your "total benefit" *TB* depends on the goods you own as

$$TB = 10\sqrt{housing} + 10\sqrt{clothes} + 10\sqrt{food} + \text{"other things"},$$

where the labels “housing”, “clothes”, “food” and “other things” denote the units of these goods you own. Your score from this experiment depends on your “total benefit” as:

if $TB \leq 126$, your score is 0.

if $126 \leq TB$, your score is $\frac{1}{6}(TB - 126)$.

You start with 100 units of "resources". You can acquire housing, clothes, food and "other things" by manufacture, but not by trade with somebody else. There are 3 technologies of manufacturing - technologies *C*, *A* and *B*. Each technology uses different quantities of “resources” as inputs to manufacture a unit of housing, clothes and food. In particular, the “resources” used up to produce a unit of housing, clothes or food using the different technologies are described as:

		Units of "resources" used to manufacture 1 unit of output using technology:		
		C	A	B
Output	housing	1	3	2
	clothes	2	1	3
	Food	3	2	1
	"other things"	1	1	1

One third of students are using Technology *C*, one third of students are using Technology *A* and one third of students are using Technology *B. You can only use Technology C*.

You may only manufacture integer units of housing, clothes, food and "other things". Scores are rounded to 1 decimal point. For different values of *x*, the values of $10\sqrt{x}$ which you are to use to calculate your score are shown in the Appendix.

At the start of class on _____ or earlier, you must return your Production Plan of housing, clothes and food. "Inputs" not used to produce housing, clothes and food are assumed to be used to produce "other things". The Production Plan form is shown at the end of these instructions. Production Plans handed in late will not be accepted.

EXAMPLES OF CALCULATING THE CONTRIBUTION TO YOUR GRADE

EXAMPLE 1: Your production is:

Housing :	15	units
Clothes :	23	units
Food :	9	units

To produce these outputs, you use up (15x1) + (23x2) + (9x3) = 88 "resources". Therefore, you have remaining 100-88 = 12 “resources” which you use to produce 12 “other things”.

TB is calculated as:

$$TB = 10\sqrt{15} + 10\sqrt{23} + 10\sqrt{9} + 12 = 128.7$$

Your score is:

$$\frac{1}{6}(128.7 - 126) = 0.45.$$

EXAMPLE 2: Your production is:

Housing :	3	units
Clothes :	21	units
Food :	15	units

To produce these outputs, you use up (3x1) + (21x2) + (15x3) = 90 "resources". Therefore, you have remaining 100-90 = 10 "resources" which you use to produce 10 “other things”.

TB is calculated as:

$$TB = 10\sqrt{3} + 10\sqrt{21} + 10\sqrt{15} + 10 = 111.8$$

Because $TB \leq 126$, your score is *0* .

APPENDIX: VALUES OF x AND $10\sqrt{x}$

x	$10\sqrt{x}$
1	10.0
2	14.1
3	17.3
4	20.0
5	22.4
6	24.5
7	26.5
8	28.3
9	30.0
10	31.6
11	33.2
12	34.7
13	36.1
14	37.4
15	38.7
16	40.0
17	41.2
18	42.4
19	43.6
20	44.7
21	45.8
22	46.9
23	48.0
24	49.0
25	50.0
26	51.0
27	52.0
28	53.0
29	53.9
30	54.8
31	55.7
32	56.6
33	57.5
34	58.4
35	59.2
36	60.0
37	60.8
38	61.6
39	62.4
40	63.2

PRODUCTION PLAN: TO BE HANDED IN

YOUR #: _____

TECHNOLOGY: _____

YOUR NAME: _____

My production plan is:

Housing : ____ units.

Clothes : ____ units.

Food : ____ units.

I am using the “resources” left over after the manufacture of the above quantities of housing, clothes and food to manufacture “other things”.

I calculate my "total benefit" as: _____ .

I calculate my score in this experiment is: _____ .

APPENDIX D

EXPERIMENT: INSTRUCTIONS FOR STUDENTS WITH TECHNOLOGY A

Your number and technology for this experiment are the same as the ones assigned to you for the warm-up. They are shown on the course web-page, or you can get them by asking the instructor.

The instructions shown below are for students with Technology A. If you have Technology B or C, please read the correct instructions.

When recording production or trades, you must use the number which has been assigned to you: using a number which has not been assigned to you could affect the score of another student.

This is an experiment in economic decision-making. The instructions are simple and, if you follow them carefully, you can earn points towards your grade.

Out of the 100 possible points used to calculate your final grade, 90 points come from your scores in the midterm and final exams, and 10 points come from your scores in the warm-up and from this experiment. Note that it is possible for your total score from the warm-up and from this experiment to exceed 10, e.g., you could score 3.3 in the warm-up and 8 in the experiment making your total score from both as 11.3 out of 10. You cannot earn a negative score in this experiment, and hence participating in the experiment cannot cause your score to be lower than if you do not participate.

Your "total benefit" *TB* depends on the goods you own as

$$TB = 10\sqrt{clothes} + 10\sqrt{food} + 10\sqrt{housing} + \text{"other things"},$$

where the labels "clothes", "food", "housing" and "other things" denote the units of these goods owned. Your score from this experiment depends on your "total benefit" as:

if $TB \leq 138$, your score from this experiment is 0.

if $138 \leq TB \leq 186$, your score from this experiment is $\frac{1}{6}(TB - 138)$..

if $186 \leq TB$, your score from this experiment is 8.

Scores are rounded to 1 decimal point. For different values of x, the values of $10\sqrt{x}$ which you are to use to calculate your score are shown in the Appendix.

You start with 100 units of "resources". You can acquire clothes, food, housing and "other things" by manufacture or by trade with somebody else.

Manufacture:

Clothes, food, housing and "other things" may be manufactured. There are three technologies - technologies *A, B* and *C* . Each technology uses different quantities of "resources" as inputs to manufacture a unit of clothes, food and housing. In particular, the "resources" used up to produce a unit of clothes, food or housing using the different technologies are described as:

		Units of "resources" used to manufacture 1 unit of output using technology:		
		A	B	C
Output	clothes	1	3	2
	food	2	1	3
	housing	3	2	1
	"other things"	1	1	1

One third of students can use Technology *A*, one third of students can use Technology *B* and one third of students can use Technology *C*. *You can use only Technology A.*

You manufacture clothes, food and housing for your own use or to trade with other students. "Resources" left over at the end of the experiment are assumed to be used to manufacture "other things".

Trade:

Clothes, food and housing can be traded only for "resources". The buyer of the goods must own the "resources" he/she gives in exchange for the good, and the seller of the goods must own the goods he/she sells. E.g., if you agree to buy 6 food from a student with number 125 at a price of 1.4 (units of "resources" per unit of food), you must have at least 6x1.4=8.4 "resources" on hand and the student with number 125 must have at least 6 food - acquired either by production or by trade.

Only integer units of clothes, food and housing can be manufactured, sold or bought, but prices need not be integers. Trades which have been effected cannot be altered.

The next section describes how to record production, how to record a trade and how to calculate the final contribution towards your grade. The official record of a production decision is a signed production slip. The official record of a trade is a trade slip signed by both you and the student with whom you trade. I will calculate your score using only official records.

A log is provided at the end of these instructions to help you keep track of your decisions. Some production and trade slips are attached. Please bring these to class and please see the instructor if you need more

Class-time on _____ and _____ is put aside for you to produce and to trade. All production and trade must be made in these sessions. Production and trade slips completed during these sessions should be handed in during these sessions. At the end of class on _____ you must return your Final Outcome sheet giving your final ownership of clothes, food, housing, and "resources". At the same time all outstanding production and trade slips must be handed in.

HOW TO RECORD A PRODUCTION DECISION

A sample production slip looks like:

PRODUCTION SLIP: FOR STUDENT USING TECHNOLOGY A

Student with # (1)_____ manufactures (2)_____ units of (3)_____.

Signature: (4)_____.

You record the manufacture of clothes, food or housing by completing the spaces on the production slip as:

(1) write your number.
(2) write the number of units manufactured.
(3) write the product (i.e., clothes, food or housing) manufactured.
(4) write your signature.

After a production slip is completed, it is to be handed to the instructor at the end of the session.

To keep track of your decisions, you should update your log.

EXAMPLE OF PRODUCTION:

Your number is 450 and the last entry in your log looks like:

		Holding after action			
		Clothes	*Food*	*Housing*	*"Resources"*
.....					
11.	*Bought 10 food* for *15* "resources "	*10*	*10*	*14*	*74*

You decide to manufacture 5 units of food. You complete the production slip as:

PRODUCTION SLIP: FOR STUDENT USING TECHNOLOGY A

Student with # (1) *450* manufactures (2) *5* units of (3) *food* .

Signature: (4) *xxxxxxxxxx*

To update your log: write your action in the left part of the log, add 5 units to your holding of food and subtract the inputs used, 10 units, from your holding of "resources". You carry forward your holdings of clothes and housing. Your log now appears as:

		Holding after action			
	Action	*Clothes*	*Food*	*Housing*	*"Resources"*
.....					
11.	*Bought 10 food* for *15* "resources "	*10*	*10*	*14*	*74*
12.	*Manufacture 5 food* for *10* "resources "	*10*	*15*	*14*	*64*

HOW TO RECORD A TRADE

A sample trade slip appears as:

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

A trade is recorded when both buyer and seller complete the spaces on the same trade slip as:

(1) write the number of the student selling the clothes, food or housing.
(2) write the number of the student buying the clothes, food or housing.
(3) write the number of units of clothes, food or housing sold.
(4) write the goods (i.e., clothes, food or housing) sold.
(5) write the agreed price (units of "resources" per unit of good sold).
(6) write the seller's signature.
(7) write the buyer's signature.

After a trade slip is completed, it should be handed to the instructor.

Note: only one trade slip is handed-in for each transaction. The seller and the buyer do NOT each complete a separate trade slip.

Note: the price recorded in (5) is the price *per unit* sold and NOT the total resources transferred.

To keep track of your decisions, you should update your log.

EXAMPLE OF SELLING:

Your number is 450 and the last entry of your log looks like:

	Action	Holding after action Clothes	Food	Housing	"Resources"
.....					
12.	*Manufacture 5 food* for *10* "resources "	*10*	*15*	*14*	*64*

You agree to sell 4 units of housing to the student with number 135 at a price of 1.75 (units of "resources" per unit of housing). You and the buyer together complete a trade slip as:

TRADE SLIP

Student with # (1) *450* sells to student with # (2) *135*

(3) *4* units of (4) *housing*

at a price of (5) *1.75* (units of "resources" per unit of good sold)

Signature of seller: (6) *xxxxxxxxxx* Signature of buyer: (7) *yyyyyyyyyy*

To update your log: write your action in the left part of the log, subtract 4 units from your holdings of housing and add the "resources" gained, 4x1.75=7 units, to your holdings of "resources". You carry forward your holdings of clothes and food. Your log now appears as:

	Action	Holding after action Clothes	Food	Housing	"Resources"
.....					
12.	*Manufacture 5 food* for *10* "resources "	*10*	*15*	*14*	*64*
13.	*Sell 4 housing* for *7* "resources"	*10*	*15*	*10*	*71*

EXAMPLE OF BUYING:

Your number is 450 and the last entry in your log looks like:

				Holding after action			
				Clothes	Food	Housing	"Resources"
.....							
13.	*Sell*	4 *housing*	for 7 "resources"	*10*	*15*	*10*	*71*

You agree to buy 6 units of clothes from the student with number 125 at a price of 1.4 (units of "resources" per unit of clothes). You and the seller together complete a trade slip as:

TRADE SLIP

Student with # (1) *125* sells to student with # (2) *450*

(3) *6* units of (4) *clothes*

at a price of (5) *1.4* (units of "resources" per unit of good sold)

Signature of seller: (6) *zzzzzzzzzz* Signature of buyer: (7) *xxxxxxxxxx*

To update your log: write your action in the left part of the log, add 6 units to your holdings of clothes and subtract the "resources" given up, 6x1.4=8.4 units, from your holdings of "resources". You carry forward your holdings of food and housing. Your log now appears as:

				Holding after action			
	Action			Clothes	Food	Housing	"Resources"
.....							
13.	*Sell*	4 *housing*	for 7 "resources"	*10*	*15*	*10*	*71*
14.	*Buy*	6 *clothe*	for *8.4* "resources"	*16*	*15*	*10*	*62.6*

EXAMPLES OF CALCULATING YOUR SCORE

EXAMPLE 1:The last entry in your log looks like:

	Action	*Holding after action* *Clothes*	*Food*	*Housing*	*"Resources"*
....					
14.	*Buy 6 clothes* for *8.4* "resources"	*16*	*15*	*10*	*62.6*

You use the remaining 62.6 resources to manufacture 62.6 "other things." Your "total benefit" *TB* is calculated as

$$TB = 10\sqrt{16} + 10\sqrt{15} + 10\sqrt{10} + 62.6 = 172.9$$

Your score is

$$\tfrac{1}{6}(172.9 - 138) = 5.8$$

EXAMPLE 2: The last entry in your log looks like:

	Action	*Holding after action* *Clothes*	*Food*	*Housing*	*"Resources"*
.....					
16.	*Sell 8 housing* for *13* "resources"	*3*	*21*	*20*	*21.6*

You use the remaining 21.6 resources to manufacture 21.6 "other things." Your "total benefit" *TB* is calculated as

$$TB = 10\sqrt{3} + 10\sqrt{21} + 10\sqrt{20} + 21.6 = 129.4$$

Because $TB < 138$, your score is 0.

EXAMPLE 3: The last entry in your log looks like:

	Action	*Holding after action* *Clothes*	*Food*	*Housing*	*"Resources"*
.....					
18.	*Buy 4 clothes* for *13* "resources"	*28*	*30*	*16*	*75*

You use the remaining 75 resources to manufacture 75 "other things." Your "total benefit" *TB* is calculated as

$$TB = 10\sqrt{28} + 10\sqrt{30} + 10\sqrt{16} + 75 = 222.8$$

Because *186 <TB*, your score is 8.

FINAL OUTCOME: TO BE HANDED IN

YOUR #: _____

YOUR NAME: _____

I calculate my final outcome as:

Clothes : ____ units.

Food : ____ units.

Housing : ____ units.

I am using any “resources” left over after my manufacturing and trading decisions to manufacture “other things”. I calculate my final amount of “other things” as:

“Other things”: ____ units.

I calculate my "total benefit" as: _____ .

I calculate my score in this experiment as: ____ .

APPENDIX: VALUES OF x AND $10\sqrt{x}$

x	$10\sqrt{x}$
1	10.0
2	14.1
3	17.3
4	20.0
5	22.4
6	24.5
7	26.5
8	28.3
9	30.0
10	31.6
11	33.2
12	34.7
13	36.1
14	37.4
15	38.7
16	40.0
17	41.2
18	42.4
19	43.6
20	44.7
21	45.8
22	46.9
23	48.0
24	49.0
25	50.0
26	51.0
27	52.0
28	53.0
29	53.9
30	54.8
31	55.7
32	56.6
33	57.5
34	58.4
35	59.2
36	60.0
37	60.8
38	61.6
39	62.4
40	63.2

LOG

	Action	*Holding after action* Clothes	Food	Housing	"Resources"
	START	0	0	0	100
1.	_____ _____ _____ for ____ "resources"	____	____	____	_____
2.	_____ _____ _____ for ____ "resources"	____	____	____	_____
3.	_____ _____ _____ for ____ "resources"	____	____	____	_____
4.	_____ _____ _____ for ____ "resources"	____	____	____	_____
5.	_____ _____ _____ for ____ "resources"	____	____	____	_____
6.	_____ _____ _____ for ____ "resources"	____	____	____	_____
7.	_____ _____ _____ for ____ "resources"	____	____	____	_____
8.	_____ _____ _____ for ____ "resources"	____	____	____	_____
9.	_____ _____ _____ for ____ "resources"	____	____	____	_____
10.	_____ _____ _____ for ____ "resources"	____	____	____	_____
11.	_____ _____ _____ for ____ "resources"	____	____	____	_____
12.	_____ _____ _____ for ____ "resources"	____	____	____	_____
13.	_____ _____ _____ for ____ "resources"	____	____	____	_____
14.	_____ _____ _____ for ____ "resources"	____	____	____	_____
15.	_____ _____ _____ for ____ "resources"	____	____	____	_____
16.	_____ _____ _____ for ____ "resources"	____	____	____	_____
17.	_____ _____ _____ for ____ "resources"	____	____	____	_____
18.	_____ _____ _____ for ____ "resources"	____	____	____	_____
19.	_____ _____ _____ for ____ "resources"	____	____	____	_____

Action *Clothes Food Housing "Resources"*

20. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
21. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
22. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
23. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
24. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
25. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
26. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
27. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
28. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
29. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
30. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
31. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
32. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
33. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
34. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
35. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
36. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
37. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
38. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
39. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
40. _____ _____ _____ for ____ "resources" ____ ____ ____ _____

PRODUCTION SLIP

PRODUCTION SLIP: FOR STUDENT USING TECHNOLOGY A

Student with # (1)_____ manufactures (2)_____ units of (3)_____.

Signature: (4)_____.

PRODUCTION SLIP: FOR STUDENT USING TECHNOLOGY A

Student with # (1)_____ manufactures (2)_____ units of (3)_____.

Signature: (4)_____.

PRODUCTION SLIP: FOR STUDENT USING TECHNOLOGY A

Student with # (1)_____ manufactures (2)_____ units of (3)_____.

Signature: (4)_____.

PRODUCTION SLIP: FOR STUDENT USING TECHNOLOGY A

Student with # (1)_____ manufactures (2)_____ units of (3)_____.

Signature: (4)_____.

PRODUCTION SLIP: FOR STUDENT USING TECHNOLOGY A

Student with # (1)_____ manufactures (2)_____ units of (3)_____.

Signature: (4)_____.

PRODUCTION SLIP: FOR STUDENT USING TECHNOLOGY A

Student with # (1)_____ manufactures (2)_____ units of (3)_____.

Signature: (4)_____.

PRODUCTION SLIP: FOR STUDENT USING TECHNOLOGY A

Student with # (1)_____ manufactures (2)_____ units of (3)_____.

Signature: (4)_____.

PRODUCTION SLIP: FOR STUDENT USING TECHNOLOGY A

Student with # (1)_____ manufactures (2)_____ units of (3)_____.

Signature: (4)_____.

PRODUCTION SLIP: FOR STUDENT USING TECHNOLOGY A

Student with # (1)_____ manufactures (2)_____ units of (3)_____.

Signature: (4)_____.

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

APPENDIX E

EXPERIMENT: INSTRUCTIONS FOR STUDENTS WITH TECHNOLOGY B

Your number and technology for this experiment are the same as the ones assigned to you for the warm-up. They are shown on the course web-page , or you can get them by asking the instructor.

These instructions are for students with Technology B. If you have Technology A or C, please read the instructions associated with your technology.

When recording production or trades, you must use the number which has been assigned to you: using a number which has not been assigned to you could affect the score of another student.

This is an experiment in economic decision-making. The instructions are simple and, if you follow them carefully, you can earn points towards your grade.

Out of the 100 possible points used to calculate your final grade, 90 points come from your scores in the midterm and final exams, and 10 points come from your scores in the warm-up and from this experiment. Note that it is possible for your total score from the warm-up and experiment to exceed 10, e.g., you could score 3.3 in the warm-up and 8 in the experiment making your total score from both as 11.3 out of 10. You cannot earn a negative score in this experiment, and hence participating in the experiment cannot cause your score to be lower than if you do not participate.

Your "total benefit" *TB* depends on the goods you own as

$$TB = 10\sqrt{food} + 10\sqrt{housing} + 10\sqrt{clothes} + \text{"other things"},$$

where the labels "food", "housing", "clothes" and "other things" denote the units of these goods owned. Your score from this experiment depends on your "total benefit" as:

if $TB \leq 138$, your score from this experiment is 0 .

if $138 \leq TB \leq 186$, your score from this experiment is $\frac{1}{6}(TB - 138)$.

if $186 \leq TB$, your score from this experiment is 8 .

Scores are rounded to 1 decimal point. For different values of x, the values of $10\sqrt{x}$ which you are to use to calculate your score are shown in the Appendix.

You start with 100 units of "resources". You can acquire food, housing, clothes and "other things" by manufacture, or by trade with somebody else.

Manufacture:

Food, housing, clothes and "other things" may be manufactured. There are three technologies - technologies *A, B* and *C* . Each technology uses different quantities of "resources" as inputs to manufacture a unit of food, housing and clothes. In particular, the "resources" used up to produce a unit of food, housing or clothes using the different technologies are described as:

		Units of "resources" used to manufacture 1 unit of output using technology:		
		B	C	A
Output	food	1	3	2
	housing	2	1	3
	clothes	3	2	1
	"other things"	1	1	1

One third of students can use Technology *A*, one third of students can use Technology *B* and one third of students can use Technology *C*. *You can use only Technology B.*

You manufacture food, housing and clothes for your own use or to trade with other students. "Resources" left over at the end of the experiment are assumed to be used to manufacture "other things".

Trade:

Food, housing and clothes can be traded only for "resources". The buyer of the goods must own the "resources" he/she gives in exchange for the good, and the seller of the goods must own the goods he/she sells. E.g., if you agree to buy 6 housing from Subject 125 at a price of 1.4 (units of "resources" per unit of housing), you must have at least 6x1.4=8.4 "resources" on hand and Subject 125 must have at least 6 housing - acquired either by production or by trade.

Only integer units of food, housing and clothes can be manufactured, sold or bought, but prices need not be integers. Trades which have been effected cannot be altered.

The next section describes how to record production, how to record a trade and how to calculate the final contribution towards your grade. The official record of a production decision is a signed production slip. The official record of a trade is a trade slip signed by both you and the student with whom you trade. I will calculate your score using only official records.

A log is provided at the end of these instructions to help you keep track of your decisions. Some production and trade slips are attached. Please bring these to class and please see the instructor if you need more.

Class-time on _____ and _____ is put aside for you to produce and to trade. All production and trade must be made in these sessions. Production and trade slips completed during these sessions should be handed in during these sessions. At the end of class on _____ you must return your Final Outcome sheet giving your final ownership of food, housing, clothes and "resources". At the same time all outstanding production and trade slips must be handed in.

HOW TO RECORD A PRODUCTION DECISION

A sample production slip looks like:

PRODUCTION SLIP: FOR STUDENT USING TECHNOLOGY B

Student with # (1)_____ manufactures (2)_____ units of (3)_____.

Signature: (4)_____.

You record the manufacture of food, housing or clothes by completing the spaces on the production slip as:

(1) write your subject number.
(2) write the number of units manufactured.
(3) write the product (i.e., food, housing or clothes) manufactured.
(4) write your signature.

After a production slip is completed, it is to be handed to the instructor at the end of the session.

To keep track of your decisions, you should update your log.

EXAMPLE OF PRODUCTION:

Your subject number is 450 and the last entry in your log looks like:

Action	Holding after action Food	Housing	Clothes	"Resources"
.....				
11. *Bought 10 housing* for *15* "resources "	*10*	*10*	*14*	*74*

You decide to manufacture 5 units of housing. You complete the production slip as:

PRODUCTION SLIP: SUBJECT USING TECHNOLOGY B

Subject # (1) *450* manufactures (2) *5* units of (3) *housing*.

Signature: (4) *xxxxxxxxxxxx*

To update your log: write your action in the left part of the log, add 5 units to your holding of housing and subtract the inputs used, 10 units, from your holding of "resources". You carry forward your holdings of food and clothes. Your log now appears as:

Action	Holding after action Food	Housing	Clothes	"Resources"
.....				
11. *Bought 10 housing* for *15* "resources "	*10*	*10*	*14*	*74*
12. *Manufacture 5 housing* for *10* "resources "	*10*	*15*	*14*	*64*

HOW TO RECORD A TRADE

A sample trade slip appears as:

TRADE SLIP

Subject # (1)_____ sells to Subject (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

A trade is recorded when both buyer and seller complete the spaces on the same trade slip as:

(1) write the subject number of the seller of the food, housing or clothes.
(2) write the subject number of the buyer of the food, housing or clothes.
(3) write the number of units of food, housing or clothes sold.
(4) write the goods (i.e., food, housing or clothes) sold.
(5) write the agreed price (units of "resources" per unit of good sold).
(6) write the seller's signature.
(7) write the buyer's signature.

After a trade slip is completed, it should be handed to the instructor at the end of the session.

Note: only one trade slip is handed-in for each transaction. The seller and the buyer do NOT each complete a separate trade slip.

Note: the price recorded in (5) is the price *per unit* exchanged and NOT the total resources transferred.

To keep track of your decisions, you should update your log.

EXAMPLE OF SELLING:

Your subject number is 450 and the last entry of your log looks like:

		Holding after action			
	Action	*Food*	*Housing*	*Clothes*	*"Resources"*
.....					
12.	*Manufacture 5 housing* for *10* "resources "	*10*	*15*	*14*	*64*

You agree to sell 4 units of clothes to Subject 135 at a price of 1.75 (units of "resources" per unit of clothes). You and the buyer together complete a trade slip as:

TRADE SLIP

Subject # (1) *450* sells to Subject (2) *135*

(3) *4* units of (4) *clothes*

at a price of (5) *1.75* (units of "resources" per unit of good sold)

Signature of seller: (6) *xxxxxxxxxx* Signature of buyer: (7) yyyyyyyyyy

To update your log: write your action in the left part of the log, subtract 4 units from your holdings of clothes and add the "resources" gained, 4x1.75=7 units, to your holdings of "resources". You carry forward your holdings of food and housing. Your log now appears as:

		Holding after action			
	Action	*Food*	*Housing*	*Clothes*	*"Resources"*
.....					
12.	*Manufacture 5 housing* for *10* "resources "	*10*	*15*	*14*	*64*
13.	*Sell* 4 *clothes* for *7* "resources"	*10*	*15*	*10*	*71*

EXAMPLE OF BUYING:

Your subject number is 450 and the last entry in your log looks like:

		Holding after action			
		Food	*Housing*	*Clothes*	*"Resources*
.....					
13.	*Sell 4 clothes* for *7* "resources"	*10*	*15*	*10*	*71*

You agree to buy 6 units of food from Subject at a price of 1.4 (units of "resources" per unit of food). You and the seller together complete a trade slip as:

TRADE SLIP

Subject # (1) *125* sells to Subject (2) *450*

(3) *6* units of (4) *food*

at a price of (5) *1.4* (units of "resources" per unit of good sold)

Signature of seller: (6) *zzzzzzzzzz* Signature of buyer: (7) *xxxxxxxxxx*

To update your log: write your action in the left part of the log, add 6 units to your holdings of food and subtract the "resources" given up, 6x1.4 = 8.4 units, from your holdings of "resources". You carry forward your holdings of housing and clothes. Your log now appears as:

		Holding after action			
	Action	*Food*	*Housing*	*Clothes"*	*Resources"*
.....					
13.	*Sell 4 clothes* for *7* "resources"	*10*	*15*	*10*	*71*
14.	*Buy 6 food* for *8.4* "resources"	*16*	*15*	*10*	*62.6*

EXAMPLES OF CALCULATING YOUR SCORE

EXAMPLE 1:The last entry in your log looks like:

	Action	*Holding after action* *Food*	*Housing*	*Clothes*	*"Resources"*
....					
14.	*Buy* 6 *food* for 8.4 "resources"	*16*	*15*	*10*	*62.6*

You use the remaining 62.6 resources to manufacture 62.6 "other things." Your "total benefit" *TB* is calculated as

$$TB = 10\sqrt{16} + 10\sqrt{15} + 10\sqrt{10} + 62.6 = 172.9$$

Your score is

$$\frac{1}{6}(172.9 - 138) = 5.8$$

EXAMPLE 2: The last entry in your log looks like:

	Action	*Holding after action* *Food*	*Housing*	*Clothes*	*"Resources"*
.....					
16.	*Sell* 8 *clothes* for 13 "resources	*3*	*21*	*20*	*21.6*

You use the remaining 21.6 resources to manufacture 21.6 "other things." Your "total benefit" *TB* is calculated as

$$TB = 10\sqrt{3} + 10\sqrt{21} + 10\sqrt{20} + 21.6 = 129.4$$

Because $TB < 138$, your score is 0.

EXAMPLE 3: The last entry in your log looks like:

	Action	*Holding after action* *Food*	*Housing*	*Clothes*	*"Resources"*
.....					
18.	*Buy 4 food* for *13* "resources"	*28*	*30*	*16*	*75*

You use the remaining 75 resources to manufacture 75 "other things." Your "total benefit" *TB* is calculated as

$$TB = 10\sqrt{28} + 10\sqrt{30} + 10\sqrt{16} + 75 = 222.8$$

Because *186 <TB*, your score is 8.

FINAL OUTCOME: TO BE HANDED IN

YOUR #: _____

YOUR NAME: _____

I calculate my final outcome as:

Food : ___ units.

Housing : ___ units.

Clothes : ___ units.

I am using the “resources” left over after my manufacturing and trading decisions to manufacture “other things”. I calculate my final amount of “other things” as:

“Other things” : ___ units.

I calculate my "total benefit" as: _____ .

I calculate my score in this experiment is: ___ .

APPENDIX: VALUES OF x AND $10\sqrt{x}$

x	$10\sqrt{x}$
1	10.0
2	14.1
3	17.3
4	20.0
5	22.4
6	24.5
7	26.5
8	28.3
9	30.0
10	31.6
11	33.2
12	34.7
13	36.1
14	37.4
15	38.7
16	40.0
17	41.2
18	42.4
19	43.6
20	44.7
21	45.8
22	46.9
23	48.0
24	49.0
25	50.0
26	51.0
27	52.0
28	53.0
29	53.9
30	54.8
31	55.7
32	56.6
33	57.5
34	58.4
35	59.2
36	60.0
37	60.8
38	61.6
39	62.4
40	63.2

LOG

Action	*Holding after action* Food	Housing	Clothes	Resources"
START	0	0	0	100
1. _____ _____ _____ for ___ "resources"	____	____	____	_____
2. _____ _____ _____ for ___ "resources"	____	____	____	_____
3. _____ _____ _____ for ___ "resources"	____	____	____	_____
4. _____ _____ _____ for ___ "resources"	____	____	____	_____
5. _____ _____ _____ for ___ "resources"	____	____	____	_____
6. _____ _____ _____ for ___ "resources"	____	____	____	_____
7. _____ _____ _____ for ___ "resources"	____	____	____	_____
8. _____ _____ _____ for ___ "resources"	____	____	____	_____
9. _____ _____ _____ for ___ "resources"	____	____	____	_____
10. _____ _____ _____ for ___ "resources"	____	____	____	_____
11. _____ _____ _____ for ___ "resources"	____	____	____	_____
12. _____ _____ _____ for ___ "resources"	____	____	____	_____
13. _____ _____ _____ for ___ "resources"	____	____	____	_____
14. _____ _____ _____ for ___ "resources"	____	____	____	_____
15. _____ _____ _____ for ___ "resources"	____	____	____	_____
16. _____ _____ _____ for ___ "resources"	____	____	____	_____
17. _____ _____ _____ for ___ "resources"	____	____	____	_____
18. _____ _____ _____ for ___ "resources"	____	____	____	_____
19. _____ _____ _____ for ___ "resources"	____	____	____	_____

Action *Food Housing Clothes "Resources"*

20. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
21. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
22. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
23. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
24. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
25. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
26. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
27. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
28. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
29. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
30. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
31. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
32. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
33. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
34. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
35. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
36. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
37. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
38. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
39. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
40. _____ _____ _____ for ____ "resources" ____ ____ ____ _____

PRODUCTION SLIP

PRODUCTION SLIP: FOR STUDENT USING TECHNOLOGY B

Student with # (1)_____ manufactures (2)_____ units of (3)_____.

Signature: (4)_____.

PRODUCTION SLIP: FOR STUDENT USING TECHNOLOGY B

Student with # (1)_____ manufactures (2)_____ units of (3)_____.

Signature: (4)_____.

PRODUCTION SLIP: FOR STUDENT USING TECHNOLOGY B

Student with # (1)_____ manufactures (2)_____ units of (3)_____.

Signature: (4)_____.

PRODUCTION SLIP: FOR STUDENT USING TECHNOLOGY B

Student with # (1)_____ manufactures (2)_____ units of (3)_____.

Signature: (4)_____.

PRODUCTION SLIP: FOR STUDENT USING TECHNOLOGY B

Student with # (1)_____ manufactures (2)_____ units of (3)_____.

Signature: (4)_____.

PRODUCTION SLIP: FOR STUDENT USING TECHNOLOGY B

Student with # (1)_____ manufactures (2)_____ units of (3)_____.

Signature: (4)_____.

PRODUCTION SLIP: FOR STUDENT USING TECHNOLOGY B

Student with # (1)_____ manufactures (2)_____ units of (3)_____.

Signature: (4)_____.

PRODUCTION SLIP: FOR STUDENT USING TECHNOLOGY B

Student with # (1)_____ manufactures (2)_____ units of (3)_____.

Signature: (4)_____.

PRODUCTION SLIP: FOR STUDENT USING TECHNOLOGY B

Student with # (1)_____ manufactures (2)_____ units of (3)_____.

Signature: (4)_____.

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

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at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

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Signature of seller: (6)_____ Signature of buyer: (7)_____

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at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

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at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

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(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

APPENDIX F

EXPERIMENT: INSTRUCTIONS FOR STUDENTS WITH TECHNOLOGY C

Your number and technology for this experiment are the same as the ones assigned to you for the warm-up. They are shown on the course web-page, or you can get them by asking the instructor.

These instructions are for students with Technology C. If you have Technology A or B, please read the instructions associated with your technology.

When recording production or trades, you must use the number which has been assigned to you: using a number which has not been assigned to you could affect the score of another student.

This is an experiment in economic decision-making. The instructions are simple and, if you follow them carefully, you can earn points towards your grade.

Out of the 100 possible points used to calculate your final grade, 90 points come from your scores in the midterm and final exams, and 10 points come from your scores in the warm-up and from this experiment. Note that it is possible for your total score from the warm-up and the experiment to exceed 10, e.g., you could score 3.3 in the warm-up and 8 in the experiment making your total score from both as 11.3 out of 10. You cannot earn a negative score in this experiment, and hence participating in the experiment cannot cause your score to be lower than if you do not participate.

Your "total benefit" *TB* depends on the goods you own as

$$TB = 10\sqrt{housing} + 10\sqrt{clothes} + 10\sqrt{food} + \text{"other things"},$$

where the labels "housing", "clothes", "food" and "other things" denote the units of these goods owned. Your score from this experiment depends on your "total benefit" as:

if $TB \leq 138$, your score from this experiment is 0.

if $138 \leq TB \leq 186$, your score from this experiment is $\frac{1}{6}(TB - 138)$.

if $186 \leq TB$, your score from this experiment is 8.

Scores are rounded to 1 decimal point. For different values of x, the values of $10\sqrt{x}$

which you are to use to calculate your score are shown in the Appendix.

You start with 100 units of "resources". You can acquire housing, clothes, food and "other things" by manufacture, or by trade with somebody else.

Manufacture:

Housing, clothes, food and "other things" may be manufactured. There are three technologies - technologies *A, B* and *C* . Each technology uses different quantities of "resources" as inputs to manufacture a unit of housing, clothes and food. In particular, the "resources" used up to produce a unit of housing, clothes or food using the different technologies are described as:

		Units of "resources" used to manufacture 1 unit of output using technology:		
		C	A	B
Output	housing	1	3	2
	clothes	2	1	3
	food	3	2	1
	"other things"	1	1	1

One third of students can use Technology *A*, one third of students can use Technology *B* and one third of students can use Technology *C*. *You can use only Technology C.*

You manufacture housing, clothes and food for your own use or to trade with other students. "Resources" left over at the end of the experiment are assumed to be used to manufacture "other things".

Trade:

Housing, clothes and food can be traded only for "resources". The buyer of the goods must own the "resources" he/she gives in exchange for the good, and the seller of the goods must own the goods he/she sells. E.g., if you agree to buy 6 clothes from Subject 125 at a price of 1.4 (units of "resources" per unit of clothes), you must have at least 6x1.4=8.4 "resources" on hand and Subject 125 must have at least 6 clothes - acquired either by production or by trade.

Only integer units of housing, clothes and food can be manufactured, sold or bought, but prices need not be integers. Trades which have been effected cannot be altered.

The next section describes how to record production, how to record a trade and how to calculate the final contribution towards your grade. The official record of a production decision is a signed production slip. The official record of a trade is a trade slip signed by both you and the student with whom you trade. I will calculate your score using only official records.

A log is provided at the end of these instructions to help you keep track of your decisions. Some production and trade slips are attached. Please bring these to class and please see the instructor if you need more.

Class-time on _____ and _____ is put aside for you to trade. All production and trade must be made in these sessions. Production and trade slips completed during these sessions should be handed in during these sessions. At the end of class on _____ you must return your Final Outcome sheet giving your final ownership of housing, clothes, food and "resources". At the same time all outstanding production and trade slips must be handed in.

HOW TO RECORD A PRODUCTION DECISION

A sample production slip looks like:

PRODUCTION SLIP: SUBJECT USING TECHNOLOGY C

Subject # (1)_____ manufactures (2)_____ units of (3)_____.

Signature: (4)_____.

You record the manufacture of housing, clothes or food by completing the spaces on the production slip as:

(1) write your subject number.
(2) write the number of units manufactured.
(3) write the product (i.e., housing, clothes or food) manufactured.
(4) write your signature.

After the production slip is completed, it is to be handed to the instructor at the end of the session.

To keep track of your decisions, you should update your log.

EXAMPLE OF PRODUCTION:

Your subject number is 450 and the last entry in your log looks like:

		Holding after action			
		Housing	*Clothes*	*Food*	*"Resources"*
.....					
11.	*Bought 10 clothes* for *15* "resources "	*10*	*10*	*14*	*74*

You decide to manufacture 5 units of clothes. You complete the production slip as:

PRODUCTION SLIP: SUBJECT USING TECHNOLOGY C

Subject # (1) *450* manufactures (2) *5* units of (3) *clothes*

Signature: (4) *xxxxxxxxxxxxx*

To update your log: write your action in the left part of the log, add 5 units to your holding of clothes and subtract the inputs used, 10 units, from your holding of "resources". You carry forward your holdings of housing and food. Your log now appears as:

		Holding after action			
	Action	*Housing*	*Clothes*	*Food*	*"Resources"*
.....					
11.	*Bought 10 clothes* for *15* "resources "	*10*	*10*	*14*	*74*
12.	*Manufacture 5 clothes* for *10* "resources "	*10*	*15*	*14*	*64*

HOW TO RECORD A TRADE

A sample trade slip appears as:

TRADE SLIP

Subject # (1)_____ sells to Subject (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

A trade is recorded when both buyer and seller complete the spaces on the same trade slip as:

(1) write the subject number of the seller of the housing, clothes or food.
(2) write the subject number of the buyer of the housing, clothes or food.
(3) write the number of units of housing, clothes or food sold.
(4) write the goods (i.e., housing, clothes or food) sold.
(5) write the agreed price (units of "resources" per unit of good sold).
(6) write the seller's signature.
(7) write the buyer's signature.

If a trade slip is completed, it should be given to the instructor.

Note: only one trade slip is handed-in for each transaction. The seller and the buyer do NOT each complete a separate trade slip.

Note: the price recorded in (5) is the price *per unit* sold and NOT the total resources transferred.

To keep track of your decisions, you should update your log.

EXAMPLE OF SELLING:

Your subject number is 450 and the last entry of your log looks like:

	Action	Holding after action Housing	Clothes	Food	"Resources"
.....					
12.	*Manufacture 5 clothes* for *10* "resources "	*10*	*15*	*14*	*64*

You agree to sell 4 units of food to Subject 135 at a price of 1.75 (units of "resources" per unit of food). You and the buyer together complete a trade slip as:

TRADE SLIP

Subject # (1) *450* sells to Subject (2) *135*

(3) *4* units of (4) *food*

at a price of (5) *1.75* (units of "resources" per unit of good sold)

Signature of seller: (6) *xxxxxxxxxx* Signature of buyer: (7) yyyyyyyyyy

To update your log: write your action in the left part of the log, subtract 4 units from your holdings of food and add the "resources" gained, 4x1.75=7 units, to your holdings of "resources". You carry forward your holdings of housing and clothes. Your log now appears as:

	Action	Holding after action Housing	Clothes	Food	"Resources"
.....					
12.	*Manufacture 5 clothes* for *10* "resources "	*10*	*15*	*14*	*64*
13.	*Sell* 4 *food* for *7* "resources"	*10*	*15*	*10*	*71*

EXAMPLE OF BUYING:

Your subject number is 450 and the last entry in your log looks like:

		Holding after action			
		Housing	*Clothes*	*Food*	*"Resources*
.....					
13.	*Sell 4 food* for *7* "resources"	*10*	*15*	*10*	*71*

You agree to buy 6 units of housing from Subject 125 at a price of 1.4 (units of "resources" per unit of housing). You and the seller together complete a trade slip as:

TRADE SLIP

Subject # (1) *125* sells to Subject (2) *450*

(3) *6* units of (4) *housing*

at a price of (5) *1.4* (units of "resources" per unit of good sold)

Signature of seller: (6) *zzzzzzzzzz* Signature of buyer: (7) *xxxxxxxxxx*

To update your log: write your action in the left part of the log, add 6 units to your holdings of housing and subtract the "resources" given up, 6x1.4 = 8.4 units, from your holdings of "resources". You carry forward your holdings of clothes and food. Your log now appears as:

		Holding after action			
	Action	*Housing*	*Clothes*	*Food*	*"Resources"*
.....					
13.	*Sell 4 food* for *7* "resources"	*10*	*15*	*10*	*71*
14.	*Buy 6 housing* for *8.4* "resources"	*16*	*15*	*10*	*62.6*

EXAMPLES OF CALCULATING YOUR SCORE

EXAMPLE 1: The last entry in your log looks like:

	Action	*Holding after action* *Housing*	*Clothes*	*Food*	*"Resources"*
....					
14.	*Buy* 6 *housing* for *8.4* "resources"	*16*	*15*	*10*	*62.6*

You use the remaining 62.6 resources to manufacture 62.6 "other things." Your "total benefit" *TB* is calculated as

$$TB = 10\sqrt{16} + 10\sqrt{15} + 10\sqrt{10} + 62.6 = 172.9$$

Your score is

$$\tfrac{1}{6}(172.9 - 138) = 5.8$$

EXAMPLE 2: The last entry in your log looks like:

	Action	*Holding after action* *Housing*	*Clothes*	*Food*	*"Resources"*
.....					
16.	*Sell* 8 *food* for *13* "resources"	*3*	*21*	*20*	*21.6*

You use the remaining 21.6 resources to manufacture 21.6 "other things." Your "total benefit" *TB* is calculated as

$$TB = 10\sqrt{3} + 10\sqrt{21} + 10\sqrt{20} + 21.6 = 129.4$$

Because $TB < 138$, your score is 0.

EXAMPLE 3: The last entry in your log looks like:

	Action	*Holding after action* *Housing*	*Clothes*	*Food*	*"Resources"*
.....					
18.	*Buy 4 housin* for *13* "resources"	*28*	*30*	*16*	*75*

You use the remaining 75 resources to manufacture 75 "other things." Your "total benefit" *TB* is calculated as

$$TB = 10\sqrt{28} + 10\sqrt{30} + 10\sqrt{16} + 75 = 222.8.$$

Because *186 <TB*, your score is 8.

FINAL OUTCOME: TO BE HANDED IN

YOUR #: _____

YOUR NAME: _____

I calculate my final outcome as:

Housing : ____ units.

Clothes : ____ units.

Food : ____ units.

I am using the “resources” left over after my manufacturing and trading decisions to manufacture “other things”. I calculate my final amount of “other things” as:

“Other things” : ____ units.

I calculate my "total benefit" as: _____ .

I calculate my score in this experiment is: ____ .

APPENDIX: VALUES OF x AND $10\sqrt{x}$

x	$10\sqrt{x}$
1	10.0
2	14.1
3	17.3
4	20.0
5	22.4
6	24.5
7	26.5
8	28.3
9	30.0
10	31.6
11	33.2
12	34.7
13	36.1
14	37.4
15	38.7
16	40.0
17	41.2
18	42.4
19	43.6
20	44.7
21	45.8
22	46.9
23	48.0
24	49.0
25	50.0
26	51.0
27	52.0
28	53.0
29	53.9
30	54.8
31	55.7
32	56.6
33	57.5
34	58.4
35	59.2
36	60.0
37	60.8
38	61.6
39	62.4
40	63.2

LOG

Action	*Holding after action* Housing	Clothes	Food	"Resources"
START	0	0	0	100
1. _____ _____ _____ for ___ "resources"	___	___	___	_____
2. _____ _____ _____ for ___ "resources"	___	___	___	_____
3. _____ _____ _____ for ___ "resources"	___	___	___	_____
4. _____ _____ _____ for ___ "resources"	___	___	___	_____
5. _____ _____ _____ for ___ "resources"	___	___	___	_____
6. _____ _____ _____ for ___ "resources"	___	___	___	_____
7. _____ _____ _____ for ___ "resources"	___	___	___	_____
8. _____ _____ _____ for ___ "resources"	___	___	___	_____
9. _____ _____ _____ for ___ "resources"	___	___	___	_____
10. _____ _____ _____ for ___ "resources"	___	___	___	_____
11. _____ _____ _____ for ___ "resources"	___	___	___	_____
12. _____ _____ _____ for ___ "resources"	___	___	___	_____
13. _____ _____ _____ for ___ "resources"	___	___	___	_____
14. _____ _____ _____ for ___ "resources"	___	___	___	_____
15. _____ _____ _____ for ___ "resources"	___	___	___	_____
16. _____ _____ _____ for ___ "resources"	___	___	___	_____
17. _____ _____ _____ for ___ "resources"	___	___	___	_____
18. _____ _____ _____ for ___ "resources"	___	___	___	_____
19. _____ _____ _____ for ___ "resources"	___	___	___	_____

Action *Housing Clothes Food "Resources"*

20. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
21. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
22. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
23. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
24. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
25. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
26. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
27. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
28. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
29. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
30. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
31. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
32. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
33. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
34. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
35. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
36. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
37. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
38. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
39. _____ _____ _____ for ____ "resources" ____ ____ ____ _____
40. _____ _____ _____ for ____ "resources" ____ ____ ____ _____

PRODUCTION SLIP

PRODUCTION SLIP: FOR STUDENT USING TECHNOLOGY C

Student with # (1)_____ manufactures (2)_____ units of (3)_____.

Signature: (4)_____.

PRODUCTION SLIP: FOR STUDENT USING TECHNOLOGY C

Student with # (1)_____ manufactures (2)_____ units of (3)_____.

Signature: (4)_____.

PRODUCTION SLIP: FOR STUDENT USING TECHNOLOGY C

Student with # (1)_____ manufactures (2)_____ units of (3)_____.

Signature: (4)_____.

PRODUCTION SLIP: FOR STUDENT USING TECHNOLOGY C

Student with # (1)_____ manufactures (2)_____ units of (3)_____.

Signature: (4)_____.

PRODUCTION SLIP: FOR STUDENT USING TECHNOLOGY C

Student with # (1)_____ manufactures (2)_____ units of (3)_____.

Signature: (4)_____.

PRODUCTION SLIP: FOR STUDENT USING TECHNOLOGY C

Student with # (1)_____ manufactures (2)_____ units of (3)_____.

Signature: (4)_____.

PRODUCTION SLIP: FOR STUDENT USING TECHNOLOGY C

Student with # (1)_____ manufactures (2)_____ units of (3)_____.

Signature: (4)_____.

PRODUCTION SLIP: FOR STUDENT USING TECHNOLOGY C

Student with # (1)_____ manufactures (2)_____ units of (3)_____.

Signature: (4)_____.

PRODUCTION SLIP: FOR STUDENT USING TECHNOLOGY C

Student with # (1)_____ manufactures (2)_____ units of (3)_____.

Signature: (4)_____.

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

TRADE SLIP

Student with # (1)_____ sells to student with # (2)_____

(3)_____ units of (4)_____

at a price of (5)_____ (units of "resources" per unit of good sold)

Signature of seller: (6)_____ Signature of buyer: (7)_____

APPENDIX G: AN ALGORITHM TO CALCULATE SCORES IN THE EXPERIMENT

As noted in Section 3.4, I find many students make mistakes in recording their logs. I therefore recreate the production and trade flows, and then compute each student's score. I describe below the algorithm I use:

First I sort the production and trade slips into separate piles, and number them so that if a student queries a transaction I can readily find it. I enter this data into a spreadsheet as:

PRODUCTION					
(1) Transaction #	(2) Student #	(3) Technology	(4) Quantity Produced	(5) Product Type	
1	17	B	18	F	
2	4	A	9	C	
3	23	B	12	H	
...	...	...	...	...	
TRADE					
(1) Transaction #	(2) Seller #	(3) Buyer #	(4) Quantity Exchanged	(5) Product Type	(6) Price
1	17	4	8	F	1.6
2	23	17	4	H	1.7
3	4	17	4	C	1.3
...	..	...	...	...	...

I copy the trade date, interchanging Columns (2) and (3) so that Column (2) now lists the buyer and Column (3) now lists the seller, and paste below the original trade data as:

PRODUCTION					
(1) Transaction #	(2) Student #	(3) Technology	(4) Quantity Produced	(5) Product Type	(6) Cost (per unit)
1	17	B	18	F	1
2	4	A	9	C	1
3	23	B	12	H	2
...	...	...	...	...	
TRADE					
(1) Transaction #	(2) Seller #	(3) Buyer #	(4) Quantity sold	(5) Product Type	(6) Price (per unit)
1	17	4	8	F	1.6
2	23	17	4	H	1.7
3	4	17	4	C	1.3
...	..	...	...	...	...
(1) Transaction #	(2) Buyer #	(3) Seller #	(4) Quantity bought	(5) Product Type	(6) Price (per unit)
1	4	17	8	F	1.6
2	17	23	4	H	1.7
3	17	4	4	C	1.3
...	...	...	...	...	...

Using the spreadsheet above, I create the spreadsheet below. In particular, quantity (Column (5)) is either quantity sold pre-multiplied by -1 (to reflect that a sale lowers the quantity owned of the good) or quantity produced or quantity bought. The resource change (Column (8)) is calculated as:

- quantity x price or cost

where the negative sign is introduced because a sale is associated with the gain of resources and production or a purchase is associated with the loss of resources.

(1) Transaction	(2) Student #	(3) Transaction type	(4) Trading partner or technology	(5) Quantity	(6) Product	(7) Price/Cost (per unit)	(8) Resource Change
1	17	Produce	B	+18	F	1	-18
2	4	Produce	A	+9	C	1	- 9
3	23	produce	B	+12	H	2	- 24
...	...	...	...	...	...		...
1	17	sell	4	-8	F	1.6	+12.8
2	23	sell	17	-4	H	1.7	+6.8
3	4	sell	17	-4	C	1.3	+5.2
...	...	...	...	...	...	...	...
1	4	buy	17	+8	F	1.6	-12.8
2	17	buy	23	+4	H	1.7	-6.8
3	17	buy	4	+4	C	1.3	-5.2
...	...	...	...	...	...	...	...

Sorting by Column (2) and then Column (6) and then Column (5) gives the table:

(1) Transaction	(2) Student #	(3) Transaction type	(4) Trading partner or technology	(5) Quantity	(6) Product	(7) Cost/Price (per unit)	(8) Resource Change
3	4	sell	17	-4	C	1.3	+5.2
2	4	produce	A	+9	C	1	-9
1	4	buy	17	+8	F	1.6	-12.8
...	...	...	...	...	...	...	...
3	17	buy	4	+4	C	1.3	-5.2
1	17	sell	4	-8	F	1.6	12.8
1	17	produce	B	+18	F	1	-18
2	17	buy	23	+4	H	1.7	-6.8
...	...	...	...	...	...	...	...
2	23	sell	17	-4	H	1.7	+6.8
3	23	produce	B	+12	H	2	-24
...	...	...	...	...	...	...	...

With the spreadsheet organized as above, the final quantities of clothes, food, housing and “other things” is readily calculated. E.g. the student with number 4 has -4 + 9 = +5 units of clothes, +8

units of food, 0 units of housing and 100 + 5.2 - 9 -12.8 units of "other things"; these numbers are entered in a new spreadsheet to facilitate the calculation of the total benefit and the score for each student.[24]

Student #	clothes	food	housing	other things	total benefit	score
4	5	8	0	83.4	134.1	0
...	...	...	...	...	...	...
17	4	10	4	82.8	154.4	2.7
...	...	...	...	...	...	...
23	0	0	8	82.8	111.1	0
...	...	...	...	...	...	...

It typically takes me (or my Teaching Assistant) 15 hours to complete the spreadsheet for the Experiment with 200 students (it is much quicker for fewer students).

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ENDNOTES

1. Hazlett (2006) provides a useful overview of running market experiments in the classroom.

2. This "symmetry in opportunity" is also present in Anderson et al. (2005).

3. Bernard and Schulze (2000) describe an experiment designed to assist students in seeing the connection between the marginal cost curve and the supply curve.

4. Of course, there is no particular reason why the instructor cannot reveal to all students the full distribution of values and costs.

5. I believe this aspect is not sufficiently stressed in most introductory classes.

6. A wise selling strategy is to sell to any buyer bidding a price above the seller's cost.

7. Often, when a trading pit is used, each completed trade is reported to the instructor who then posts the price on the blackboard. In large classes I find there is not sufficient time to make such announcements and I do not follow this "public disclosure" rule.

8. Motivation is likely to be an issue in the large classes often taught at the undergraduate introductory level.

9. Alternatively, the pay-off could be made as points which form extra credit.

10. For example, in the Experiment the competitive prediction is a score of 6.2. In Principles of Microeconomics Fall 2005, the mean score was 4.1 and the standard deviation was 2.7; in Intermediate Microeconomics Spring 2007, the mean score was 4.5 and the standard deviation

was 2.9. For Microeconomics for MA students in Fall 1996, the mean score was 6.1 and the standard deviation was 0.9.

12. Note that the objective is linear and separable in *x* (the numeraire) and so an analysis based on consumer and producer surplus is appropriate.

13. Davis and Holt (1993) suggest that it is good practice to avoid reference to any particular good in order to prevent unobserved connotations biasing the results. I believe that the typical student in an introductory class prefers labeling goods as "clothes", "food", "housing" and "other things" to more abstract labeling "*c*", "*f*", "*h*" and "*x*". However, abstract labeling may be used if desired.

14. I want a unit change in a student's quantity of *c*, *f* or *h* to provide a reasonable change in the student's objective (facilitating calculation by the student) without a large change in his score. The use of the twin objectives *TB* and *S* facilitates this. I find that all students realize that maximizing S_1 is equivalent to maximizing *TB* and chose to maximize *TB* as being easier. But a large change in *TB* gives a relatively small change in the student's score S_1 .

15. The values of $10\sqrt{i}$ are rounded to one decimal and, in order to be consistent with the Law Of Diminishing Marginal Benefit, slightly adjusted so that $10\sqrt{i} - 10\sqrt{i-1}$ decreases steadily as *i* increases.

16. The units on the vertical axis in Figure 1 are "Units of "other things" per unit of clothes" because the marginal benefit is technically measured as the units of numeraire ("other things")

which gives the same increase in benefit as the unit of clothes, and the marginal cost is measured as the units of numeraire ("other things") foregone when a unit of clothes is manufactured.

17. It is easy to rephrase the analysis using the comparison of the marginal rate of substitution and the opportunity cost.

19. I set the course scoring as follows. A student's course score is out of 100 points. I divide these points between the class exams and the experiment as: 90 points from the class exams and 10 points from the Warm-up and the Experiment. If a student's score is S_1 in the Warm-up and S_2 in the Experiment, he scores $S_1 + S_2$ out of 10 for the full experiment. Note that a student scoring 3.3 in the Warm-Up and 8 in the Experiment has a score for the full experiment of 11.3 out of 10.

20. This is why, unlike in the experiments of Chamberlin (1948), Smith (1962) and others, my instructions inform each student of all the existing technologies.

21. At the Pareto-efficient outcome, individuals with the least cost method of manufacturing a good may either manufacture units for own use or acquire units from others with the same technology. In practice, very few units are bought by individuals having the least cost method of manufacturing that good (in the experiment described, 320 units of good were bought by individuals who had the least cost method of manufacturing that good), and I ignore this potential trade in my discussions.

22. The instructions for each student include a log, 9 production slips and 20 trade slips and the instructions tell the student to bring these to the class. In addition, for a class of 200 students, I

bring in 80 additional production slips, 200 additional trade slips and 10 additional logs. These quantities may be pro-rated for smaller classes.

[24] If a student's final quantity of clothes, food or housing is negative (i.e. the student's sales exceeds his production plus purchases), I "correct" the entry by forcing the student to manufacture the shortage. E.g. a student has Technology B and his entry for clothes is -6. I force the student to manufacture 6 additional units of clothes and reduce his "other things" by 18.