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 underd89r2 350.33 Tm[(50)]TJET0BT1 0 0.(Sa Tm[(50)]T

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

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.

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:

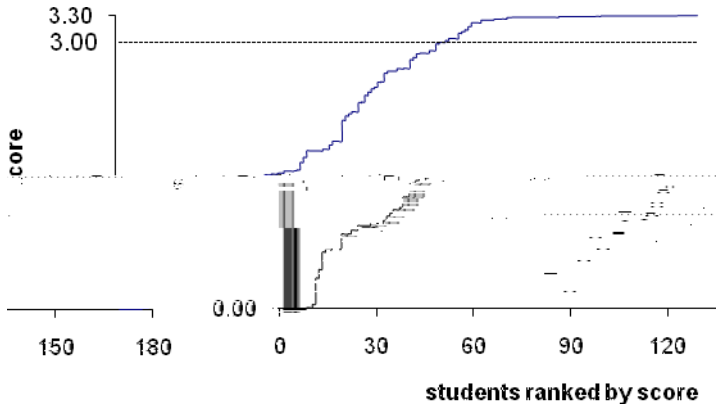
		Units of “resources” used to manufacture 1 unit of output using technology:		
		A	B	C
Output	clothes	1	3	2
	food	2	1	3
	housing	3	2	1
	“other things”	1	1	1

Table 1: the three technologies

One-third of the students are assigned Technology *A*, one-third of students are assigned Technology *B*

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:

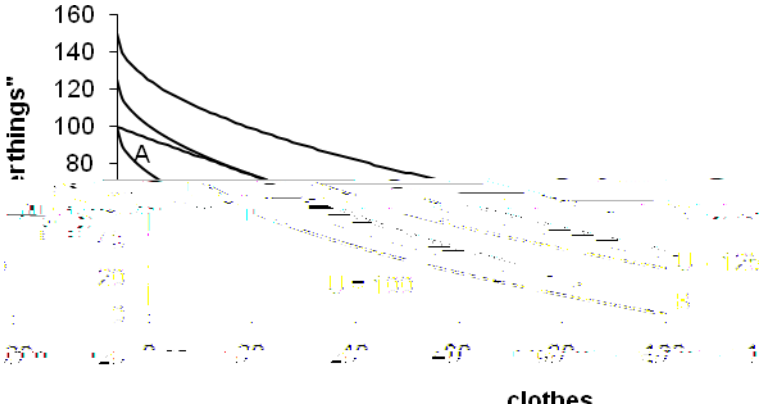


Figure 2: indifference curve analysis

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

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

3.3 Discussion

3.3.1 Power Of Prediction

Studen ɋ ɋ ɳ ɻ Ɋ

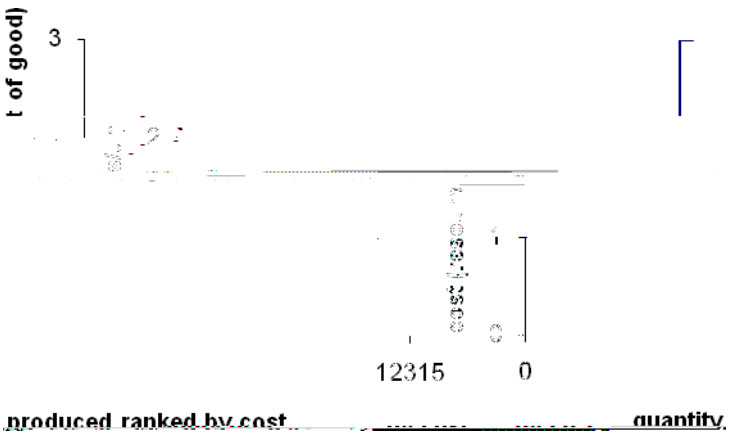
the competitive price is a good prediction for the price of most trades in the second class put aside for trading, when students have become experienced.

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

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

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. Tre

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.

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*

with: “The experiment.” Although the principal benefit of the experiment is that it provides the students with t

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

		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.

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* .

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:

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	

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:

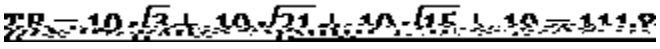
$$\frac{1}{6}(128.7 - 126) = 0.45.$$

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:



Because *TB* ≤ *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 “r

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

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

if $186 \le TB$, 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 "					

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)

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:

TRADEq/l-113(L)1(pI)13(P]TJETQq72.384 503.77 46

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

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

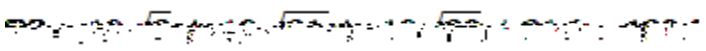
Your score is

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

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



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 #:

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"	____	____	____	_____

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)2.42 Tm[ )]TJETQ EMC /P <</MCID 6>>0.34 Tm[()5(3)-6())]TJETQq72.384 52

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) 79 Tm0 g[ )]TJETQ5eJe18 retPgi[79 Tm0 g"5JEETQq72.3

TRADE SLIP

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

(3)_____ units of (4)_____

at a price of (5)

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)

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)

TRADE SLIP

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

(3)

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

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)

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

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 subjeco 410.95 Tm[((1))I.95 Tl 667.78 Tm[3j)-9..02 410.95 Tm[((1))BT1 0 0 1 431.71Nd-A

EXAMPLE OF PRODUCTION:

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

		Holding after action			
	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*

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 eac (e)3S024 245.3

EXAMPLE OF SELLING:

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

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)

LOG

Holding after action

	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.								

"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)_____.

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) 306.05 565.42 T(u)-

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)_____

TRADE SLIP

Student with # (1)

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

TRADE SLIP

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

(3)_____ units of (4)_____

at a price of (5) Qq72.384 519.07 467.35 200.21 reW*nBT1 0 0 1 190.94 620.62 77.059

_____

TRADE SLIP

Student with # (1)

APPENDIX F

EXPERIMENT: INSTRUCTIONS FOR STUDENTS WITH TECHNOLOGY C

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

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 produc

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:

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:

		Holding after action			
	Action	*Housing*	*Clothes*	*Food*	*"Resources"*
.....					
12.	*Manufacture*				

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

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

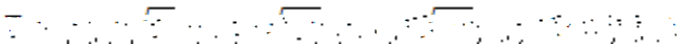
Your score is

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

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



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" ____ -9( )]TJETBT1 0 0 1 279.177/"(JETBT7 301 0 0 1 303.17
38.

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)

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)

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)

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)

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 Ty q306.4

PRODUCTION

(1)

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).

REFERENCES

Anderson, L.R., E. Blanchard, K. Chaston, C. Holt, L. Razzolini and R. Singleton. 2005. Production and Gains from Trade. Working Paper of the College of William and Mary 16.

Bergstrom, T.C. and J.H.Miller. 2000. Experiments with Economic Principles: Microeconomics. New York, NY: Irwin McGraw-Hill.

Bernard, J.C. and W. Schulze. 2000. Teaching Marginal Cost, Supply and Efficiency with an English-Auction Experiment. Journal of Economic Education 31:52-59.

Chiang, E.P. 2007. Asymmetric Information, Bargaining and Comparative Advantage in Trade Relationships: An Interactive Game. Southern Economic Journal 74: 601-608.

Chamberlin, E. H. 1948. An experimental imperfect market. Journal of Political Economy 56: 95-108.

Davis, D. D. and C. A. Holt. 1993. Experimental Economics. Princeton, NJ: Princeton University Press.

Gremmen, H. and J. Potters. 1997. Assessing the efficiency of gaming in economic education. Journal of Economic Education 28: 291-303.

Hazlett, D. 2006. Using Classroom Experiments to Teach Economics. In Teaching Economics: More Alternatives to Chalk and Talk, edited by W.E. Becker, M. Watts and S.R. Becker. Northampton, MA: Edward Elgar.

Holt, C.A. 2007. Markets, Games, & Strategic Behavior. New York, NY: Pearson Addison Wesley

Smith, V. L. 1962. An experimental study of competitive market behavior. Journal of Political Economy 70: 111-137.

Smith, V.L. 1964. Effect of market organization on competitive equilibrium. Quarterly Journal of Economics 78: 181-201

ENDNOTES

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

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")