A GAME FOR TEACHING MICRO-ECONOMICS

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Abstract

As part of courses in micro-economics a game has been developed which teaches students to apply basic economic theories and concepts. The theoretical background of the game is a neoclassical general equilibrium model. Players make decisions about production, investment, consumption, labour supply or trade in a simplified market framework. Although most students enjoy playing the game, a very transparant comment by the game leader is necessary for obtaining good didactic results. Students who played the game have higher scores on a test on micro-economics.

PURPOSE OF THE GAMES

Most students have difficulties in grasping micro-economic theory. Basic concepts in micro-economics such as marginal utility, price elasticity of demand, and equilibrium are difficult to understand for students partly because it is not possible to perceive those abstract concepts directly in the "real" world. This has been a motive to create a game world, where students are forced to use these concepts in making their decisions. A family of game economies has been developed that is consistent with neoclassical textbook micro-economic theory. They are designed to fill the gap between abstract theory and the real world.

During the game the players have to solve micro-economic problems. Their experiences may help them in developing an intuition for the relevance of micro-economic theory. For example, the players make decisions that are modelled in micro-economic consumption theory. This theory assumes that consumers maximize their utility. In the game the abstract idea of a utility function is made concrete in the shape of score boards. The score boards show the utilities of the products. Utility is measured cardinally in points. When deciding to buy or not to buy the players have to compare the number of points of the products they get with the number of points they give away. This is a kind of reasoning the students are familiar with in other games. But at the same time it has a deep theoretical foundation. In comparing points, the students compare marginal utilities, a core concept in micro-econononomic theory.

This basic idea can be used for the development of a whole group of games. At this moment three varieties have been developed. The first game is focused on trade and consumption. It is a prerequisite for all other games to understand this simple game. The second game extends the first game with investment and production. The third game is focused on labour supply and social security. All games can be used for positive analyses of the basic micro-economic mechanisms as well as for welfare theoretical evaluation of economic systems.

PRINCIPLES OF THE GAMES

The games are derived from neoclassical general equilibrium theory. The players have to maximize their utility (or profits) given their preferences, production technology, and market conditions. In contrast to the abstract mathematical optimisation models in textbook theory, the decisions in the games are made by the players themselves. Although the players try to maximize their utility (the number of points), they are not obliged to do

that. In contrast with textbook theory, information in the game is not perfect. The market conditions are not fully known to the players, and are even partly determined by their own decisions. Hence, the players have to search for their optimal decisions. This search process is essential for gaining a better understanding of the processes that can be analysed with micro-economic theories.

Coloured beads serve as products. The value of these beads is visualized on score boards with holes for plugging in the beads. The utility functions representing the value of the products for the players are the foundation of the game. The utility functions of the players have the following general form:

$$U = \sum_{p=1}^{P} \sum_{i=1}^{I_p} (a_p - q_{ip})$$

Where:

U = utility of the player
P = the number of types of products in the game
I_p = the number of products of type p in stock
q_{ip} = the ith number of product p in stock

Hence, the marginal utility functions for all products p are linear:

$$MU_p = a_p - q_{ip}$$

where:

MU_p = marginal utility of product p

Figure 1. An example of a score board (* are units of product)

bread (green)		meat (red)	
9	*	21	*
8	*	20	*
7	*	19	*
6	*	18	*
5	*	17	
4		16	
3		15	
2		15	
1		13	
0		12	

The utility function are visualized with the help of score-boards. A score-board may look like figure 1. Figure 1 shows an example of a score-board for a game with two types of product. The products are bread and meat. Bread is represented by the green beads, meat by the red beads. The constant

a_p for bread equals 10, while the a_p for meat equals 22. The player attaches his products (here symbolized with *) next to the numbers on his score board, starting at the top. The marginal utility[1] can be read directly off the score-board. For example, the utility of the fifth unit of bread is 5, while a sixth unit of bread would have a utility of 4. Total utility can be computed by summation of the marginal utilities of all the products. For example, the total utility of all five units of bread equals 9 + 8 + 7 + 6 + 5 = 35.

In the simplest version of the game, each student starts with a fixed stock of products. In most versions of this game also a special product called "money" is used. Money is defined as a product with a marginal utility that equals 1 independent of the stock of money. In the game money serves as a unit of account and as a means of exchange. During the game the players discover the role of money for facilitating exchange in an economy when they find out that they need money to exploit the more refined transaction opportunities.

In the example that will be presented, there are five normal products and money. When the game starts each player has a stock of money of 200 dollar and has "produced" 40 units of one type of product. Hence, in the simple game supply is fixed. The players have different utility functions (score-boards) and different initial stocks of products. The players are expected to maximize their utility by means of free exchange. The initial stocks of product are distributed over the players so that every player has the same level of total utility at the start of the game. Hence it is easy to evaluate the rise in utility as a consequence of free exchange, and to compare the results for the different players.

During the game students have to use their utility functions to make decisions about exchange. After some time, the students will find out that some commodities are scarcer than others, and they will adjust their exchange rates accordingly. When the most profitable exchanges have been carried out, it becomes necessary to engage in transactions which do not only involve commodities in direct exchange, but also money. Thus, students discover the importance of the divisibility of money.

After about half an hour of seeming chaos, the students have exploited most of the exchange opportunities. When all mutually beneficial exchange opportunities have been exhausted, a so-called Pareto-optimum is reached. Thus, the students discover the meaning of this abstract concept. Also, in searching for new exchange opportunities they discover the abstract law of equal marginal utilities which states the conditions under which consumers maximize their utility.

When the game is finished, the final positions of the players are typed into the computer, and calculations are made. The results are presented to the players. Each player gets an account of his own decisions. Tables and graphs about the game economy can be presented with the help of an overhead projection screen. Let us look at two of those tables.

Table 1 shows the average results per type of producer. There are 5 types of producer, one for each product. For the sake of simplicity it is assumed that players who produce the same product have also the same preferences (score-boards). Hence players who produced the same type of product can compare their results.

A first observation is that all players have increased their utility. This is a direct consequence of the principle of free exchange: no rational individual will exchange unless it is beneficial for him. For some students even this simple observation is already revealing. It may be a starting point for discussing the costs and benefits of a free exchange economy.

A second and more important observation is the difference in the results of different producers. To explain those differences, the increase in utility is divided into three parts: the market value of production, the profits as a consequence of trading at non-equilibrium prices (exchange profits), and the consumer's surplus. The market value of production is

defined as the number of products in the beginning of the game multiplied by the price of the product. Each player started with 40 units. The price of the product is presented in table 2. Hence, the market value of the 40 units of shoes for the shoe producer is equal to 40 x 4.8 = 192.[2] The differences between the rises in utility amongst the players can partly be explained by differences in the market value of their products as a consequence of differences in market prices.

Table 1. Average welfare results per type of players

Producer of:	Increase in utility	Market value of production	Exchange profits	Consumer's surplus	Initial utility
shoes	383.0	193.9	79.5	229.6	320.0
bread	281.4	188.7	32.0	180.7	320.0
meat	406.4	329.6	23.6	173.2	320.0
beer	407.0	362.6	-45.9	210.3	320.0
lemonade	353.3	425.2	-134.8	182.8	320.0
average	365.0	291.8	0.0	195.2	320.0

An economist tries to explain differences in market prices by differences in scarcity. Table 2 may be helpful for this. Although total supply (production) of meat is the same as the supply of bread (both 200), demand differs. From the definition of the utility function follows that the value of the first unit of a product for a player is a good indication for the intensity of demand for that product. One can observe in table 2 that the value of the first unit of bread is only 21 for the 5 shoe-producers and 15 for the five bread producers. For the other players the value of the first unit of bread is 9. The average value of the first unit of a product gives an indication of the intensity of demand. This is 12.9 for bread. Compared with the average value of the first unit of meat of 16.4 this is rather low. Hence, the demand for meat is lower than the demand for bread. This explains the difference in equilibrium price. As a matter of course this can be visualized with demand and supply graphs. For many students it is a useful exercise to derive the demand curves directly from the utility functions on their score-boards.

Table 1 shows that the differences in utility are not only a consequence of differences in the market values of products, but also of differences in the exchange profits and the consumer's surplus. Exchange profits are a result from selling at prices above the equilibrium price or buying at prices below the equilibrium price. Because a seller can only get a higher price at the expense of a buyer, the sum of all exchange profits equals 0. This implies that the national income in the game equals 0; national income only measures market values. The rise in aggregate utility (welfare) in the game is only caused by a rise in consumer's surplus, and thus is not included in national income statistics. This result may deepen the insight in the logic of income statistics, and may be a motive to digress further on the relevance of comparing national incomes or personal incomes.

Table 2. Demand and supply conditions

Producer	Number of players	Value of the first unit of: bread	meat	shoes	lemonade	beer
shoes	5	21.0	9.0	15.0	18.0	12.0
bread	5	15.0	18.0	9.0	21.0	12.0
meat	5	9.0	15.0	12.0	18.0	21.0
beer	4	9.0	21.0	18.0	12.0	15.0
lemonade	4	9.0	21.0	12.0	15.0	18.0
average value of the first unit		12.9	16.4	13.0	17.1	15.5
total production		200.0	200.0	200.0	160.0	160.0
production per individual		8.7	8.7	8.7	7.0	7.0
equilibrium price		4.7	8.2	4.8	10.6	9.1
price elasticity of demand		0.5	0.9	0.5	1.5	1.3

The column exchange profits has another intriguing feature: players with a high market value of their initial stock of products (for example the lemonade producers) suffer exchange losses, while players with a low market value of their initial stock of products (for example the bread producers) enjoy exchange profits. This result is caused by imperfect information. At the beginning of the game the players do not know that the equilibrium price of bread is half of the price of lemonade. Hence, players may exchange one unit of bread for one unit of lemonade (see table 2). But when they do this, the lemonade producer exchanges a product with a value of 10.6 against a product with a value of 4.7 and hence suffers a loss of 10.6 - 4.7 = 5.9. But this loss for the producer of lemonade is a profit for the producer of bread, a product with a low market value. Hence, because of imperfect information, poor players like the bread producers end up less poor and rich players like the lemonade producers end up less rich than when information would have been perfect. This result may motivate inquiry into the general prejudice that more information is always better.

In the foregoing it is implicitly assumed that the market can be analysed as if all players fail to have monopoly power. In practice, this assumption will be correct when players play the game for the first time. Students normally do not cooperate during the game. But after the game is finished, it may be revealing to show that for some types of producers it would have been beneficial to collude. The price elasticities of demand presented in table 2 are relevant for the analysis of the possibilities to create cartels.[3] Monopolistic behaviour would have been beneficial for producers of products with inelastic demand (with a price elasticity of demand of less than 1, such as bread), but not for products with very elastic demand (with a price elasticity of demand of more than 1, such as lemonade). When for example the bread producers would restrict their sales of bread by 23 units, the equilibrium price would increase 1. Hence, the sales revenues on the 177 remaining products would be 177 x 1 = 177 higher. This more than compensates the loss in revenues from the products they will not sell that is equal to 23 x 4.7 = 108.[45] When monopolistic power is used by the players, the effects are recorded as exchange profits in the game

statistics, because the value of the products is evaluated at perfect competition equilibrium prices.

Although other topics can be discussed, the foregoing may be sufficient to show the type of conclusions that can be derived from the results of this relatively simple game. During the game, the players become familiar with micro-economic concepts like the utility function and they discover micro-economic principles like the law of equal marginal utilities and the role of money. After the game is finished some theoretical issues like equilibrium, consumer's surplus, imperfect information, and monopoly power can be discussed.

VARIATIONS ON A GAME

The basic principles behind the simple welfare game sketched in the last section can be applied for the development of a whole family of games. At this moment there are two other games: the investment game that extends the simple game with investment and production, and the labour game that extends the simple game with labour supply and social security. Both games require a good insight in the principles of the simple game.

To illustrate the method by which new games can be developed, one may look at the investment game. The investment game extends the simple game with production and investment. Hence, the players not only have to make decisions as consumers and traders, but also have to make decisions as producers and investors. Because investment has long term consequences, the game is played in several rounds.

The investment game has two other features that makes it interesting. First, economies of scale in production are introduced to stimulate specialisation. The more one produces, the lower the production costs are. Second, the players play in small groups of three or four individuals. These groups may symbolize firms or countries depending on the theoretical context of the game.

Normally, the investment game is played in three rounds, each consisting of an investment stage and a production/exchange/consumption stage (abbreviated further as production stage). At the start of the game, the players receive a sum of money. In the investment stage of the first round they can use this money for buying machines. They have to decide how much to invest, and in which products to invest. The investments during the investment stage determine the production capacity in the production stage, and hence the opportunities for economies of scale. On the computer screen they can see the decisions of the other players.

When the investment stage is finished, the production stage starts. The players are allowed to produce until their production capacity is reached. The more they produce of the same product the lower the costs per unit of product are. Hence, in general it is beneficial to specialise. The products can be traded immediately. Production and exchange form a continuous process comparable to the simple exchange process in the simple game.

After about half an hour, the production stage is finished. The results are typed into the computer, and the game leader presents the results. The feedback by the game leader is essential for a proper understanding of the players of what is going on. Although the decisions of the players are relatively simple, the evaluation of the consequences of those decisions are rather complex. Because all players are free to invest in all products, all players compete with each other. But because of the existence of economies of scale, large scale producers may set a barrier to entry for new producers by setting a price that is lower than the price of a small producer. In their pricing, production, and investment decisions the players have to apply micro-economic rules such as monopoly pricing, limit pricing, variable cost accounting, and the strategy of market penetration. Most students need help from the game leader in their reasoning in making proper decisions.

When the players understand the processes of the first round, the second and third rounds can be played in about one hour. The game requires about four hours.

EVALUATION OF THE DIDACTIC EFFECT OF THE GAMES

In Maastricht the game is scheduled for the second half of the introductory course in micro-economics. Before the game starts, the game leader explains the theoretical background of the game. The students make some exercises about the exchange processes. These are then discussed by the game leader. Although the game proper requires only half an hour, we have scheduled four hours for the game. This includes one hour preparation and at least two hours evaluation. So, most of the time of the session scheduled for the first game is used for the introduction and the evaluation of the game.

This explains why the students do not like the simple game as much as the more complicated games. But without an extensive evaluation of the game the students are not able to link their experiences with their knowledge of economic theory. A good evaluation of the simple game is essential as a preparation for the more interesting complex games.

After the game is played the students were asked to fill in an inquiry. Most students enjoyed the games, especially the more complicated ones. But the students have difficulty in understanding the theoretical implications of the game. They do not think that the game is too difficult, but discussions after the game reveal that they have missed some important clues. It seems that the feedback has to be improved. As far as we can overlook now, the structure of the evaluation of the game was not transparent enough for students at an introductory level. For intermediate students the game is easier to understand. But also for them the game has to be scheduled after they have studied the theories that are relevant in the game.

Table 3. Progress test results
(true -/- false as % of the number of questions)
(* = difference between the two groups is significant on a 5 % level)

	players	non-players
Test before the game		
- micro-economics	-2	4*
- other subjects	22	28*
Test after the game		
- micro-economics	16	9*
- other subjects	25	24

a) 7 questions that refer to micro-economic subjects mentioned in the game.

In Maastricht there is an excellent opportunity for testing the effectiveness of the game as an educational instrument. Students are tested

at frequent intervals during their study with a so-called progress test. This test with true-?-false questions has the same level of difficulty for all students and hence is a measuring rod for the advancements of the students. Because all students are tested before and after the game with a test with the same type of questions, while not all students have played the game, this is an excellent opportunity to test the effect of the game on their micro-economic capabilities. The first results of this research are promising. The true-false score on the micro-economic part of the test after the game was 16 % for students who played the game, and 9 % for students who did not play the game (see table 3).

Students were free to choose to play the game. Hence it is relevant to compare some other features of the two groups that are compared. First, the results on micro-economics may be compared with the result on other subjects. On those subjects, the results did not differ significant. Second, tje results may be compared with the results on the test before the game. It is surprising that the students who played the game had significantly lower scores than other students. Apparently, low scores on the progress test motivated students to participate in the game. And the result seems rewarding for those students.

CONCLUSION

The family of games which has so far been developed seem to be a useful supplement for courses in micro-economics. The games create an opportunity to "play" with micro-economic concepts in an intuitive way. But it is difficult for students to grasp the theoretical meaning of the games. Hence, a good preparation of the students and a transparent presentation and evaluation by the game leader is essential for the effectiveness of the games as an eduational tool.

NOTES

1. Defined as the value of the last unit or the value of an extra unit. These two definition are the same when continuous differentiable utility functions are used as in textbooks, but are different in the game.

2. The small difference is a consequence of rounding errors.

3. It may be a useful excercise for students to derive the price elasticities of demand themselves.

4. This result is very useful in the game with investment and production, where the players have to think continuously about the possibilities to use monopoly power.

5. This analysis is not completely correct, because the opportunity costs of supply are excluded from the analyses. For advanced students, it is easy to incorporate this in their analysis.