AN ECONOMIC GAME AS AN INTERACTIVE LEARNING ENVIRONMENT

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Abstract[1]

In an abstract discipline like economics it is difficult to find case-studies in the real world that directs the students towards the theory. In the natural sciences laboratory experiments are used to solve this problem. In economics this approach is exceptional and only available for microeconomic theory. For teaching macroeconomics many games are available where the student has to maximize macroeconomic performance in a traditional model of the economy. This type of game instructs students in the dynamics of the particular model used. But those games do not improve the understanding of the microeconomic fundamentals of macroeconomic dynamics. For this purpose an interactive macroeconomic game has been developed that is played on a computer network.

The players in the game are firms that produce consumer goods and/or investment goods. The firms have to maximize their profits by deciding about their price, wage, labour demand and investment. Interaction between the decisions of firms determines to a large extent the performance of the economy. For example, when for some reason many firms increase their investment outlays, this implies more demand for the other players and may induce other firms to invest, too. Then a very severe hausse emerges. But when the players expect that the extra demand is only temporary, they may not invest so much and therefore moderate the hausse. In this manner the players get an intuitive feeling for the relation between decision making of firms and the dynamics of the macroeconomic system.

[1] I am grateful to Wim Gijselaers and Charles Power for their comments on an earlier draft of

Introduction

Many non-economists perceive economics as an abstract and contra-intuitive science. This may be the consequence of the teaching method. Krueger et al. (1991) refer to the formal approach in economics teaching, where the focus is on "the grammar of the discipline, rather than its substance" (p 1041). They suggest that we should include more applications and real world linkages in our courses (p 1052). But such applications are complex compared with static equilibrium theory as taught in introductory economics. Furthermore, it is very difficult for students to imagine the decision making processes behind the theories. Although this is already true for microeconomics, it is even more difficult in macroeconomics. In teaching practice, macroeconomics is only marginally related with microeconomics and decision making. For non-economists it is very difficult to imagine the decision processes behind the formulas in macroeconomics.

In the natural sciences one tries to solve this type of problem through experiments. But until recently experiments in economics have been exceptional in research as well as in teaching. While some teachers introduce microeconomic laboratory experiments in the classroom,[2] macroeconomic laboratory experiments are completely absent. The many macroeconomic simulation games that have been developed[3], are not experimental in character. Macroeconomic games give the players the task of trying to maximize national welfare by manipulating instruments of macroeconomic policy. This helps students to understand the logic of macroeconomic models, but does not improve the understanding of the decision making process behind the behavioural equations in the macroeconomic models nor the relationship of macroeconomics with microeconomic theory.

In this paper a game will be described that is focused on the microeconomic decisions which influence macroeconomic change. First, some background for the design of the game will be discussed. Then the structure of the game will be presented from the perspective of the players. The next section summarizes some results of the game. The interpretation of the results of the game requires systematic training of the players. The last section shows that the game is a prototype of a family of games that will be developed soon.

The design of the game

The educational purpose of the game is:[4]

- putting economic concepts into practice;
- to recognize the interdependence of economic variables;
- to show the microeconomic decisions behind macroeconomic theories;
- to show the role of expectations of human beings in macroeconomic dynamics;
- to show that understanding macroeconomics is useful for strategic decision making of firms.

The macroeconomic game represents a closed national economy. Because the decision making of firms is a central factor in understanding macroeconomic dynamics, the players represent the firms in the economy. The Central Bank, government, consumers and labour unions

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[2] For example Williams and Walker (1993), DeYoung(1993), Wells (1991).

[3] For example Gremmen(1989), Scott(1993).

[4] The game is also used in experimental research.

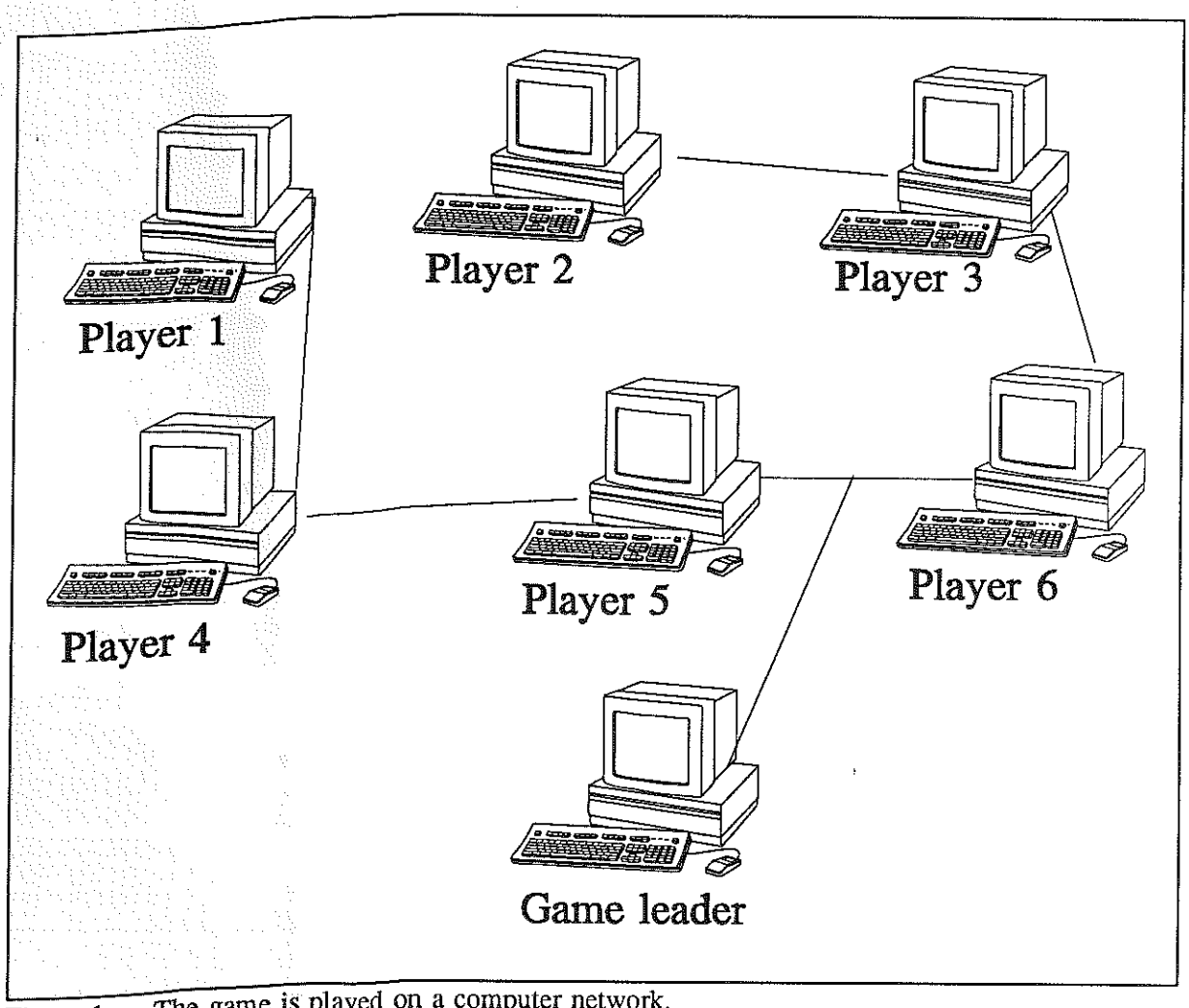

Figure 1. The game is played on a computer network.

are simulated by the central computer of the game leader. To keep things simple, the firms produce homogeneous output with machines and homogeneous labour. The computer model divides this output over machines and consumer goods.[5] Independently from each other the players decide about investment, labour demand, price and wage. Because the focus of attention is on the coordination problem, no a priori equilibrium is enforced on the markets. For example, when national demand is lower than national production, the stocks of the firms rise, something that is ignored in most textbooks. The firms may try to decrease those stocks by lowering their price. Or they may decrease production by firing employees. Because the effect of those decisions depends on the decisions of the other players, it is very important that the information about the decisions of the other players is quickly available. Therefore, the decision period in the game has to be short; a decision period of a month seems a reasonable approximation of the delay of information in the real world.

Because macroeconomics deals to a large extent with long term developments, we require that students experience at least two business cycles (i.e. about 14 years). This implies that one game consists of about 168 decision periods. In order to play such a game in a reasonable time, it is necessary to do it interactively, i.e., on a computer network. In the game one month of

[5] In a more advanced version of the game the players are divided in producers of machines and producers of consumer goods.

simulation time is about one minute in real time. Such a short decision period implies that the consequences of strategies of the players will become visible already after two hours of playing.

In summary, the game is an interactive simulation of an economy consisting of independent firms. It simulates about two business cycles divided into monthly decision periods. The behaviour of the economy is mainly determined by the decisions of the players.

An intuitive explanation of the game

Players start the game with the decision screen (table 1). This screen is used to change values of the four decision variables (i.e., wage, labour demand, price, investment). The player can change those variables at any moment he likes. The values of the decision variables at the end of each month (see the bottom left of the decision screen) are used to compute the results. The most recent values of the most important results are presented at the right side of the decision screen. By choosing "other options" the player can investigate the development of more than eighty variables, most of which are the consequence of the decisions of the players.

Firm 1	policy	actual		
			minimum wage per month:	1425.00
			average wage per month (-2):	1500.00
			unemployment (%) (-2):	5.00
■ Wage	1500	1500	average price (-2):	2.48
■ Labour demand	1000	1000	price machines:	267857
■ Price	2.48	2.48	delivery time machines (months):	9
■ Machines to be ordered	0	0	interest (% per year):	4.91
Labour per machine	10	10	inflation (% per year)	2.11
■ Don't replace machines				
			sales per month (-2):	757149
			production per month(-2):	757149
			stock of products (-1):	378574
			number of machines:	100
			ordered machines:	8
			utilisation rate labour (%)(-2):	100
			number of employees:	1000
o = Other options				
			profit margin in % price:	2.79
			equity capital (x1000) (-1):	10034
Decisions: march of year 1			av. own. cap. (x1000) (-1):	10034
			lended capital(x1000) (-1):	4430
Current time: 12:23:41			market share (%) (-2):	100

Table 1. The decision screen.

The players are asked to maximize long term profits. In practice this implies that they should maximize the value of the firm at the end of the game. Part of this value consists of equity capital at the end of the game. This is presented at the bottom right side of the decision screen, where "(-1)" indicates that the presented value is from last month. The other part is summarized as "goodwill" and should indicate the net present value of future profits. Market share is used as the indicator of "goodwill". Market share is presented at the bottom right side of the decision

In order to play the game effectively, the players must translate the abstract goal of long term profit maximization into more operational goals such as sales, utilisation rates of capital and labour, a profit margins and stocks. Some useful information about those variables of strategic relevance, are presented at the middle right part of the decision screen.

For effective decision making players need market information. The upper right part of the decision screen shows some useful information about the labour market (unemployment, minimum wage and average wage), the output market (average price), the price and delivery time of machines, and the cost of credits (interest and inflation rate).

Before the game starts, the players get some information about the effects of their decisions. The *wage* rate per month is the first decision variable. When a firm has a higher wage rate than the average player, it becomes easier to attract new employees from other firms.

Employees can be hired and fired by changing the second decision variable, *labour demand*. When labour demand is lower than the actual number of employees, requests for dismissal are executed, but it requires three months before the employees are fired. When labour demand is higher than the actual number of employees, vacancies are created. It requires at least two months to fulfil them, but when the unemployment rate is low and the wage rate is not higher than the wage rate of other firms, one may not be able to attract new employees at all.

Because machines have a limited capacity, it is obvious that it is only useful to attract new employees when enough machine capacity is available. Otherwise, some employees will not be productive. Then the utilisation rate of labour will be less than 100%. The players may either fire employees by lowering labour demand or buy new machines.

When a firm employs less labour than can be used productively, the utilisation rate of machines is less than 100%. This implies that the firm can expand production by attracting more labour. When unemployment is low and the wage rate of the firm is low compared with that of other firms, it will be difficult to attract new employees. Then one can only attract new labour by setting a higher wage rate.

Price is the third decision variable. When price of a firm is lower than average price in the economy, a firm can attract new customers. But when demand is higher than production plus stock, the firm will not be able to satisfy the demand and the customers will move to the competitors. In such a situation a firm can increase its profits by rising its price. But when the utilisation rate of capital is lower than 100% the firm may expand production by attracting new employees. When the utilisation rate of capital is 100% one can only expand production by investment in new machines.

Investment in machines is the last decision variable. The delivery time of machines depends on demand and supply conditions of the machine producing industry. All ordered machines that have not been delivered yet are presented at the right side of the decision screen. When a firm orders a machine, it can choose the type of machine. This is defined by the maximum number of employees that can be employed. After 100 months of production machines have to be replaced. An option for automatic replacement of those machines is available.

This sketch of the game economy defines the most important features of the game. It shows that it is possible to give an intuitive explanation of the game. With the help of this information the players can play the game in a reasonable manner. Evidently it requires a lot of training before players are able to develop a sophisticated policy.

Some results of the game

When the players start the game they first have to become familiar with its principles. First, they must learn to change the decision variables. Then they may create some graphs to compare their business performance with that of other players. Finally they may focus on the macroeconomic results and its consequences for their decisions.

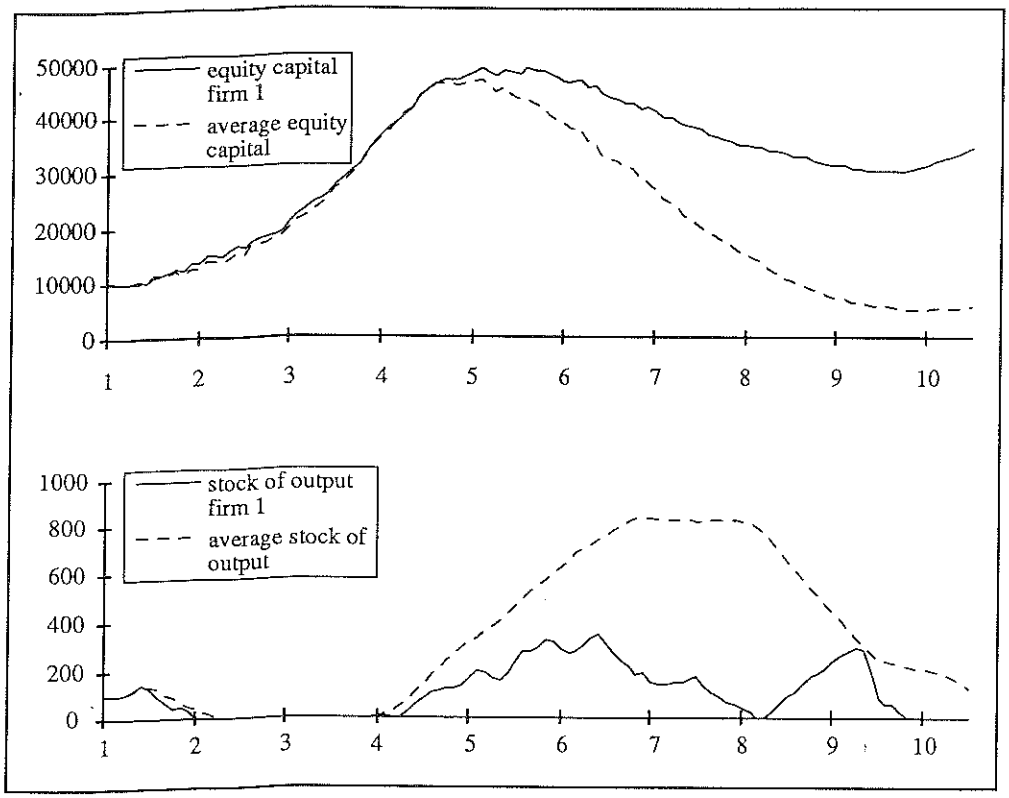

Figure 2. Equity capital and stock of firm 1 compared with the average player.

Figure 2 shows an example of a business performance analysis. It shows that during the recession that started in year 4, equity capital of firm 1 decreased less than on average. The lower part of figure 2 gives the suggestion that the better performance can be explained by a smaller stock. When the player has this hypothesis, he may investigate the cost of stock, and may investigate graphs about its relative price and production to explain the better performance with respect to its stock.

The decisions of the players determine the development of the business cycle. Table 2 summarizes the dynamics of the business cycle in a game played by law students. During the first year of the game some players decided to expand and therefore ordered a lot of machines. This implied a high level of demand for machines. Therefore, firms could sell their products easily, and saw that the stock of output declined from 2697 in year 1 till 204 in year 2. This high level of demand encouraged firms to expand further. Therefore, in year 2 a lot more machines were ordered than in year 1. This implied a further rise in aggregate demand and consequently all firms were out of stock in year 3. When the new machines were delivered in year 3 and 4, all firms tried to attract employees. But they were not able to get them because the unemployment rate was low (the natural rate of unemployment is about 5% in the game). The shortage of labour is shown by the negative rate of structural unemployment. When this problem of overinvestment was recognized, most players decreased their investment demand. As a consequence aggregate demand declined and a severe recession emerged.

The first part of the recession was necessary to solve the problems generated by the overinvestment in the first two years of the game. But even when in year 8 the structural problem was solved, the firms didn't invest; they couldn't sell enough. But ironically the cause of this low

year	real national income	ordered machines	stock of output	utilisation rate of capital	unempl%	struct unempl%
1	62436	90.00	2697	95.85	8.32	-0.83
2	63089	134.00	204	96.14	5.23	-3.63
3	62800	89.00	0	92.90	4.63	-7.46
4	54821	44.00	3543	89.16	4.59	-11.26
5	54122	30.00	12107	87.44	4.53	-13.03
6	55777	38.00	19880	89.67	5.52	-9.82
7	55514	15.00	21897	85.93	12.96	-6.11
8	50451	13.00	17574	73.27	38.91	7.18
9	45591	18.00	7588	77.41	35.89	8.30
10	47807	84.00	3109	93.42	28.14	16.57
11	36648	132.00	0	93.30	41.88	30.18

Table 2. Simulated macroeconomic outcomes: cyclical and structural unemployment over eleven "years"

level of demand was the low level of investment. It was difficult to break through this vicious circle generated by self-fulfilling pessimistic expectations. The high level of unemployment in year 8 and 9 suggests a typical example of Keynesian unemployment.

This sketch of some aspects of an economy of novice players shows how incorrect expectations and short term decision making generated a business cycle as well as severe structural problems. Games with more experienced players are more stable.

Some educational results

The game has been played by students in law, culture, business administration and economics. Participation in the game was voluntary.[6] Students could play twice, but not everyone did. The students who did were very satisfied about it. The average response to assessment questions like "The game is interesting", "I learned a lot of the game" and "Such a game has to be repeated" was about 4.2 on a scale of 5.

The students who played the game twice had a significantly higher score on an economics exam after the game (the score of the players was more than one point higher[7] both in 1992 and 1993, where the difference was most significant for questions that required the ability to apply knowledge and not significant on questions that required detailed knowledge). Because one cannot expect that playing a game two half days has significant influence on a test about knowledge of half a year, this result suggests a selection effect: only the best students enjoyed the game so much that they played the game till the last session. For 1992 this interpretation is reinforced by a significant positive correlation between the test score and the ability of students to improve their strategy during the game. This correlation was especially strong for the analytical questions in the

[6] In june 1994 it will be an obligatory part of the study in economics and business administration.

[7] With a t-value of 5.

test. In 1992 only the more analytically gifted students seem most able to appreciate the game and profit from it.

Since 1992 the game has been improved by the addition of accompanying exercises. This may explain why in 1993 the number of players who finished the game doubled compared with 1992. Furthermore, the correlation between the test scores and the ability to improve the strategy during the game was absent in 1993. This suggests that we have been successful in empowering the less talented students to play the game intelligently. A thorough educational design is a sine qua non for a good game.

The future

At this moment a prototype of the elementary game is finished. The game will become available at the end of 1994. Some new options will be introduced. First, a facility for programming automatic policies will be introduced. Second, interactive exercises and help functions will be added to the application. Third, the firms in the game may become more complex, for example by introducing research and development, or adding some new marketing variables. Fourth, more sectors will be introduced (a version with investment goods and consumer goods is almost finished). Fifth, more types of actors will be developed. For example, commercial banks, a stock market, a government, a central bank or labour unions can be developed. In this manner the game can be adapted to different levels of difficulty.

Final remarks

In this paper a game has been developed for simulating the coordination of behaviour in a closed macroeconomy. This game is different from other games in that the decisions of the firms determine to a large extent the macroeconomic performance of the game. Because the players decide about all the variables that are important from a macroeconomic point of view, it will help them to understand the decisions behind the macroeconomic models. Furthermore, because knowledge of macroeconmics helps players increase profits by making better microeconomic decisions, the game motivates to investigate macroeconomic dynamics. But to reach those results, one has to remember that training of players combined with structured feedback is essential for good results. When one likes to develop more complex versions of the game, one has to keep in mind that it is only useful to do so when the players understand clearly the principles of the basic game.

References

DeYoung, R. (1993), Market experiments: The laboratory versus the classroom. Journal of Economic Education, 24, 335-51.

Gremmen, H.J.F.M. (1989). SIER, a macroeconomic computer game on cooperation and conflict in international economics. Dissertation Katholieke Universiteit Brabant, The Netherlands.

Krueger, A.O., et al (1991), Report of the Commission on Graduate Education in Economics. Journal of Economic Literature, **29**, 1035-1053.

Scott, A. (1993), Running the British economy. This book.

Wells, D. (1991), Laboratory experiments for undergraduate instruction in economics. Journal of Economic Education, **22**, 293-300.

Williams, A.W., & Walker, J.M. (1993), Computerized laboratory exercises for microeconomics education: three applications motivated by experimental economics. Journal of Economic Education, **24**, 291-315.