

Results from the Use of Two Simulations in Principles of Micro

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Additional information about the simulation is available at the web site: <http://marketsim.ysu.edu>. Thomson Learning is distributing a revised version of the software, for information on that version see <http://marketsim.swlearning.com>.

NOTE: The results are preliminary and should not be quoted without permission.

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Introduction

The MarketSim project involved the design and testing of two simulated economies for principles of microeconomics. The first simulation, Jeremy's Market, is a barter economy designed to illustrate the gains from specialization and trade. The second simulation, Adam's Market, is a monetary economy designed to help students learn the rules for utility maximization, profit maximization, and capital investment. Students participate in the simulations asynchronously via the Internet. In both simulations exchanges are made through students posting offers to other students.

To test the effect of the simulation on student learning and attitudes, the participants in the project constructed a controlled experiment. In the 2002-2003 academic year data was gathered on a control group which did not use the software, and in the following academic year we gathered the same information from classes that used the simulations.

Literature Review on the Use of Simulations in Economics Instruction¹

While Economics is inherently an applied discipline, it is frequently difficult for students to appreciate how the theoretical models reflect the behavior of actual actors in the economy. This is especially true in the case of traditional students (students 18 to 24 years old), who typically have had little or no experience in the problems faced by business managers.

Since the 1970's articles in the economics education literature have discussed both the advantages of the use of economic simulations and the lack of controlled studies of their effectiveness. Soper (1974) concluded in a survey of the use of mainframe-based

¹ A subgroup of the authors has written a paper that provides a more extensive review of the literature on simulations in Porter, Riley, and Ruffer (2004).

CAI: “In the papers surveyed above, one benefit appears to be quite substantial: CAI can be used very effectively in showing students *what economists do* and *how they do it* (italics in the original). This is next to impossible to teach by means of textbooks and lectures, yet it would be of extreme importance in our educational objectives.” Later surveys by Yoho and Walstad (1990), Grimes and Ray (1993), P. Davies (1994), and Walstad et al (1998) concluded that simulations running on personal computers were valuable because they give students an opportunity to actively apply the concepts they are learning in the course. Those articles also noted that the use of simulations was still limited, and their effectiveness still unproven. P. Davies (1994) emphasized that there must be a clear relationship between the students’ experiences with the simulation and the course material.

Among the few empirical studies that have been undertaken, three studies were conducted on the effectiveness of Smithtown, a “discovery environment,” in which students uncover economic principles by changing income and prices in a simulated economy. The program is designed so that different goods have set characteristics (for example, ground beef might be a normal good, a substitute for chicken, and a complement of hamburger buns). Students can change prices of a good and the consumers’ incomes. By observing the resulting changes in the demand for the different goods, they then try to determine the characteristics of the goods. In two studies, Shute, Glaser and Raghavan (1989) and Shute and Glaser (1990), students using just Smithtown learned as much as students who attended lectures but did not use the program. Katz and Oaks (1993) found that the intensity with which students used the program was positively related to the student’s grade.

A simulation sharing some of MarketSim's characteristics was evaluated by Raehsler, Haggerty, and Caroppreso (1996). Students took on the roles of producers and consumers and prices and output levels were set by the students' buy and sell orders. In this case the simulation was incorporated into a principles of macroeconomics course to illustrate the circular flow model. The authors found that the classes that used the simulation had a more favorable opinion of the course and higher grades, but the difference in the grades was not statistically significant. The study had a relatively small sample size (28 in the control group and 82 in the classes using the simulation).

Anthony Davies, the author of EcoSim, a predecessor of MarketSim, conducted an informal, unpublished survey of 50 principles of micro students who used EcoSim. A high percentage of the students reported that EcoSim increased their understanding of economic theory and made the course more interesting.

Characteristics of MarketSim

As noted earlier, MarketSim consists of two parts, Jeremy's Market and Adam's Market. Jeremy's Market has the following characteristics:

- Households consume two goods and leisure time
- Students must decide how to divide their allotted time between producing goods and consuming leisure time.
- Each household belongs to a group of households that share the same utility and production functions. The functions are chosen to create the potential for gains from trade between the groups.
- Households are able to post offers to trade their production with other households.

Adam's Market has the following characteristics:

- Each student is responsible for one consumer and one firm.
- Consumers receive utility from consuming two different goods and leisure time.
- Consumers have some fixed amount of time which they must divide between working for firms and consuming as leisure.
- Consumers try to sell their time to the firms by posting offers to work; they purchase goods by accepting offers to sell goods posted by firms.
- Firms attempt to earn profits by purchasing labor, producing output, and selling the output to consumers.

In addition to the basic characteristics of Adam's Market, the sophistication of the simulation can be increased by turning on the following options:

- depreciation of capital and inventory
- purchases of capital
- switching industries
- sale of bonds

Both simulations include worksheet and action pages.² Worksheet pages allow students to discover how to maximize utility or profit without having to directly use the program's underlying utility and production functions. Action pages contain the interface used to actually make exchanges, produce goods, or consume goods.

Two additional pages complete the site. A "Functions and Graphs" page displays

² This section describes the version of MarketSim developed under the NSF grant. A commercial version of the program distributed by Thomson Learning has a slightly different design. For example, in the Thomson version the worksheets appear in a separate window from the other pages, and the Functions and Graphs page was split into two separate pages, one for functions and the other for graphs.

the functions of the different groups and graphs showing summary information about the simulation. A “User Record” page displays a summary of all of the actions taken by the student.

The basic concept of a computerized, simulated economy that functions by having students post and accept offers was inspired by EcoSim, a program written for VAX computers by Antony Davies. Tod S. Porter and Kriss Schueller designed Jeremy’s and Adam’s Markets, using JavaScript on the client side and active server pages (ASP) on the server side.

MarketSim also shares many similarities with classroom experiments designed to illustrate how markets work. The advantages of a web-based design over a classroom experiment include:

- Since the server keeps track of the actions of the students, it is possible to have large numbers of students participate in the simulation
- Students can participate in the simulation outside of class, freeing class time for other activities.
- By providing worksheets and using the computer to do the calculations, students can participate in a much more sophisticated economy.

MarketSim from a User’s View

To provide a better understanding of how the simulation works the following describes two hypothetical players participating in Adam’s Market.

Like all players, Andrew is responsible for both a consumer and a firm. However, in this instance he is trying to make decisions for his consumer. To set his strategy, Andrew goes to the Consumer Worksheet page to check on the most recent prices for the

two goods and labor. Andrew searches for the lowest prices offered posted for the three different goods and the current wage offers. By entering different values into the worksheet, Andrew can see how his utility changes as he purchases different amounts of the two goods and sacrifices more or less leisure time to generate additional income. Given the current prices, Andrew finds he will maximize his utility if he works for 50 hours and purchases 30 units of pizza and 25 units of soda.

Andrew then switches to the Consumer Actions page to try to implement his strategy. He sees an offer to sell pizza at a price below the previous offers and purchases the pizza with part of his initial cash endowment. The software transfers the appropriate amount of cash from Andrew to the firm that made the offer, increases Andrew's consumption of pizza, changes his utility, reduces the firm's inventory by the amount of pizza sold, and updates the amount of profit earned by the firm. Next, Andrew posts offers to sell labor time and logs out of the simulation. He hopes that by the next time he logs in a firm will have accepted his offer. By taking on the role of a consumer Andrew gains a better understanding of utility maximization and tradeoffs between work and leisure.

Molly has decided to plot strategy for her firm today. Just as Andrew did, Molly will go to the web site to look at the most recently quoted prices. She will need to check the prices offered for labor and the output she sells, pizza. She then enters the prices into the Firm Worksheet, and looks for the level of employment and output that would generate the greatest profit. She then goes to the Firm Actions page, accepts Andrew's offer to sell labor, and posts an offer to sell the pizza she has just produced.

As a producer, Molly can also choose to purchase capital, which will increase the

firm's output in succeeding periods. Molly has also been comparing the profits of the firms in the pizza industry and the profits in the soda industry. If the profits in making soda continue to be high, she may decide to switch industries.

Her role as a producer forces Molly to think about concepts such as the profit-maximizing rules for employment and output, capital investment, and market entry and exit. What both Andrew and Molly will come to appreciate is that markets are a dynamic process in which the independent exchanges between buyers and sellers signal consumer's preferences and the costs of production.

Description of the Data

The data for the test of the simulation was gathered from Principles of Microeconomics classes taught at Youngstown State University (YSU). YSU is a public, open admissions institution with an enrollment of approximately 13,000 students. The over-whelming majority of students live off campus. All of the class sections used in the study were taught in the daytime during the regular workweek (Monday to Friday), so the proportion of traditional students (students below the age of 24) in the dataset was somewhat higher than the overall proportion of traditional students at YSU.

The control group for the test was made up of nine sections taught in the 2002-03 academic year (5 in the fall semester, and 4 in the spring semester). The experimental group included ten classes from the following academic year (five in each semester) which used the simulations. The schedules for the three instructors involved were designed to be as similar as possible for both years. In both years Instructor #1 only taught principles of micro in the fall semester, Instructor #3 only taught sections of the course in the spring, and Instructor #2 taught sections in both fall and spring. (see Table

1).

At the beginning of the semester the students were given a 10 question quiz from the Test of Economic Literacy. They were also surveyed on the number of hours they worked and their attitude towards the class. During the semester additional information was added from the students' official records. At the end of the semester, the students were surveyed again and a set of 25 multiple choice questions were incorporated into the class' final exams. Approximately 600 usable observations were gathered over the two years.³

Tables 2 and 3 show that the students from the experimental group and the control group had very similar characteristics. In Table 2, none of the differences were statistically significant at the 10 percent level using a two-tailed test. The results show that the typical student in the study held a job, and those students spent an average of 20 hours per week working. There was a relatively wide range in the ACT scores of the students in the classes as evidenced by the size of the standard deviations. The averages for the different sections were close to the median values nationally. About one-third of the students had taken a course in economics in high school.

One additional point that should be made is that the experience of students using the software in the fall was substantially different from the experience of students participating in the simulation in the spring. The coding of the program took longer than expected, and in the fall of 2003 the software was in more of a "late-beta" phase, as

³ The maximum enrollment in the sections was 60 students, and the initial enrollment for all the sections was close to 1250 students. However, approximately 450 students did not take the final exam (most had withdrawn from the course, some students who were failing did not take the final exam). Of the remaining 800 students, about 150 did not have an ACT score. Excluding students without ACT scores reduced the proportion of nontraditional students in the dataset; only students who have graduated from high school in the last two years are required to take the ACT for admission to YSU. Of the remaining students, approximately 40 were dropped from the sample because they did not fill out one or both of the surveys.

opposed to a polished final project. Numerous bugs and design flaws became apparent, and in the process of fixing these problems, additional errors were sometimes introduced. As a result, a number of students became frustrated with the software and either stopped participating or participated infrequently in the simulation. By the spring semester all of the coding problems had been resolved and the use of the software went very smoothly. By spring user and instructor manuals were complete, which provided the students and instructors with helpful support materials.

Comparison of Outcomes in Student Learning

As a first attempt to test whether the simulation had any affect on student learning, we compared the mean number of correct responses to the 25 multiple choice questions for the control and experimental groups. In addition, when the multiple choice questions were originally written, we identified 17 questions that were directly related to principles that the student would need to use to be a successful participant in the simulation. We also compared the mean number of correct answers of the control and experimental groups for those 17 questions. The comparisons were made both for all sections and by instructor (see Table 4).

Using all sections and all questions, the experimental group had a slightly higher average score, and the difference was significant at the 10 percent level using a one-tailed test. For the 17 questions directly related to the simulation the experimental group again had a higher score, and in this case the difference was statistically significant at the 5 percent level.

There was interesting variation in the results by instructor. In the case of Instructor 1, the experimental group had a higher score both when all questions were used

and when the simulation-related subset was used, but the differences were not statistically significant. In the case of Instructor 2, the control group had the higher average scores, and the difference for all questions was significant at the 10 percent level using a one-tailed test. For Instructor 3, the use of the simulation resulted in an increase in the average scores for both measures that was statistically significant at the 1 percent level.

Two different regression models were estimated to test for the differences in student performance, a model with 15 independent variables and a reduced form version with 4 variables. The variables common to both models were the student's score on the English and math sections of the ACT exam, the score on the questions from the Test of Economic Literacy (to measure the student's knowledge of economics at the start of the course), and a dummy variable indicating whether the student was in the control group or experimental group.

The larger model included dummy variables for the student's major (business and economics majors were the omitted group), gender, whether the student had taken a course in economics in high school, and instructor (students taking instructor 3 were the omitted group). Additional control variables included credit hours completed prior to the start of the semester, age, hours worked per week, and hours spent studying for all classes. Each model was estimated using both the number of correct responses on all 25 questions and the 17 simulation-related questions as the dependent variable.

In all four regression estimates the coefficient for the experimental group dummy was positive. For the models using correct responses to all questions as the dependent variable, the coefficient was significant at the 2.5 percent level. For the model using the number of correctly answered simulated-related questions, the coefficient was significant

at the 1 percent level (see Table 5). The results were quite robust in the sense that being in the experimental group consistently increased the average score by about half a question when we simply compared means from the control and experimental groups, used a reduced-form regression model, or used a model that included 15 independent variables.

Student Attitudes

To examine student attitudes, survey results from the two semesters were compared. In the surveys, students were asked to compare the course and instructor relative to other college courses and college instructors on a scale from 1 (lowest) to 5 (highest). Students were asked to rank their interest in the subject matter of the course, the importance of the subject matter, and the overall teaching effectiveness of the instructor. A summary of the responses for the control and experimental groups are shown in Table 6.

The distribution of the rankings for student interest in the subject matter of the course and the importance of the subject matter was very similar for both groups. However, there was a difference between the two groups in the distribution of the evaluation of teaching effectiveness. Contingency table tests were used to determine if the differences between the responses of the control and experimental groups were statistically significant (see Table 7). For teaching effectiveness the contingency table test indicated that there were significant differences in the responses of the two groups.

Again, the results varied substantially by instructor. For instructor 1, use of the simulation reduced the evaluation of teaching effectiveness, with fewer students giving a rating of 5 (highest) and more students giving a rating of 4 (above average). For

instructor 2, the simulation did not result in any substantial change in the distribution. For instructor 3, use of the simulation resulted in higher teaching evaluations (see Table 8). Contingency table tests showed that the change in responses for instructors 1 and 3 were statistically significant at the 10 percent level (see Table 9).

Since instructor 1 only used the simulations in the fall (when numerous disruptions in the use of the software took place), and instructor 3 only used the simulations in the spring (when the software was operating reliably), it is hard to say whether the differences in the evaluation of teaching effectiveness are due to student resentment towards having to use an unreliable program or some interaction between the teaching style of the instructor and the simulation. A third explanation is simple sampling variation. While the number of individual student responses is fairly large, the number of classes taught by an individual instructor in the data set is very small, and the variation in responses may depend on how well an instructor happened to relate to a particular class.

Conclusion

The results of the study provide some encouraging evidence that the use of economic simulations can improve student understanding, especially given that students had a much less than ideal experience with the simulation in one of the two semesters in which it was used. While the results for student attitudes are mixed, the results for instructor 3 imply that, at least for some faculty, the software may raise the perceived quality of instruction.

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TABLE 1
Number of Sections and Usable Observations
by Semester and Instructor

	Instructor					
	1		2		3	
	Classes	Obs.	Classes	Obs.	Classes	Obs.
Fall 2002	3	114	2	66	0	0
Spring 2003	0	0	1	32	3	85
Fall 2003	3	97	2	73	0	0
Spring 2004	0	0	2	59	3	92

TABLE 2
Means and Standard Deviations of Student Characteristics

Variable	Did Not Use Simulation		Used Simulation		P value of difference in means
	Mean	Std. Dev.	Mean	Std. Dev.	
Credit hours completed	39.34	30.87	40.14	26.70	.691
Hours worked per week, survey 1 (of students who worked)	25.23	9.38	24.48	8.45	.319
Score on English portion of the ACT exam	20.24	4.82	19.96	4.87	.459
Score on Math portion of the ACT exam	21.53	4.86	21.10	4.51	.277
Score on Natural Science portion of the ACT exam	22.03	4.35	21.58	3.82	.174
Score on Reading portion of the ACT exam	21.39	5.63	21.50	5.23	.816
Student's age	20.46	2.13	20.42	2.91	.860
Undergraduate GPA	2.49	1.23	2.41	1.19	.430
Hours worked per week, survey 2 (of students who worked)	26.53	9.70	26.03	9.43	.529
Total hours per week spent studying	9.45	7.72	10.24	8.26	.234
Hours per week spent studying economics	2.69	2.31	2.67	2.14	.904
Number of correct answers on TEL (10 questions)	6.09	1.99	6.25	1.94	.303

TABLE 3
Frequency Distributions of Student Characteristics

	Did not use simulation	Used Simulation
Employment, Survey 1		
Employed	247	273
Not Employed	49	47
Major		
Business or economics	151	182
Science, math, computer science, or engineering	79	62
Education	24	28
Other	41	40
Instructor		
#1	114	97
#2	98	132
#3	85	91
Gender		
Male	180	189
Female	117	131
Race		
White	273	293
Black	11	11
Asian Pacific	6	2
Hispanic	2	5
Other	3	8
American Indian	0	1
English is Native Language		
Yes	292	312
No	5	7
Took High School Economics Course		
Yes	86	103
No	210	217

TABLE 4
Number of Multiple Choice Questions Answered Correctly

	Mean Score, Control Group	Mean Score, Experimental Group	t score, difference in means
All Questions			
All sections	14.44	14.96	1.59
Instructor 1	14.06	14.44	0.79
Instructor 2	15.18	14.54	-1.36
Instructor 3	14.11	16.13	2.90
Simulation-Related Questions			
All sections	10.31	10.74	1.87
Instructor 1	9.97	10.28	0.82
Instructor 2	10.53	10.40	-0.38
Instructor 3	10.48	11.70	2.44

There were a total of 25 multiple choice questions, 17 questions were identified as being directly relevant to participation in the simulation.

TABLE 5
Regression Results for Number of Questions Answered Correctly

	All Questions		Simulation-Related Questions	
	Model 1	Model 2	Model 1	Model 2
Constant	-.052*	3.03***	1.72*	2.67***
	(1.62)	(4.24)	(1.48)	(5.18)
English ACT	.213***	.224***	.137***	.138***
	(5.28)	(6.10)	(4.74)	(5.19)
Math ACT	.257***	.243***	.164***	.169***
	(6.18)	(6.33)	(5.50)	(6.10)
Hours Completed	-.003		-.001	
	(-0.58)		(-0.22)	
Science Major	.002		-.073	
	(0.01)		(-0.27)	
Education Major	-.888*		-.565*	
	(-1.62)		(-1.44)	
Other Majors	-.708*		-.661**	
	(-1.64)		(-2.14)	
Female	-.214		-.240	
	(-0.68)		(-1.06)	
HS Econ	.695**		.562***	
	(2.22)		(2.63)	
TEL Correct	.265***	.282***	.211***	.200***
	(3.23)	(3.67)	(3.57)	(3.62)
Instructor 1	-1.07***		-1.20***	
	(-2.99)		(-4.68)	
Instructor 2	-.495*		-.872***	
	(-1.41)		(-3.45)	
Student Age	.173***		.081**	
	(2.62)		(1.69)	
Hours working	-.014*		-.010*	
	(-1.28)		(-1.31)	
Hours studying	.039**		.021*	
	(2.21)		(1.62)	
Used simulation	.632**	.569**	.536***	.477***
	(2.25)	(2.17)	(2.66)	(2.41)
R-squared	0.36	0.33	0.35	0.29
F	20.20	71.41	18.68	60.91
N	549	598	549	598

The numbers in parentheses are t-scores.

* Statistically significant at the 0.10 level using a one-tailed test

** Statistically significant at the 0.05 level using a one-tailed test

*** Statistically significant at the 0.01 level using a one-tailed test

TABLE 6
Measures of Student Attitude in Percentages

	Interest in Subject Matter		Importance of Subject Matter		Teaching Effectiveness	
	Without Simulation	With Simulation	Without Simulation	With Simulation	Without Simulation	With Simulation
Lowest 1	10.3	10.0	3.4	2.4	5.2	1.7
2	13.4	16.9	9.7	9.3	6.2	5.2
Average 3	37.2	34.8	30.0	29.7	18.6	14.5
4	30.0	29.7	40.3	40.0	24.8	33.8
Highest 5	9.0	8.6	16.6	18.6	45.2	44.8

TABLE 7
Contingency Table Tests of Differences in Attitudes

	Chi-Square Statistic	Significance Level
Interest in Subject Matter	1.41	0.84
Importance of Subject Matter	0.91	0.92
Teaching Effectiveness	10.75	0.03

TABLE 8
Instructor Evaluation in Percentages

	Instructor 1		Instructor 2		Instructor 3	
	Without Simulation	With Simulation	Without Simulation	With Simulation	Without Simulation	With Simulation
Lowest 1	1.9	0	0	0.8	15.3	5.3
2	1.9	2.2	1.0	1.6	17.6	14.7
Average 3	12.0	13.0	9.3	6.5	37.6	29.3
4	23.1	40.2	30.9	27.6	20.0	36.0
Highest 5	61.1	44.6	58.8	63.4	9.4	14.7

TABLE 9
Contingency Table Tests of Instructor Evaluation

	Chi-Square Statistic	Significance Level
Interest in Subject Matter	8.98	0.062
Importance of Subject Matter	1.86	0.761
Teaching Effectiveness	9.39	0.052