

Cournot Competition and Hit-and-Run Entry and Exit in a Teaching Experiment

Simon Gächter, Christian Thöni,
and Jean-Robert Tyran

Abstract: Instructors can use a computerized experiment to introduce students to imperfect competition in courses on introductory economics, industrial organization, game theory, and strategy and management. In addition to introducing students to strategic thinking in general, the experiment serves to demonstrate that profits of a firm fall as the number of competitors is increased in a market and that firms enter profitable markets. The authors have used the experiment in undergraduate classes on strategy and management as well as in master of business administration courses with great success.

Key words: Cournot competition, entry, exit, experiment, teaching
JEL codes: A2, L1, D4, C9

Key ideas in strategic behavior are that firms take competitors' actions into account and make their best responses to them and that competition tends to reduce profits. These ideas can be introduced at different stages in education and at different levels of formal detail. The experiment we describe allows students to experience strategic competition and to witness the precision with which economic theory predicts such outcomes.

The purpose of the experiment is to introduce students to imperfect competition and strategic thinking in general. Our computerized teaching experiment has two phases. In the first phase, subjects participate in separate oligopolistic Cournot markets with different numbers of firms in each market. This phase allows a demonstration of the effect of market size on imperfect quantity competition. In the second phase, costless market entry and exit are possible. Theory predicts equalization of profits across markets as profitable markets attract competitors from less profitable markets. In both phases, the theoretical predictions are almost perfectly met by actual experimental play. The experiment is therefore a powerful illustration of the ideas of the static concept that fewer competitors in a market lead to higher profits and the dynamic concept that hit-and-run entry and

Simon Gächter is a professor at the School of Economics, University of Nottingham, United Kingdom. *Christian Thöni* is a postdoc at the University of St. Gallen, Switzerland. *Jean-Robert Tyran* is a professor in the Department of Economics, University of Copenhagen, Denmark (e-mail: jean-robert.tyran@econ.ku.dk). The authors are grateful for helpful comments by three anonymous referees and Georg von Krogh. **Copyright © 2006 Heldref Publications**

exit tends to equalize profits across markets. We have successfully used this two-phase experiment in undergraduate and master of business administration (MBA) courses. Although we have used the two-phase experiment, which we describe later, alternative organizations are possible as well. For instance, instructors can, according to their time budget and audience, choose to run the two phases at different sessions or only run phase 1.

The main advantage of our teaching experiment is that it is a compact workhorse to introduce several key issues in industrial organization with a single experiment. It is mainly a computerized extension of the market-entry experiment described by Garratt (2000). In Garratt's design, students can choose to enter one of four markets. Once entered, they automatically produce and sell one unit. In our experiment, students are exogenously allocated to one of four markets and play 10 periods in fixed markets. In a subsequent phase, they can switch markets. The students within a market play a Cournot oligopoly game.

The authors of earlier articles have focused on Cournot games alone, such as Williams and Walker (1993) and Oxoby (2001), who illustrated monopoly pricing. Hemenway, Moore, and Whitney (1987), Meister (1999), and Beckman (2003) demonstrated oligopolistic competition. The experiment we describe allows instructors to discuss monopoly, oligopoly, and the effects of market entry and exit in one unified framework.

Our experiment is computerized, with the help of the widely used experimental software "z-Tree" (Fischbacher 1999). This feature further distinguishes our teaching experiment from those mentioned earlier. The drawback of a computerized teaching experiment is, of course, that one needs enough networked computers to run the experiment. Our compact workhorse is probably not feasible in a pure classroom experiment. However, in our experience, if a computerized experiment is feasible, students like going to the lab because it is a welcome change in teaching methods. Moreover, we also found it effective to ask students to think about theoretical predictions and to look at the data they have just generated. The students like this assignment because they can analyze their own behaviour and compare it to the theoretical predictions.

We first describe the experiment and an example of how to structure a lecture around the experiment and then briefly discuss alternative ways to organize a class. We present the experimental details before discussing predictions and actual results of previous classroom experiments. We suggest how to structure classroom discussion. We document the instructions (Appendix A), the screenshots of information and decision screens (Appendix B), and a sample of assignments (Appendix C).

THE STRUCTURE OF THE EXPERIMENT AND THE LECTURES

We describe here the experiment as we conducted and discussed it in class. At the end of this section, we also mention some alternative ways of organizing the experiment and the classroom discussion.

Because our classes had a number of participants that was divisible by 10, we chose to run the experiment with groups of 10 participants and market sizes of

1, 2, 3, and 4 competitors. In each period, all firms simultaneously chose a quantity q . Demand (price = $100 - Q$, where Q was total market quantity) and production costs ($c = q$) were the same in all markets and periods (for the choice of parameters, we followed Huck, Normann, and Oechssler 2004). Participants were told that their hypothetical profit was $q(100 - Q) - q$.

Our experiment consisted of two phases with 10 periods each.¹ In the first 10 periods of the experiment (phase 1), markets were separated from one another, whereas in periods 11 to 20, (phase 2), free entry and exit is possible.

In phase 1, participants were exogenously allocated to markets. All participants were informed at the beginning of the experiment that all markets were identical, except for the number of firms (see the instructions in Appendix A). When they made a decision, students knew how many other firms were in their market (see the screen shot in the instructions). At the end of each period, participants were informed about the number of competitors and average profits in the four markets (Figure B2, Appendix B).²

At the beginning of each period of phase 2, firms first simultaneously chose the market in which they wanted to compete. When they made this choice, they knew how many firms had been in the four different markets in the previous period and what the average profit had been (Appendix B, Figure B3). The firms then learned the number of contestants in the market they had chosen and made their quantity decision (for the decision screen, see the instructions). Market entry and exit is costless in our experiment.³ One purpose of phase 2 was to observe whether entry and exit led to an equalization of profits across the four markets.

We have used this experiment in several managerial economics courses at the MBA level and in undergraduate courses on strategy and management. Classes had between 20 and 40 students. We first carefully explained the experiment to the students (15 minutes), let them do the computerized experiment (approximately 40 minutes), let groups of students analyze the experimental data, and guided group discussions by an assignment (30–45 minutes, see Appendix B). Students then presented their findings (5 minutes per group, 1 or 2 groups). The presentations were followed by a plenary discussion (10–15 minutes) and a lecture (90 minutes). Hence, running and carefully discussing the experiment took about four hours, including breaks. If an instructor intends to devote only three hours of teaching time to the experiment, the assignment and discussion can be dropped. However, we feel that students gained valuable insights by analyzing and discussing the data. Their presentations typically set the stage for the lecture.

Our teaching experiment can be adapted easily to the specific needs of instructors because the software is quite flexible. The following are some suggestions for alternative organizations of a class if the instructor cannot spend four hours in one block of time on this experiment.

First, the instructor may run the Cournot markets (phase 1) only⁴ and confine the discussion to the topic of quantity competition. This can be covered within one lecture of 90 minutes. Second, if less time is available, the instructor can split the experiment and the lectures. For example, in courses in which classes meet twice a week, the instructor can do the experiment (with one or two phases) in the

first meeting, give the assignment for homework (see Appendix C for examples), and have the presentations, discussions, and lectures in the second meeting of the week. Third, with our software, it is also possible to run the two phases on two different occasions because the software does not require prior play of phase 1 before phase 2 can be played.

PROCEDURES

Software and Hardware Requirements

The experiment is computerized and the program we used is programmed with the experimental software z-Tree (Fischbacher 1999).⁵ z-Tree is a popular and easy-to-use toolbox for economic experiments. Adapting our program to the instructors' specific needs does not require extensive knowledge of z-Tree or specific programming skills. The software is freely available (see <http://www.iew.unizh.ch/ztree/index.php>)⁶ and must be installed on networked computers before our program can be used. Details can be found in Fischbacher (1999). z-Tree runs under Windows NT, 2000, and XP (but not under Windows 98). To run the experiment, one instructor's computer and any number of networked workstations are needed. Ideally, all participants use separate computers. However, if there are more participants than computer terminals available, two participants can use some computers, and these participants are asked to make their decisions jointly.

Materials Needed

In addition to the computers and the program, materials needed are instructions to explain the experiment to participants beforehand, the class assignment, and lecture notes. The instructions, screen shots, and the assignments are reproduced in Appendixes A to C. The other materials, including the program and the lecture notes (PowerPoint), are available on request from the authors.

Instructions

The instructor must first turn on all computers, start z-Tree on the server (the instructor's computer) and then start the z-leafs on the participants' computers. The instructor must then allocate participants to computers, verify that all clients appear in the "clients table" (scrollbar "run") in the z-Tree program, and double-click on "background" to set the number of participants.

Participants read the instructions of the first phase (Appendix A), which explain the decision situation and the user interfaces.⁷ A calculator is integrated into the decision screen, which allows the participants to calculate the profits resulting from hypothetical quantity choices. The participants were told that the experiment lasts for 10 periods, but they were not told at the beginning of the experiment (to avoid confusion) that the experiment would have two phases. The information about phase 2 is provided on a separate screen that appears automatically in the

course of the experiment (the instructor can choose when this screen appears by selecting after which period phase 2 starts).

To provide students with incentives, we told them that a ranking of students according to performance (points earned relative to equilibrium number of points) would be published at the end of the experiment.⁸

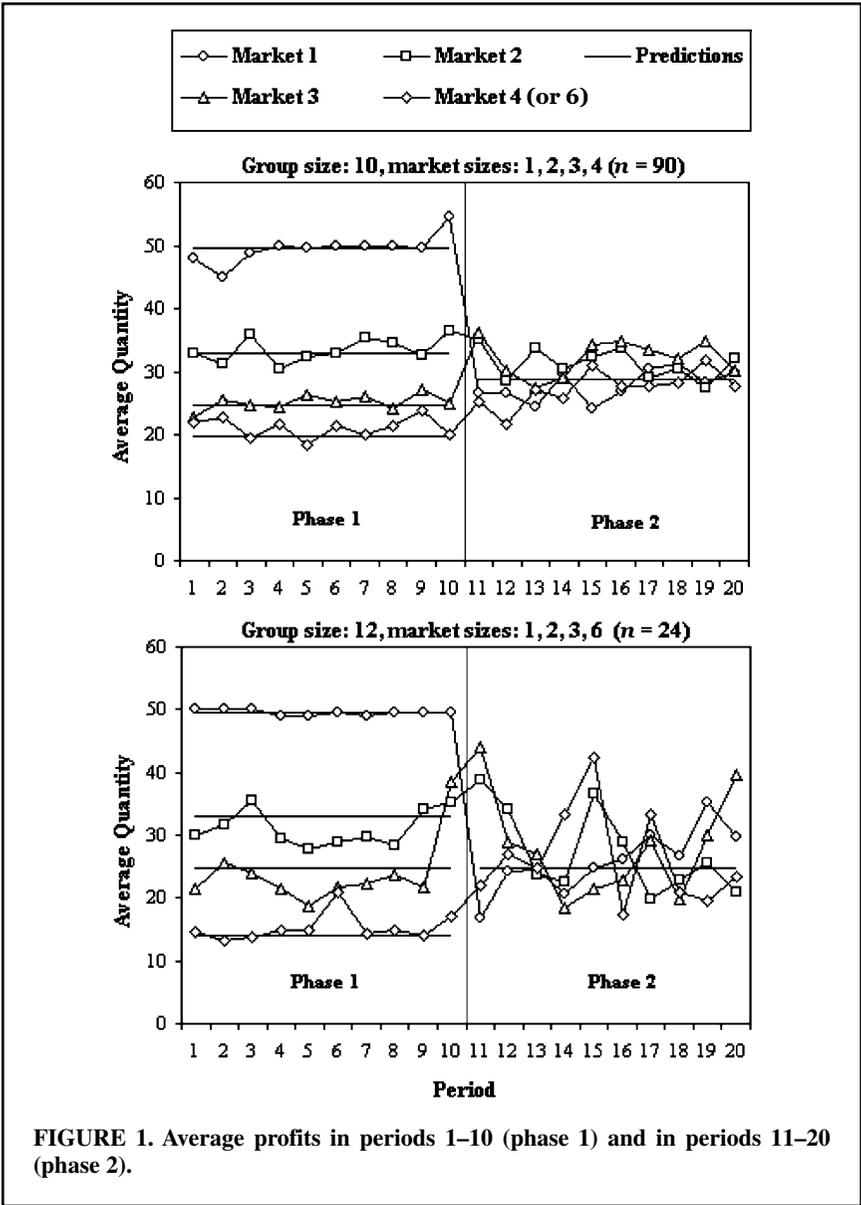
PREDICTIONS AND RESULTS

We now report the results from three MBA economics classes and in an undergraduate course in strategy and management. In each of the four classes, we had either two or three independent groups with 10 participants. In one class, we had two groups of 12 participants each. In total, 114 students participated in the experiments.⁹ Most participants had no in-depth prior knowledge of economics except for a short introduction to basic economic concepts. In general, the results of the experiment are very much in line with theoretical predictions, illustrating the power of economic theory to predict actual behavior under the conditions implemented in this experiment.

The predictions for phase 1 are as follows. The profit maximizing monopolist equates marginal cost (which equals 1) with marginal return (which equals $100 - 2q$). Hence, the optimal quantity choice $q^* = 49.5$ (i.e., 49 or 50 because only integers can be chosen in the experiment), yielding a profit of 2,450 points ($100q^* - q^{*2} - q^*$). In the oligopoly case, the profit of a firm i is $\pi_i = [100 - (q_i + Q_{-i})]q_i - q_i$, where Q_{-i} is the sum of the $n - 1$ other players' quantities. The best reply of firm i is $q_i(Q_{-i}) = (99 - Q_{-i})/2$. Because the players are symmetric, all players choose the same quantity in equilibrium, that is, $Q_{-i} = (n - 1)q_i$. Substituting this condition into the best reply of firm i leads to the Nash-equilibrium quantity of $q_i^*(n) = 99/(n + 1)$. Total quantity in the market is $Q(n) = 99n/(n + 1)$, a firm's profit is $\pi_i(n) = [99/(n + 1)]^2$, and total welfare is $(2n + n^2)99^2/[2(n + 1)^2]$. These expressions nicely illustrate the influence of the number of competitors n on the market outcome. A firm's quantity and profit decreases in n whereas the total quantity and welfare (the sum of the firms' profits plus the consumer rent) increase in n . In addition, the limit case with $n \rightarrow \infty$ is equal to a market with perfect competition, that is, price equals marginal cost (1), profits are equal to 0, and welfare is maximal.

In the two panels of Figure 1, we show the average firms' quantities observed in the 20 periods of our experiment. The data of the upper panel are taken from the experiments with groups of 10 participants ($n = 90$), the lower panel shows the data for two groups of 12 participants ($n = 24$). In the former case, the markets consisted of 1, 2, 3, and 4 firms in phase 1 whereas in the latter case the markets in phase 1 consisted of 1, 2, 3, and 6 firms. The thin horizontal lines indicate the predicted values. In phase 1, we show a prediction for each market separately (depending on market size). In phase 2, the prediction is the same for all markets.¹⁰

As can be seen in both panels, the observed average quantities in phase 1 are very close to the predicted quantities. Because we integrated a profit calculator, it



is relatively easy for participants to find the profit-maximizing monopoly quantity. Nine out of 11 monopolists found this quantity in the first period, and the remaining participants found it after three periods. Convergence to equilibrium was slower in the duopoly markets. In 3 out of 11 markets, the two firms succeeded in colluding (i.e., they chose $q_i = 25$ each) for some periods. Although several markets with three or four firms attempted to collude ($Q = 45$ is the smallest aggregate quantity observed in one of these markets), tacit collusion

broke down after one or two periods. These results are in line with the observations in Huck, Normann, and Oechssler (2004).

In phase 2 (periods 11–20) of the experiment, we observed a lot of movement between markets. In particular, subjects switched markets in 31 percent of all cases when they had the opportunity to switch. The right part of both panels of Figure 1 shows that quantities oscillate around the predicted values.

Competition should lead to an equalization of the profits across markets in phase 2. As can be seen in the right part of the figure, the possibility of switching markets obviously induces a tendency to equalize average quantities in the four markets. Consequently, the standard deviation of the firms' profits—which is 635 in phase 1—shrinks to 237 in phase 2.

The variance of average quantities in phase 2 is larger in the lower than in the upper panel of the figure. This results from having only two observations per market (as opposed to nine in the upper panel). In phase 2, the variability of the payoffs increases. This occurs mainly because the allocation of firms to markets is not stable over time. Firms switch markets frequently, even in the case of a group size of 12 participants, that is, when an equal distribution of firms to markets (four triopolies) is feasible.

What determines the decision to enter or exit a market? In Table 1, we show the net change of the number of firms in markets of different sizes (we have pooled the data from all classes). The results show that noncompetitive markets (with less than three competitors) tend to attract entrants from competitive markets. For example, 83 percent of the 63 monopolistic (and empty) markets in period t attracted one or more entrants in period $t + 1$ of phase 2, whereas none of these 63 markets had (net) exits. In contrast, only 4 percent of the highly competitive markets with 4 competitors attracted (net) entrants, but 78 percent of these markets had a net movement out of this market. Therefore, the data exhibits a very clear pattern, as expected.

As can be seen from the data in Table 1, the general tendency was that firms moved from markets with many competitors to markets with few competitors in the previous period. However, because entry choices were simultaneous and firms were not allowed to communicate, firms faced a coordination problem. As a consequence, it happened quite often (in 19 percent of the cases) that a monopoly (or empty) market in period t attracted three or more entrants in period $t + 1$. Sometimes a firm that chose to remain in a market that was a triopoly (14 percent) or quadropoly (9 percent) in period t was lucky to be a monopolist in period $t + 1$.

CLASSROOM DISCUSSION

After the experiment, we had a short break to prepare the data for the students. The students were then given the data and an assignment asking them to analyze and discuss the data (Appendix C). For example, students were asked to produce the diagram shown in Figure 1, to reflect on the economic prediction and to compare the theoretical predictions with observed behavior. Students worked in small groups on the data (to this end, students must be equipped with a computer and a

TABLE 1. Net Change of the Number of Firms ($n = 440$ Markets, Periods 11–20)

Market size	No. obs.	Entry (%)	No change (%)	Exit (%)
≤ 1	63	83	17	0
2	160	40	47	13
3	140	17	35	48
4	54	4	19	78
> 4	23	0	0	100

spreadsheet calculation program like Excel). After 30 to 45 minutes, students convened and presented their findings (5 minutes). Depending on the insights reached by the first group, we let a second group present. After these presentations, we discussed the experiment in class.

Depending on the time available and the students' prior knowledge, the discussion of the first phase of the experiment can be used to explain the following:

Nash equilibrium and disequilibrium behavior gravitating toward equilibrium. Students who do not know game theory are often quite surprised to see that economic theory predicts so well in Cournot markets. Also, the fact that they have just replicated the results of a research experiment typically makes quite an impression on students. For a reference, the instructor may want to show Figure 1 in Huck et al. (2004, 442).

The relation of market outcomes to the number of competitors. More competitors imply lower equilibrium profits and higher aggregate production. The instructor may also explain the relation of prices, quantities, profits, and measures of welfare, including the consumers who were simulated in this experiment by the falling demand curve. In particular, the instructor can use the results to illustrate that more competition means that market prices are lower, which benefits consumers and increases overall welfare.

Tacit collusion is less likely to be observed as the number of competitors increases. The instructor can add a discussion of conditions that could facilitate collusion (or cooperation among competitors), such as communication and the ability to sanction others in cartels. In more advanced classes, the instructor may want to discuss the relation of static equilibrium concepts and that the game is (finitely) repeated. For example, attempts to collude are more likely to be observed in early periods as the benefits of collusion can be reaped for more periods and implicit threats (high production) loom larger. A related issue is that a player may try to impose himself as the Stackelberg leader by deliberately choosing a quantity above the Nash equilibrium in the hope that other players will accommodate to his choices (Huck, Müller, and Normann 2001). The textbook explanation is that there is a first-mover advantage in a sequential game, but this may prevail even in a simultaneous but repeated game if one player is bolder than the others.

The second phase of the experiment can serve to discuss the following issues:

Entry and exit. The general message can be conveyed that profitable markets tend to attract more competitors whereas crowded markets do the opposite. Free entry and exit lead to an equalization of profits.

In more advanced classes, the concept of *mixed equilibrium* can be applied to examine the decision problem the students face when deciding to switch markets.

NOTES

1. The number of periods can be easily changed within our program.
2. In period 7 of the experiments, we announced that free entry and exit would be possible from period 11 onward. The idea was to allow for anticipation effects (i.e., changed quantity choices). Because we never observed any noticeable anticipation effect, we recommend announcing phase 2 immediately before it starts.
3. This can be easily changed in the program if the instructor would like to discuss the effects of barriers to entry.
4. Author Simon Gächter has used phase 1 only in his course on game theory.
5. The z-Tree program `cournot_and_entry.zt` is freely available from us. The program is documented. It can, in principle, be used without any prior knowledge of z-Tree (with the exception of knowing how to install it and how to run a program [see Fischbacher 1999]). Those versatile in z-Tree can easily adopt parameters. For instance, in our version of the program, we used the same demand function in all four markets. However, the program is written so that an instructor can define a different demand function in each market and can also specify the number of firms per market. Finally, the program contains a parameter *MovementCost*, that is, the cost of switching markets. In the experiments we ran, we set *MovementCost* = 0. However, if the instructor chooses to discuss barriers to entry, *MovementCost* > 0 can be chosen.
6. This Web page also contains a manual, helpful tips and tricks, and many sample programs for those who want to use z-Tree for further demonstration or research experiments.
7. In one class, we distributed written instructions. In another class, we explained the experiment orally (the PowerPoint presentation is available from the authors on request). The oral presentation seemed to be sufficient and took less time.
8. The instructor may announce that performance will be graded or a ranking of students' performance will be posted. Monetary incentives do not seem to be necessary to obtain the results described.
9. Simon Gächter also used phase 1 only for several courses in game theory. The results were always the same as those we documented.
10. The software is fully flexible with respect to the number of participants and allows for arbitrary market sizes. Therefore, the instructor can adopt the number of firms per market as he or she sees fit. The configuration with market sizes from 1, 2, 3, and 6 has the advantage that in phase 2 an equal number of firms per market is possible, whereas in the configuration of market sizes 1 to 4, this is not possible. Thus, in the former case, there is a clear focal equilibrium in the allocation of firms to markets, that is, every market consists of three firms that all earn the same profit. The predicted quantity therefore equals the quantity of the triopoly (24.8). In the configuration with market sizes 1 to 4, the equilibrium allocation necessarily consists of unequal numbers of firms in the four markets (2, 2, 3, and 3) and, consequently, unequal profits. This presumably renders the allocation of firms to markets instable over time. The predicted average quantity shown in Figure 1 is the average of the duopoly and the triopoly quantity (28.9). Irrespective of whether an equal distribution of firms is possible or not, a mixed equilibrium, exists when all firms choose their market randomly (with equal probabilities for all four markets). In this case, the expected quantity is 30.3 for the group size of 10 and 27.9 for the group size of 12 (not shown in Figure 1).

REFERENCES

- Beckman, S. 2003. Cournot and Bertrand games. *Journal of Economic Education* 34 (1): 27–35.
- Fischbacher, U. 1999. *z-Tree. Toolbox for readymade economic experiments: Experimenter's manual*. Working paper No. 21. Institute for Empirical Research in Economics, University of Zürich.
- Garratt, R. 2000. A free entry and exit experiment. *Journal of Economic Education* 31 (3): 247–43.

- Hemenway, D., R. Moore, and J. Whitney. 1987. The oligopoly game. *Economic Inquiry* 25 (October): 727–30.
- Huck, S., W. Müller, and H. T. Normann. 2001. Stackelberg beats Cournot: On collusion and efficiency in experimental markets. *Economic Journal* 111 (October): 749–66.
- Huck, S., H. T. Normann, and J. Oechssler. 2004. Two are few and four are many: Number effects in experimental oligopoly. *Journal of Economic Behavior and Organization* 53 (4): 435–46.
- Meister, P. J. 1999. Oligopoly—An in-class economic game. *Journal of Economic Education* 30 (4): 383–91.
- Oxoby, R. J. 2001. A monopoly classroom experiment. *Journal of Economic Education* 32 (2): 160–68.
- Williams, A. W., and J. M. Walker. 1993. Computerized laboratory exercises for microeconomics education: Three applications motivated by experimental economics. *Journal of Economic Education* 24 (4): 291–315.

APPENDIX A

SAMPLE INSTRUCTIONS

In this experiment you are in the role of a firm who has to decide how many units to produce. We have separated you into groups of 10 people each. Each group of 10 people is randomly allocated to **one** of four independent markets as follows.

- Market 1 consists of 1 firm.
- Market 2 consists of 2 firms.
- Market 3 consists of 3 firms.
- Market 4 consists of 4 firms.

To keep this experiment simple, we make three assumptions:

1. **All firms produce the same homogeneous product.**
2. **Market demand is the same in all four markets:** Price = $100 - Q$, where Q is the sum of all units that are produced by all firms in a particular market. For example, if in Market 2 the two firms produce 20 and 25 units, then $Q = 20 + 25 = 45$ and the realized market price is $P = 100 - 45 = 55$. There are no real consumers in this experiment. The consumers' role is played by the computer, the market price is automatically determined as a function of total quantity.
3. **The unit costs of production are 1 for all firms in all markets.** Thus, in the previous example, firm 1 has costs of 20 and firm 2 has costs of 25.

The **profit** of a particular firm is calculated as $Pq - q$, where Pq is the realized revenue (market price times quantity q of the individual firm), from which the total costs—which amount to q —are deducted. In the example above, profits are as follows:

$$\begin{aligned} \text{Firm 1: } & 55 \times 20 - 20 = 1080. \\ \text{Firm 2: } & 55 \times 25 - 25 = 1350. \end{aligned}$$

Thus, because the market price is a decreasing function of *all* quantities brought to the market, the profit you can make depends not only on your production decision, but on the production decision of all your competitors as well. The only exception is Market 1, where there is no competitor.

Assume you are the CEO who has to make the production decision. **Which production level do you choose?**

Figure A1 shows the screen you will see during the experiment.

- In the upper left corner you will see the remaining periods. In this experiment, we will play for 10 rounds. You compete with the same firms in all 10 periods.
- The upper right corner shows the remaining time to make your decision.

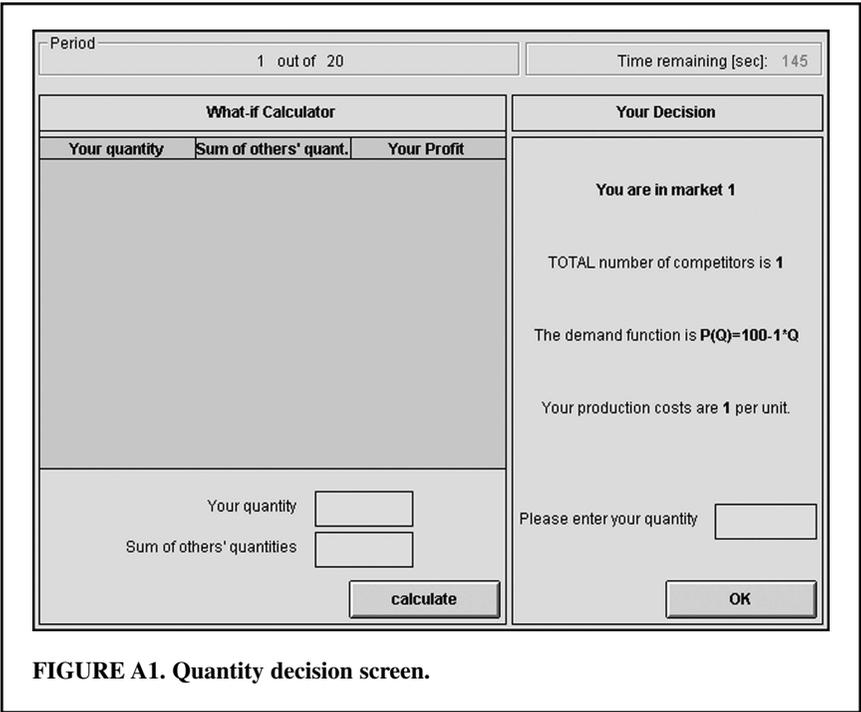


FIGURE A1. Quantity decision screen.

- The screen is separated into two parts. The left part is a **calculator**, which allows you to make hypothetical profit calculations. In the lower part you can enter a quantity choice of your liking, given any conjecture you have about the sum of the quantities of your competitors. You can make as many hypothetical choices as you like.
- The real decisions are made in the right part of the screen. This part indicates (i) in which market you currently operate, (ii) the number of competitors, and (iii) it also restates the demand function. In this screen you indicate your actual quantity choice. **You can choose any level between 0 and 100.**

GOOD LUCK!

**APPENDIX B
SCREEN-SHOTS**

Figure B2 shows the screen that subjects see after they have made a decision in phase 1. Figure B3 documents the decision screen for changing markets. The decision screen for making quantity choices is documented in the instructions.

Period 1 out of 20 Time remaining [sec]: 53

You are in market 1

Your quantity 49
 Total quantity 49
 Price 51
 Your income in this period 2450

The table below indicates for each of the four markets in your group the number of competitors and the average income gained.

Period	Market 1	Market 2	Market 3	Market 4
1	1 / 2450.0	2 / 900.0	3 / 420.0	4 / 261.0

FIGURE B2. Information screen after a subject has made a quantity decision in phase 1.

Period 10 out of 20 Time remaining [sec]: 44

You are in market 1

Your quantity 49
 TOTAL quantity 49
 Price 51
 Your income in this period 2450

You have now the opportunity to **change the market**. This change is costless, i.e., the costs are 0.

The following field indicates the number of your market. If you want to change market, please enter the number of the market you want to move into:

The table below indicates for each of the four markets in your group the number of competitors and the average income gained.

Period	Market 1	Market 2	Market 3	Market 4
2	1 / 2450.0	2 / 1054.0	3 / 526.7	4 / 242.0
3	1 / 2450.0	2 / 949.0	3 / 526.7	4 / 222.5
4	1 / 2450.0	2 / 949.0	3 / 464.7	4 / 139.5
5	1 / 2450.0	2 / 1015.0	3 / 526.7	4 / 182.0
6	1 / 2450.0	2 / 1015.0	3 / 486.0	4 / 202.5
7	1 / 2450.0	2 / 1054.0	3 / 420.0	4 / 95.0
8	1 / 2450.0	2 / 994.0	3 / 442.7	4 / 261.0
9	1 / 2450.0	2 / 1072.0	3 / 420.0	4 / 242.0
10	1 / 2450.0	2 / 949.0	3 / 420.0	4 / 117.5

FIGURE B3. Decision screen in phase 2 for changing market.

APPENDIX C ASSIGNMENTS

(Here we reprint the assignment distributed at the end of the experiment.)

In this experiment, two independent and identical groups of 10 firms were active. In each group the following markets were open.

Market 1 consists of 1 firm.

Market 2 consists of 2 firms.

Market 3 consists of 3 firms.

Market 4 consists of 4 firms.

The experiment had 2 Phases.

Phase 1: Periods 1–10: Markets 1–4 were separated.

Phase 2: Periods 11–20: Firms were free to choose the market they wanted to compete in. They could change the market in any period at no cost.

1. Describe market outcomes

Use the variables from the excel-file provided on the server (“summary”):

Phase 1: Produce a graph showing average profits over both markets of the same type over all periods (i.e., a bar diagram with 4 bars). Repeat the exercise with quantities. How do quantities and profits relate to the number of competitors?

Phase 2: Describe how firms move between markets (try to summarize). For example, do markets with few firms in a particular period tend to have more, less or the same number of firms in the consecutive period? How do average profits in the four markets compare (compare averages over all periods)?

2. Explain observed market outcomes

What is the economic prediction for quantities and profits in phase 1 in the respective markets? Hint: $P = 100 - (q_i + Q_{-i})$, where q_i is firm i 's quantity choice and Q_{-i} is the sum of the $n - 1$ other players' quantities. Firms produce at constant marginal cost of 1. Start with the case of 1 firm, proceed to 2 firms, 3 firms etc. You might not be able to find all predictions. Compare the theoretical predictions with the experimental data.

What would you have expected for phase 2 from an economic perspective? How does that compare with actual observations?

3. Prepare a 5-minute presentation in which you describe and explain market outcomes

Please stick to the time limit of 5 minutes. Be concise and analytical. The presentation will be followed by a plenary discussion. Issues (observations, thoughts, feelings) that could not be appropriately addressed in the short and graded presentation can be raised then.