Lessons to be learned from using Gertner's game of Cournot oligopoly in the classroom

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Since the early 1990s, economics departments at Australian universities have become increasingly concerned with falling undergraduate enrolments. This follows concerns by students regarding the relevance of economics courses both in content and delivery to their future occupations and incomes. It is also a result of competition from the more generic business and marketing courses that have been introduced in many commerce faculties. Together with the broader goal of universities to produce employable, well-rounded graduates, the attrition of economics undergraduates has steered attention within undergraduate economics classes to experimenting with a wide range of teaching tools. One such tool introduced by the authors in a second-year competition and business strategies unit in 2004 – a tutorial game on Cournot interdependence – is described in this paper.

INTRODUCTION

Tertiary teaching has always been a challenge for university academics, many of whom have no formal teaching qualifications, and have reputations more closely linked with published research in the discipline, obtaining competitive grants, and attracting postgraduate students than with teaching undergraduates. Teaching in a business school is even more of a challenge, as the worlds of academia and business collide, merge and diverge.

Broader issues for universities that transcend discipline groupings include meeting the needs of employers for employable, well-rounded graduates; the increasing amenity of computers for communication, data gathering and information sharing; the globalisation of commerce and knowledge; the teaching/research nexus that divides academic time and efforts; and the redefinition of the student body as paying clients.

A specific issue for economics departments in Australia over the last decade is falling undergraduate enrolments (Hellier et al. 2004; Lewis & Norris 1997; Maxwell 2003; Millmow 1995; 1997; 2000). Speculations regarding the causes of this decline include the growth of more generalist business degrees (Lewis et al. 2004). Another reason cited by potential students is the relevance of economics courses both in content and delivery. Coupled with the broader issues facing universities, attention to undergraduate economics teaching has spawned a wide range of teaching tools which, together with curriculum thinning, have attempted to slow the attrition of undergraduates.

In addition, economics is often taught at high levels of abstraction that can hinder some students from an intuitive understanding of the concepts. On the other hand, students are often sceptical and therefore biased against economic theory, questioning its relevance. Classroom exercises designed so that students interact and make decisions in the economic paradigm can be of some use in alleviating these problems (Grobelnik et al. 1999; Meister 1999). In this paper, the use of the 'Shrimp Game' as an interactive tutorial tool to demonstrate the relevance of Cournot games in a second-year business economics unit in 2004 is described.

COURNOT GAMES

Augustine Cournot (1838, trans. 1929) published *Researches into the Mathematical Principles of the Theory of Wealth*, where he conceptualised the nature of interdependence and competition between players in an industry. The model, often known as the 'work-horse' of oligopolists (Martin 1993), is a simple static game consisting of two firms in competition for market share in the market for spring water. In the original model the production cost of the firms is zero, however later models assume either that both firms have symmetrical cost structures (typically constant costs or constant returns to scale) or that one firm has a superior technology that allows it to produce output with a lower cost structure than the other.

The Cournot model is a simultaneous-move single-shot game where the strategy space for each player (firm) is the same as for every other player. As is well known, the initial basis for a Cournot solution is formed on the assumption that in an undifferentiated duopoly, each duopolist believes that his rival will go on producing a definite quantity irrespective of what he himself produces. In these circumstances, each duopolist believes that he can calculate the quantity he should produce in order to maximise his own profits. He can do this by deducting the fixed quantity of the rival's output from the market quantity demanded, to determine the output he should produce in order to maximise his own profits. Once he obtains his individual demand function, he may then proceed to equate his individual marginal revenue to his marginal cost.

A central contribution of Cournot is the reaction function that he derives for each of the duopolists in the market. Reaction functions may be linear even if the demand and cost functions are not. Each reaction function is written as a function of the rival's output. For the two players A and B, A's output is a function of B's output and vice-versa. Cournot reaction functions are typically linear and monotonically decreasing, and the main proposition is that intersection marks stable equilibrium which, in the context of game theory, is the Nash-Cournot equilibrium from which neither firm has a unilateral incentive to deviate. In other words, if either firm produces either more or less than this quantity, given the quantity of the other firm, then the payoff to that firm declines (Fellner 1949, p. 60).

The Cournot reaction function model, however, has not been without its share of criticisms. Fellner (1949) criticises the presumed determinateness of the Cournot solution, and stipulates that the players are 'right' for the 'wrong reasons' in the context of the equilibrium that they arrive at. In Daughety's (1988) view, the Cournot story of disequilibrium behaviour, where each firm observes the other's output and then chooses a new production level assuming that the other firm will stay at its observed output, 'strains credulity as firms in the story never learn that other firms do adjust' (p. 6). Yet another criticism that is launched at the reaction function (also known as response function, best response function, or best reply function) is that any notion of 'reaction' implies a dynamic process and sequential moves that are not, in principle, permissible in what is essentially a static model.

A final criticism, or perhaps better labelled consideration, raised by Kreps and Scheinkman (1983), is that the solutions to the game rely on both the strategic variables and the strategic context of the game. That is, 'the timing of decisions and information reception are as important as the nature of the decisions' (p. 327). That is, the rules for the game may be influencing the results. Consideration of this concern will be addressed in the Semester 2, 2005 offering of the Shrimp Game that we discuss in this paper.

The Cournot story concerns producers who simultaneously and independently make production quantity decisions, and who then bring what they have produced to market, with the market price being the price that equates total supply with demand. Prices in the Cournot model are determined by a mythical auctioneer. Kreps and Scheinkman (1983, p. 327) critique and eliminate the need for an auctioneer by introducing a two-stage game as a mechanism to generate Cournot-like outcomes. Capacities are set in the first stage by the two producers. Demand is then determined by Bertrand-like price competition, and production takes place at zero cost, subject the to capacity constraints generated by the first-stage decisions. Such a modification adds weight to the quantity-setting assumption of the Cournot model, which might otherwise remain implausible.

Traditional methods for teaching Cournot models incorporate tree diagrams, payoff matrices, numerical simulations and the algebraic derivation of reaction functions, with the objective of working out the Nash equilibrium. These methods are typically conceptual, technical, and esoteric enough that they may pose a learning barrier to the reach of the average business student, who is most likely not to have a strong mathematical background. Students typically become so concerned and engrossed with the technical and theoretical derivations that they miss the practical value of the model. In addition, traditional teaching methods focus on the equilibrium outcome, and not the process by which the equilibrium results.

The Shrimp Game (Garicano & Gertner 1999) is an imaginative teaching method that overcomes these difficulties from a number of perspectives. Firstly, students work with a relatively simple function. This function is written with the intention of drawing students' attention to the notion of interdependence, without involving them in the intricacies of algebraic manipulation. The student activity is essentially concrete, so that students become aware of optimising under conditions of interdependency. The relevance of other players' choices becomes apparent, and this can be explained by the tutors with reference to choices the business people must make using assumptions about their competitors' behaviours.

Games illustrating interdependencies are numerous in the game theory literature, but are principally abstract in nature and therefore difficult to interpret and translate into a class-room activity. Furthermore, the applications that arise from these are few and far between. For instance, the chicken game or battle of the sexes game are both ideal at a theoretical level to explain mixed-strategy equilibrium. However apart from exercises in calculations, which can theoretically illustrate the point, these games do not readily translate into activities that are sensible. By this we mean, how is it possible to simulate either of these games in the classroom? Moreover, while mixed strategies can be shown to exist theoretically, there are obvious difficulties in interpreting these in the business context.

In contrast, the Cournot model of interdependency is easily interpreted for heuristics, particularly in the context of business analogies. The model, often called 'the workhorse' of oligopolists (see Martin 1993 for some discussion of this) is well illustrated in intermediate textbooks, and therefore readily accessible. In addition, the Cournot game, as an example of quantity-setting oligopoly, translates readily into appropriately manageable classroom exercises.

Laboratory experiments simulating simple markets in controlled situations go as far back as Chamberlin's (1948) experiments to assess theories of imperfect competition against laboratory results. Holt's (1985; 1995) laboratory experiments relate directly to the Cournot model. In his 1985 experiments, Holt specifically tests the consistent-conjectures hypothesis associated with the Cournot equilibrium with data for an individual's behaviour. In these experiments, subjects simultaneously choose output in a sequence of market periods, in the context of complete information about the relationship between decisions and profits for all participants. Holt's experiments and other previous experiments were not, however, teaching tools. The subjects were students, but the goal of the experiments was not to instruct students about interdependence or about the Cournot model. Grobelnik et al. (1999) deviate away from this general trend and design a classroom game to illustrate strategic interactions. The Shrimp Game follows this example.

Other similar games that were looked at for use in our 2004 business strategies unit tended to involve students using computers within a laboratory setting. In the main, these required students to work alone. The use of computers was not an option for our students in 2004. We also felt that interdependency was better played out in groups.

SHRIMP GAME

The Shrimp Game (created by Robert Gertner, Graduate School of Business, University of Chicago) is built from the Cournot assumptions that firms choose outputs and make their production decisions simultaneously (Garicano & Gertner 1999). This one-shot game is restricted to be set in a non-cooperative framework, and does not permit cooperation between players. This version permits repeated play of a one-shot simultaneous game. The Shrimp Game has been introduced in the classroom elsewhere. For example, Fiona Scott Morton (Yale School of Management) plays two rounds of Cournot, one round of cheap talk (no commitment) by one player, one round of Stackelberg, one round where players talk without any commitment, and then two more rounds. This adds up to seven rounds played in real time in the classroom (Scott Morton 2003).

The Shrimp Game involves three shrimpers, named in Gertner's creation as Arnold, Beatrice and Charlotte, competing in the same town for market share. They are the only shrimpers in town, and the only suppliers to this market. The shrimpers have a family history of feuds and do not communicate with each other. This assumption is used to confirm the non-cooperative nature of the game and the rule prohibiting collusion.

These shrimpers have identical constant cost functions fixed at $5.00 per pound of shrimp (including opportunity cost). The price that each of the shrimpers receives from the market is determined by the function $P(Q_A, Q_B, Q_C) = 45 - 0.2(Q_A + Q_B + Q_C)$, and this is common knowledge. The maximum amount of shrimp that any shrimper is allowed to catch is 75 pounds per day and, since shrimp goes bad after one day, no shrimper can store some of the catch from one day and sell it on the next. The quantity constraint keeps the shrimpers focused on increasing profit via increasing market share, rather than by expanding the total market. The profit for each of the shrimpers is calculated as the number of pounds caught multiplied by the profit margin, and is written as $\pi_i(Q_A, Q_B, Q_C) = Q_i[(P(Q_A, Q_B, Q_C) - 5]$. The goal of each shrimper is to maximise profits, and each of the shrimpers has no regard for the profits of the others. All shrimp caught are traded at the end of the day when the catch is brought to market. At this time, the production levels that were chosen by each shrimper, and hence the aggregate production and market clearing price, become common knowledge.

It is assumed that shrimp are homogeneous in order to be consistent with the Cournot assumption. Relaxing this assumption may encourage students to engage in price discrimination based on quality differentiation of the product. Moreover, the assumption of homogeneity allows drawing symmetrical conclusions between firms in the industry.

Collusion is not allowed as mentioned above. The possibility of collusion does exist in the game, but has been deliberately avoided by prohibiting communication between the shrimpers. Relaxing this rule is a modification that we may introduce to some groups in Semester 2, 2005. Nonetheless, it is possible that some covert cooperation may enter the game, even with a finite number of rounds. For example, Kreps et al. (1982) suggest that, contrary to expectations, this may result from incomplete information about one or both players' options, motivation or behaviour.

Purpose and aims

The purpose of the Shrimp Game is to illustrate the notion of interdependency, which is the quintessential feature of oligopoly competition. This concept (the assumptions and expected outcomes) could be explained to students in lectures. Alternatively, textbooks and lecture notes can adequately present the Cournot equilibrium in a static framework, complete with linear demand and reaction functions. In terms of Skilling's (1969) hierarchy however, the remembering of the process of interdependence is less likely from these aural and visual methods. Instead, let the students be the Cournot competitors, inviting them into the strategic decision-making process.

The teaching and learning requirements for tutorials include an emphasis on active rather than passive learning. This is premised on the pedagogical claim that students learn more from seeing and doing (active learning) than from note taking (passive learning). Skilling (1969), in his Eleven Commandments for Teachers, lists as number eight: 'Let the student work, for work is remembered long after words are forgotten. Hearing is weak, seeing is better, doing is best.'

The game shows that individually (without cooperation), the joint profit maximum cannot be achieved (Bori 2002). The equilibrium output for each firm in a three-firm industry with identical cost functions, given the parameters of the Shrimp Game, is 50 pounds, and the equilibrium price for this output is \$15.00 per pound. At equilibrium, total industry output is 150 pounds, and each firm earns a profit of \$500.00 (Church & Ware 2000). Consequently, the only Nash equilibrium in this game is where

$Q_A = Q_B = Q_C = 50$ pounds of shrimp, and any unilateral deviation from this equilibrium can only lead to worsened outcomes for each of the three shrimpers.

Instructions

Two sets of instructions were prepared and distributed. One of these was distributed to students via the unit's web presence. The other set was given via email to tutors. These are shown in Appendices 1 and 2 respectively.

The instructions to students gave the process for playing the game, including how quantities and price in each round are chosen and determined respectively. The students in class were given a mathematical version of the Cournot-Nash game from the textbook, with the emphasis on the reaction function treatment. Other than the previous week's lecture material on the difference between cooperative and non-cooperative games, the students were not given any details as to the context or expected outcomes of the game.

The instructions to tutors were broader. In addition to specific guidelines for the conduct of the game, tutors were briefed on the aims and expectations of the game. It was emphasised that the learning outcomes did not include the derivation of the equilibrium strategy (as might be expected with an algebraic or graphical treatment of a non-cooperative game example). Instead students were, through the process of rounds, to experience the interdependent nature of their choices, and the benefits of cumulative behaviours.

The lecturer and tutors met prior to the conduct of the Shrimp Game tutorials to clarify the instructions and design the results template. This was important to control for bias in the results arising from differences in tutorial management.

Conduct

In each tutorial, students were arranged in groups of three or four, depending on the total class size. Students in a group of three were designated as the three shrimpers. One of these students also kept records of quantities, and calculated price and profits. It is unclear whether these shrimper/recorder students gained a strategic advantage. Discerning this will be addressed in Semester 2, 2005. Students in groups of four were designated as the three shrimpers and a recorder.

Five rounds of the game were played, each round representing one day. The key to successful completion of each round was the simultaneous announcement of quantities by each shrimper. The groups resolved their own means of ensuring simultaneity. For example, in some groups the quantities were written down and hidden until the announcement (by the tutor) of trading (revealing quantities brought to market). Other groups used a countdown (3, 2, 1, 0), with the quantities being announced when 'zero' was reached.

RESULTS AND DISCUSSION

The unit had an enrolment of 130 students in Semester 2, 2004, but only about 40 students participated in the Cournot version of the Shrimp Game. Other students undertook Stackelberg versions of the game, but these are not reported here. There were also the usual no-shows (about one-third) for the tutorials. The results recorded for each 'trading day' for each tutorial group are shown in Appendix 3.

The closest to equilibrium results were shown by groups six and nine. In both of these cases, on average the shrimpers produced 50 pounds per day (48 and 49 in groups 6 and 9 respectively) and the average daily profit for each shrimper was about $500 ($512 and $484 respectively).

Group one commenced on day one with aggregate profit at its best at $1,920. This was also the best of day one trade across all groups. The market price was highest on day one for group one. Profits declined on day two and further declined on day three, after which the group rallied on days four and five. The day five aggregate profit result was the same as for day two. The high level of profit achieved on day one was not reached again within the five-day cycle. The pattern of profit across the three shrimpers in group one was however quite different on days two and five, with Arnold selling most on day two, and receiving the highest individual profit. In contrast on day five, Arnold and Charlotte achieved the same profit results and Beatrice's extremely low level of profit was due to her very low poundage brought to market. Overall, group one had average daily profit of $364 per shrimper, and average day's trade of 54 pounds per shrimper.

Group two had the highest average poundage per shrimper at 62 pounds per day, and the lowest average daily profit of $164 per shrimper. The daily profit across the three shrimpers ranged from $195 to $451 per day, while industry output ranged from 180 to 195 pounds per day. With Beatrice and Charlotte intent on keeping their production close to the allowable maximum of 75 pounds each, the industry was unable to achieve better profit outcomes. Arnold alone attempted lower quantities which improved his daily profit somewhat but, due to the high output of his competitors, was unable to make better profits.

Group three achieved a middle of the range average daily profit per shrimper of $283, and daily output per shrimper of 58 pounds. Arnold started with output at the allowable maximum of 75 pounds, and gradually decreased this over the five days. His first day's profit was high as Beatrice chose a lower quantity (but greater than the equilibrium of fifty pounds) as did Charlotte, whose 37.5 pounds was well below the equilibrium. With both Beatrice and Charlotte's production increasing on the second day's trade, and Arnold lowering his output, aggregate profit on day two was much less. Arnold progressively decreased his output over days three to five, and his profit increased. But his profit on these days was not as high as either of his competitors. Beatrice performed an interesting manoeuvre in almost halving her output on day five, having spent the first four days gradually increasing output from 60 to 75 pounds. Her close-to-equilibrium profit result on day five was not due so much to her output choice but to Arnold, who was keeping his output low. Charlotte was thus able to keep both her output and profit high on day five.

Group four's daily results reflected yo-yoing in shrimpers' choices. Industry profits ranged from $0 to $1,500, although industry output hovered around its average of 181 pounds for each day's trade. A zero profit for all shrimpers in group four was the day two result. All shrimpers had kept their output high (70, 60, 70), so the market price minus cost was zero. This was an attempt by the shrimpers to improve on the profit outcomes from the first day's trade. This outcome shocked all shrimpers into re-thinking their strategies, so that day three saw their best profit outcomes both in aggregate and individually. The average profit for day three was at its equilibrium. Unfortunately for this group, output decisions on day four resulted in low profit. Charlotte expanded her output from 40 pounds on day three to 75 pounds (the maximum allowable) on day four, achieving higher profits than Arnold and Beatrice for that day. However, these profits were not as high as her day three result. She tried to regain profit levels on day five, but her competitors both went for the maximum allowable output thus stymieing her efforts.

Group five had average daily output and profit per shrimper of 57 pounds and $259 respectively. The best day's profit for this group was day two, and this was achieved by disparate choices of output by each of the three shrimpers. Arnold chose output of thirteen pounds, Beatrice the maximum allowable catch of 75 pounds, and Charlotte 35 pounds. On day two, Beatrice had a profit of $1,155, well above her competitors' profits of $200 and $539. But she was only able to achieve this result because Arnold and Charlotte had set their output at below equilibrium levels. Day five trade would have been a surprise to all three shrimpers, as the industry and individual profit levels were negative. All shrimpers opted for large outputs (73, 65 and 70) and this was sufficient to push the market price down below cost.

Group six had average results closest to the equilibrium levels of 50 pounds and $500 profit per shrimper. Industry profits were consistently high over all five days of trade. Individual profits averaged $444, $576 and $516 for Arnold, Beatrice and Charlotte respectively. Market price ranged from $10.60 on day two to $20.60 on day four.

Average industry output and profit of 45 pounds and $559 were achieved by group seven. The aggregate profit each day did not fall below $1,200, and all shrimpers had three days of above equilibrium profit levels. The lowest profit was made by Beatrice on day four, when the other two shrimpers produced almost 25 percent more poundage.

Group eight realised the second lowest average profit per day of $188. Average output per day was 61 pounds. Industry profits bounced around over the five days, with a range from –$290 on day three to $1,558 on day four. The negative industry profit level occurred on day three when the industry output was about forty percent above its equilibrium level. This put downward pressure on the market price on that day, and in fact the trading price was below cost, hence the losses. The best profit level of $1,558 was achieved on day four, by Beatrice suppressing her production to about half that of her competitors. This enabled industry output to approximate the equilibrium level, and Arnold and Charlotte to each achieve twice the profits of Beatrice. The other four days trade saw industry output well above the equilibrium level, thus keeping profits down.

Group nine achieved an average daily output per shrimper of 49 pounds, the closest of the groups to the equilibrium output of 50 pounds. Average daily profit of $484 per shrimper was close to the equilibrium profit level of $500. Arnold traded between 30 and 40 pounds on days one to four, achieving reasonable profits. On day five his output jumped to 70 pounds, and his profit stayed high mainly because Beatrice and Charlotte kept their outputs low – Beatrice at 47 pounds and Charlotte at 50 pounds. Industry profits were positive on all days, with days one, three and four having at or above equilibrium profit levels. Charlotte seemed to have a sense of equilibrium output, with her production choices hovering between 50 and 60 pounds. Beatrice attempted the maximum allowable catch of 75 pounds on day two but, finding her profits eroded, revised her output to 30 pounds on day three.

Group ten results were mixed across individuals, although on average the daily output and profit levels were slightly above and below the equilibrium respectively. Arnold and

Beatrice were partial to the maximum allowable catch of 75 pounds. They each chose this on three of the five days. On day two when they both opted for 75 pounds, the individual and industry profit levels became negative. The industry profit peaked on day four when Arnold and Charlotte opted for below equilibrium output of 35 pounds each, and Beatrice produced 75 pounds. On day five, Beatrice set her output at only five pounds, which meant that industry profit was high ($1,755), Arnold and Charlotte achieved decent profit levels of $975 and $715 respectively, but that her own profit was a pitiful $65.

The results seem to indicate four things. First, the shrimpers are increasingly aware of their interdependency with successive rounds. Second, each competitor is trying to guess what they think the other two shrimpers will choose. Third, evidence of convergence to equilibrium appears to be weak. This may be addressed in 2005 by increasing the number of rounds, or allowing rounds to continue within some finite time constraint. Finally, some frustration at ‘fumbling around in the dark’ seemed to lead to some extreme output choices by some competitors in some groups. Meister (1999) also reported some frustration by students with their inability to influence their rivals’ actions. One student commented that ‘the artificial construction of the game meant it wasn’t really a good model of a real market situation’. This could be attributed to the veto on cooperation or collusion that remained throughout the game.

In discussion with tutors following the week of Shrimp Game tutorials, three main changes to the conduct of the game were mooted for 2005. Firstly, the learning of strategies might improve with a greater number of days of trading. This could be achieved by either setting a fixed number of days, or setting a time limit.

Another change that might discourage the sort of ‘giving up’ that may have been occurring for some individuals in some groups is to award a prize for the best group. This could be those closest to achieving the equilibrium levels of output and profit in the final round, either across all groups or for each of the tutorial groups. Motivation is a key ingredient to encouraging serious participation and keeping students on track. A tangible prize might just increase the competitive edge in the game! As Cheung (2003) notes:

> When experiments are used in economics research, it is important that subjects are motivated to (attempt to) pursue maximum payoffs through the use of real cash payments based on their performance in the experimental market. Many teachers have mimicked this procedure in the design of classroom experiments, awarding cash, in-kind gifts, or assessment points to reward payoffs earned by students in these activities.

Finally, it was thought that the next time the game is played students could receive information about the purpose and process of the games similar to the instructions given to the tutors.

CONCLUSIONS

The Shrimp Game allows students to forage in the interdependencies that oftentimes characterise the world of (big) business. As Hellier et al. (2004, p. 24) argue, ‘students who experience a more market-oriented approach when taught economics may benefit from the added value provided’. This assertion is similar to that argued by Azzalini and Hopkins (2002, p. 15) in their review of what second-year business students think of economics.

As a tool to assist learning outcomes related to the topic of interdependencies in oligopoly, the Shrimp Game appeared to be useful for at least two reasons. First, students liked the game itself. While there was no formal evaluation of the game, anecdotes from students included:

> When I started the game I pretty much knew the theory behind the workings of the Cournot, Bertrand and Stackelberg models, how their actions were taken and how the equilibrium was set. However, from playing the game, I really understood the motivations of the players … it really showed how the model works in reality and not just as a one-shot theoretical model.

> I enjoyed the interactive nature of the game and its demonstration of the importance of market power in deciding prices.

Second, the Shrimp Game was useful as a change from the usual tutorial regime of question and (perhaps) prepared answer (chalk and talk). For example, one student made the following comment:

> It made a change from trying to avoid answering tute questions.

These are two very good reasons for using the game again, as is planned for Semester 2, 2005.

Moreover, the Shrimp Game encourages the development of the communication skills that employers prize so highly (Hellier et al. 2004, p. 230). While the game rules prohibited personal contact during the quantity deliberations in each round, discussion within groups and in each larger tutorial group throughout the course of the game encouraged students to articulate their concerns and outcomes. They discussed their results at the end of each round with each other and with the tutor, using both the results and the discussion to guide their next choice. These tutorials tended to be more lively and better remembered by students revising for exams than the other talk-and-chalk type tutorials.

In terms of the broader goal of encouraging students to stay in the economics discipline, the response is unclear. The Shrimp Game was played in one of eleven weeks (about half way through the semester) for a second-year business economics unit. The tutorials in the other ten tutorials were conducted on traditional question and answer lines. It is unlikely that one interactive game session would change student behaviour or enrolment choices. However, the success of this very different hands-on approach could be taken up with other topics within the unit, or in other tutorials across all economics units. It is important however not to 'overkill' by offering too many game-type sessions. Diversity in delivery is as important as topic heterogeneity in keeping today's students engaged and 'learning by doing'.

Finally, if the decline in economics enrolments is to be stymied, and employer requirements are to be met by economics graduates, a practical orientation to economics course content is paramount. The Shrimp Game can be just one of many teaching tools to achieve this goal.

REFERENCES

Azzalini, P., and S. Hopkins. 2002. What business students think of economics: Results from a survey of second year students. *Economic Papers* 21: 11–7.

Bori, J. 2002. The campus jobseeker's dilemma. *Chicago Business*, September 30.

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

Cheung, S. 2003. On the use of classroom experiments in 'aligned' teaching. *Economic Analysis and Policy* 33 (1): 61–72.

Church, J., and R. Ware. 2000. *Industrial organization: A strategic approach*. New York: McGraw-Hill International Editions.

Cournot, A.A. 1838, trans. 1929. *Researches into the mathematical principles of the theory of wealth*. New York: Macmillan.

Daughety, A.F. 1988. Introduction, purpose and overview. In *Cournot oligopoly: characterization and applications*. Edited by A. F. Daughety. New York: Cambridge University Press.

Fellner, W. 1949. *Competition among the few: oligopoly and similar market structures*. New York: A.A. Knopf.

Garicano, L., and R. Gertner. 1999. The dynamics of price competition. *Financial Times*, October 18, 2.

Grobelnik, M., C. Holt, and V. Prasnikar. 1999. Classroom games: Strategic interaction on the internet. *Journal of Economic Perspectives* 13 (2): 211–20.

Hellier, P., M. Keneley, R. Carr, and B. Lynch. 2004. Towards a market oriented approach: employer requirements and implications for undergraduate economics programs. *Economic Papers* 23 (3): 213–33.

Holt, C. 1985. An experimental test of the consistent-conjectures hypothesis. *American Economic Review* (June): 314–25.

Holt, C. 1995. Industrial organization: A survey of laboratory research. In *The handbook of experimental economics*. Edited by A. Roth and J. Kagel. Princeton: Princeton University Press.

Kreps, D.M., P. Milgrom, J. Roberts, and R. Wilson. 1982. Rational cooperation in the finitely repeated prisoners' dilemma. *Journal of Economic Theory* 27 (2): 245–52.

Kreps, D.M., and J.A. Scheinkman. 1983. Quantity precommitment and Bertrand competition yield Cournot outcomes. *Bell Journal of Economics* 14 (2): 326–37.

Lewis, P.E.T., A. Daly, and D. Fleming. 2004. Why study economics? The private rate of return to an economics degree. CLMR Discussion Paper Series 04/5.

Lewis, P.E.T., and K. Norris. 1997. Recent changes in economic enrolments. *Economic Papers* 16: 1–13.

Martin, S. 1993. *Advanced industrial economics*. Oxford: Blackwell Publishers.

Maxwell, P. 2003. The rise and fall (?) of economics in Australian universities. *Economic Papers* 22: 79–92.

Meister, J.P. 1999. Oligopoly – an in-class economic game. *Journal of Economic Education* (Fall): 383–91.

Millmow, A. 1995. The market for economists in Australia. *Economic Papers* 14: 83–96.

Millmow, A. 1997. To eke out a marginal existence: Economics in business schools. *Economic Papers* 16: 88–97.

Millmow, A. 2000. The state we're in: University economics 1989/99. *Economic Papers* 19: 43–52.

Scott Morton, F. 2003. A request: The shrimp game.

Skilling, H.H. 1969. *Do you teach? Views on college teaching*. New York: Holt, Rinehart, and Winston.

APPENDIX 1

Instructions for students

Arnold, Beatrice, and Charlotte own the only three shrimp boats on the island of Augustine. Each incurs a cost of $5.00 per pound of shrimp (this includes the opportunity cost of time), and each can catch at most 75 pounds per day. At the end of each day they bring their catch to market, where price is determined by market demand and the supply of shrimp. Let Q_A, Q_B, and Q_C denote Arnold's, Beatrice's and Charlotte's catch, respectively. Once each has decided when to stop fishing and has brought his or her shrimp to market, the price is determined by the following equation:

$$P(Q_A, Q_B, Q_C) = 45 - 0.2(Q_A + Q_B + Q_C).$$

Each shrimper agrees that the above equation correctly predicts the market price of shrimp, and each tries to catch enough shrimp so as to maximise his or her dollar profits. All shrimp goes bad after one day, so a shrimper cannot keep shrimp off the market and sell them the next day. The profits for each shrimper equals the number of pounds caught multiplied by their profit margin, that is:

$$\pi_i(Q_A, Q_B, Q_C) = Q_i[(P(Q_A, Q_B, Q_C) - 5].$$

You are Arnold, Beatrice, or Charlotte. Each day you will be asked to set that day's level of production. Note that you are not able to catch more than 75 pounds of shrimp per day. The amount of money you earn at the end of the day will equal the value described above. Remember that your goal is to maximise your own profits; you do not care at all about the profits of the other shrimpers.

All shrimp is traded at the fish market. When trade takes place each shrimper reveals their level of production for that day, so this information becomes public knowledge. The three shrimpers have a history of family feuds and no personal contact. Each will have to set its shrimp production for the day without knowing what levels the other two shrimpers set. However, as described above, at the end of each day the production levels that were set by each shrimper will become public knowledge.

In class, you will be divided into teams and asked to make quantity decisions for one of the shrimpers. There will be a several rounds and several different scenarios. In some cases, all decisions will be made simultaneously, while in others, one shrimper will go before the other two. In the latter case, the first-mover's decision will be announced to its two rivals before they make their decisions.

APPENDIX 2

Instructions for tutors

The objective of this classroom simulation is to get students to understand the basis of the Cournot game. The key ideas that we would like to see elucidated are that the payoff for each of the shrimpers is dependent upon the market price that each of them receives, and that this is dependent upon the summation of the entire supply. What is also important to note is the adjustment process that each of the shrimpers goes through, and the method by which the shrimpers learn about their interdependencies.

In their lectures, the students have heard about two-player oligopolies. The only context in which the three-player game has been discussed is in the Cournot 1838 model, assuming zero costs in production. In general, in an industry consisting of n firms, each firm will produce $1/(n+1)$ of – and the total industry output will be $n/(n+1)$ of – the perfectly-competitive industry output. Therefore for $n = 3$, each of the firms will supply ¼ of, and the total industry output is ¾ of, the competitive output.

The students have no need to solve this problem algebraically. We are interested in seeing the adjustment process, and how they go about reaching their conclusions. The game, its introduction and summing up should take 45 minutes.

1. Prepare for the game, by setting up a score board, as follows:

	A	B	C	Profit
Round 1				
Round 2				
Round 3				
Round 4				

2. Break the class into groups of three or four (this should take five minutes) and assign shrimpers – Arnold, Beatrice, and Charlotte. Also have one person to record all information within the group.
3. Clearly identify groups – group one, group two and group three, for instance. (This may take another five minutes.)
4. Clearly read the instructions aloud and make sure students understand what is expected of them.
5. Play the first round of the game, say ten minutes. Record on the board. Calculate the profit for each group.
6. Play the second round of the game, time again for ten minutes. Record the score. Compare to see if there is any learning going on.
7. Play the third round of the game. Once again record all scores and compute profits.
8. Discuss all results, and note if there have been any deviations from the predictions of economic theory.

APPENDIX 3

Results

Group	Day	Q_A	π_A	Q_B	π_B	Q_C	π_C	P_M	Total Q	Total π	Average Q	Average π
	1	60	960	20	320	40	640	21	120	1920		
	2	70	630	30	270	55	495	14	155	1395		
1	3	70	70	75	75	50	50	6	195	195	54	364
	4	70	210	65	195	50	150	8	185	555		
	5	75	675	5	45	75	675	14	155	1395		
	1	75	75	70	70	50	50	6	195	195		
	2	35	140	75	300	70	280	9	180	720		
2	3	35	140	75	300	70	280	9	180	720	62	164
	4	50	100	75	150	65	130	7	190	380		
	5	50	120	70	168	68	163.2	7.4	188	451.2		
	1	75	412.5	60	330	37.5	206.25	10.5	172.5	948.75		
	2	60	84	68	95.2	65	91	6.4	193	270.2		
3	3	50	150	70	210	65	195	8	185	555	58	283
	4	40	200	75	375	60	300	10	175	875		
	5	30	330	45	495	70	770	16	145	1595		
	1	75	225	60	180	50	150	8	185	555		
	2	70	0	60	0	70	0	5	200	0		
4	3	50	500	60	600	40	400	15	150	1500	60	210
	4	40	160	65	260	75	300	9	180	720		
	5	75	150	75	150	40	80	7	190	380		
	1	57	250.8	50	220	71	312.4	9.4	178	783.2		
	2	13	200.2	75	1155	35	539	20.4	123	1894.2		
5	3	74	88.8	70	84	50	60	6.2	194	232.8	57	259
	4	45	369	50	410	64	524.8	13.2	159	1303.8		
	5	73	–116.8	65	–104	70	–112	3.4	208	–332.8		
	1	40	464	60	696	42	487.2	16.6	142	1647.2		
	2	75	420	50	280	47	263.2	10.6	172	963.2		
6	3	32	486.4	50	760	42	638.4	20.2	124	1884.8	48	512
	4	35	546	45	702	42	655.2	20.6	122	1903.2		
	5	38	304	55	440	67	536	13	160	1280		
	1	45	585	40	520	50	650	18	135	1755		
	2	36	590.4	47	770.8	35	574	21.4	118	1935.2		
7	3	47	498.2	45	477	55	583	15.6	147	1558.2	45	559
	4	58	429.2	47	347.8	58	429.2	12.4	163	1206.2		
	5	43	705.2	45	738	30	492	21.4	118	1935.2		

Group	Day	Q_A	π_A	Q_B	π_B	Q_C	π_C	P_M	Total Q	Total π	Average Q	Average π
8	1	70	70	50	50	75	75	6	195	195	61	188
	2	63	151.2	60	144	65	156	7.4	188	451.2		
	3	67	–93.8	75	–105	65	–91	3.6	207	–289.8		
	4	57	604.2	30	318	60	636	15.6	147	1558.2		
	5	69	358.8	55	286	50	260	10.2	174	904.8		
9	1	40	400	50	500	60	600	15	150	1500	49	484
	2	40	200	75	375	60	300	10	175	875		
	3	37	577.2	30	468	55	858	20.6	122	1903.2		
	4	30	450	45	675	50	750	20	125	1875		
	5	70	462	47	310.2	50	330	11.6	167	1102.2		
10	1	25	175	75	525	65	455	12	165	1155	55	345
	2	75	–75	75	–75	55	–55	4	205	–205		
	3	75	375	30	150	70	350	10	175	875		
	4	35	385	75	825	35	385	16	145	1595		
	5	75	975	5	65	55	715	18	135	1755		

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