THE SHRIMP GAME: ENGAGING STUDENTS IN THE CLASSROOM

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ABSTRACT

This paper, presented at the 11th Australasian Teaching Economics Conference in July 2005, and revised in the light of further experimentation, describes the use of the Shrimp Game (a tutorial game on Cournot interdependence) in a second year business strategies unit in 2004 and 2005. The paper firstly summarises Cournot games in general and introduces an example of these, the Shrimp Game, as it was conceived by Gertner in 1999 and adapted by Scott in 2003. The details of the game and its active learning requirements are then explained in Section 3. The fourth section of the paper contains findings that include heightened student awareness of interdependencies but weak convergence to equilibrium. The conclusions refer to the Shrimp Game as being a useful addition to the arsenal of practical experience for economics undergraduates.

Key Words: Shrimp Game, Cournot, business strategies, strategic interdependence, classroom games.

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1. INTRODUCTION

The first teaching economics conference held in Darwin in the early 1990s had less than a handful of economics lecturers attending. They were the vanguard of a new era of concern for engaging students in the classroom. The Darwin conference spawned yearly conferences that grew in attendance and were hosted by sandstone and new universities around the country. Interest from across the Tasman saw the 2001 conference being held in New Zealand. The most recent 2005 conference had the title
of 11th Australasian Teaching Economics Conference (ATEC) with participants from across Australia, New Zealand, the UK and Singapore.

This evolution of interest in the teaching of economics was accompanied by concern by economics departments around Australia over falling undergraduate enrolments (Hellier et al. 2004; Lewis and Norris 1997; Maxwell 2003; Millmow 1995; 1997; 2000). Speculations regarding the causes of this decline include the growth of the more generalist business degrees (Lewis, Daly, and Fleming 2004).

Another reason cited by potential students is the relevance of economics courses both in content and delivery. “Academic economists have not kept pace with the changing instructional methods in higher education that have beckoned, successfully, other disciplines” (Becker and Watts 1998: 2). 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. Many of these tools have been introduced at successive teaching economics conferences.

Another reason for student dissatisfaction with learning economics is that it is often taught at high levels of abstraction. This can hinder some students from an intuitive understanding of the concepts. Classroom exercises designed so that students interact and make choices and decisions in the economic paradigm can be of some use in alleviating these problems (Becker and Watts 1998; Grobelnik, Holt, and Pransinkar 1999; Meister 1999).

One such exercise is the Shrimp Game, a demonstration of Cournot interdependence designed to enable students to practice decision-making (choosing their own daily shrimp catch) in ignorance of competitors' current decisions but with knowledge of past decisions. This classroom game was introduced in a second year business strategies unit in 2004 and revised for use in 2005.

The aims of this paper are to present an evaluation of the Shrimp Game as an example of techniques designed to engage students in the classroom, as well as highlight this experience as part of an arsenal of tools to attract students to, and retain students in, economics majors. The remainder of the paper is organised as follows. Section 2 summarises Cournot games generally and introduces the Shrimp Game as an example of these. Details of the game are presented in Section 3. Findings from the inclusion of the Shrimp Game in second year tutorials at The University of Western Australia in 2004 and 2005 are discussed in Section 4 followed by conclusions in Section 5.
2. COURNOT GAMES

Augustine Cournot (1838, translation 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. His model, often known as the 'work-horse' of oligopolists (Martin 1993), is a simple static game consisting of two firms in competition for a fixed market share in the market for spring water. In the original model, the production cost of the firms is zero. Later models allow for greater numbers of firms and more asymmetries between the firms.

A central contribution of Cournot is the reaction function for each of the duopolists in the market. Each reaction function is written as a function of the rival’s output. Despite criticism (Daughety, 1988; Fellner, 1949; Kreps and Scheinkman, 1983), the Cournot model continues to be taught in intermediate undergraduate economics courses because of its relative simplicity and its symmetry with the more popular Bertrand model. Importantly, the Cournot model provides a useful introduction to discussion of strategic interdependence in oligopoly markets.

Traditional methods for teaching Cournot models incorporate tree diagrams, payoff matrices, numerical simulations and 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 unlikely to have a strong mathematical background. Students typically become so concerned and engrossed about 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 it is reached.

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 classroom activity. Furthermore, the applications that arise from these are few and far between. For instance, the chicken game or the battle of sexes game are both ideal at a theoretical level in order to explain mixed strategy equilibrium. However, apart from exercises in calculations, which can theoretically illustrate the point, these games do not readily translate to activities that are sensible.

Laboratory experiments simulating simple markets in controlled situations go as far back as the Chamberlain (1948) experiments designed 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 designs a laboratory experiment to specifically test the consistent-conjectures hypothesis associated with the Cournot equilibrium with data for an individual’s behaviour. In these experiments, subjects simultaneously chose 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, Holt and Prasnikar (1999) deviate away from this general trend and design a classroom game to illustrate strategic interactions. The Shrimp Game follows this example.

3. DESCRIPTION OF THE SHRIMP GAME

The Shrimp Game (created by Robert Gertner, University of Chicago, Graduate School of Business and introduced in the classroom elsewhere (Scott 2003)) is built from the Cournot assumptions that firms choose outputs and make their production decisions simultaneously (Garicano and 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 is an imaginative teaching method with useful teaching and learning features. 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 optimizing under conditions of interdependencies. The relevance of other players’ choices becomes apparent and this can be explained by the tutors with reference to choices business people must make using assumptions about their competitors’ behaviours. The specifics of the game are as follows.

The 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 are 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.

It costs these shrimpers $5.00 per pound of shrimp inclusive of 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 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 the next day. This quantity constraint keeps the shrimpers focused on increasing profit via increasing market share rather than via 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 written as \( \pi_A(Q_A, Q_B, Q_C) = Q_A[P(Q_A, Q_B, Q_C) - 5] \).

The goal of each shrimper is to maximise profits and each of the shrimpers has no regard for the profits of the other shrimpers. All shrimp caught are traded at the end of the day when the catch is brought to the market. At this time the production levels that were chosen by each shrimper, and hence aggregate production and market clearing price, become common knowledge.

It is assumed that shrimps 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 although it is possible that some covert cooperation may enter the game 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.

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 (see Besanko et al. 2007 or Church and Ware 2000 for the general method for computing equilibrium output). The equilibrium has the property that taking into account the effect that a change in quantity will have on price, each shrimper will not choose to change his behaviour of catching 50 pounds per period, when his competitors also catch 50 pounds each per period. At this Nash equilibrium, total industry output is 150 pounds and each firm will earn a profit of $500.00 (Church and Ware 2000).
3.1 Purpose and aims

The purpose of the Shrimp Game is to illustrate the notion of interdependency which is the quintessential feature of oligopoly competition. The specific aims of the incorporation of this game into a second year tutorial in a business strategies unit are twofold. First, students can experience the achievement of equilibrium through the dynamics of playing the game. A second aim relates to the teaching and learning requirements for tutorials which 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'.

3.2 Instructions

Two sets of instructions were prepared and distributed. One of these sets was distributed to students via the unit's web presence. The other set was given via email to tutors. These are shown in Appendices A and B 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 text book with the emphasis on reaction curve 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 rounds of the game, tutors were briefed on the aims and expectations of the games. 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 due to differences in tutorial management.

3.3. 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. Students in groups of four were designated as the three shrimpers and a recorder.

Five rounds of the game were played in 2004. Each round represented 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.

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 this unit. Also we felt that interdependency was better played out in groups.

Some changes were made to the conduct of the game for 2005. Firstly, the number of days of trading was increased to eight. In 2004, the tutors felt that the limit of five days did not give students enough time to develop strategic moves. Another change that was thought to discourage the sort of 'giving up' that may have been occurring for some individuals in some groups was to award a prize (see Cheung (2003) for the rationale for rewards) for the best group and the best shrimper, 'best' being defined in terms of highest profit. That is, in each tutorial group, the student who achieved the highest profit at the end of the game received a fun-size Mars bar. Finally, it was thought that, in 2005, students could receive more information about the purpose and process of the games similar to the instructions given to the tutors.

Most tutorial groups in 2005 allowed at least one day’s trade at the conclusion of the game for cooperation. That is, each group decided quantities collaboratively to optimise the group's (rather than the individual's) profit. Students found this a relief from the ‘second guessing’ required in the game itself.
4. FINDINGS 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. In 2005, 99 students were enrolled and about two thirds of these students participated. In 2004, other students undertook Stackelberg versions of the game; in 2005, all participating students completed a round of monopoly (collusion) after their last round of Cournot. For the purposes of this paper, the results for each round for each group and each tutorial class are not included here. They are available from the authors by request.

The discussion of the results is differentiated by year with the 2004 and 2005 results discussed separately. However, there are some outcomes that applied to both years. For example, students in both years experienced the frustration of second guessing their competitors quantity choices. Another commonality in both years was the range of students' numerical abilities. For students struggling with arithmetic, the estimation of prices was a challenge. However, most groups had at least one student who was able to do the necessary calculations. Few students were able to correctly estimate equilibrium price and quantities either preceding their choices, or during or at the conclusion of the game. This problem with weak numeracy skills is an issue common to many university economics programmes.

In 2004, the results seemed to indicate four things. First, the shrimpers are increasingly aware of interdependencies with successive rounds. This awareness is necessary as it was a key reason for introducing the game as an example of Cournot interdependence. Whilst some students were only reactive to the changing fortunes of the shrimpers, many students attempted to gain the upper hand in the market, thereby reaping bigger profits. Of course, the latter students were always at the mercy of extreme quantity choices by their competitors.

Second, each competitor is trying to guess what they think the other two shrimpers will choose. Those students who had estimated (correctly or otherwise) the market equilibrium price and quantity, were also attempting to use the latter to respond to what they were guessing about their competitors' choices. For example, the savvy competitor may know that the equilibrium quantity for the market is 150 pounds of shrimp. If they guess that the other two shrimpers are going to announce catches of 50 pounds each, then they might also only offer 50 pounds to the market. Of course, if the guess is wrong (say the other shrimpers offer 60 pounds each), then this competitor has a catch that is too high. Thus, his profits will suffer.
Third, evidence of convergence to equilibrium appears to be weak. Increasing the number of rounds or allowing rounds to continue within some finite time constraint was thought to be an effective solution to this. Hence in 2005, the number of rounds was increased to eight.

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 2004 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.

It is difficult to determine whether the game engendered enthusiasm for economics, per se, or encouraged students who may have been thinking of changing their major to stay with economics. Comments from students, some of which are below, are mainly related to the Cournot experience or the tutorial conduct. It may be the case that this single tutorial within one unit has insufficient impact to influence disgruntled students.

The results in 2005 were similar to those in 2004. For some groups, convergence to optimum quantities in the non-cooperative game was apparent; in other groups there were considerable differences from one day's trade to the next as well as between shrimpers. For all groups, the one day's cooperative trade showed better group profit results, as expected.

Whilst there was no formal evaluation in either year of the game, anecdotes from students in 2004 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.

Comments made in 2005 included:

- I didn’t mind it. It was fun. It demonstrated strategic interdependence.
- When the results were on the board, it was interesting to see how those striving to win actually did the worst, and those less ambitious did the best.
• It was a good demonstration and exciting.
• I liked it.
• A good change rather than rote learning.
• A real life example.

5. CONCLUSIONS

Hellier et al. (2004: 24) argue that 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: 15) in their review of what second year business students think of economics. The Shrimp Game encompasses such opinions.

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. 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 2004 student made the comment "It made a change from trying to avoid answering tute questions".

In terms of the broader goal of encouraging students to stay in the economics discipline, the response is unclear. In both 2004 and 2005, the Shrimp Game was played in one of eleven weeks (about half way through the semester) for a second year business economics unit. 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.
ACKNOWLEDGEMENTS

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APPENDIX A

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 fish. 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:

$$P(Q_A, Q_B, Q_C) = 45 - .2 (Q_A + Q_B + Q_C).$$

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

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

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 your goal is to maximize 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 his 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 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 B

Instructions for Tutors

The objective of this class-room simulation is to get students to understand the basis of the Cournot game. The key idea that we would like to see made clear is 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. The generalization that came from this model is that in an industry consisting of n firms, each will provide 1/(n+1) of the market and the industry output will be n/(n+1)=1/(n+1)*n. Therefore, for n = 3, each of the firms will supply ¼ of the market and the total industry output is ¾ of the entire market.

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.

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

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<th>ROUND</th>
<th>ArnoArnold</th>
<th>BeatBeatrice</th>
<th>CharCharlotte</th>
<th>PROFIT</th>
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<td>ROUND 8</td>
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</table>

- Break the class into a group of 3 or 4 (should take 5 minutes) and assign shrimpers- Arnold, Beatrice, and Charlotte. Also have 1 person to record all information within the group.
• Clearly identify groups- for example-group 1, group2 or group 3 for instance. (Maybe about another 5 minutes).
• Clearly read the instructions aloud and make sure students understand what is expected of them.
• Play 1st round of the game- say time 10 minutes. Record on the board. Calculate the profit for each group
• Play 2nd round of the game- time again for 10 minutes. Record the score. Compare to see if there is any learning going on.
• Play 3rd round of the game. Once again record all scores and compute profits.
• Discuss all results, and note if there have been deviations from predictions of economic theory.
REFERENCES


