Using Problem-based Learning for Introducing Producer Theory and Market Structure in Intermediate Microeconomics[1]

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Abstract

This paper shows how instructors can use the problem-based learning method to introduce producer theory and market structure in intermediate microeconomics courses. The paper proposes a framework where different decision problems are presented to students, who are asked to imagine that they are the managers of a firm who need to solve a problem in a particular business setting. In this setting, the instructors' role is to provide both guidance to facilitate student learning and content knowledge on a just-in-time basis.

JEL classification: A22, C72, D21, D43

1. Introduction

There are two major pedagogical views with respect to student learning, which can be summarised as active/cooperative and passive learning (see, for instance, Colander, 2004; Keyser, 2000; Smith and Waller, 1997). As noticed by McManus (2001), in passive learning 'students are assumed to enter the course with minds like empty vessels or sponges to be filled with knowledge', whereas in active learning 'students can learn to restructure the new information and their prior knowledge into new knowledge about the content and to practise using it'. Different types of active/cooperative learning exist, such as academic controversy, student-team-achievement divisions, teams-games-tournaments, group investigation, jigsaw, teams-assisted-individualisation, cooperative integrated reading and composition, or problem-based learning (see, for instance, Johnson, Johnson and Stanne, 2000).

Many studies exist that highlight the advantages of active/cooperative learning methods against traditional approaches based on 'chalk and talk' in many different fields. Johnson, Johnson and Smith (1998) analyse 305 studies that compare the relative efficacy of cooperative, competitive and individualistic learning on individual achievement in college and adult settings. They find that cooperative learning promotes higher academic success, greater quality of relationships and is more highly correlated with a wide variety of indices of psychological adjustment than the other methods. Johnson, Johnson and Stanne (2000) perform a meta-analysis with 158 articles studying eight cooperative learning methods at different educational levels and find that cooperative learning significantly increases student achievement when properly implemented. Maxwell *et al.* (2005)

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compare problem-based learning (PBL) and traditional instructional approaches in building knowledge of macroeconomic concepts and principles in high school students. Their results suggest that problem-based instruction can improve student learning if the instructors who implement it are well trained in both the PBL technique and economics. Forsythe (2002) summarises the existing research literature and notices that, relative to conventional lecture-based method, PBL fosters a deeper approach to learning, promotes more versatile studying methods, and develops greater knowledge retention and recall skills. Besides, PBL students tend to exhibit stronger knowledge application skills and from a teacher perspective PBL appears to be a very satisfying method of teaching.

In spite of this evidence, many undergraduate courses in economics are still taught by using traditional passive learning methods (Becker and Watts, 2001a, 2001b; Benzing and Christ, 1997; Watts and Becker, 2008). Although many reasons exist for the predominance of 'chalk and talk' in the teaching of economics, the lack of suitable materials is likely to be one of them. This paper shows how instructors can use problem-based learning to introduce producer theory and market structure in intermediate microeconomics courses. Active/cooperative learning is at the heart of the problem-based learning method (see, for instance, Johnson, Johnson and Smith, 1991). In PBL students learn content, strategies and self-directed learning skills by collaborating to solve problems, reflecting on their experiences and engaging in self-directed inquiry (Hmelo-Silver, 2004; Hmelo-Silver, Duncan and Chinn, 2007). The instructors' role is to provide both guidance to facilitate student learning and content knowledge on a just-in-time basis (Hmelo-Silver *et al.*, 2007).

Although several resources exist for instructors wishing to implement active/cooperative learning (see, for instance, Becker and Greene, 2005; Beckman, 2003; Brouhle *et al.*, 2005; Cheung, 2005; Dixit, 2005; Elliott, Meisel and Richards, 1998; Gächter, Thoni and Tyran, 2006; Garratt, 2000; Hartley, 2001; Meister, 1999; Zahka, 1990), materials for applying PBL to specific parts of the economics curriculum do not abound (for some examples see Forsythe, 2002). This paper advocates using the PBL method to introduce producer theory and market structure in intermediate microeconomics courses by asking students to imagine that they are the managers of a firm who need to solve a problem in a particular business setting. The approach involves both concrete (such as solving simple numeric examples by using calculators or spreadsheets) and general tasks (such as formulating and solving abstract parameterised optimisation problems). Although the approach relies essentially on problem solving (and the presentation and discussion of results using posters), it includes a game to generate experiential data for the development of conceptual understanding.

2. Problem-based learning activities

To integrate PBL into the economics curriculum it is necessary to follow three steps (Forsythe, 2002): designing problems and/or tasks, assessing the response to the problem/tasks and designing the PBL environment. This paper ignores the last two steps (for an accurate exposition of the details involved see Forsythe, 2002) and focuses on the design and presentation of specific problems included in intermediate microeconomics curricula to the students.

Designing problems/tasks for a PBL environment usually involves four steps (Forsythe, 2002):

- The form of the PBL environment must be determined. The activities proposed in this article have been designed for a 'partial' PBL environment, where PBL coexists with traditional lectures. That is, after the proposed PBL activities instructors should then go through the traditional lecture-based approach (although it is also possible to skip the details completely and encourage students to use a textbook to study the topics either on their own or in groups).

- The instructor must focus on target learning outcomes. The problems proposed in this paper have four major goals. First, they intend to provide some context to the theory and models used for teaching producer theory and market structure and to make them more compelling to students.

Second, they underscore the connection between the various market structures. The third goal is to develop the students' modelling and problem-solving skills. Last, the problems provide a natural setting for introducing strategic decisions and to develop naturally the concepts of Nash and subgame perfect Nash equilibrium.

- Determining the learning activities associated to the PBL setting. This paper considers three different activities. The first activity assumes that only one firm exists in the market, so that the firm's managers only need to worry about consumers' tastes and willingness to pay (summarised in the demand function) and their own costs. The second activity assumes that several firms exist in the market, so that besides costs and consumers' tastes, managers must take into account their beliefs about the behaviour of their rivals. In the third activity the number of firms in the market is endogenised, so that entry can be considered.

- Presenting the tasks to the students. The different tasks which compose each of the activities proposed in the article are detailed below. The exposition outlines how the different tasks should be presented to the students, provides the answers to the proposed problems, and gives some advice for the instructors to guide the discussions. Notice that the activities have been designed for a class size of 15–30 students and groups of three students. (Bigger class sizes can be accommodated by either reducing the number of poster activities or by increasing the group sizes to 4–5 students. However, notice that in bigger groups individual responsibilities are likely to become diluted.) It is assumed that after the instructor has presented each task the students will discuss and solve the proposed problems in groups, then they will write their own answers on posters, and finally they will discuss their answers with the other groups and the instructor. Table 1 summarises the different activities, the tasks which compose each activity, and contains a suggested time schedule for the different tasks.

Table 1: PBL activities, tasks and schedule

PBL activities	Tasks	Suggested schedule
#1. Firms' costs, consumers' tastes and willingness to pay	#1.1. Objectives of firms	- Presentation of the task (5 minutes) - Group formation (5 minutes) - Work in groups (20 minutes) - Writing the poster (5 minutes) - Class discussion about the posters (15 minutes)
	#1.2. Mathematical formulation of the profit-maximisation problem	- Presentation of the task (10 minutes) - Group formation (5 minutes) - Work in groups (30 minutes) - Writing the poster (5 minutes) - Class discussion about the posters (30 minutes)
	#1.3. Solving the profit-maximisation problem	- Presentation of the task (10 minutes) - Group formation (5 minutes) - Work in groups (30 minutes) - Writing the poster (5 minutes) - Class discussion about the posters (30 minutes)
	#1.4. Implications on market outcomes of different assumptions on costs and the shape of the demand function	- Presentation of the task (10 minutes) - Group formation (5 minutes) - Work in groups (30 minutes) - Writing the poster (5 minutes) - Class discussion about the posters (30 minutes)
#2. Beliefs about the behaviour of rival firms	#2.1. Statement and analysis of the problem	- Presentation of the task (5 minutes) - Group formation (5 minutes) - Work in groups (20 minutes) - Writing the poster (5 minutes) - Class discussion about the posters (15 minutes)
	#2.2. Cournot game	- Presentation of the task (10 minutes) - Group formation (5 minutes) - Work in groups to decide the quantity produced in the first round (15 minutes) - Computation of market price and firms' profits (5 minutes) - Work in groups to decide the quantity produced in the subsequent rounds (5 minutes/round) - Class discussion about the outcome of the task (10 minutes)
	#2.3. Computing the equilibrium output for each firm	- Presentation of the task (10 minutes) - Group formation (5 minutes) - Work in groups (45 minutes) - Writing the poster (5 minutes) - Class discussion about the posters (45 minutes)
	#2.4. Effects on market outcomes of increasing the number of firms in the market	- Presentation of the task (5 minutes) - Group formation (5 minutes) - Work in groups (20 minutes) - Writing the poster (5 minutes) - Class discussion about the posters (15 minutes)

#3. Entry	#3.1. Stating the problem and writing and analysing the game tree	- Presentation of the task (5 minutes) - Group formation (5 minutes) - Work in groups (30 minutes) - Writing the poster (5 minutes) - Class discussion about the posters (15 minutes) -(optional) Instructor writing the game tree (10 minutes) - Work in groups (20 minutes) - Writing the poster (5 minutes) - Class discussion about the posters (15 minutes)
	#3.2. Solving the game	- Presentation of the task (10 minutes) - Group formation (5 minutes) - Work in groups (45 minutes) - Writing the poster (5 minutes) - Class discussion about the posters (45 minutes)

3. Activity #1: Firms' costs, consumers' tastes and willingness to pay

This activity is designed for students to reflect on the objectives of firms and to realise that monopolists need to take into account both their costs and market demand when taking their pricing and production decisions. This activity involves four tasks. First, firms' goals are analysed. Then, the profit-maximisation problem is formulated mathematically. The third task involves solving the profit-maximisation problem. The last task deals with the implications on market results of different assumptions on costs and the shape of the demand curve.

Task #1.1: The objectives of firms. To introduce students to the problems faced by firms, instructors should divide the class in groups of three students and ask them to imagine that they are the owners of the only firm in a certain market. The firm produces a good with no close substitutes. Instructors should ask students what goal they would pursue as firm owners and how they would achieve it. Students should discuss their approach to the problem and write their answers on posters attached to the classroom walls, so that each group can read its classmates' answers. Instructors should guide a subsequent discussion so that students realise that firms may have different goals, but that owners are likely to be interested in maximising profits.

Task #1.2: Mathematical formulation of the profit-maximisation problem. In the next step, instructors should ask the groups to formulate mathematically the profit-maximising problem faced by a firm in the previous setting and repeat the process of writing their answers on posters and discussing these answers with the instructor and the rest of the class. When confronted with such a general question after going through consumer theory and the cost of production, students may suggest writing profits as $pq - c(q)$. In that case, instructors should ask students how *p* and *q* are related and guide the discussion so that students realise that consumer theory tells us that price and quantity are inversely related. Here the concept of inverse demand function should be introduced/refreshed. Instructors need to make sure that students realise that the demand function gives the quantity of product that consumers are willing to buy at a given price and that the inverse demand function gives the maximum price at which consumers are willing to buy a given quantity. Next, instructors should ask the groups whether in order to maximise profits they (in their role of firm managers) would choose price or quantity. It is useful to suggest that since costs are expressed as a function of the quantity produced, it may be convenient to resort to the inverse demand function. After this remark, instructors should ask students to reformulate the profit-maximising problem faced by their imaginary firm when no competitors exist in the market and the process of writing answers in posters and discussing them with their instructor and the classmates may then be repeated.

Task #1.3: Solving the profit-maximisation problem. The next step is to ask the groups to solve the problem

$$\underset{q}{Max} \quad \pi(q) \equiv p(q) \cdot q - c(q),$$

where q is the quantity produced, $p(q)$ is the inverse demand function, $c(q)$ is the cost function and $\pi(p)$ is the profit. For simplicity, it can be assumed that the inverse demand function is given by $p(q) = M - q$, where M is a positive constant. Different assumptions regarding the cost function are possible depending on the technology available to firms. In order to avoid difficulties, it is convenient to assume that constant returns to scale are present, so that the cost function is $c(q) = cq$ (where c is a positive constant). (Notice that if there are no fixed costs firms face a single decision: how much to produce. Thus shutdown decisions are sidestepped. See activity no 3 for a more complex setting.) Assuming that $M > c$, the firm solves the problem:

$$\underset{q}{Max} \quad \pi \equiv [M - q] \cdot q - c(q).$$

Profits are maximised when:

$$\frac{d\pi}{dq} \equiv M - 2q - c = 0 \Rightarrow q^* = \frac{1}{2}[M - c].$$

The price is $p = M - q = M - \tfrac{1}{2}[M - c] = \tfrac{1}{2}[M + c]$. Profits are $\pi = \left[\tfrac{1}{2}(M - c)\right]^2$. If students find it difficult to solve this problem, it may be useful to set a concrete example and assume, for instance, that the market demand for a product is given by $p(q) = 2000 - q$ and the cost function of individual firms by $c(q) = q$. This numerical problem has the advantage of provident students with the opportunity to use calculators and/or spreadsheets (which students may perceive as more akin to business settings than calculus) in their inquiry (see Kreps, 2004 for a textbook approach to using spreadsheets instead of calculus in microeconomics courses).

Task #1.4: Implications on market outcomes of different assumptions on costs and the shape of the demand function. After discussing the monopolist problem, instructors may ask students how firms' decisions are affected by their own costs and the shape of the demand function (see Malueg, 1994). For instance, it is useful to ask students to solve Problem no 1 in the Appendix for different values of M and c. This helps students realise that even monopolies face market constraints. Students should notice that the relationship between price and revenue (the revenue earned by producing an additional unit, $M - 2q$, is lower that price, $M - q$, because in order to sell some additional units a monopolist must lower the price of all units). The condition for profit maximisation (produce at the quantity where marginal revenue equals marginal cost) can be analysed in detail at this point.

4. Activity #2: Beliefs about the behaviour of rival firms

The next stage involves asking students how their answers to the questions in the previous tasks may be influenced by the presence of other firms in the market. To do this, it is useful to present four tasks to the students. First, the problem faced by the firms should be stated and analysed. Then, a Cournot game can be played. The third task involves solving the profit-maximisation problem faced by each firm. Finally, the effects of increasing the number of firms in the market are analysed.

Task #2.1: Statement and preliminary analysis of the problem. It is convenient to proceed as follows:

- Divide the class in groups of three students. Each group is a firm.

- Each firm is told that another identical firm is in the market. Each firm has a production cost given by $c(q) = cq$ and faces an inverse demand function which depends on the sum of the quantity produced by each firm.

- Students in each group are asked to work out independently (that is no talking between groups, aka collusion, is allowed) what quantity their firm would produce in order to maximise profits.

- Students in each group are told that after working out the solution with their group they can pose publicly any questions they may have. Instructors should answer the questions keeping in mind that at this stage they do not want to influence the students' proposed solution to the problem.

In this setting, students may find it difficult to get started. Nevertheless, by analysing the problem, students will realise that although each firm can only control its own output, the price paid by consumers (and hence each firm's profit) is a function of the total quantity that the two firms bring to the market. However, students may not figure out how solve the profit maximisation problem. In that case, instructors can formulate the problem and ask students to solve it. Notice that firm 1 must solve the problem

$$\underset{q_1}{Max} \quad \pi_1 \equiv p(q_1 + q_2) \cdot q_1 - c(q_1),$$

and similarly for firm 2. For the specific inverse demand and cost functions considered above, firm 1 solves the problem

$$\underset{q_1}{Max} \quad \pi_1 \equiv [M - q_1 - q_2] \cdot q_1 - c \cdot q_1 .$$

Profits are maximised when:

$$\frac{d\pi_1}{dq_1} \equiv M - 2q_1 - q_2 - c = 0 \Rightarrow q_1 = \frac{1}{2}[M - c - q_2].$$

Instructors should make sure that their students realise the economic intuition behind this first order condition: besides production cost and consumers' tastes, the optimal output for firm 1 depends on the decision by firm 2 and vice versa.

Task #2.2: Cournot game. At this point students need to realise that a conjecture about the behaviour of its rival must be made by each firm. They may get stuck in a chain of circular reasoning. They may realise that their firm's best response depends on the action taken by the rival firm, that is, the managers of firm 1 know that the other firm knows this and vice versa. Nevertheless, it is not easy to figure out how to break up this chain of reasoning. A brief digression about how each firm can anticipate the other firm's behaviour in practice and/or the introduction of the Nash equilibrium concept might seem appropriate here. However, an in-class simulation along the lines proposed by Meister (1999) gives students an active role in the learning process and helps them to realise the different aspects which need to be taken into account to solve the problem. Essentially, Meister (1999) proposes a game where students are divided in five groups, where each group is a firm. Each firm produces a product identical to that of its competitors and must decide how much to produce during each time period. Each firms' costs are given by $c(q_i) = 20q_i$. Each firm has a maximum capacity of $\overline{q}_i = 82$ per period and market demand is given by $P(Q) = \max(200 - 0.5Q, 0)$, where $Q = \sum_{i=1}^{5} q_i$. Students do not know in advance when the game ends. With this data, the Cournot equilibrium involves each firm producing 60 units, a market price of 50 and each firm's profits are 1800. The collusion result involves each firm producing 36 units, a market price of 110 and each firm's profits are 3240. In a typical play of this game my students got the results shown in Table 2. In this case seven rounds were played. After each round, I wrote on the blackboard the quantity produced by each firm and computed the market price and each firm's profits. By playing the game repeatedly and with the instructors' guidance, students experience how their firms' profits change with their own decisions and those of their rival. For instance, students realise that when profits are low putting less output in the market may pay off. Thus, in the end students (with some guidance from the instructor) will reach the conclusion that each firm needs to choose its output level so that each firm's profits are maximised given the other firm's decision.

Table 2: Results of a Cournot game

			Round						
			#1	#2	#3	#4	#5	#6	#7
Group	#1	Output	82	60	60	65	72	82	70
		Profit	4,119.3	-30	3,030	1,495	1,764	2,009	1,330
	#2	Output	82	65	41	70	75	75	82
		Profit	4,119.3	-32.5	2,070.5	1,610	1,837.5	1,837.5	1,558
	#3	Output	40	82	56	66	36	36	52
		Profit	2,009.4	-41	2,828	1,518	882	882	988
	#4	Output	46	72	46	65	60	50	46
		Profit	2,310.8	-36	2,323	1,495	1,470	1,225	874
	#5	Output	9.5	82	56	48	68	68	72
		Profit	478.7	-41	2,828	1,104	1,666	1,666	1,368
Total output			259.5	361	259	314	311	311	322
Price			70.2	19.5	70.5	43	44.5	44.5	39
Average output			51.9	72.2	51.8	62.8	62.2	62.2	64.4
Average profit			2,607.5	-36.1	2,615.9	1,444.4	1,523.9	1,523.9	1,223.6

Task #2.3: Computing the equilibrium output for each firm. After playing the game students should be asked to solve formally the problem faced by each firm. Again, the students' answers can be written on posters attached to the classroom walls. During the subsequent discussion of the students' answers, instructors should point out that firms need to solve the system,

$$\begin{cases} q_1 = \frac{1}{2}[M - c - q_2] \Rightarrow 2q_1 + q_2 = M - c \\ q_2 = \frac{1}{2}[M - c - q_1] \Rightarrow q_1 + 2q_2 = M - c. \end{cases}$$

The solution to this system of two equations in two unknowns gives the profit-maximising output $q_1{*}=q_2{*}=\tfrac{2}{3}\left[M-c\right]$, the price $p=\tfrac{1}{3}M+\tfrac{2}{3}c$, and the profits $\pi_1=\pi_2=\tfrac{2}{9}\left[M-c\right]^2$. In order to analyse the general case when *N* firms exist in the market, instructors should ask students to solve Problem no 2 (see the Appendix). Notice that with *N* firms in the market, firm *i* must solve the problem

$$\underset{q_i}{Max} \quad \pi_i \equiv p\left[q_1+q_2+...+q_N\right]\cdot q_i - c\left(q_i\right),$$

and similarly for the rest of the firms. The following system of equations (which summarises the first-order conditions of the problem) must be solved

$$\begin{cases} 2q_1+q_2+...+q_N=M-c \\ q_1+2q_2+...+q_N=M-c \\ ... \\ q_1+q_2+...+2q_N=M-c. \end{cases}$$

The quantity of output which solves the system is $q_1{*}=q_2{*}=...=q_N{*}=\tfrac{1}{(N+1)}\left[M-c\right]$, the price $p=\tfrac{1}{(N+1)}M+\tfrac{N}{(N+1)}c$, and profit $\pi_1=\pi_2=...=\pi_N=N\left[\tfrac{1}{(N+1)}\left(M-c\right)\right]^2$.

Task #2.4: Effects on market outcomes of increasing the number of firms in the market. Finally, instructors should ask students what happens when the number of firms in the market is very high. In that case each firm produces a quite small part of the total output. Hence, the effect of the output of a particular firm on price is almost negligible. A concrete problem with *M* = 1000, *c*= 1 and 999 firms in the market can be used for this purpose. The effect on price of a new firm entering the market is:

$$\frac{p_{1.000}-p_{999}}{p_{999}}\cdot 100=\frac{\frac{1}{1.001}M+\frac{1.000}{1.001}c-\frac{1}{1.000}M-\frac{999}{1.000}c}{\frac{1}{1.000}M+\frac{999}{1.000}c}\cdot 100=-0{,}05\%.$$

Hence, each individual firm can regard price as given. Here instructors need to be aware that the Cournot oligopoly model need not converge to perfect competition when the number of firms tends to infinity. Indeed, convergence takes place if, and only if, there are no economies of scale (Ruffin, 1971), that is, if, and only if, average cost is non-decreasing.

During the discussion of posters after the problem-solving task it is useful to compare the outcomes from different market structures in terms of total output, price, firms' profits and consumer surplus. This is shown in

Table 3, inspired in Binmore (2007, ch. 10) and Perloff (2008, ch. 13). As the number of firms increase total output and consumer surplus goes up, price converges to marginal cost and firms' profits converge to zero (see also Problem no 3 in the Appendix). This comparison helps highlighting how a simple model can accommodate different assumptions regarding the real world. Besides, at this point it is natural to talk about long run equilibrium. Instructors should pose questions so that students realise that if there are some firms in the market earning positive economic profits, then new firms will have incentives to enter the market. Thus, it should become apparent that long run equilibrium implies a number of firms and a quantity of output such that each firm's profits are zero.

Table 3: Outcomes in different market structures

	Total output	Price	Total profit for firms	Consumer surplus
1 firm (monopoly)	$\frac{1}{2}(M-c)$	$\frac{1}{2}(M+c)$	$\frac{1}{2}(M-c)^2$	$\frac{1}{8}(M-c)^2$
2 firms (duopoly)	$\frac{2}{3}(M-c)$	$\frac{1}{3}(M+2c)$	$\frac{2}{9}(M-c)^2$	$\frac{2}{9}(M-c)^2$
N firms (oligopoly)	$\frac{N}{N+1}(M-c)$	$\frac{1}{N+1}(M+Nc)$	$\frac{N}{(N+1)^2}(M-c)^2$	$\frac{N^2}{2(N+1)^2}(M-c)^2$
$N \to \infty$ firms (perfect competition)	$\lim\limits_{N\to\infty} \frac{N}{N+1}(M-c) = M-c$	$\lim\limits_{N\to\infty} \frac{1}{N+1}(M+Nc) = c$	$\lim\limits_{N\to\infty} \frac{N}{(N+1)^2}(M-c)^2 = 0$	$\lim\limits_{N\to\infty} \frac{N^2}{2(N+1)^2}(M-c)^2 = \frac{1}{2}(M-c)^2$
Entry with 2 firms	$\frac{2}{3}(M-c)$	$\frac{1}{3}(M+2c)$	$\frac{1}{2}(M-c)^2 - 2K$	$\frac{2}{9}(M-c)^2$

Activity #3: Entry

At the last stage a new layer of difficulty can be added to the previous settings. Here, instructors can adopt a dynamic perspective and ask students to imagine how firms decide whether to enter a market and how much output they should produce. This activity involves two tasks. First, the problem faced by the firms should be stated and a game tree should be written and analysed. Then, the game should be solved.

Task #3.1: Stating the problem and writing and analysing the game tree. The approach proceeds as follows (for other types of entry games which could be adapted to this paper's setting see, for instance, Cheung, 2005 and Garratt, 2000):

- Divide the class in groups of three students. Each group is considering whether to start a business.

- Each group is told that there is another firm pondering whether to enter the market. Thus, if the group decides to go ahead with the new business, it is possible that there will be two firms competing in the same market and that each firm will be identical to each other. Thus, each group needs to ponder whether to enter the market, characterised by the inverse demand function $p(q) = M - q$, which at the moment is not served by any firm.

- If a firm decides to enter the market, then it pays a set up cost $K > 0$ (for instance, firms must build a new plant). After entering the market, each firm has a production cost given by $c(q) = cq$. Assume that $K < \frac{2}{9}[M-c]^2$ (this guarantees that both firms will have positive profits and both will enter the market).

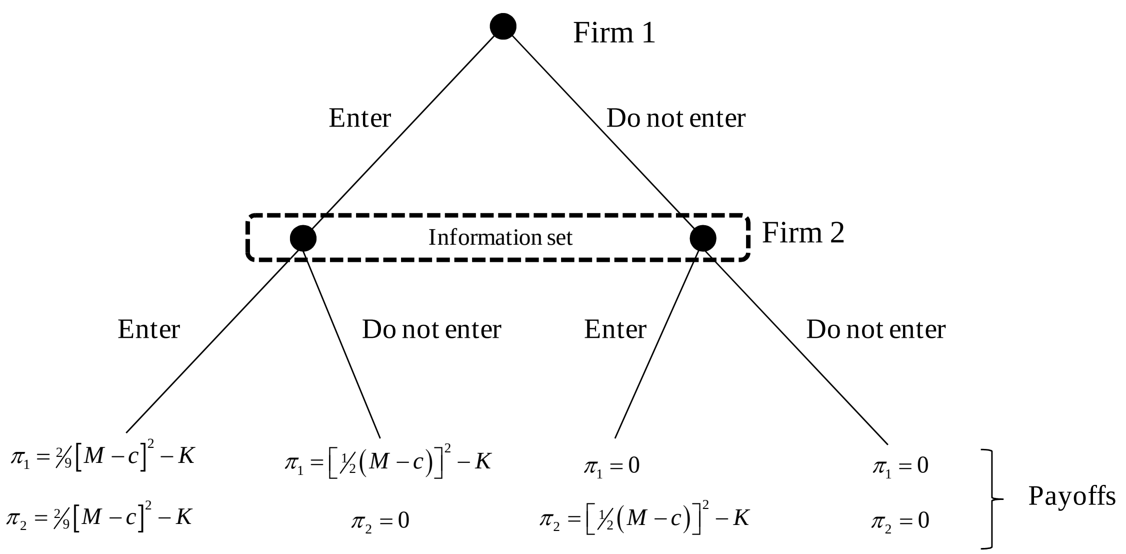
- The different groups are asked to work out independently whether they would enter the market and what quantity they would produce in order to maximise their own firms' profits.

- Students in each group are told that after working out the solution with their group they can pose publicly any questions they may have. Instructors should answer the questions keeping in mind that at this stage they do not want to influence the students' proposed solution to the problem.

Students may find this game a bit puzzling, since they need to realise that they must proceed in two stages. First, the firms simultaneously decide whether to enter the market or not. Then, if the two firms enter, then they play a Cournot game. Students may not realise that they need to solve the second stage first and then proceed backwards. In that case, instructors can foster their students' understanding by writing a game tree, leaving the payoffs blank, and asking them to fill in the blanks (see **Error! Reference source not found.** and task #3.2). As in previous activities, students should work in groups, write their answers on posters, and discuss their answers with their classmates and the instructor.

Task #3.2: Solving the game. In this task instructors should ask students to use the game tree as a tool for deciding whether to enter the market. This helps students to develop intuitively both the concept of backward induction and of subgame perfect Nash equilibrium. Remember that if a firm decides to enter, then it pays the setup cost *K*. If the two firms enter, then each firm's payoff is the duopoly payoff minus the setup cost, that is, $\pi_1 = \pi_2 = \frac{2}{9}[M-c]^2 - K$. If only one firm enters, then the entrant's payoff is the monopoly payoff minus the setup cost, that is, $\pi_1 = \left[\frac{1}{2}(M-c)\right]^2 - K$, and the payoff for the other firm is zero. If neither firm enters, then each firm earns zero.

After solving this problem it is advisable to proceed with the general case with *N* firms and discuss how the results depend on the magnitude of *K* and the beliefs on the number of firms entering the market. To do so it is convenient to ask students to solve Problem #4 in the Appendix.



5. Concluding comments

The approach suggested in the paper may be valuable for instructors wishing to get their students actively involved in the process of learning producer theory and market structure in intermediate microeconomics courses. The approach is also useful to highlight the connection between perfect competition, oligopoly and monopoly. Furthermore, it develops modelling and problem-solving skills and provides a natural setting for introducing strategic decisions and to develop naturally the concepts of Nash and subgame perfect Nash equilibrium. When later on in the course these concepts are presented formally, students, having seen them already at work, will immediately understand their relevance. Indeed, spending some valuable classroom time with PBL activities and playing Cournot games ultimately pays off, since instructors may then go through the traditional lecture-based approach (competitive supply and competitive, monopolistic, and oligopolistic markets) faster or even skip the details completely and encourage students to use a textbook to study the topics either on their own or in groups. Besides, the approach presents students with opportunities to simulate complex situations which they may face in real life. Instructors adopting the PBL approach are likely to find out that students prefer this hands-on approach over more traditional expositions.

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Appendix

1. a) Sketch the graph of the inverse demand function $p(q) = M - q$ and the production cost by $c(q) = cq$ (where *M* and *c* are positive constants, with *M* greater than *c*) for different values of *M* and *c*. Interpret the economic meaning of both parameters.

2. Assume that the market demand for a product is given by $p(q) = M - q$ and the cost function of individual firms by $c(q) = cq$ (where *M* and *c* are positive constants, with *M* greater than *c*) for different values of *M* and *c*.

a) Find the profit-maximising output for an individual firm when three identical firms are in the market (no collusion allowed). Find the resulting market price.

b) Repeat part a) for four firms.

c) Given your answers in parts a) and b) and the exposition in class, can you give a formula for the profit-maximising output and the market price when there are *N* firms in the market?

3. Assume that the market demand for a product is given by $p(q) = 100000 - q$ and the cost function of individual firms by $c(q) = q$.

a) Find the profit-maximising output for an individual firm when two identical firms are in the market (no collusion allowed). Find the resulting market price, the total profits for the firm and the consumer surplus.

b) Repeat part a) when three identical firms are in the market (no collusion allowed).

c) Repeat part a) for 10 firms.

d) Repeat part a) for 10,000 firms.

e) What value does market quantity approaches as the number of firms grows larger? What about price?

4. Assume that the market demand for a product is given by $p(q) = M - q$ and the cost function of individual firms by $c(q) = cq$ (where *M* and *c* are positive constants, with *M* greater than *c*) for different values of *M* and *c*. Assume that *N* identical firms are pondering whether to enter the market or not. Entering the market implies a fixed cost $K > 0$. All potential firms take their entry decision simultaneously. All firms that have entered play a Cournot game. Assuming that in equilibrium firms cannot have negative profits,

a) Find the equilibrium number of entrants.

b) Explain how the equilibrium number of entrants changes when M, c, and K change. Explain the economic intuition of your answer.

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