Editorial

Peter Davies, Ross Guest and David McCausland

Interest in classroom experiments and games continues to grow. The previous special issue of IREE was testament to this trend and several papers in the current issue feature classroom experiments or games. Two of these papers, one by Moore and the other by Rigall-I-Torrent, are about Cournot games for intermediate microeconomics. Cournot games can help students to see the relationships between the alternative market structures, in particular that between oligopoly and monopoly, and can provide a useful introduction to game theory. Rigall-I-Torrent shows how this can be done by setting up a Cournot game with increasing complexity. In Moore's game, the typical textbook model of costs is extended in order to show that colluding firms do not necessarily behave like a monopolist as they do in the typical model. Damianov and Sanders describe an experiment that shows how the pursuit of positional goods by individuals in order to signal their relatively high income is socially sub-optimal, and that mechanisms for publicly disclosing their income would allow a Pareto improvement. Students are encouraged to explore implications for public policy.

It is perhaps not surprising that the majority of classroom experiments and games that have been published to date, including those in this journal, have been in the field of microeconomics broadly defined. Students can readily play the roles of individuals and firms. It also reflects the increasing prominence of game theory and behavioural economics in the economics literature over perhaps the past two decades. Yet a number of unresolved puzzles in macroeconomics have resurfaced in the literature of recent years. Obvious examples are the genesis and evolution of financial crises, the efficacy of fiscal stimulus in response to such crises, and the role for monetary policy in a very low inflation economy. There is a gap in the economics education literature of classroom experiments that can help students to explore these ideas. Indeed the collection of experiments/games on macroeconomics is relatively thin. Further work beckons.

Echoes of another special IREE issue, Issue 8.2 in 2009 on pluralism in economics education, are evident in the article in this issue by Colander and Nopo. They argue for two separate streams in graduate economics education, at least in Latin America – one focusing on the traditional, more technical, economics training and another on a 'heterdox' approach to economics which would give weight to alternative schools of thought, and to institutions and politics. The latter stream would lead to a PhD in political economy so the authors argue. This view is based on surveys of students and faculty in Latin America, Europe and the US. The Latin American students were found to place greater importance on topics such as history of economic thought and economic development, and on a practical working knowledge of the institutions in an economy.

Turning to student achievement, we are publishing a critique by Edmund Cannon of an article in IREE, Issue 7.2 in 2008, which argued that students who downloaded PowerPoint slides prior to attending the lecture performed better than those students who attended the lecture but did not download the slides prior to attendance. Cannon argues that the econometric methodology was flawed because it did not take account of endogeneity of attendance and downloading decisions. We gave the original authors, Chen and Lin, the opportunity to respond to this critique which they did and we publish their response here. This debate highlights the difficulty in isolating determinants of educational achievement. The endogeneity problem is pervasive.

University teachers are under increasing pressure to provide evidence of their performance in promoting student learning through their teaching. The well known limitations of the traditional student evaluation instrument are prompting the search for alternatives. One such alternative is a face-to-face interview or discussion group between students and an evaluator. In this case the students' comments are confidential but not anonymous since the students are present in person. The article by Meagher in this issue provides statistical evidence showing that the resulting student evaluations are biased in favour of the teacher compared with evaluation data which is both confidential and anonymous. The reason given is fear by students that negative comments about teaching may lead, somehow, to negative consequences for them. One possible response to this problem and also to the accepted shortcomings of evaluations, might be some form of statistical adjustment of student evaluation scores to correct for biases. In addition to the biases identified by Meagher, there are potential biases in student evaluations arising from class size, whether the course is mandatory or an elective, and various aspects of the teaching environment. Again, there is scope for work in this area.

We are delighted to announce that this and future issues of IREE will incorporate articles that would have otherwise appeared in CHEER (Computers in Higher Education Economics Review). We look forward to continuing CHEER's longstanding contribution to the development of innovative practice in the use of ICT in economics education. Insofar as this exciting field is ultimately about enhancing learning and teaching in higher education economics, it is within the scope of IREE. So incorporating articles in this field into IREE will provide a unified reference for readers and help to build connections between ICT and other innovations in economics education.

The first of two articles in this field refers to a well-known business problem: the travelling salesman problem (TSP). A salesman needs to visit all his customers located in different cities in his region, and he would like to find the cheapest route that assure all cities have been visited. Unfortunately the TSP is not easy to formulate, and relatively hard to solve. Our paper by Rasmussen shows how innovative use of spreadsheets can render TSP that were previously regarded as 'big' easily solvable. The paper details how the flexibility of spreadsheets can be used in solving many real world variants of the TSP, and discusses important issues in the careful formulation of TSP solutions using spreadsheets.

Finally, we look at a further innovative use of spreadsheets to illustrate Hannah and Kay's concentration axiom. Most courses in industrial economics and industrial organisation cover the measurement of industry concentration. The classic paper of Hannah and Kay (1977) details a set of desirable criteria against which any of the numerous concentration measures may be judged. The paper by Latreille and Mackley shows how these criteria can be illustrated for students, for several of the most popular measures, using an Excel spreadsheet designed to give them an improved understanding of some of the strengths and limitations of a range of the commonly used statistical measures and hence their value in underpinning policy and regulation.

References

Hannah, L. and Kay, J.A. (1977). *Concentration in Modern Industry: Theory, Measurement and the UK Experience*, London: Macmillan.

Improving Understanding of Collusion in Intermediate Microeconomics

Evan Moore

Abstract

Standard treatments of collusion in intermediate microeconomics textbooks frequently involve a Cournot duopoly facing linear demand with constant marginal costs of production. These presentations leave students with the misunderstanding that firms jointly behaving like a single-firm monopolist and profit maximising collusion are one and the same. We present a simple and effective way for improving student comprehension of collusion; this exercise results in collusion where the duopolists produce more total output than that of a monopolist while enjoying greater joint profits. The exercise can be used to clarify and lead to a better understanding of collusion and profit maximisation.

JEL classification: A22, D43

1. Introduction

Collusion is broadly defined as an agreement among firms to fix prices or output, usually with the aim of maximising profits. Standard treatments of collusion in intermediate microeconomics textbooks frequently involve a Cournot duopoly facing linear demand with constant marginal costs of production. For example, see:

1. Caroll (2009, p.237) – marginal costs of *k*

2. Perloff (2009, p.459) – marginal costs of $147

3. Pindyck and Rubinfeld (2009, p. 453) – zero marginal costs

4. Frank (2008, p. 415) – zero marginal costs

5. Perloff (2008, p.473) – marginal costs of $147

6. Varian (2007, p. 497) – zero marginal costs

7. Nicholson and Snyder (2006, p. 415) – zero marginal costs

8. Hey (2003, p. 378) – marginal costs of $10

9. Eaton, Eaton and Allen (2002, p. 501) – marginal costs of $40

However, these presentations leave a misunderstanding on the nature of joint profit maximisation. In each of the examples in the textbooks listed above the collusive outcome coincides with each of the duopolists producing one half of the monopolist's output.[1] Unfortunately, if this is the sole presentation of collusion then students frequently equate collusion among firms with jointly behaving as a monopolist.

2. Teaching collusion in intermediate microeconomics

We begin by defining collusion and then pointing out that the goal of colluding is to maximise joint profits. To be more specific, we use Pindyck and Rubinfeld's (2009) definition that when firms collude, '…they coordinate prices and output to maximize joint profits'. We tell students that, like the book, we will use a duopoly with identical cost functions for both firms.[2]

We then present the standard treatment using constant marginal costs of production. We use a linear inverse demand function $P=100-Q_1-Q_2$ where P is price and Q_i is the output of firm i. Each firm has total costs of production $TC_i=Q_i$. With this total cost function the firms have constant marginal costs $MC=1$. This results in the firms producing $Q_1=Q_2=33$ when engaged in Cournot competition. The collusive outcome, which coincides with joint output equal to that of a monopolist, is $Q_1=Q_2=24.75$. The derivations for these results and those following are in the appendix.[3] Using the outputs as the two strategy choices and profits as the payoffs, we can construct a simple 2x2 normal form game (see Figure 1) revealing the resulting 'prisoners' dilemma' that is commonly associated with Cournot's equilibrium.[4]

Figure 1: Duopolists with marginal costs of 1

		Firm 2: 24.75	Firm 2: 33
Firm 1	24.75	1225.13 1225.13	1361.25 1020.94
	33	1020.94 1361.25	1089 1089

We then inform the class that we are going to change the production costs for the firms. This involves changing the nature of the total costs from linear to quadratic, resulting in $TC_i=Q_i^2$. The marginal costs are then $MC_i=2Q_i$. The Cournot equilibrium is $Q_1=Q_2=20$. The monopolist's profit maximising output is

[1] Another textbook presentation involving constant marginal costs is Salvatore (2009, p. 360), which uses four firms with collusion resulting, once again, in the monopoly solution. Besanko and Braeutigam (2008, p.430) provide a different approach with duopolists having differing quadratic total costs, as does Caroll (2009, p.238). However, this overcomplicates the issue and is usually covered in Industrial Organisation textbooks, for example see Waldman and Jensen (2007, p.278) or Pepall *et al.* (2002, p.146).

[2] We use Pindyck and Rubinfeld (2009) in our course.

[3] The interested reader will also find figures containing the reaction functions and isoprofit curves for the exercises as well.

[4] Additionally, we usually provide Figures 1 through 4, with the payoffs, to the students so as not to use too much class time on the profit calculations. In each case the figures are provided after determining the appropriate outputs.

25; splitting this output evenly yields Q_1=Q_2=12.5. Using these outputs as the two strategy choices results in the 2x2 normal form game in Figure 2.

Figure 2: Duopolists with marginal costs of $2Q_i$

		Firm 2	
		12.5	20
Firm 1	12.5	781.25 781.25	950 687.5
	20	687.5 950	800 800

The Nash equilibrium is to produce the Cournot output as in Figure 1. However, unlike Figure 1, the joint profits from the Cournot outcome (800+800) exceed those of splitting the monopolist's output (781.25+781.25). We stress to the students that colluding as a monopolist results in lower profits for the firms.

We then use a well known and simple technique to teach collusion when firms face identical demand and cost structures: multiply the slope of the demand curve by the number of firms and solve for the profit maximising output as a monopolist, which is each firms' output.[5] In both of the previous examples this results in inverse demand of P=100-2Q. In the first example this results in a profit function of Π=(100-2Q)Q-Q. The resulting joint profit maximising outputs are Q_1=Q_2=24.75, exactly as they are in Figure 1. However, using this technique with the quadratic cost function results in a profit function of Π=(100-2Q)Q-Q^2 with the collusive outputs of Q_1=Q_2=16.67. We build upon Figure 2 by including these outputs as a third strategy choice as illustrated in Figure 3. Figure 3 allows the students to see clearly the profits associated with each output choice.

Figure 3: Duopolists with marginal costs of $2Q_i$ and collusive strategies

		Firm 2		
		12.5	16.66	20
Firm 1	12.5	781.25 781.25	902.78 729.17	950 687.5
	16.66	729.17 902.78	833.33 833.33	866.67 777.77
	20	687.5 950	777.77 866.67	800 800

Using Figure 3 also allows the students to recognise the Nash equilibrium as the Cournot output decision, as in Figure 2.

[5] The instructor may opt for the students to determine the collusive outputs by solving the joint profit maximising function for each case, i.e. *Joint* Π=(100-Q_1-Q_2)(Q_1-Q_2)- Q_1-Q_2 with firms facing TC_i=Q_i and *Joint* Π=(100-Q_1-Q_2)(Q_1-Q_2)-Q_1^2-Q_2^2 with firms facing TC_i=Q_i^2.

Finally, we provide a reduced version of the previous figure, similar to that of Figure 1, that includes only the collusive and Cournot outputs. This is shown in Figure 4.

Figure 4: Prisoners' dilemma with marginal costs of $2Q_i$

		Firm 2	
		16.66	20
Firm 1	16.66	833.33 833.33	866.67 777.77
	20	777.77 866.67	800 800

This figure allows the students to see the Cournot output decisions in the familiar 'prisoners' dilemma' context. More importantly, the exercise as whole reinforces the notion that collusion does not necessarily imply jointly behaving as a monopolist.[6]

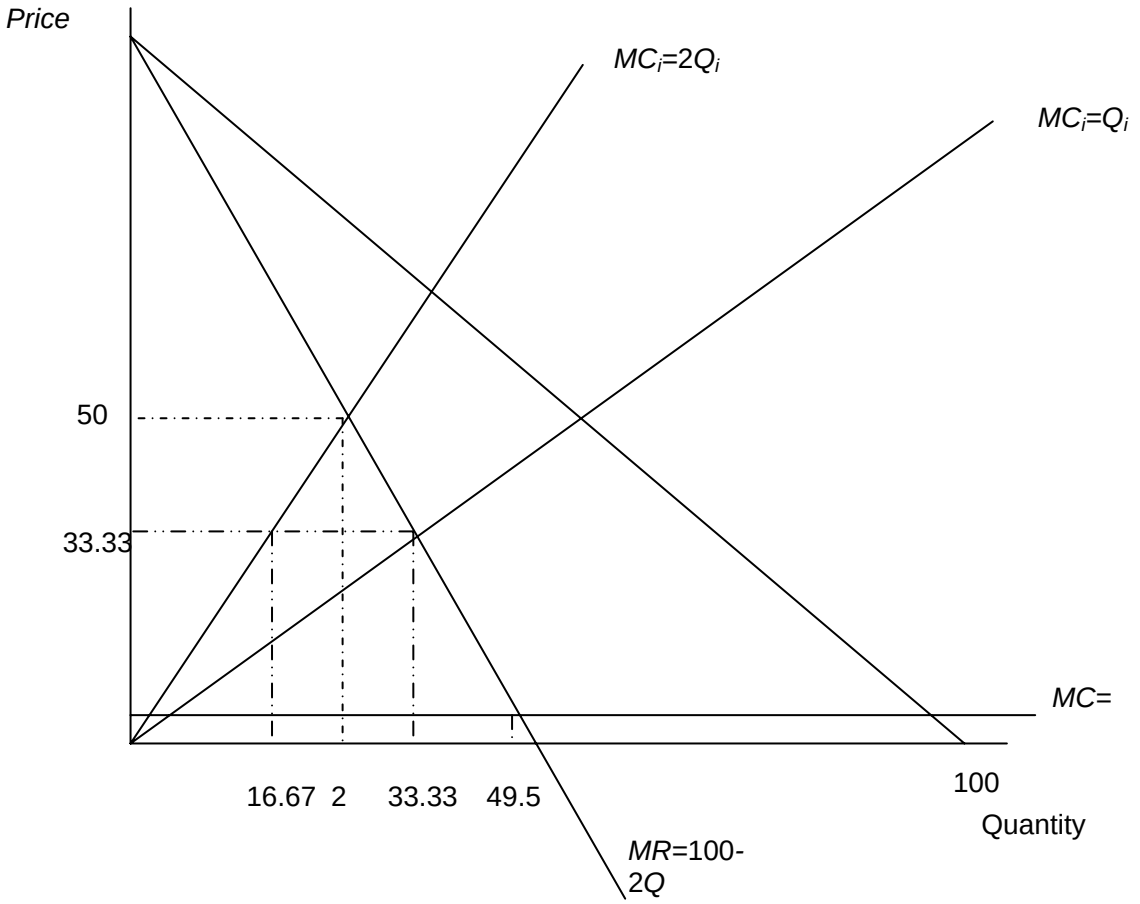
Students may ask for an explanation as to why collusion among the duopolists facing quadratic costs does not result in the monopoly level of output. We will provide two possible avenues for explaining this result. The first explanation involves equating the industry marginal revenue with the industry marginal cost to maximise industry profits. Figure 5 presents the industry demand and marginal revenue curves. Additionally, the marginal cost curves for both scenarios, firms facing total costs of $TC_i=Q_i$ and $TC_i=Q_i^2$, are included. The *industry* marginal cost curve for each case is obtained by summing horizontally the firms' marginal cost curves.[7]

For the firms facing $TC_i=Q_i$, with constant marginal costs of MC=1, the industry marginal cost curve is identical to that of any firm. It is this relationship between the industry and firm marginal costs that results in the duopolists jointly producing, in a profit maximising collusive arrangement, the monopolist's output of 49.5 units.

[6] The exercise also provides for an opportunity to expound on returns to scale. While not the focus of this paper, we find that drawing the average total cost (ATC) functions and discussing the implications of a constant ATC versus an increasing ATC to be enlightening.

[7] See Salvatore (2009, p.359) or Waldman and Jensen (2007, p.278) for more information on deriving industry marginal cost curves.

Figure 5: Industry marginal costs, demand, and marginal revenue



Now consider firms facing total costs of $TC_i=Q_i^2$. If the market is served by a monopolist then the monopoly's marginal cost curve, $MC=2Q$, and the industry marginal cost curve are identical. This results in the monopolist choosing to producing 25 units to maximise profit. However, a firm's marginal cost curve is not equal to the industry marginal cost curve in the duopoly setting. Each firm faces $MC_i=2Q_i$ while the industry marginal cost is $MC=Q$. For the duopolists the industry marginal costs are lower than those of the monopolist. The duopolists can increase joint output, relative to the monopoly output of 25 units, leading to greater joint profits. The collusive duopolists will jointly produce 33.33 units. Equating the industry wide marginal revenue $MR=100-2Q=33.33$ with each firms marginal cost, $MC_i=2Q_i$, reveals that each firm will produce 16.66 units. This outcome is shown in Figure 5 above.

If the instructor is not interested in using the industry marginal cost diagram then a similar explanation to the one above can be given without using the figure. For the $TC_i=Q_i^2$ scenario, point out that the industry marginal revenue of producing 25 units, the monopolist's output, is $MR=100-2Q=50$. If each firm produces half of the monopolist's output then they will each produce 12.5 units. The marginal cost for each firm is then $MC_i=2Q_i=25$. As the marginal revenue exceeds the marginal cost for each firm, as well as the industry marginal cost, they should increase output to increase profits. The instructor can propose each firm produce 15 units, pointing out that the industry marginal revenue is then $MR=100-2Q=40$ and each firm's marginal cost is $MC_i=2Q_i=30$. Each firm's profits increase from 781.25 to 825. The duopolists will increase output until the joint output equals 33.33. The marginal revenue decreases to

MR =100-2Q = 33.33 and the marginal cost for each firm is MC_i=2Q_i=33.33, as each firm produces 16.66 units. As discussed earlier, this results in each firm earning profits of 833.33.

3. Conclusions

The use of a simple duopoly Cournot model, with quadratic costs, can be very enlightening for undergraduate students when teaching collusion and joint profit maximisation. Unfortunately the standard textbook presentations in principles and intermediate microeconomics usually leave students with the misunderstanding that firms jointly behaving like a single-firm monopolist and collusion are one and the same. We find that the exercise presented in this paper can be used to clarify the issue and lead to a better understanding of collusion and profit maximisation.

References

Besanko, D.A and Braeutigam, R.R. (2005). *Microeconomics* (2nd edn), Hoboken: John Wiley & Sons.

Caroll, T. (2009). *Intermediate Microeconomic Theory* (1st edn), Dubuque: Kendall/Hunt.

Eaton, B.C., Eaton, D.F. and Allen, A.W. (2002). *Microeconomics* (5th edn), Harlow: Prentice Hall.

Frank, R.H. (2008) *Microeconomics and Behavior* (7th ed.), Singapore: McGraw-Hill Education.

Hey, J.D. (2003). *Intermediate Microeconomics,* New York: McGraw Hill Higher Education.

Nicholson, W. and Snyder, C.M. (2006). *Intermediate Microeconomics and its Application* (10th edn), Mason: South-Western College Publishing.

Pepall, L., Richards, D.J. and Norman, G. (2002) *Industrial Organization: Contemporary Theory and Practice* (2nd edn), Mason: South-Western College Publication.

Perloff, J.M. (2008). *Microeconomics: Theory and Applications with Calculus* (1st edn), Harlow: Pearson Education.

Perloff, J.M. (2009). *Microeconomics* (5th edn), Harlow: Pearson Education.

Pindyck, R.S. and Rubinfeld, D.L. (2009). *Microeconomics* (7th edn), Harlow: Prentice Hall.

Salvatore, D. (2009). *Microeconomics: Theory and Applications* (5th edn), Oxford: Oxford University Press.

Varian, H.R. (2005). *Intermediate Microeconomics: A Modern Approach* (7th edn), New York: W. W. Norton.

Waldman, D.E. and Jensen, E.J. (2007). *Industrial Organization: Theory and Practice* (3rd edn), Harlow: Pearson Addison Wesley.

Appendix

P=100-Q_1-Q_2 and $TC_i=Q_i$.

For Figure 1

Monopolist output (profit maximising collusion):

$$\Pi = (100 - Q)Q - Q$$

$$\frac{d\Pi}{dQ} = 100 - 2Q - 1 = 0$$

$$Q = 49.5$$

$$Q_1 = Q_2 = 24.75$$

$$P = 100 - 24.75 - 24.75 = 50.5$$

$$\pi_1 = \pi_2 = 50.5 * 24.75 - 24.75 = 1{,}225.13$$

Cournot competition:

$$\Pi_i = (100 - Q_i - Q_j)Q_i - Q_i$$

$$\frac{d\Pi_i}{dQ_i} = 100 - 2Q_i - Q_j - 1 = 0$$

$$Q_i = 49.5 - 0.5Q_j$$

$$Q_1 = Q_2 = 33$$

$$P = 100 - 33 - 33 = 34$$

$$\pi_1 = \pi_2 = 34 * 33 - 33 = 1{,}089$$

If Q_i = 24.75 and Q_j = 33:

P = 100 – 24.75 – 33 = 42.25

$$\pi_i = 42.25 * 24.75 - 24.75 = 1{,}020.94$$

$$\pi_j = 42.25 * 33 - 33 = 1{,}361.25$$

P=100-Q_1-Q_2 and $TC_i=Q_i^2$.

For Figures 2, 3 and 4

Monopolist output:

$$\Pi = (100 - Q)Q - Q^2$$

$$\frac{d\Pi}{dQ} = 100 - 2Q - 2Q = 0$$

$$Q = 25$$

$$Q_1 = Q_2 = 12.5$$

$$P = 100 - 12.5 - 12.5 = 75$$

$$\pi_1 = \pi_2 = 75 * 12.5 - 12.5^2 = 781.25$$

Cournot competition:

$$\Pi_i = (100 - Q_i - Q_j)Q_i - Q_i^2$$

$$\frac{d\Pi_i}{dQ_i} = 100 - 2Q_i - Q_j - 2Q_i = 0$$

$$Q_i = 25 - 0.25Q_j$$

$$Q_1 = Q_2 = 20$$

$$P = 100 - 20 - 20 = 60$$

$$\pi_1 = \pi_2 = 60 * 20 - 20^2 = 800$$

If Q_i = 12. 5 and Q_j = 20:

P = 100 – 12.5 – 20 = 67.5

$$\pi_i = 67.5 * 12.5 - 12.5^2 = 687.5$$

$$\pi_j = 67.5 * 20 - 20^2 = 950$$

Profit maximising collusion:

$$\Pi_i = (100 - 2Q_i)Q_i - {Q_i}^2$$

$$\frac{d\Pi_i}{dQ_i} = 100 - 4Q_i - 2Q_i = 0$$

$$Q_i = 16.67$$

$$P = 100 - 16.67 - 16.67 = 66.66$$

$$\pi_1 = \pi_2 = 66.66 * 16.67 - 16.67^2 = 833.33$$

If Q_i = 12. 5 and Q_j = 16.66:

P = 100 – 12.5 – 16.66 = 70.83

$$\pi_i = 70.83 * 12.5 - 12.5^2 = 729.17$$

$$\pi_j = 70.83 * 16.66 - 16.66^2 = 902.78$$

If Q_i = 16.66 and Q_j = 20:

P = 100 – 16.66 – 20 = 63.33

$$\pi_i = 63.33 * 16.66 - 16.66^2 = 777.77$$

$$\pi_j = 63.33 * 20 - 20^2 = 866.67$$

Figures containing reaction functions and isoprofit curves

Figures A1, A2, and A3 pertain to the duopoly scenario with each firm having total costs of production $TC_i=Q_i$.

Figure A1: Reaction functions – firms facing $TC_i=Q_i$

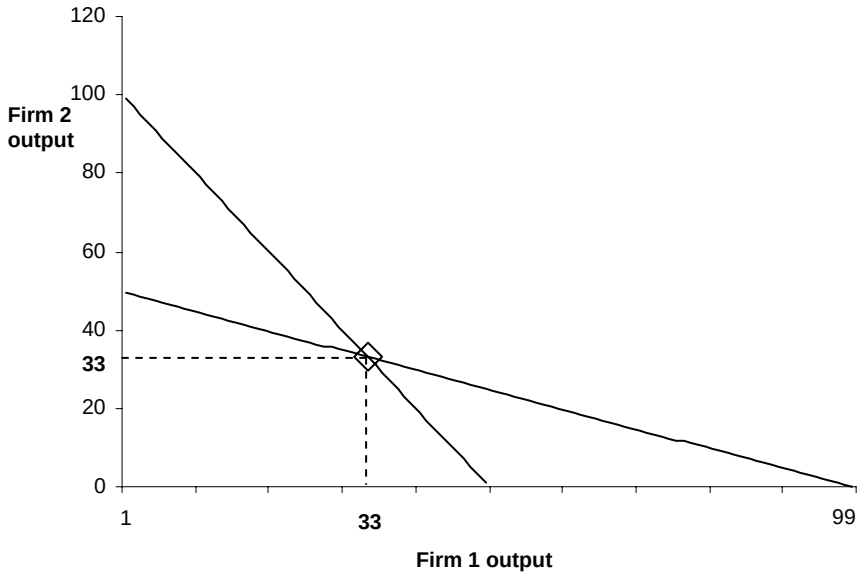


Figure A2: Isoprofit curves – firms facing $TC_i=Q_i$

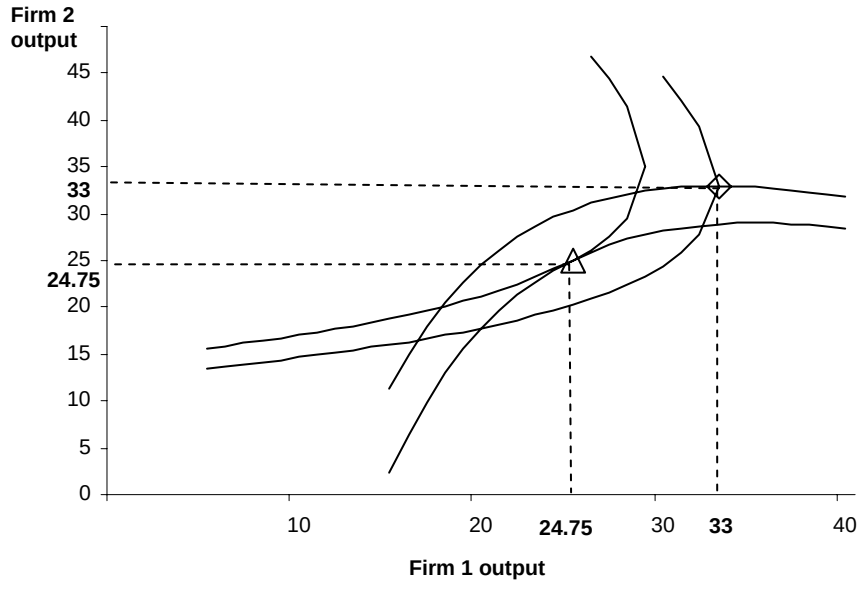
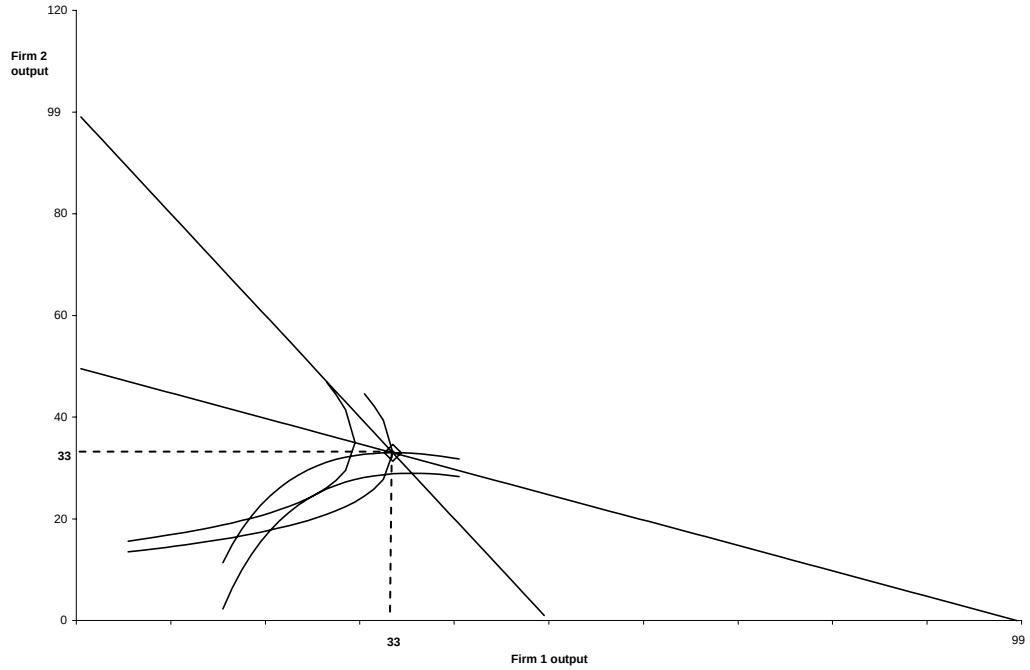


Figure A1 presents the reaction functions $Q_i=49.5-0.5Q_j$ for the duopolists. Note that the intersection at $Q_1=Q_2=33$ is the Cournot equilibrium outputs (indicated by ◊ in the figure). Figure A2 presents the isoprofit curves. The curves indicating profits of 1089 for each firm intersect at $Q_1=Q_2=33$, the Cournot equilibrium (again indicated by ◊). Joint profits are maximised at the tangency of the isoprofit curves at

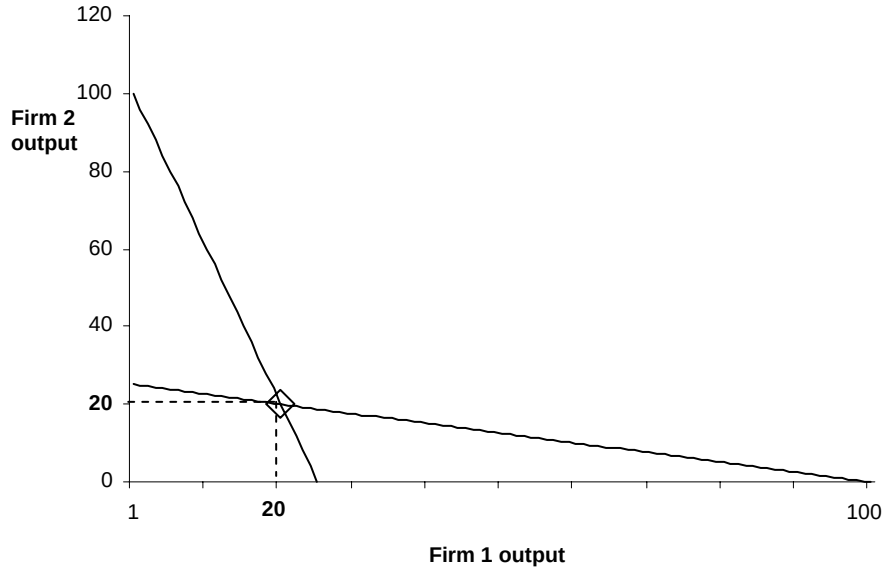
$Q_1=Q_2=24.75$ (this is indicated by Δ). This collusive outcome results in each firm earning profits of 1225.125. Figure A3 combines Figures A1 and A2 revealing that the intersection of the reaction functions and the Cournot equilibrium isoprofit curves coincides with the Cournot equilibrium outputs.

Figure A3: Reaction functions and isoprofit curves - firms facing $TC_i=Q_i$



Figures A4, A5, and A6 pertain to the duopoly scenario with each firm having total costs of production $TC_i=Q_i^2$. The reaction functions in Figure A4 are $Q_i=25-0.25Q_j$. The Cournot outcome, $Q_1=Q_2=20$, is indicated by ◊.

Figure A4: Reaction functions – firms facing $TC_i=Q_i^2$



Unlike the previous scenario with constant marginal costs of production, the collusive outcome does not coincide with each firm producing half of the monopolist's level of output. The isoprofit curves for each firm, as shown in Figure A5, represent the profits from collusion, i.e. 833.33, from Cournot competition, i.e. 800, and from producing half of the monopolist's level of output, i.e. 781.25. The Cournot outcome, $Q_1=Q_2=20$, is indicated by ◊ and the collusive outcome, $Q_1=Q_2=24.75$, by Δ.

Figure A6 combines Figures A4 and A5 revealing that the intersection of the reaction functions and the Cournot equilibrium isoprofit curves coincides with the Cournot equilibrium outputs.

Figure A5: Isoprofit curves – firms facing $TC_i=Q_i^2$

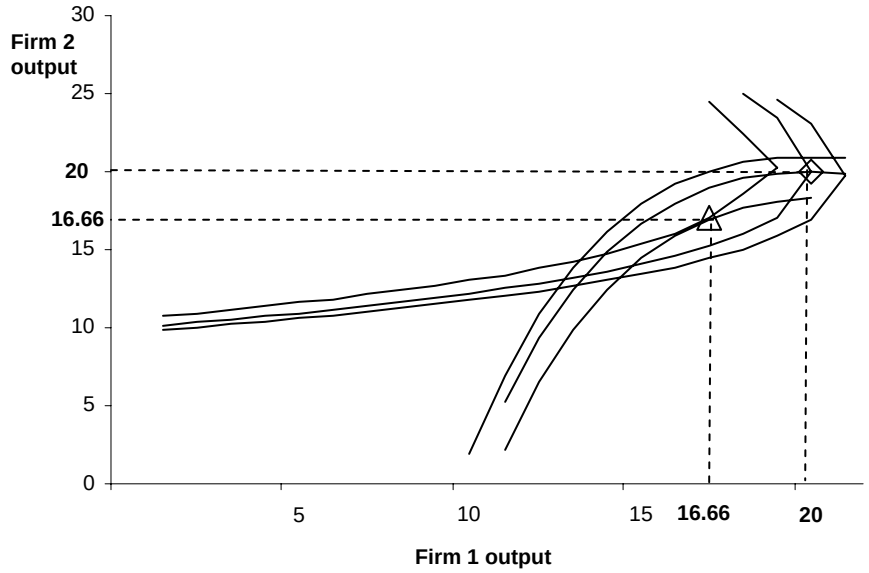
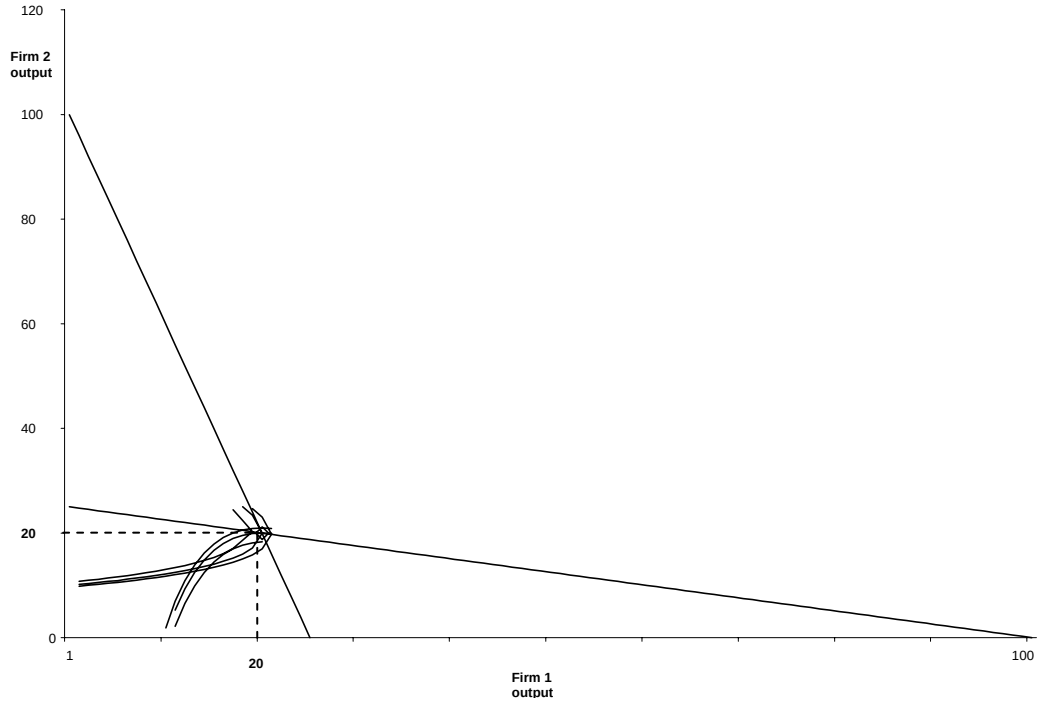


Figure A6: Reaction functions and isoprofit curves - firms facing $TC_i=Q_i^2$



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

Ricard Rigall-I-Torrent

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)
	#3.2. Solving the game	- Work in groups (20 minutes) - Writing the poster (5 minutes) - Class discussion about the posters (15 minutes) - 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 $p = M - q = M - \frac{1}{2}[M - c] = \frac{1}{2}[M + c]$. Profits are $\pi = \left[\frac{1}{2}(M - c)\right]^2$. 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 $q_1^* = q_2^* = \frac{2}{3}[M-c]$, the price $p = \frac{1}{3}M + \frac{2}{3}c$, and the profits $\pi_1 = \pi_2 = \frac{2}{9}[M-c]^2$. 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

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

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 $q_1^* = q_2^* = ... = q_N^* = \frac{1}{(N+1)}[M-c]$, the price $p = \frac{1}{(N+1)}M + \frac{N}{(N+1)}c$, and profit $\pi_1 = \pi_2 = ... = \pi_N = N\left[\frac{1}{(N+1)}(M-c)\right]^2$.

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)	$\lim_{N\to\infty}\frac{N}{N+1}(M-c)=M-c$	$\lim_{N\to\infty}\frac{1}{N+1}(M+Nc)=c$	$\lim_{N\to\infty}\frac{N}{(N+1)^2}(M-c)^2=0$	$\lim_{N\to\infty}\frac{N^2}{2(N+1)^2}(M-c)^2$ $=\frac{1}{2}(M-c)^2$
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).

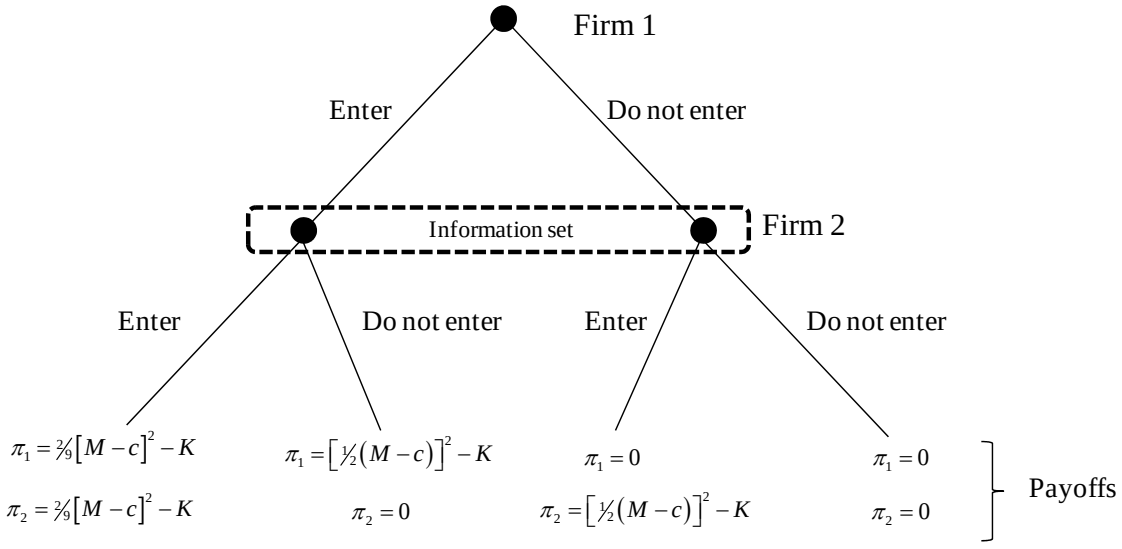
- The different groups are asked to work out independently whether they would enter the market and what quantity they would produce in order to maximise their own firms' profits.

- 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.

References

Becker, W. E. and Greene, W. H. (2005). 'Using the Nobel laureates in economics to teach quantitative methods', *Journal of Economic Education*, Vol. 36, pp. 261–77.

Becker, W. E. and Watts, M. (2001a). 'Teaching economics at the start of the 21st century: still chalk-and-talk', *The American Economic Review*, Vol. 91, pp. 446–51.

Becker, W. E. and Watts, M. (2001b). 'Teaching methods in U.S. undergraduate economics courses', *Journal of Economic Education*, Vol. 32, pp. 269–79.

Beckman, S. R. (2003). 'Cournot and Bertrand games', *Journal of Economic Education*, Vol. 34, pp. 27–35.

Benzing, C. and Christ, P. (1997). 'A survey of teaching methods among economics faculty', *Journal of Economic Education*, Vol. 28, pp. 182–8.

Binmore, K. (2007). *Playing for Real: A Text on Game Theory*, New York: Oxford University Press.

Brouhle, K., Corrigan, J., Croson, R., Farnham, M., Garip, S., Habodaszova, L., *et al.* (2005). 'Local residential sorting and public goods provision: a classroom demonstration', *Journal of Economic Education*, Vol. 36, pp. 332–44.

Cheung, S. L. (2005). 'A classroom entry and exit game of supply with price-taking firms', *Journal of Economic Education*, Vol. 36, pp. 358–68.

Colander, D. (2004). 'The art of teaching economics', *International Review of Economics Education*, Vol. 3, pp. 63–76.

Dixit, A. (2005). 'Restoring fun to game theory', *Journal of Economic Education*, Vol. 36, pp. 205–19.

Elliott, D., Meisel, J. and Richards W. (1998). 'The Senior Project: using the literature of distinguished economists', *Journal of Economic Education*, Vol. 29, pp. 312–20.

Forsythe, F. (2002). 'Problem-based learning' (in P. Davies, ed.). *The Handbook for Economics Lecturers*, The Economics Network.

Gächter, S., Thoni, C. and Tyran, J.-R. (2006). 'Cournot competition and hit-and-run entry and exit in a teaching experiment', *Journal of Economic Education*, Vol. 37, pp. 418–30.

Garratt, R. (2000). 'A free entry and exit experiment', *Journal of Economic Education*, Vol. 31, pp. 237–43.

Hartley, J. E. (2001). 'The Great Books and economics', *Journal of Economic Education*, Vol. 32, pp. 147–59.

Hmelo-Silver, C. E. (2004). 'Problem-based learning: What and how do students learn?', *Educational Psychology Review*, Vol. 16, pp. 235–66.

Hmelo-Silver, C. E., Duncan, R. G. and Chinn, C. A. (2007). 'Scaffolding and achievement in problem-based and inquiry learning: a response to Kirschner, Sweller and Clark (2006)', *Educational Psychologist*, Vol. 42, pp. 99–107.

Johnson, D. W., Johnson, R. T. and Smith. K. A. (1991). *Active Learning: Cooperation in the College Classroom*, Edina, MN: Interaction Book Company.

Johnson, D. W., Johnson, R. T. and Smith., K. A. (1998). 'Cooperative learning returns to college: what evidence is there that it works?', *Change*, Vol. July/August, pp. 27–35.

Johnson, D. W., Johnson, R. T. and Stanne, M. B. (2000). 'Cooperative learning methods: a meta-analysis', from http://www.co-operation.org/

Keyser, M. W. (2000). 'Active learning and cooperative learning: understanding the difference and using both styles effectively', *Research Strategies*, Vol. 17 pp. 35–44.

Kreps, D. M. (2004). *Microeconomics for managers*, New York: W. W. Norton & Company.

Malueg, D. A. (1994). 'Monopoly output and welfare: The role of curvature of the demand function', *Journal of Economic Education*, Vol. 25, pp. 235–50.

Maxwell, N. L., Mergendoller, J. R., Bellisimo, Y. and Kennedy, P. (2005). 'Problem-based learning and high school macroeconomics: a comparative study of instructional methods', *Journal of Economic Education*, Vol. 36, pp. 315–31.

McManus, D. (2001). 'The two paradigms of education and the peer review of teaching', *Journal of Geoscience Education*, Vol. 49 pp. 423–34.

Meister, J. P. (1999). 'Oligopoly – an in-class economic game', *Journal of Economic Education*, Vol. 30, pp. 383–91.

Perloff, J. M. (2008). *Microeconomics: Theory and applications with calculus*, Boston: Pearson Addison Wesley.

Ruffin, R. J. (1971). 'Cournot oligopoly and competitive behaviour', *The Review of Economic Studies*, Vol. 38, pp. 493–502.

Smith, K. A. and Waller, A. (1997). 'Afterword: New Paradigms of College Teaching' (in W. Campbell and K. A. Smith, eds), *New Paradigms for College Teaching*, Edina, MN: Interaction Book Co.

Watts, M., and Becker, W. E. (2008). 'A little more than chalk and talk: results from a third national survey of teaching methods in undergraduate economics courses', *Journal of Economic Education*, Vol. 39, pp. 273–86.

Zahka, W. J. (1990). 'The Nobel Prize economics lectures as a teaching tool', *Journal of Economic Education*, Vol. 21, pp. 395–401.

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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Status Spending Races, Cooperative Consumption and Voluntary Public Income Disclosure

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Abstract

Scholars from Duesenberry to Frank have argued that the pursuit of a higher social status, although rational from the individual's viewpoint, might be wasteful to society. Status conscious individuals find it optimal to over-consume positional goods and thus exert a negative externality on their peers. This paper presents a classroom experiment to introduce students to the theories of relative income. The experiment illustrates the external effect of positional goods consumption and discusses social arrangements to alleviate this externality problem. Students learn that a social arrangement as simple as voluntary income disclosure can revert individual consumption back to socially optimal levels.

JEL classification: A22, C92, D11

1. Introduction

Scholars from Duesenberry (1949) to Frank (1985a) have shown that status concerns can have a profound impact on consumer behaviour. Status conscious individuals, led by self-interest, find it optimal to over-consume positional goods (i.e. goods that one purchases at least partly for the sake of status considerations) in order to attain a higher position in their local environment.

As an illustration of this problem, consider a pool of recent college graduates each of whom applies for the same job opening. Suppose that some applicants decide to purchase an expensive designer suit to impress the interviewers. This behaviour adversely affects the employment chances of the other applicants. As a result, all graduates find themselves in a prisoner's dilemma situation whereby they feel forced to match the expenditure in order to maintain their original prospect of landing the job.[1] Except for the expensive suits, not much in this job market situation has changed: each applicant's hiring chances remain the same.

Despite the empirical validity of the relative income hypothesis, Duesenberry's (1949) theory has been dominated by Friedman's permanent income hypothesis and the subsequent life-cycle models of consumption and savings. Indeed, most of economic theory posits that individuals are concerned only with their absolute level of consumption. The permanent income hypothesis states that individuals base consumption decisions on prices and upon their long-term expected income profile. The relative income hypothesis states, in essence, that consumer choice is a function of prices, income and

[1] This example was put forth by Robert Frank (2008).

community consumption standards. The last consideration, that community consumption influences a consumer's choice behaviour, rests upon the premise that individuals derive status from their consumption behaviours and that status, in turn, is determined within a community-specific context. The relative income hypothesis stands at odds with the permanent income hypothesis in that it treats individual preferences as interdependent – at least within a community setting.

In contrast to the dominant permanent income hypothesis, the recent empirical literature provides ample evidence that individuals evaluate their own consumption relative to that of others. Oswald (1997) conducts an excellent survey of the first wave of empirical studies on the relative income hypothesis, which lends support to the idea that individual utilities are *interdependent* and the optimal consumption choice of each individual is, at least to some extent, driven by the choices of others. Luttmer (2005) and Solnick and Hemenway (2005) offer more recent and definitive evidence of relative income considerations. While concluding that relative income has some role in determining individual well-being, Stevenson and Wolfers (2008) estimate a positive relationship between per capita income and subjective well-being in a country.

Kosicki (1987) develops a theoretical model that incorporates a relative standing component into a permanent income framework in which consumers divide their income between consumption and savings. Using the 1972 Consumer Expenditure Survey, he develops an empirical test to examine whether average propensity to save depends on income rank, while controlling for the absolute income level. The regression results indicate that income rank is an important determinant of the saving rate.

In light of these findings, Frank (2005b) writes,

'…his (Duesenberry's) theory of consumer behavior clearly outperforms the alternative theories that displaced it in the 1950's- a striking reversal of the usual pattern in which theories are displaced by alternatives that better explain the evidence. His disappearance from modern economics textbooks is an intriguing tale in the sociology of knowledge. But it also has important practical implications. Unless we understand what drives consumption, which makes up two-thirds of total economic activity, we cannot predict how people will respond to policy changes like tax cuts or Social Security privatization…Most economists, it appears, just never wanted to believe the relative-income hypothesis- perhaps because it suggests the possibility of wasteful spending races' (pp. 1, 2–3).

Clark and Oswald (1996) also address the policy importance of the relative income hypothesis,

'Despite what economics textbooks say, comparisons in the utility function seem to matter. This has a number of implications. In a world with comparisons, the case for growth as a way of increasing happiness is no longer so clear (see Easterlin, 1974 and Layard, 1980). Optimal tax policies are affected because there are negative externalities from high earners (see Oswald, 1983). In an analogous way, the wages offered by firms may have low variance if there are intra-firm comparison effects, and may rise over time if workers compare their current wage to their own previous wages (see Frank and Hutchens, 1993). Moreover, because preferences are intrinsically interdependent, the standard optimality results of the free market may fail to hold' (p. 375).

Evidently, there is a present gap between economics research and economics teaching on the topic of relative income concerns. Also, there is little current understanding, beyond Frank (1985a&b), as to the efficacy of arrangements to limit the scope of positional good spending races. Frank (1985a) constructs a novel theoretical model in which consumers allocate income between a positional and a non-positional good. He shows positional good spending races to be the result of non-cooperative consumption of positional goods, where the purchase of such goods is externally costly to the status of others. Frank further discusses several public programmes that apparently limit the scope and damage of positional goods spending races. These include forced retirement savings programmes, overtime

laws and various forms of safety regulation. Forced retirement savings programmes, for example, limit status spending races by constraining a portion of an individual's income toward the purchase of non-positional goods.

More recently, Frank's (1985a) model has been reexamined and extended in several directions by Hopkins and Kornienko (see Hopkins and Kornienko 2004, 2006 and 2009). Hopkins and Kornienko (2004) consider a game of status in which individuals are concerned with both their absolute and relative level of consumption. Within the status game, the authors examine how the optimal individual decisions depend on the distribution of income. In their model, each individual signals his or her position in the distribution of income by purchasing a positional good (similar to the setting presented here). In the symmetric Nash equilibrium of this status game, a person's status rank can be inferred from his or her revealed consumption behaviour. The analysis, which focuses on how exogenous changes in the distribution of income affect individual decisions, uncovers the so-called 'Red Queen' effect: an increase in average income (in the sense of a refinement of first order stochastic dominance of the income distribution function) leads to an increase in conspicuous consumption to such an extent that total welfare remains unchanged or even decreases. Hence, a more affluent society can have a lower utility at each income level. The reason is that individuals waste their entire increase in income on conspicuous consumption such that all individuals 'run in order to keep at the same place' in the social hierarchy.[2]

The purpose of the present paper is to develop pedagogical tools for instructors who wish to introduce their students to the theories of relative income. We design a classroom experiment and develop an exercise problem that can be used in introductory or higher-level courses in economics to present the effect of positional considerations on consumer choice and social welfare. The theoretical analysis is quite straightforward and does not require advanced mathematical skills. The experiment, which requires less than one hour of class time, can be naturally incorporated into an introductory economics course once the instructor has introduced the concepts of utility and consumer choice.[3] The experiment can also be embedded in a general discussion about externalities, market failures and various social arrangements intended to correct market failures.

In our hypothetical environment, students are asked to allocate their income across two goods: a partially positional and a purely non-positional good. Participants in the experiment vary by income. Half of the students are high income earners and the other half are low income earners. The experiment illustrates that high income earners have an incentive to signal their position by overspending on the positional good. We then discuss social arrangements that can alleviate this externality problem. In particular, students learn through the experiment that a social arrangement as simple as the voluntary disclosure of income can revert individual consumption back to socially optimal levels. Within the paper, the term 'voluntary income disclosure' suggests a policy in which an individual can allow a particular government agency, such as an income tax collecting body, to report his or her income in a public forum.

As in Frank's (1985a) model, participants in the experiment know the income distribution within their community in an anonymous manner. In other words, every individual knows the number of high and low income earners without knowing their identities. This partial knowledge creates incentives for individuals to non-cooperatively signal their income status through positional good spending. Such an

[2] The Red Queen is a character from Lewis Carroll's (1871) book *Through the Looking Glass*. The Red Queen explains to Alice that in her country it takes all the running you can do to keep in the same place after Alice observes that, although they run faster and faster they remain in the same spot.

[3] The authors ran the experiment in a survey of economics course using 10 minutes to outline the experiment, 10 minutes to conduct a practice run of the first treatment, and 30 minutes (with results tabulation) to conduct the actual experiment. The total course time used was approximately 50 minutes.

exercise is costly because high income individuals over-consume the positional good to an extent that dissuades lower income individuals from matching the status signal. If people were to disclose income publicly, however, positional goods spending would lose its value as a signal of income status and consumption would revert back to socially optimal levels.

The remainder of the paper is organised as follows. The next section explains how instructors can initiate a discussion of the concepts of positional goods and status spending races by using the standard consumer choice framework. We then go on to describe the classroom experiment and its equilibria. The fourth section presents the empirical results of the classroom experiment for two class sections, where students who participated in the experiment were assigned class bonus points based on their within-group utility ranking. Further, the fourth section tests to what degree the theoretical equilibria of the experiment predicted real behaviour. The final section contains the debriefing of the experiment and presents questions and ideas that instructors can use for further discussion or as a course assignment. Appendix A presents the instructions of the experiment, and Appendix B reports the choices that students made so as to encourage other instructors to replicate the classroom experiment. Appendix C presents an exercise for instructors who wish to discuss the topic using only a numerical problem. Lastly, Appendix D provides an alternative treatment of the exercise analysed presently. In the alternative treatment, a government policy is explored that forces individuals to spend at least 50 per cent of their personal income on a non-positional good. The welfare properties of such a policy are discussed.

2. Introducing the topic in the classroom

A discussion of the concepts of relative income and positional goods can be incorporated into the curriculum shortly after students are introduced to the concepts of utility and consumption choice. As a starting point for the classroom discussion, the instructor might project the standard two-goods consumer choice graph with the budget constraint and the system of indifference curves and ask students to list the factors that affect the optimal choice of the consumer. Once students identify that prices and consumer preferences play a role, the instructor can inquire whether the consumption choices of peers, co-workers, neighbours or relatives could affect the preferences of the consumer and eventually his or her consumption choice. Are there items that one wishes to possess mostly to demonstrate that he or she can afford them? Are there goods that people consume just to 'keep up with the Joneses'? The instructor can ask students to provide examples of goods that have a positional or demonstration element. Items that students frequently mention include cell phones, designer clothing, houses in rich neighbourhoods, swimming pools, expensive cars, etc. The instructor can then explain that status spending races will be the major topic of discussion and either distribute the experimental instructions (see Appendix A) or present the exercise (see Appendix C).

3. Experimental design and equilibria

Setting

In this section, we present a simple model that incorporates positional considerations into the standard textbook consumer choice problem. Within the model, there are two equally represented consumer types: high income individuals and low income individuals. The model illustrates that high income individuals have an incentive to signal their position by overspending on the positional good. The individual quest for status creates an externality that biases high income consumers' choices away from the social optimum. We posit that a mechanism as simple as the voluntary public disclosure of income can act as a cooperative mechanism so as to restore socially optimal consumption levels to a status-conscious community.

Consider a community of $N \geq 2$ individuals, where N is an even number. Half of the community members earn an individual income of \$6000 per month. We will refer to these people as 'high income earners'. The remaining half of community members earn an individual income of \$5000 per month and are referred to as 'low income earners'. Each community member decides how to split his income between two goods, *x* and *y*, where income can be allocated in multiples of \$1000. The first good, *x*, is purchased for its direct use only. Its consumption has no relation to the status an individual enjoys in the community. An example of such a good might be an insurance policy or toilet paper. The second good, *y*, is consumed partly for its direct use and partly for demonstration purposes. Other members of the community observe how much of this good is consumed by each individual, and this consumption choice determines the income status of each individual in the community (i.e. whether an individual is perceived as earning a high income or a lower income). One might think of home size as being a (partly) positional good. Additional home size can be useful (i.e. can give a person non-positional utility) but is, at the same time, considered a sign of status (i.e. can give a person positional or status utility).

Within the model, those who exceed the median expenditure on good *y* (i.e. the top half positional good spenders) are perceived as high earners and receive 3 units of status or positional utility. All other individuals are perceived as low earners and receive no status or positional utility. If there is a tie at the median spending level for good *y*, community members involved in the tie share the remaining community status utility equally. For example, if two members tie for the last position as a 'high' (top half) spender on good *y*, then they each receive (3/2) = 1.5 units of status utility. If three community members tie for the last two positions as a 'high' spender on good *y*, then they each receive (2*3)/3 = 2 units of utility. If all community members spend the same amount on good *y*, each member receives $\left(\frac{3N}{2N}\right)$ = 1.5 units of status utility. The unit price for each good is \$1000. Table I below states the non-positional marginal utility schedules for each good.

Table 1: Non-positional marginal utility schedules for each good

Units purchased	Marginal utility of good *x* (toilet paper)	Marginal utility of good *y* (home size)
1	45	45
2	40	40
3	30	30
4	15	15
5	10	10
6	5	5

4. Equilibrium analysis

In this section, we analyse how consumers allocate their income in the (Nash) equilibrium of this market setting. Our main result is captured in the following statement.

(Separating equilibrium). In the Nash equilibrium of this market game, high earners spend \$4000 on purchases of the partially positional good y *and \$2000 on purchases of the non-positional good* x*. Lower earners spend \$3000 on good* y *and \$2000 on good* x*.*

Proof. To show that these levels of spending form a Nash equilibrium, we must verify that no deviation can be profitable for any individual.

High income earners

According to the strategy profile above, high earners invest more in *y* than do lower earners. Hence, high earners are identified as such and receive 3 units of status utility. Their total utility is 6+5+4+3 (from the consumption of good *y*), plus 6+5 (from the consumption of good *x*), plus the additional 3 units of status utility. These values sum to 32 units of utility. The marginal utility of the 5th unit of good *y* is 2 units, and the marginal utility of the 2nd unit of good *x* is 5 units. It is therefore obvious that a high income earner has no incentive to increase his allocation of good *y* at the expense of consuming less of good *x*. Would it be profitable for a high income earner to purchase 3 units of each good? In such a case, the high income earner's non-positional utility would be (6+5+4) for each of the two goods. This sums to 30 units of non-positional utility. As the high income earner can no longer be differentiated from lower earners, he shares one unit of high income status with $\frac{N}{2}$ other individuals. The utility derived from this tie equals

$$\frac{2}{\frac{N}{2}+1}$$

which is less than 2. Hence, it is not profitable for a high income earner to split his budget equally across the two goods – a behaviour that would be optimal without status considerations.

Low income earners

Low income earners spend \$3000 on the consumption of good *y* and \$2000 on good *x*. This allocation of income is already optimal to low income earners without status consideration. The total utility attained from the income allocation is 6+5+4+6+5 = 26 units. We need only examine the deviations in which lower income earners invest more in status. Consider the situation in which one lower income earner imitates the behaviour of the high income earners. His non-positional utility is 6+5+4+3+6 = 24 units. Such a lower income earner ties with $\frac{N}{2}$ high income earners. His status utility is

$$\frac{2 \cdot \frac{N}{2}}{\frac{N}{2}+1} = \frac{2}{1+\frac{2}{N}} < 2$$

.

Hence, the total utility from the deviation is less than 26 units, and such a deviation is not profitable. The strategy profile described above is an equilibrium. It is interesting to consider whether there are other equilibria in this model. According to the strategy profile described above, lower income earners do not strive for status and invest according to the social optimum (3 units in good *y* and 2 units in good *x*). Some of them might find it equally rewarding to shift to a consumption of 2 units of good *y* and 3 units of good *x*. They will still be regarded as lower income and derive the same utility from this income allocation. Thus, there are equilibria in which some (but not all) of the lower income citizens buy 2 units of *y* and 3 units of *x*. If all lower income individuals behaved in this way, would such a behaviour still constitute an equilibrium? In this case, high income earners would enjoy a profitable deviation by buying 3 units of each good (which is socially optimal), as they would still be able to differentiate themselves from the lower income individuals. Thus, the only equilibrium possible is the separating equilibrium described above.

Voluntary disclosure of income

In this section, we explore the impact of a voluntary income disclosure mechanism. We maintain the assumption that income is private information but allow for a technology through which individuals may disclose their income. The act of disclosing income guarantees a high income (low income) status and 3 (0) additional units of status utility to individuals earning $6000 ($5000). Non-disclosing individuals, on the other hand, engage in a signalling contest amongst themselves. The total value of the signalling game is equal to 3 units multiplied by the number of high income earners who fail to disclose their income. In other words, community members can infer the aggregate amount of status that 'should be' assigned to non-disclosing individuals in that they know the aggregate income distribution for the community and thus for the sub-community of income disclosers. What incentives exist for high income earners to disclose their income level? The next statement describes the equilibrium profile of the voluntary income disclosure setting.

In the voluntary disclosure equilibrium, each high income earner discloses his income, invests $3000 in each of goods x *and* y *and attains a total utility of 33 units. The lower income individuals are indifferent between disclosing and not disclosing their income and attain a total level of 26 units of utility by investing either $3000 in good* x *and $2000 in good* y *or $2000 in good* x *and $3000 in good* y*.*

Observe that, by disclosing their income status, high income earners are able to secure their position in the income distribution. Disclosure by such a person is rewarded with an additional 3 units of utility. Thus, the incentive for a high income earner to signal status through 'additional' purchases of the positional good, and sacrifice non-positional utility in doing so, is eliminated. An income-disclosing, high income earner will obtain a utility of 2(6+5+4) = 30 units of utility from consumption and 3 additional units from status. These values sum to 33 units of total utility. If high income earners disclose their income, it is immaterial whether lower income earners disclose because their earnings can be inferred. Lower income earners maximise their utility either by purchasing 2 units of good x and 3 units of good y or by purchasing 3 units of good x and 2 units of good y. Either choice gives such an individual 26 units of utility. Voluntary disclosure of income restores the socially optimal level of consumption for the two goods. To obtain more details regarding the experimental design, please see the experimental instruction sheet in Appendix A.

5. Experimental results

The classroom experiment was conducted across two sections of an undergraduate Survey of Economics course at Nicholls State University in the Fall semester of 2009, shortly after students learned about utility and consumer choice. Each student received an experimental instruction sheet (see Appendix A) and was randomly assigned to an income group such that half of the students received an income of $6000 per month and the remaining students received an income of $5000 per month. The instruction sheet listed the marginal utility and status utility rules associated with consumption of the two goods. Each student fully allocated personal income between (integer quantities of) goods *x* and *y*, where each good carried a unit price of $1000. Students recorded their allocations on a sheet of paper and handed the paper to the professor. The professor recorded the allocations for each individual, ranked the students in terms of status good allocations and assigned status utility accordingly.

It is important to note that students were incentivised through the assignment of course extra credit points. In each of the two treatments, those who earned an overall utility level at or above the median overall utility level in their income group were given 3 points of extra credit. Those falling below the median utility level for their income group in a given treatment were given 1 extra credit point. Individual choices across the two sections are summarised in Tables IIa to IId below.

Table II a: Positional good allocation among high earners – treatment 1, section 1

Units of y	Frequency (n = 18)	Non-positional utility	Total utility
6	0	21	24
5	5	26	29
4	10	29	31.57
3	2	30	30
2	1	29	29
1	0	26	26
0	0	21	21

Table II b: Positional good allocation among lower earners – treatment 1, section 1

Units of y	Frequency (n = 18)	Non-positional utility	Total utility
5	0	20	23
4	3	24	26.57
3	11	26	26
2	2	26	26
1	2	24	24
0	0	20	20

Table II c: Positional good allocation among high earners – treatment 1, section 2

Units of y	Frequency (n = 19)	Non-positional utility	Total utility
6	2	21	24
5	7	26	29
4	8	29	30.85
3	2	30	30
2	0	29	29
1	0	26	26
0	0	21	21

Table II d: Positional good allocation among lower earners – treatment 1, section 2

Units of *y*	Frequency (*n* = 19)	Non-positional utility	Total utility
5	2	20	23
4	5	24	25.85
3	9	26	26
2	2	26	26
1	0	24	24
0	1	20	20

In Treatment 1, the case with no income disclosure option, the predicted choice for each group ($4000 spending on the positional good by high income individuals and $3000 by lower income individuals) was more frequently chosen than any other option for the group. This outcome was observed in each of the two sections. Further, average positional good allocations for the high income groups (4.06 and 4.47) and the low income groups (2.83 and 3.21) lie closest to the respective predicted equilibrium point. Lastly, those whose allocations matched the predicted equilibrium received the highest possible outcome given their status. In other words, participants interacted in such a way that the choices forming the predicted equilibrium were indeed optimal.

In Treatment 2, we introduced the option of income disclosure. That is to say, participants had the option to reveal their income before choosing allocations of the positional and non-positional good. The outcomes for this case are featured in Tables IIIa to IIId below.

Table III a: Positional good allocation among high earners – treatment 2, section 1

Units of *y*	Revealed	Frequency (*n* = 18)	Non-positional utility	Total utility
6	No	0	21	24
6	Yes	0	21	24
5	No	1	26	29
5	Yes	0	26	29
4	No	1	29	30
4	Yes	4	29	32
3	No	0	30	30
3	Yes	10	30	33
2	No	0	29	29
2	Yes	2	29	32
1	No	0	26	26
1	Yes	0	26	29
0	No	0	21	21
0	Yes	0	21	24

Table III b: Positional good allocation among lower earners – treatment 2, section 1

Units of *y*	Revealed	Frequency (*n* = 18)	Non-positional utility	Total utility
5	No	0	20	23
5	Yes	0	20	20
4	No	2	24	25
4	Yes	0	24	24
3	No	8	26	26
3	Yes	3	26	26
2	No	2	26	26
2	Yes	3	26	26
1	No	0	24	24
1	Yes	0	24	24
0	No	0	20	20
0	Yes	0	20	20

Table III c: Positional good allocation among high earners – treatment 2, section 2

Units of *y*	Revealed	Frequency (*n* = 19)	Non-positional utility	Total utility
6	No	0	21	24
6	Yes	0	21	24
5	No	3	26	29
5	Yes	0	26	29
4	No	2	29	29.6
4	Yes	3	29	32
3	No	0	30	30
3	Yes	9	30	33
2	No	0	29	29
2	Yes	1	29	32
1	No	0	26	26
1	Yes	1	26	29
0	No	0	21	21
0	Yes	0	21	24

Table III d: Positional good allocation among lower earners – treatment 2, section 2

Units of *y*	Revealed	Frequency (*n* = 19)	Non-positional utility	Total utility
5	No	1	20	23
5	Yes	0	20	20
4	No	3	24	24.6
4	Yes	0	24	24
3	No	8	26	26
3	Yes	3	26	26
2	No	2	26	26
2	Yes	2	26	26
1	No	0	24	24
1	Yes	0	24	24
0	No	0	20	20
0	Yes	0	20	20

Across the two sections, most high income earners revealed their income (16 of 18 and 14 of 19), whereas a minority of lower income earners reveal their income (6 of 18 and 5 of 19). Most high income earners understood the advantage of income disclosure over costly positional good signalling. We know that higher income earners used disclosure in lieu of the signal because the typical consumption (over-consumption) level for good *y* among this group fell drastically from Treatment 1 to Treatment 2. High income earners scaled back in average consumption of good *y* from 4.06 to 3.28 in class section 1 and from 4.47 to 3.63 in class section 2. This resulted in an increase of average utility in each section (from 30.54 to 32.28 and from 29.36 to 31.59 in the respective sections).

To test whether the typical high income earner experienced a statistically significant income gain from Treatment 1 to Treatment 2, we employ a paired samples t-test and a Wilcoxon signed rank sum test for each class section's high income group. The paired samples t-test indicates that high income earners consume less of good *y* (two-tailed p-values = 0.0063 and less than 0.0001, respectively) and consequently achieve higher levels of utility from consumption (two-tailed p-values for each section < 0.0001). The Wilcoxon signed rank sum test also suggests, at a reasonable confidence level, that consumption of good *y* fell (p-values = 0.0026 and 0.0002, respectively) and that high income earners consequently earned higher utility levels (p-values = 0.0002 and 0.0003, respectively). Students in the lower income group did not experience significant changes in their consumption or utility levels across treatments. Within each sample, utility levels rose by a statistically insignificant amount for lower income earners. The insignificance of this result follows the predicted experimental outcome. Lower income earners had no incentive to over-invest in the positional good in either case. They stood only to profit in the status signalling game if a sufficient number of high income earners deviated from their optimal choice for a given treatment. Such deviations among high income earners were equally plausible in either treatment.

6. Discussion after the experiment

A good means by which to initiate the debriefing of the experiment is to ask whether students made different choices in the two treatments. The instructor can count the number of students who spent more on the partially positional good in Treatment I (compared to Treatment II), the students who did not change their choice across the two treatments, and the students who spent less on the status good

in Treatment I. Then, the instructor can ask students which is the best consumption choice for high income individuals, and which is the best consumption choice for low income individuals. Typically, low income earners report that they tried to maximise their non-positional utility, while many high income earners share that they attempted to maximise the sum of their positional and non-positional utilities. As a next step, the instructor can ask whether students realised a difference in utility level across the two treatments and count hands again. The instructor can then ask what (experimental design) factor accounts for the change in utility level across treatment.

The instructor can further help students relate the exercise to realistic behaviour by asking them for examples of social scenarios in which they have observed individuals engaged in status spending races. What are the consequences of such races? The instructor can mention that the high rates of personal bankruptcy and real estate foreclosures, as well as the high proportion of individuals without health insurance in the United States, may partly result from status spending races. Finally, we lay out some additional questions that instructors can discuss at the end of the class session and list some observed student comments.

Potential questions for discussion:

1) What is the chief problem associated with status races according to the experiment?

2) In the first treatment of the experiment, income groups have already been established. Given this, is it optimal for a high income individual to avoid a status race altogether (given that other high income individuals will engage in the status race regardless)?

3) Can government policy change the extent to which individuals enter into a status race?

4) Which goods in reality do you believe to be highly positional (i.e. to be observed for the purposes of status comparison within a community)?

Observed student comments:

1) School uniforms in secondary school may act to restrict status signalling through fashion expenditures.

2) Some secondary schools disallow students from driving to school. Such schools may wish to keep (automobile-related) status spending at bay.

3) A good must be observable by one's peers to be an effective status signal.

4) Non-anonymous charitable donations may be a way to signal one's income status.

7. Conclusion

Recent advances in the empirical literature on the relative income hypothesis challenge the traditional assumption that individuals are concerned only with their absolute level of consumption. A departure from this assumption has significant implications for our understanding of the way markets coordinate the incentives of economic agents. When individuals are concerned with their relative social standing, free markets lead to spending races on positional goods and generally result in Pareto inferior allocations.

This paper presents a classroom experiment to introduce students to the relative income model and illustrate the effects of positional considerations on consumer choice. We develop a simplified version of Frank's (1985a) theoretical model of consumer choice, discuss its theoretical properties, and compare student behaviour during the experiment with the theoretical solution of the model. Our

analysis does not require the use of advanced mathematical techniques, yet the model illustrates how the incentives of individuals lead to overspending on the positional good.

The experiment features two income groups and a mechanism in which participants can disclose income. High income earners within the experiment are shown to over-invest in units of a positional good in the absence of a public income disclosure mechanism. However, this over-investment problem largely subsides when a public income disclosure mechanism becomes available. This is found to be true both within the predicted Nash equilibrium outcome and within experimental results. Consequently, high income earners achieve significantly higher levels of utility. Public income disclosure serves to discredit the signalling value of positional goods spending within the experiment.

References

Clark, A. and A. Oswald (1996). Satisfaction and comparison income. *Journal of Public Economics*, Vol. 61(3), pp. 359–81.

Duesenberry, J. (1949). Income, saving, and the theory of consumer behaviour, Cambridge: Harvard University Press.

Easterlin, R. (1974). Does economic growth improve the human lot? in (P. David and M. Reder, eds), *Nations and Households in Economic Growth: Essays in Honour of Moses Abramovitz*, Pp. 89125, New York, London: Academic Press.

Frank, R. (1985a). The demand for unobservable and other nonpositional goods, *American Economic Review,* Vol. 75(1), pp. 101–16.

Frank, R. (1985b). Choosing the right pond: human behavior and the quest for status, New York: Oxford University Press.

Frank, R. (2005). The mysterious disappearance of James Duesenberry, *The New York Times,* http://www.nytimes.com/2005/06/09/business/ 9scene.html (June 2005; rretrieved April 2008).

Frank, R. (2008). Should public policy respond to positional externalities?, *Journal of Public Economics,* Vol. 92, pp. 1777–86.

Frank, R. and R. Hutchens (1993). Wages, seniority, and the demand for rising consumption profiles, *Journal of Economic Behaviour and Organization,* Vol. 21(3), pp. 251–76.

Hopkins, E. and T. Kornienko (2004). Running to Keep in the Same Place: Consumer Choice as a Game of Status, *American Economic Review*, Vol. 94(4), pp. 1085–107

Hopkins, E. and T. Kornienko (2006).Inequality and Growth in the Presence of Competition for Status, *Economics Letters*, Vol. 93, pp. 291–6.

Hopkins, E. and T. Kornienko (2006). Status, Affluence, and Inequality: Rank-Based Comparisons in Games of Status, *Games and Economic Behavior*, Vol. 67 (2), pp. 552–68.

Kosicki, G. (1987). A Test of the Relative Income Hypothesis, *Southern Economic Journal,* Vol. 54(2), pp. 422–34.

Layard, R. (1980). Human satisfactions and public policy, *The Economic Journal,* Vol. 90(360), pp. 737-–50.

Luttmer, E. (2005). Neighbors as negatives: Relative earnings and well-being, *The Quarterly Journal of Economics*, Vol. 120(3), pp. 963–1002.

Oswald, A. (1983). Altruism, jealousy, and the theory of optimal non-linear taxation, *Journal of Public Economics*, Vol. 20(1), pp. 77–87.

Oswald, A. (1997). Happiness and economic performance, *The Economic Journal*, Vol. 107(445), pp. 1815–31.

Solnick, S. and D. Hemenway (2005). Are positional concerns stronger in some domains

than in others?, *American Economic Review*, Vol 95, pp. 147–51.

Stevenson, B. and J. Wolfers (2008). Economic growth and subjective well-being:

Reassessing the Easterlin Paradox, Manuscript, University of Pennsylvania.

Appendix A (Instructions)

Experiment on Positional Goods
Student Instructions

You are a member of a community consisting of all students in the classroom. Half of the community members earn $6000 per month, and the other half earn $5000 per month. The instructor will privately tell you how much your monthly earnings are in this experiment (Without revealing the number to anyone, turn to the last page of your sheet for this information.) No one except you will know how much you earn, and you also will not know how much other individuals are earning. You can spend your income on two goods.

The first good, *x*, is purchased for its direct use only. It cannot influence how others feel about you (i.e. whether others believe you to belong to the high or the low earners). You might think of this good as an insurance policy or toilet paper.

The second good, *y*, is consumed partly for its direct use and partly for positional reasons. The second consumption motivation suggests that other members of the community observe how much of this good you consume, and this consumption choice determines your position in the community (i.e. whether you are perceived to be a high income or a low income person). You might think of a positional good as home size. Additional home size can be useful (i.e. can give you non-positional utility) but is, at the same time, observed as a sign of status (i.e. can give you positional or status utility).

Your non-positional marginal utility schedules for each good are as follows:

Table 1: Non-positional utility in consumption of *x* and *y*

Units purchased	Marginal utility of good *x* (toilet paper)	Marginal utility of good *y* (home size)
1	6	6
2	5	5
3	4	4
4	3	3
5	2	2
6	1	1

Treatment I

Your expenditures on good *y* are observed by other members of your community, and they determine how much utility you receive from status in addition to the direct utility received from y (as listed above). If you are in the top half of community members, in terms of quantity of good y consumed, you receive 3 units of status or positional utility. If you are in the bottom half, you receive 0 units of status utility. If there is a tie at the median spending level for good *y*, community members involved in the tie will share the remaining community status utility equally. For example, if two members tie for the last position as a 'high' (i.e. top half) spender on good *y*, then they each receive (3/2) = 1.5 units of status utility. If three community members tie for the last two positions as a 'high' spender on good *y*, then they each receive (2*3)/3 = 2 units of utility. If all community members spend the same amount on good *y*, each member receives 1.5 units of status utility. Each unit of good *x* costs $1000, as does each unit of good *y.* Please choose how you wish to spend your income with the objective of maximising your utility. Do so by checking your chosen box in the 'Choice' column. If you are a low income person, check only one box of the low income table. If you are a high income person, check only one box of the high income table.

Low income:

Choice	Good *x*	Good *y*
	$0	$5000
	$1000	$4000
	$2000	$3000
	$3000	$2000
	$4000	$1000
	$5000	$0

High income:

Choice	Good *x*	Good *y*
	$0	$6000
	$1000	$5000
	$2000	$4000
	$3000	$3000
	$4000	$2000
	$5000	$1000
	$6000	$0

Your income level is: (either '$5000' or '$6000' here, depending upon random draw).

Treatment II

Your income remains the same, but you can now voluntarily disclose your income level to all community members. If you are a high income person and disclose this information, you will receive additional 3 units of utility associated with your high income status. If you are a low income individual and disclose this information, you will receive no additional utility. After deciding whether to disclose income, you will decide how to split your income across the two goods. Your marginal utilities associated with the direct consumption of *x* and *y* are the same as in the first treatment (see Table 1).

The pool of students who do not reveal their income in Treatment II will receive status utility according to the following rules. The instructor will first calculate how many high income individuals did not disclose their income. This number will serve as the number of high status positions 'available' within the positional good status signalling game. Suppose that *m* high income individuals did not disclose their income. Of the students who did not disclose their income, whether they be high income or low income, the top *m* individuals in terms of consumption levels of good *y* receive 3 units of status utility. All other non-disclosing individuals receive 0 units of status utility. If there is a tie at the median spending level for good *y*, community members involved in the tie will share the remaining community status utility equally as in the sharing rule of Treatment I.

Given these rules do you wish to disclose your income to other students? Check one option.

_____Yes _____No

Now, decide how much of good *x* and how much of good *y* you wish to purchase with the objective of maximising utility (i.e. check one box in the appropriate table).

Low income:

Choice	Good *x*	Good *y*
	$0	$5000
	$1000	$4000
	$2000	$3000
	$3000	$2000
	$4000	$1000
	$5000	$0

High income:

Choice	Good *x*	Good *y*
	$0	$6000
	$1000	$5000
	$2000	$4000
	$3000	$3000
	$4000	$2000
	$5000	$1000
	$6000	$0

Appendix B (Tables)

Table I: Non-positional utility in consumption of *x* and *y*

Units purchased	Marginal utility of good *x* (toilet paper)	Marginal utility of good *y* (home size)
1	6	6
2	5	5
3	4	4
4	3	3
5	2	2
6	1	1

Table II a: Positional good allocation among high earners – treatment 1, section 1

Units of y	Frequency (*n* = 18)	Non-positional utility	Total utility
6	0	21	24
5	5	26	29
4	10	29	31.57
3	2	30	30
2	1	29	29
1	0	26	26
0	0	21	21

Table II b: Positional good allocation among lower earners – treatment 1, section 1

Units of *y*	Frequency (*n* = 18)	Non-positional utility	Total utility
5	0	20	23
4	3	24	26.57
3	11	26	26
2	2	26	26
1	2	24	24
0	0	20	20

Table II c: Positional good allocation among high earners – treatment 1, section 2

Units of *y*	Frequency (*n* = 19)	Non-positional utility	Total utility
6	2	21	24
5	7	26	29
4	8	29	30.85
3	2	30	30
2	0	29	29
1	0	26	26
0	0	21	21

Table II d: Positional good allocation among lower earners – treatment 1, section 2

Units of *y*	Frequency (*n* = 19)	Non-positional utility	Total utility
5	2	20	23
4	5	24	25.85
3	9	26	26
2	2	26	26
1	0	24	24
0	1	20	20

Table III a: Positional good allocation among high earners – treatment 2, section 1

Units of *y*	Revealed	Frequency (*n* = 18)	Non-positional utility	Total utility
6	No	0	21	24
6	Yes	0	21	24
5	No	1	26	29
5	Yes	0	26	29
4	No	1	29	30
4	Yes	4	29	32
3	No	0	30	30
3	Yes	10	30	33
2	No	0	29	29
2	Yes	2	29	32
1	No	0	26	26
1	Yes	0	26	29
0	No	0	21	21
0	Yes	0	21	24

Table III b: Positional good allocation among lower earners – treatment 2, section 1

Units of *y*	Revealed	Frequency (*n* = 18)	Non-positional utility	Total utility
5	No	0	20	23
5	Yes	0	20	20
4	No	2	24	25
4	Yes	0	24	24
3	No	8	26	26
3	Yes	3	26	26
2	No	2	26	26
2	Yes	3	26	26
1	No	0	24	24
1	Yes	0	24	24
0	No	0	20	20
0	Yes	0	20	20

Table III c: Positional good allocation among high earners – treatment 2, section 2

Units of *y*	Revealed	Frequency (*n* = 19)	Non-positional utility	Total utility
6	No	0	21	24
6	Yes	0	21	24
5	No	3	26	29
5	Yes	0	26	29
4	No	2	29	29.6
4	Yes	3	29	32
3	No	0	30	30
3	Yes	9	30	33
2	No	0	29	29
2	Yes	1	29	32
1	No	0	26	26
1	Yes	1	26	29
0	No	0	21	21
0	Yes	0	21	24

Table III d: Positional good allocation among lower earners – treatment 2, section 2

Units of *y*	Revealed	Frequency (*n* = 19)	Non-positional utility	Total utility
5	No	1	20	23
5	Yes	0	20	20
4	No	3	24	24.6
4	Yes	0	24	24
3	No	8	26	26
3	Yes	3	26	26
2	No	2	26	26
2	Yes	2	26	26
1	No	0	24	24
1	Yes	0	24	24
0	No	0	20	20
0	Yes	0	20	20

Appendix C (Alternative exercise)

You are a member of a small neighbourhood consisting of four individuals. Two of the individuals earn a monthly income of $6000 (we will refer to them as being high income earners or 'rich' individuals), and the other two earn $5000 per month (low income earners or 'poor' individuals). Each individual knows only his/her own income, but does not know who is 'rich' and who is 'poor' of his neighbours. Each individual divides his income across two goods, *x* and *y,* and we assume for simplicity that a unit of each good costs $1000.

The first good, *x*, is purchased for its direct use only. It cannot influence how you are perceived by your neighbours (i.e. whether they believe you to belong to the high or the low earners). You might think of this good as an insurance policy or toilet paper.

The second good, *y*, is consumed partly for its direct use and partly for positional reasons. The second consumption motivation suggests that other members of the community observe how much of this good you consume, and this consumption choice determines your position in the neighbourhood (i.e. whether you are perceived to be a high income or a low income person). You might think of a positional good as home size. Additional home size can be useful (i.e. can give you non-positional utility) but is, at the same time, perceived as a sign of status (i.e. can give you positional or status utility).

Your non-positional marginal utility schedules for each good are as follows:

Units purchased	**Marginal utility of good *x* (toilet paper)**	**Marginal utility of good *y* (home size)**
1	45	45
2	40	40
3	30	30
4	15	15
5	10	10
6	5	5

The amount of good *y* that you consume is observed by other members of your community, and you also observe how many units each of your neighbours consume from the status good. These consumption quantities determine how much utility you receive from status in addition to the direct utility received from *y* (as listed above). If you are in the top half of community members, in terms of quantity of good *y* consumed, you receive 30 units of status or positional utility. If you are in the bottom half, you receive 0 units of status utility. If there is a tie at the median spending level for good *y*, community members involved in the tie will share the remaining community status utility equally. For example, if two members tie for the last position as a 'high' (i.e. top half) spender on good *y*, then they each receive (30/2) = 15 units of status utility. If three community members tie for the last position as a 'high' spender on good *y*, then they each receive 30/3 = 10 units of utility.

a) Assume that you are a high income earner. Assume also that the other high income earner purchases 4 units of the positional good, and each of the two low income earners purchase 3 units of the positional good. Fill out the table below to determine the utility that you will receive for each of the budget allocations given in the rows. What is your optimal choice?

Solution:

Positional utility	Non-positional utility	Total utility	Good *x*	Good *y*
30	*145*	*175*	$0	$6000
30	*180*	*215*	$1000	$5000
30	*215*	*245*	$2000	$4000
10	***230***	***240***	$3000	$3000
0	*215*	*215*	$4000	$2000
0	*185*	*185*	$5000	$1000
0	*145*	*145*	$6000	$0

The optimal choice is to purchase 3 units of each good.

b) Assume that you are a low income earner. Assume also that the high income earners purchase 4 units of the positional good, and the other low income earner purchases 3 units of the positional good. Fill out the table below to determine the utility that you will receive for each of the budget allocations given in the rows. What is your optimal choice?

Solution:

Positional utility	Non-positional utility	Total utility	Good *x*	Good *y*
30	*140*	*170*	$0	$5000
20	*185*	*205*	$1000	$4000
0	***210***	***210***	$2000	$3000
0	***210***	***210***	$3000	$2000
0	*185*	*185*	$4000	$1000
0	*140*	*140*	$5000	$0

The optimal choice is to purchase either 2 or 3 units of the positional good.

c) Calculate the opportunity cost of purchasing the fourth unit of the positional good for rich and for poor individuals. Why does a rich individual find it worthwhile to consume the fourth unit and a poor individual does not?

Solution:

A rich individual who increases his consumption of the positional good from 3 to 4 gains 15 additional units of utility but loses 40 units of utility due to the reduction in consumption of the non-positional good from 3 to 2 units. So, the opportunity cost is 25. This is less than 30 units gained in positional utility. A poor individual gains 15 additional units but loses 40 units due to the reduction in consumption of the

non-positional good from 2 to 1. So, the opportunity cost is 35. This is more than the positional utility that can be gained.

d) What is the utility of 'rich' individuals and the utility of 'poor' individuals in equilibrium (rich individuals consume 4 units of the positional good and poor individuals consume 3 units of the positional good).

Solution:

The total utility of a rich individual is 240 and of a poor individual is 210.

e) Assume that rich individuals are able to voluntarily disclose and verify their income, so that they can attain their status utility without the need to signal their income through conspicuous consumption. Calculate the optimal budget allocation of the rich individuals. Were they able to increase their utility?

Solution:

It is optimal for a rich individual to consume 3 units of both goods. Total utility in this case is 260.

f) Discuss government policies aimed at reducing conspicuous consumption and status spending races.

Solution:

Students can discuss taxes on positional goods, forced retirement savings programmes, and mandates on purchasing health insurance – a measure that is incorporated in the recent US healthcare reform bill.

Appendix D (An alternative Treatment II; not analysed in this paper)

This treatment serves as an alternative to Treatment II of the original exercise. It does not invoke public income disclosure but, rather, another policy designed to alleviate the cost of a status spending race. In this treatment, your income remains the same as in Treatment I, as do prices and (non-positional and positional) utility levels. However, the government now forces each individual to spend at least 50 per cent of his or her (reported) income on units of the non-positional good.

Given this constraint, decide how much of good *x* and how much of good *y* you wish to purchase with the objective of maximising utility (i.e. check one box in the appropriate table).

Low income:

Choice	Good *x*	Good *y*
unavailable	$0	$5000
unavailable	$1000	$4000
unavailable	$2000	$3000
*	$3000	$2000
	$4000	$1000
	$5000	$0

High income:

Choice	Good *x*	Good *y*
unavailable	$0	$6000
unavailable	$1000	$5000
unavailable	$2000	$4000
*	$3000	$3000
	$4000	$2000
	$5000	$1000
	$6000	$0

The predicted choices for each income type are marked with an asterisk. As can be confirmed by the utility tables provided previously, such an outcome is Pareto optimal within the present stylised example (where there are no costs of enforcing the spending policy).

Authors Biography

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Shane Sanders is an assistant professor of economics at Western Illinois University. His research focuses on the welfare implications of resource contests (e.g., conflict or non-price allocative contests). Dr. Sanders lives in Macomb, IL (U.S.), a small community in which status spending races are relatively tame. He is further liberated from the ill effects of status spending races in that his salary is a matter of public record.

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Educating Latin American Economists

David Colander and Hugo Ñopo[*]

Abstract

Graduate economic programmes in Latin America have evolved along the lines of two different traditions: one closely linked to the current economic mainstream (being in that sense 'global') and the other more local and heterodox. This paper provides an overview of perceptions, interests, concerns and opinions of global Latin American graduate economic programmes, comparing them with similar programmes in Europe and the US. It reports the findings of a survey of Latin American global economics programmes and discusses the debate between global economics and traditional economics, arguing that there is a role for both, with global economics concentrating on the science of economics and traditional economics concentrating on the applied policy 'political economy' branch of economics – which is much broader than the applied policy training that graduate students get in global economics.

JEL classification: A11, A12, A23

1. Introduction

Graduate economic programmes in Latin America can be classified into two broad groupings. One set of programmes teaches what might, for want of a better term, be called 'global economics'; what is taught in mainstream graduate economics programmes in the US, Europe and Australia/New Zealand.[1] Global economics' lingua franca is English; it sees itself as a science, and it is becoming increasingly technical. The other grouping is more likely to teach non-mainstream, or what are often called heterodox ideas, and reflect local Latin American traditions, being in that sense more 'local'.[2] It tends to be more historical, more leftist in its ideological leanings, less mathematical and less well-funded than its global counterpart.

While this paper focuses on global post-graduate economics programmes in Latin America,[3] towards the end we discuss the relationship between global programmes and those with a more traditional

[*] The views expressed in this document do not reflect those of the Bank nor its Board of Directors. Eduardo Lora provided useful comments.

[1] We call it global, not US economics, to emphasise that what it teaches (except for some bias toward US statistical data) is not perceived as US-centric by those doing it any more than modern chemistry or physics is perceived as US centric. It is what is taught in those sets of programmes that consider themselves part of the global mainstream. Japan is the developed country that has most resisted the global movement in economics.

[2] The heterodox aspects of the programmes have international connections as well, and the faculty at these schools often have contacts with other heterodox programmes throughout the world, such as the regulation school in France and programmes associated with the International Confederation of Associations for Pluralism in Economics (ICAPE).

[3] For a similar analysis, also inspired by Colander (2006), but focused on the undergraduate level see Lora and Ñopo (2007).

approach. We do so by comparing perceptions, interests, concerns and opinions of students in global Latin American graduate economic programmes, with those of students in the US and Europe. In this way, this paper provides background for considering the future of these two traditions.

The findings reported for the Latin American economics programmes come from a six-page online survey, which is similar to the one that Colander used to study US and European programmes (Colander, 2006, 2009a). While our plan was initially to focus only on global Latin American programmes taught in English (which is why we left the questionnaire in English), we quickly found that in Latin America even the global programmes are still taught both in the native language of the country and in English.[4] The survey was accessible on the web between July 2006 and March 2007, allowing for both in-session and vacation time in the programmes for both the northern and the southern hemisphere. The survey took anywhere from 15 minutes to an hour to complete.[5]

We were not especially successful in getting participation, but after a couple of requests, we did manage to get 125 respondents from 20 schools, the three largest schools reporting being the University of the West Indies, the University of Chile and IIades/Georgetown University Alberto Hurtado University in Chile. Students generally answered all questions. Some 41% of respondents were second-year students, 29% were first year students, 13% were 3rd or 4th year students, and 18% were fifth year or beyond students.

Because of the low response rate, and the lack of randomness of the responses, the results of the survey should be seen as most suggestive, providing us with a glimpse of Latin American graduate economics, and a reference point to discuss issues relevant to graduate economics education in Latin America.[6]

The paper is organised as follows. First we provide a profile of our survey respondents. Second, we compare and contrast Latin American student responses with those from the US and European surveys in terms of their attitudes, interests and views towards the profession. Third, we use the results as a springboard for a broader discussion of the relationship between global and traditional graduate education with special reference to Latin America.

[4] 25% of our respondents stated that between 70 and 100% of their courses were taught in English; 17% said between 50 and 70% were taught in English, 22% said that 30 to 50% were taught in English, 13% said that 10 to 30% were taught in English and 23% said that between 0 and 10% were taught in English.

[5] The survey was distributed by sending out email requests to 56 programme deans, asking them to send the survey out to their students. The survey was listed on SurveyMonkey; it allowed only one response per IP address, so unless students used different computers, they could only respond once. The 56 programmes were selected on the basis of personal consultations with economists from these countries. We crafted a preliminary list of institutions in the region from the programmes of the Meetings of the Latin American Economic Association, the Caribbean Economic Association (LACEA) and the Latin American Meetings of the Econometric Society (LAMES). We also did an online search of programmes and added a few other institutions that although they did not participate at the meetings that year had a postgraduate programme and an online presence. We believe that the resulting list exhausts the institutions that we are labelling as 'global' but we recognise that it also includes some more traditional programmes. However, since the questionnaire was in English, we would expect that it captured significantly more global students than it did traditional students.

[6] We have reviewed the results with knowledgeable Latin American economists to see it they noticed any significant outliers and, except where noted, the survey results were consistent with their views. The comparison groups are roughly the same, although because Latin American programmes have separate Master's programmes whereas most US programmes combine their Master's programmes into their PhD programme, there are a greater number of first and second year students in the Latin American survey.

2. Profile of global Latin American graduate economics students

The average age of our respondents is about 29 years, which is three years older than the average age of respondents in the US survey.[7] The percentage of women was 41%, which is higher than the 29% of the US survey. All but one of the students were from Latin American countries. A small majority (56%) went to graduate school directly from undergraduate college; most of those who worked before entering graduate school did economics-related work or research prior to starting graduate study. The large majority of students (80%) are native Spanish speakers (7% were Portuguese and 13% were other).

Most students came from upper-middle class backgrounds; more than 60% of their parents were college graduates; 7% of mothers and 16% of fathers had done graduate work. A majority (about 60%) did not consider going abroad to study; 20% considered studying in Europe and 10% considered studying in the US. They did not go abroad for graduate study primarily for financial reasons. Of those students surveyed who were planning to do a PhD after completing their Master's, 40% planned to do it in Europe and 60% planned to do it in the US. None planned to transfer to another Latin American programme. This reflects an important characteristic of global Latin American graduate education; it is to a large degree a feeder system into the US and European PhD programmes, rather than a set of self-standing programmes. Only about 10% considered another Latin American university than the one they attended. (This is far lower than the European and US percentages.) Most of the students were self-financing their education, although the programme tuition is subsidised by the government at most Latin American universities. 27% reported some government support besides the subsidised tuition, and 22% reported receiving a university fellowship.

The large majority of the respondents (81%) considered themselves Master's students; 19% considered themselves PhD students. This reflects a difference between Latin American graduate economic education, where, for many students, the Master's degree is a terminal degree at the university they attend, and US graduate economic education, where almost all students are directly admitted to a PhD programme. Even first-year graduate US students consider themselves PhD students who get a Master's degree on the way to getting a PhD; most first year Latin American students consider themselves Master's students who may go on to do a PhD degree at another school.

The standard course sequence that these Master's students take is essentially identical to the first two years in the US or European global programmes. The first year consists of core material (microeconomics, macroeconomics and econometrics), and sometimes includes an introductory course on mathematics. Students have more choice of courses in their second year and can take a range of courses such as economics of regulation, finance, economic development, project evaluation, as well as special topics in microeconomics, macroeconomics and econometrics, depending on the specialisation of the faculty. Most programmes require a Master's Thesis, written under the direct supervision of a faculty member, as a graduation requirement. The typical Master's programme takes two years to complete, but often advanced undergrads take Master's level courses during their senior year, and can complete the Master's programme in one year.

For the most part the students were satisfied with the programmes and with the economics they were learning. In response to a question about whether economists were relevant to society, 93% said yes. The reasons they gave for economists' relevance included 'economics informs policy-makers of consequences,' and 'good economics = good policy = well-being for society'. The percentages who would do it again were similar to the US, with 81% reporting that they would go to grad school again;

[7] The average was raised by some older students in the 50s that were not present in the US study. It was lowered by the fact that there were more first and second year students in the Latin American study than in the US or European study.

5% said they would not, and 13% were unsure. However, there was less satisfaction with their programme – 60% said they would go to the same graduate school; 19% said they would not, and 21% were unsure.

The students' level of stress was about the same as students at other global economics programmes, although, not surprisingly, given that so many of them are self-financed they did report more stress related to financial considerations than did US students who often have fellowships that cover tuition and provide a living stipend. In terms of course work, 20% of the students found course work very stressful, 28% considered it stressful, 34% considered it moderately stressful, and 17% considered it not stressful.

In response to an open-ended question about what they most liked about graduate study, students mentioned the intellectual challenge, the tools they acquired, the real world expertise of faculty and their helpfulness/interest in students, the fact that they were getting a knowledge of the academic field and the economy, and the freedom they had to study what they want. Some of the students' dislikes included the low quality of some professors, the lack of job prospects upon graduation, their difficult financial situations, the short, intense structure of the Master's programmes, the heavy focus on exams rather than on learning, the large number of mandatory courses, the fact that no economic intuition was taught, only math and theory, the incompatibility of what they were learning with income producing work, and the lack of time both to study and to have a normal life.

3. Interest and views of Latin American, US and European students

Let us now turn to students' interests and views, and how these differ from other global economics students in Europe and the US. In

Table **1** we report the field interests of Latin American, US and European students.[8] It provides the percentages of students who reported that the fields were of great interest to them.

Table 1: Percentage of students who have great interest in selected fields

	Latin Americans grad students	**European grad students**	**US grad students**
Economic Development	50%	37%	39%
Political Economy	50%	35%	24%
Microeconomic Theory	48%	43%	35%
Econometrics	46%	40%	22%
Macroeconomic Theory	46%	35%	33%
International Trade	43%	20%	19%
Money and Banking	38%	21%	21%
Public Finance	36%	20%	24%
History of Thought	34%	15%	9%
Law and Economics	29%	9%	15%
Labour Economics	25%	25%	32%
Comparative Economic Systems	18%	12%	9%
Urban Economics	12%	6%	11%

[8] The US data in this table and the following ones comes from Colander (2006), and the European data comes from Colander (2009a).

There are a number of things to note about this table. First, Latin American students seem to be more interested in everything. Second, Latin American students are relatively more interested in political economy, money and banking, international trade, and the history of economic thought. Many of these differences are possibly explained by the greater number of first and second year students in the Latin American survey. First and second year students have not had a chance to specialise yet. Another possible explanation for the relatively greater interest in political economy, money and banking and international trade is that these fields are more relevant to the policy problems facing Latin American than they are to the problems facing Europe and the US. It is impossible to choose among these explanations.

The interest in history of economic thought may be explained in that it provides a connection to earlier Latin American writings, which are now generally only presented in history of economic thought courses, and because, even though we focused on those programmes that were most globalised, even these programmes are not fully globalised: they still teach history of economic thought (at least at the undergraduate level), whereas most US graduate programmes do not. In fact, a measure of how global a programme is may well be the degree of interest in the history of economic thought expressed by the students. The more global a programme is, the less interest students will have in the history of economic thought.

Some of the most remarked-upon results of the first US study (Colander and Klamer, 1987) were students' responses to the question of what characteristics would most likely put them on the fast track.[9] Table 2 lists the responses of Latin American, European and US global students.

Table 2: Perceptions of success

	Very important			**Moderately important**			**Unimportant**		
	LA	**EURO**	**US**	**LA**	**EURO**	**US**	**LA**	**EURO**	**US**
Being smart in the sense that they are good at problem solving	60%	61%	51%	37%	34%	38%	1%	6%	7%
Being interested in, and good at, empirical research	51%	38%	30%	41%	51%	52%	8%	9%	12%
Excellence in mathematics	40%	40%	30%	51%	51%	52%	9%	9%	14%
Being very knowledgeable about one particular	20%	35%	35%	65%	48%	42%	14%	14%	15%
Ability to make connections with prominent professors	25%	30%	33%	43%	54%	40%	24%	11%	19%
A broad knowledge of the economics literature	25%	16%	11%	55%	53%	44%	16%	28%	35%
A thorough knowledge of the economy	40%	16%	9%	48%	39%	24%	11%	42%	51%

[9] Students could interpret 'fast track' as they wanted. From interviews with students in previous studies, it was found that most US and European students interpreted it as advancing within academic economics.

As you can see, Latin American students see empirical work as more important than either US or European students, and they see being knowledgeable in a particular field as being less important, although that is probably explained by the greater percentage of first and second year students in the Latin American group. However, the largest difference here is that Latin American students considered having a broad knowledge of the economics literature and having a thorough knowledge of the economy as much more important than did the US students. This suggests to us that the Latin American students are not as single-mindedly focused on techniques as is the case in US programmes, and that the Latin American programmes are giving students a broader perspective of economics than they get at top US schools, another possible reflection of the incomplete globalisation of the programmes.[10]

A number of the questions in the survey explored student views on what economics was and how students' views changed over time. Table 3 compares the 'before' and 'after' views of Latin American students with those in the US and European students on a number of propositions.

Table 3: Current vs. earlier perspectives on economics

	Latin American students		**European students**		**US students**	
	Strong agree		**Strong agree**		**Strong agree**	
	Before Grad school	**Current View**	**Before Grad school**	**Current View**	**Before Grad school**	**Current View**
The study of mainstream economics is relevant for the economic problems of today	46%	61%	37%	34%	37%	44%
Economists agree on the fundamental issues	19%	18%	11%	9%	11%	9%
We can draw a sharp line between positive and normative economics	15%	17%	10%	9%	15%	12%
Learning economics means learning a set of tools	29%	54%	23%	41%	26%	36%
Economics is the most scientific discipline among the social sciences	34%	37%	34%	36%	46%	50%

As you can see, Latin American students saw economics as being more relevant both before and after beginning their graduate studies; they saw more agreement on fundamental issues, while US students saw economists as more scientific both before and after.[11] However, the Latin American students had a lower belief than the US ones that economics is the most scientific discipline of the social sciences.

[10] We want to make it clear that we are not claiming that that interest is bad. We are simply describing the differences.

[11] For two of these questions, the phrasing was slightly different in the European and Latin American studies, so the results are not completely comparable. In the US study, the question about relevancy and about economic learning focusing on tools referred to neoclassical economics in the US study and mainstream economics in the European and Latin American study.

There was also a fairly substantial increase (from 29% to 54%) in the number of students believing learning economics means learning a set of tools.

Our interpretation of these results is that they are partly a result of the different content of the programme, and partly the result of the greater concentration of Latin American students in the first and second year, during which they get a Master's degree. The Master's portion of the Latin American programmes, like the first years of the US programmes, is more focused on tool-creation (microeconomics, macroeconomics and econometrics) than on ideas.

Table 4 reports Latin American student views on policy issues and contrasts them with European and US students' views.

Table 4: Views on policy issues

	Agree			Agree with reservations			Disagree		
	LA	**EURO**	**US**	**LA**	**EURO**	**US**	**LA**	**EURO**	**US**
Fiscal policy can be an effective tool in a stabilisation policy	37%	21%	21%	59%	59%	58%	3%	9%	12%
Central banks should maintain a constant growth of the money supply	8%	9%	7%	45%	28%	22%	42%	42%	50%
The distribution of income in developed nations should be more equal	45%	35%	32%	36%	43%	41%	15%	18%	18%
A minimum wage increases unemployment among young and unskilled workers	27%	26%	33%	32%	38%	38%	32%	25%	23%
Tariffs and import quotas reduce general economics welfare	47%	42%	51%	30%	43%	39%	16%	9%	7%
Inflation is primarily a monetary phenomenon	30%	20%	34%	20%	38%	33%	23%	27%	20%

Note: The sum of the percentages corresponding to 'Agree', 'Agree with reservations' and 'Disagree' in some cases do not reach 100% due to some respondents with no clear opinions.

For the most part, the responses are similar to US and European responses. Two results, do, however, stand out. Latin American students saw fiscal policy as more effective in stabilising the economy than either European or US students, and they more strongly favoured equality of income in developed nations. Regarding disagreements with the previous statements, Latin Americans tend to be stronger against the view that minimum wages increase unemployment among certain workers than their US counterparts.

Table 5 considers the Latin American students' views of economic assumptions and contrasts them with those of European and US students.

Table 5: Importance of economic assumptions

	Very important			Important in some cases			Unimportant		
	LA	EURO	US	LA	EURO	US	LA	EURO	US
The assumption of rational behaviour	41%	40%	51%	50%	53%	43%	7%	5%	5%
Economic behaviour according to conventions	22%	14%	9%	51%	55%	55%	17%	12%	17%
The rational expectations hypothesis	33%	25%	25%	54%	55%	58%	8%	15%	13%
Imperfect competition	66%	49%	37%	30%	44%	58%	1%	2%	3%
Price rigidities	30%	25%	14%	55%	61%	65%	11%	8%	11%
Cost mark-up pricing	21%	16%	5%	56%	50%	47%	10%	9%	18%

Here we see some major differences, especially in relation to the US. Specifically, Latin American students see imperfect competition, price rigidities and cost mark-up pricing as more important than either European or US students do, whereas the US students see the assumption of rational behavior as more important than do either Latin American or European students. The results are consistent with the other findings in the survey and suggest that the economics Latin American students are learning is somewhat more grounded in the real world than is what US students are learning.

We will summarise the remaining results rather than reporting them in tabular form. Latin American students' response to a question about students' political views were similar to the US and European students, with slightly more Latin American students that US students seeing themselves in the centre of the political spectrum.[12] Some 19% of Latin American students saw themselves as conservative; 35% saw themselves as falling in the centre; 13% classified themselves as left, and 19% classified themselves as other.[13] While the political views were similar, there was not the movement toward the right as students progressed in their studies that one saw in European and US students. Instead there was a slight leftward shift in the Latin American students. Of the 20% who changed their political views in graduate school 56% moved to the left and 44% moved to the right. However, as was the case in the US and Europe, most did not change their views, and since the surveys were done at different times (2003

[12] Because interpretations of the terms liberal and conservative differ among regions, the wording was changed slightly in the Latin American and European questionnaires.

[13] Answers differed among schools. For example, of the three schools that had the largest number of respondents, conservatives dominated at the University of the West Indies, while at Ilades/Georgetown/Alberto Hurtado, there was a wide diversity of views, and at the University of Chile, most students were centre/left.

in the US, 2006 in Europe and 2007–08 in Latin America), all we may be capturing is the change in the ideological mood over time.

Another question was an open-ended question regarding which economist, dead or alive, they admired most. While Keynesian economics may have faded from importance in the modern macroeconomics that is taught in global programmes, Keynes remains the most admired economist in the US, Europe and in Latin America. Sixteen students listed Keynes as the most admired economist; the next most listed economists, Adam Smith, Juan Antonio Morales and Arthur Lewis, were listed by six students each.

4. Global Graduate Economics in Latin America

The survey has provided a glimpse of global graduate economic education in Latin America that is currently dealing with questions of how it should change to keep up with fast evolving changes occurring in economics. While many Latin American programmes have found their niche as Master's feeder programmes for US and European global PhD programmes, many are also dealing with the issue of whether they should become global PhD programmes (and how they should be integrating the more technical side of economics that global economics focuses on) with the more real-world policy side of economics (which traditional Latin American economics programmes focus on). Put another way, the forces that separate the Latin American economics academic institutions into the traditional and global divisions seem to be also operative within the more global set of schools in our survey. Thus, in the second part of the paper, we reflect upon the struggle between these two traditions and what it might mean for Latin American graduate education in economics. While these struggles between these two traditions are neither new nor unique to Latin America, and can be seen throughout the economics profession's history, they are of particular importance to Latin American graduate education, and the survey results serve as backdrop to such a discussion.[14,15]

What previously protected the traditional programmes in Latin America were the different languages and the diverse institutional cultures of Latin American countries and the belief that development economics was different than mainstream economics. These differences sheltered the Latin American programmes that focused on development and allowed local conversations to develop. This led to graduate programmes that had a distinct Latin American identity, and which tended to focus on more policy-oriented analysis that was more relevant to local policy makers than to global programmes. In these traditional programmes one published a journal article only if one felt like it; advancement did not depend on it. Advancement instead depended on one's teaching, one's ability to advise government, and one's ability to impress other economists in one's country and in the international economics community devoted to development, which saw itself as separate and broader than the economics in many other subfields of economics.

That has now changed. Development Economics has become an important sub-branch of mainstream economics, using the same tools and approach as other branches of economics. Simultaneously, more and more graduate programmes are shifting to teaching in English. Additionally, given the emphasis of fieldwork in the production of mainstream research, an important number of research projects involve

[14] For example, the fight between the two approaches underlied the famous methodenstreit. A sense of the fights can be seen by looking at US textbooks in the 1800s and early 1900s, when the texts reflected an almost total domination of the traditional approach. At that time, the forerunners of the global mathematical global approach, such as Manfeo Panteleon's textbook, *Pure Economics,* were hardly used. (Colander, 2006).

[15] What is now considered global economics only became dominant in the US in the 1950s as what might be called traditional US economics, (which had strong Institutionalist roots and which placed heavy emphasis on economic literature, history of ideas, and heuristic applied policy), was replaced by a more formal, technical, mathematical, and statistical approach that has evolved into modern global scientific economics (Landreth and Colander, 2002).

collaboration between US and Europe-based researchers with others based in Latin America, dealing with problems that are relevant for Latin America. This means that traditional Latin American economics will have to be making some important choices in the coming decade about how much they want to integrate into global mainstream economics teaching.

While we fully agree that Latin American programmes can, and should, further integrate themselves into global economics (we will elaborate on that in the next section), we also recognise the problems of global economics training for the majority of economists who expect to be going into policy rather than into global academic research. Specifically, in terms of preparing economic scientists, global economics training has much to be said for it. However, it has less to be said for it in terms of preparing more applied political economists/hands-on, policy oriented economists, whose job is to transfer economic knowledge into workable policies, and to argue for those policies to the broader community outside of economics. Latin America and other developing countries have a great need for these policy-oriented economists. They have far less need for the economic scientists that current global programmes are turning out. Searching for workable policy solutions is more engineering-like. It has different goals than pure science, which is primarily interested in understanding, not application. It can be argued that pure science should have nothing to say about policy because policy must be based on value judgements. That was the essence of Lionel Robbins' argument in his famous book on the scope and method of economics.[16]

There are many subtle points in moral philosophy relevant to translating the insights of science to policy, and someone trained as a political economist would have training in those subtleties. Most current global economics training provides little training in such areas and thus is deficient in training students to bring economic insights to policy. Either the students learn it on their own, or they don't learn it and become ideologues, arguing for views that are dependent on value judgements without admitting that that is what they are doing. The tendency for economists to do precisely that is one of the reasons non-economists, and economists who do not agree with the value judgements implicit in mainstream economic models, find economists so frustrating.

Globally trained economists have fit the two together by concentrating their analysis on what might be called 'hands-off' policy analysis. Such analysis is written for other economists or advisors more so than it is written for policy makers. To the degree the analysis actually comes to policy conclusions, those conclusions are contingent on the implicit value judgements and goals in the models. If the policy maker accepts these value judgments and goals, and if the world works like the model, then he or she should follow this policy, but knowing when to do so and when not is a specialty that scientists are not trained in – such issues are generally considered outside of science. Scientific economists must leave it to the intermediary between the economic scientist and the policy maker to do the translation. In Robbins' view, developing models that are more easily translated into policy, and doing the translation, is the role of the political economist, and thus the appropriate training for political economists would differ from the appropriate training for an economic scientist. It requires training in moral philosophy that is currently not part of economist's core training.

What global economists have most shied away from is 'hands-on' policy analysis. This hands-on policy analysis is different from the typical policy analysis done by applied micro economists, which is more econometrically sophisticated, and is meant to be a contribution to the scientific debate. Hands-on policy analysis is designed to contribute directly to the policy debates in a country. Whereas hands-off

[16] In his book (Robbins, 1935) he provided the current definition of economics used in most texts. Robbins also argued that economists should speak out on policy, but they should not do it in their role as an economic scientist, but instead in their role as a political economist, where they explicitly make clear that their policy advocacy is based on value judgements as well as on economic knowledge. (Colander, 2009a). That separation between the science of economics and political economy, which was a central tenet of classical methodology, has been lost.

policy analysis concentrates on the scientific aspect of policy, hands-on policy applies scientific knowledge to policy by integrating economic knowledge and economic models into a broader framework. It deals explicitly with the value judgements rather than leaving them implicit. It makes the argument why consumer sovereignty is desirable, and better than the alternatives; it considers when individual freedom and market mechanisms are compatible and when they are not.

The reality is that global programmes provide students with little training in the moral philosophy aspect of policy, or in any 'hands-on' policy training. The problem is that such hands-on skills are needed by applied economists, and hence are skills that professors teaching students who will become hands-on applied economists, need to have. It is not training they currently receive in the core. The central focus of core training in global programmes is to teach students to become academic researchers, not to become teachers or practising economists working in a ministry or an NGO.

The difference between the two can be seen in the measures of their output. Output of global economists is measured not in terms of useful advice offered to decision makers, nor in any measure of how effectively students are taught, but rather in terms of academic journal article output. An article in *Econometrica* and the *Journal of Economic Theory* gets high weights in these global rankings. A book (even an enormously influential one such as Hernando de Soto's *The Mystery of Capital),* policy advice given to government on designing a working programme, or a pamphlet or newspaper article that introduces a new economic idea into the political debate in a country gets zero weight in global output measures, but would get high weight in a measure of a political economist's output. Global economics students are not taught how to do such work, or how to teach it.

The skills necessary for hands-on and hands-off policy economists are quite different. For example, to contribute to hands-on policy in Latin America, Spanish is a much more appropriate language than English. The ability to quickly study data and pull out the central elements is much more important than formal statistical analysis of heteroscedacity. The ability to write up a two-page analysis that summarises what economics has to contribute to a policy issue is much more important than the ability to write a journal article. The ability to communicate with non-economists is much more important than the ability to communicate with other economists. The list can be extended substantially.

By design, global economics programmes do not have the goal of preparing students for hands-on policy. Some global economics students nonetheless may have a natural ability at hands-on policy, and thus make good hands-on policy advisors. Their expertise in those cases comes from their natural ability or from separate training, not from their training within the global economics programme, although some of the skills cross over, and a high level of knowledge of the science of economics is extremely useful for a policy-oriented economist. The policy-oriented economist needs a consumer's understanding of economic theory, not a producer's knowledge; the two types of knowledge are quite different. While a global economist is interested in policy, his or her input into policy is generally as a technical expert – interpreting data and creating long run understanding. A hands-on policy economist must know how to use economic theory, not how to create it.

In short, political economy graduate training would concentrate not on preparing students to become economic scientists, with an ability to use the latest technical, statistical and analytic techniques, but instead, would see its role as preparing students to become hands-on economic engineers, with the ability to bring the insights of economic science to policy, and preparing professors of economics who will train students in hands-on policy. The focus of such a branch would then be policy design and implementation. The political economy branch would be more similar to engineering than to science, and would be applied economics not in the sense of being sophisticated statistical analysis, but in the sense of relating economic ideas to real world policy. It would consume, not produce, information in economic science. While this branch will probably pose new questions to its 'scientific' counterpart, it will not try to provide scientific answers to them. If traditional graduate programmes take on training

students as political economists, and not as economic scientists, they can complement global economics programmes, and not be in opposition to them.

The need for two types of training is not unique to economics. Natural science, for example, has a pure science branch and an engineering branch, and each has a separate training. There are, of course, various levels of implementation – the more hands-on, the more removed the training will be from graduate economics training. At some point, the training will go beyond economics and fit in public policy, not in economics. Our argument is just that significantly more training on implementation for future applied economists within graduate economic programmes is warranted, and global economic programmes, whatever their other virtues, are not providing that training.

5. Positioning Latin American economics in the future

In Latin America, many of the issues that would become central to the struggle between the global and traditional approaches were discussed almost 50 years ago, when, in a well known article, Pinto and Sunkel (1966) argued that Latin American economics should be separate from U.S. economics, because Latin American institutions and policy problems differ. Many Latin American economists shared their view, and a distinct Latin American economics developed. This forms the basis of traditional economics in Latin America today. That history meant that large portions of the Latin American economics profession were slow to adopt global economics. Instead, Latin American trained economists trained other Latin American economists, allowing traditional Latin American programs to differ from U.S. programs.

This view that Latin American economics should be different from U.S. economics remains strong among students today even among the globally oriented schools that we surveyed. In answer to a question “Should the research agendas of Latin American and U.S. economists differ?” students overwhelmingly answered yes. The reasons they gave included “different problems and the need to build a new economic system”, “different institutions”, “different policy problems”, and a general belief that “research should be specific to each country’s needs.” One negative comment noted, however, that some Latin American countries have no research agendas because they don’t do research at all.

In answer to a question “Should the graduate Latin American economic educational system be structured similar to the graduate U.S. economic educational system?” there was less agreement. A significant majority of the students answered no, since they felt that the educational structure should be designed to fit the specific problems and institutions of a country. However, the minority view was that a unified educational system makes sense, and since the U.S. education system is the best, Latin America should follow it. These answers differ from those in Europe, where the strong majority views were that there was only a global research agenda and their educational systems should not differ among countries.

While we agree that there is only one scientific economic theory, we believe that the type of economists developed and developing countries need may differ, and that the Latin American students’ views may be reflecting that difference. Specifically, developing countries may need economists with training in how to apply economic insights more than in how to develop new scientific insights. As opposed to being trained in pure research, which will benefit the entire world, Latin American and other developing countries need training in the “development” part of “research and development”, that is in how to translate economic insights into workable policies in a real world institutional setting.

Despite this influx of Latin American faculty trained in the US, Latin American programs are changing more slowly than continental European programs both because Latin America has no common educational policy, and because it has less of a need to rely on English since most Latin American countries speak Spanish, allowing Spanish to serve as a common language. Thus, whereas all the courses in the global European schools were taught in English, as we stated above, in the Latin

American schools we surveyed only 25% of the students had between 70% and 100% of their courses in English, and 25% had none. Only 32% of the Latin American students were going to write their dissertation in English whereas almost all of the European students were going to write in English.

Based on discussions with Latin American economists, and on our knowledge of the experience of other areas, unless a viable alternative is developed, it is likely that Latin American economics graduate programs in the future will become more technical and more global in orientation than they currently are. More and more courses will be taught in English; history of thought and non-technical political economy will decrease in importance, and global Latin American graduate MA training will become even less distinguishable from MA training elsewhere than it is now.

In thinking about this future, it is important to note that these developments do not mean that Latin America is succumbing to U.S. economics, which was a primary concern of Pinto and Sunkel. We say this because global economics has transcended U.S. economics. Although the geographic center of the economics profession remains the US, the *nationality* center of the global economics profession is no longer Americentric.[17] Modern global economics is multi-cultural, not tied to any particular nationality. A large majority of PhD economists today (over 60%) graduating from top U.S. schools are now non-US citizens.[18] As Sebastian Edwards (2003) points out, many Latin American students do well, and Latin American economists have a strong presence at all levels of the global economics profession.

Modern global economics is, however, tied to English, and one area in which Latin American students find themselves at a competitive disadvantage with U.S. students involves language. Since their native language is not English, and the language of global economics is English, Latin American economists have a harder time than those native English speaking students, or other students who have had extensive training in English. In our survey we asked students about these costs. In one question we asked students how much English reduces their productivity: 47% said that it did not reduce it at all; 16% said it reduced it by 5%; 16% said it reduced it by 16%; 12% said it reduced it between 10 and 20%, while 10% said it reduced it by more than 20%. To try and put a better figure on the cost of English to students, we also asked them how much of their income they would be willing to give up if they could change the use of English in Economics to their native language. 33% were willing to give up nothing; 16% were willing to give up 0-10%; 14% said they would be willing to give up 10 to 20%; 22% said they were willing to give up 20-50% of their income, and 16% were willing to give up more than 50%. Combining these answers, and recognizing that these are the students who have self-selected into a global program that they know is English oriented, and who responded to an on-line survey in English, the costs of using English are substantial to the students, and will likely be considerably higher for students in more traditional programs.

6. Emphasizing the Need of a Global Political Economy Branch in the Region

If our above arguments are correct, what Latin American and other developing countries most need are political economists—economic engineers. Global economics does not provide such training; it focuses on training pure scientists, and as long as that is the case, to the degree that Latin American programs become globalized, Latin American students are going to be pulled away from hands-on applying

[17] Put into a broader historical perspective, the globalization of the economics profession is not such a novel change. In the late 1800s the economics profession was global and multi-lingual; training in languages was part of graduate training, and there were centers of economics spread throughout Europe, and less so in other parts of the world. In the 1930s and 1940s, the geographic center of economics shifted to the US, as there was an exodus of scholars from continental Europe. These scholars were central in the U.S. economics profession, so while the geographic center of the global economics was in the US, its nationality center has always been more global. Other areas, such as India or Latin America had less of a role, although there were important individual cases of influence.

[18] U.S. students actually make up a larger percentage of students at less prestigious schools. (Colander, 2007)

economics and toward the creation of scientific economic knowledge. It is that tension that we believe was being captured in the student concerns in the survey, and is captured by the division between traditional economics and global economics.

The failure to provide specialized training in political economy is, in our view, a flaw in current global training of economists. That training funnels all economists through a single training designed for the creation of economic scientists. Ironically, economics, one of whose central insights is the need for specialization, does not take advantage of it in its training. Thus, our proposal is that there should be two types of global economics—one a global scientific economics very similar to what currently exists, and the other a global political economy, which is more hands-on and applied. This global political economy would grant PhDs in political economy rather than economic science, and such political economy PhDs could be the required credential for hands-on applied policy positions for economists, and for undergraduate professors of economics. A global economics science degree would be inappropriate training for such jobs in the same way that a PhD in physics is an unacceptable degree for an engineer.

The separation between scientific and hands-on economics within Latin American economics PhD training is something that de-facto has been happening, although the traditional and the global training are seen as much more in opposition than they need be, and, in our view, as they should be. The two complement each other; they do not substitute for each other. All too often the students see applied policy as a fallback job for students trained in a global tradition. Among those trained in the global tradition, those who succeed in their program, and who have no financial/fellowship obligation to go back to their countries, generally stay in the U.S. (or Europe) and focus their research on scientific economics. Even those who return generally have a strong desire to do scientific economics research; that's where they have training. Those who end up in applied policy positions manage, but they do so without explicit training.

Because of Latin America's need for economists with hands-on applied economics skills, we believe that Latin American programs should consider designing their graduate programs *with two separate tracks in economic training*—a scientific track, which is essentially the track now being offered in global economic programs, and a political economics track, which is designed to prepare students for hands-on research and for teaching students.

This political economy track would be more like the traditional training; it would involve training in a broader range of economics literature, and better knowledge of institutions, and of moral philosophy than is now taught in economics programs. For example, as opposed to writing a Master's thesis, students in political economy would be better served by writing, say, five short papers on policy issues, some with a time limit. Such programs may well be graded by practicing economists in the agencies and ministries where they will be working in conjunction with the professors in the courses. The agency economists can present the professors with a problem, which becomes the exercise. The students will have to survey the literature, compile available data, and do a ten-page report in a specified time period of from two days to two weeks. Another of the Master's degree requirements could be writing an op-ed piece for a newspaper taking a position on a certain policy.

To get some idea of how many existing students would fit the political economy program, we asked students two questions about where the student will be in the future. In response to the first, 61% said they planned to pursue an academic career, 9% did not know and 30% were uncertain. Another similar question asked where they hoped to be 15 years from now? In response, 32% said at a university, 32% said at a policy institute, 22% said in the private sector, and 13% said other, which included the public sector or international organizations. Finally, in response to a question of where they would like to work, 70% chose Latin America. Since it is likely that a global economic scientist would most likely want to be at a U.S. graduate university, our view is that about a third of the existing students in the

programs we surveyed would be better served by a program in political economy rather than a program in global economics.

The students' overwhelming view that Latin American economics should have a different research agenda from U.S. economics is consistent with the need for two different tracks. The Latin American political economy track would be more policy oriented, and would be the hands-on applied track. We believe efforts should be made to strengthen these traditional programs without losing their current applied-policy focus.

In our survey students certainly believed that something along that line was worth exploring. As we stated above, when we asked students the question "Should the research agendas of Latin American and U.S. economists differ? If so, how and why?" most responded that yes, it should be different because the issues and economies of developing countries are different, but they urged collaboration with U.S. economists due to their better training and funding. We agree. We also agree that creating these programs in a politically charged atmosphere will likely be difficult. Nonetheless, creating these programs offers a significant opportunity for Latin America to lead the way in blending the global scientific programs with the more traditional applied political economy programs, making the training more appropriate for applied economists.

References

Colander, David. 2005. "The Making of an Economist Redux." *Journal of Economic Perspectives*. Vol. 19, Issue 1. Winter. pp 175-198.

Colander, David. 2006. "What We Taught and What We Did: The Evolution of U.S. Economic Textbooks (1830-1930)." *Il Pensiero Economico Italiano.* XIV. Pp. 1-14.

Colander, David. 2009a. *The Making of a European Economist*. Edward Elgar: Cheltenham, England.

Colander, David. 2009b. "What Was It that Robbins was Defining?" *Journal of the History of Economic Thought*, pp. 437-448

Colander, David and Arjo Klamer. 1987. "The Making of an Economist." *Journal of Economic Perspectives*. Vol. 1, issue 2, pp. 95-111.

De Soto, Hernando. 2003. *The Mystery of Capital.* New York: Basis Books..

Edwards, Sebastion. 2003. "Latin American and U.S. Universities: A Forty Year Analysis." *Cuadernos de Economia* (Pontifical Catholic University of Chile). Year 40, Nº 121, (December 2003) pp. 399-412.

Harberger, Arnold. 1966. "Latin American Economists in the United States: Comment." *Economic Development and Cultural Change*, October. 1966, 15(1), pp. 87-90.

Landreth, Harry, and David Colander, 2002. *History of Economic Thought*, Houghton Mifflin, Boston.

Lora, Eduardo, and Hugo Ñopo. 2007. "La Enseñanza de Economía en América Latina." Inter-American Development Bank Working Paper.

Pinto, Anibal, and Osvaldo Sunkel. 1966. “Latin American Economists in the United States.” *Economic Development and Cultural Change*, 15(1), pp. 87-90.

Robbins, Lionel. 1932. *An Essay on the Nature and Significance of Economic Science*. London: MacMillan.

Sen, Amartya. 1970. “The Impossibility of a Paratian Liberal.” *Journal of Political Economy.* 78(1), pp. 152-57.

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Confidentiality is Not Enough: Framing Effects in Student Evaluation of Economics Teaching

Kieron Meagher and Stephen Whelan

Abstract

Contrary to previous research we show lack of anonymity is associated with large positive shifts in student evaluation of teaching. The results are consistent with the simple observation that due to higher expected future earnings economics and business students have more at stake in terms of potential retaliation by an instructor. The observed positive bias is strongest for international students. Our analysis is based on both a comparison of distributions and ordered probit multi-variate regression. These methods overcome the statistical problems associated with previous studies which looked at differences in means for ordinal responses.

JEL classification: A22, C83, C91

1. Introduction

Student evaluation of teaching (SET) is now common in universities. Although the goal of improving teaching quality is natural, the process of evaluation is widely criticised, directly on the basis of reliability and interpretation, and more tangentially because of the way SET enters into hiring and tenure/promotion decisions. Becker and Watts (1999) show that SET was extensively used in promotion, tenure and annual raise decisions in US economics departments. Utilisation of SET is likely to have increased over the intervening decade. A number of studies have also demonstrated that teaching quality (or perceptions of it) is associated with higher salaries (Katz, 1973; Siegfried and White, 1973; Moore, Newman and Turnbull, 1998).

The way in which questions are asked (framing effects), including confidentiality and anonymity, are generally well understood as a potential source of bias in data collection in the social sciences. Presumably, it is for this reason that many universities, including my own, collect SET data anonymously. In the context of SET, confidentiality can be thought of as a situation in which identifiable student evaluations are only revealed to the data collector and not to the teacher being assessed. Anonymity implies that the respondent cannot be identified by either the data collector or the individual being assessed. The practice of anonymity is being eroded by a number of SET practices. For example, many teaching professionals currently advocate the use of more in-depth data collection methods, such as face-to-face discussions/focus groups, which may promise confidentiality to participants but do not guarantee effective anonymity as the source of any response can be identified by the data collector. See for example the discussions on evaluation methods in Harvey (1998).

McPherson and Jewell (2007) find evidence that teaching evaluations vary with student grade expectations, individual characteristics and class characteristics. Higher average grade expectations in a

class are associated with higher SET scores, an outcome interpreted by the authors as 'buying better evaluations'. Similarly, the characteristics of faculty members associated with higher SET scores included tenure status (being tenured), ethnicity (white) and being younger. The type of class taught also has an impact with compulsory, theoretical and single, three-hour lecture per week classes all having a negative effect on teaching evaluations. McPherson and Jewell (2007) conclude that *there are grounds for departments adjusting their evaluations*. Studies by Hammermesh and Parker (2005) and Lawson and Stephenson (2005) find patterns similar to those reported in McPherson and Jewell (2007).

Concerns about the technical validity of SET as a measure of teaching quality and gaming of the evaluation process are extensively discussed in the literature cited above, but are not key to the framing effects analysed in this paper. Two other issues highlighted by the reviewed literature are relevant to framing issues: sample selection bias and prejudiced responses by students. Indeed the possibility of systematic bias in SET raises serious equity issues about its use as a personnel management tool, and prompted the following statement from the Canadian Association of University Teachers:

'...anonymous student evaluations of teachers may serve as vehicles for transmitting popular misconceptions, expectations and prejudices, to the disadvantage of, for example, women and visible minorities' CAUT (2006).

The assertion is that by signing evaluations students will feel more responsibility and will more truthfully evaluate the teaching rather than distorting their evaluations according to their prejudices.

Both the bias and qualitative information collection arguments, and indeed any other proposal that does not guarantee students anonymity, assume that the distortions from non-anonymous responses are negligible. This is not an unreasonable point of view since the seminal papers in the field, Stone, Spool and Rabinowitz (1977) and Feldman's (1979) survey, failed to find clear evidence of significant positive bias introduced from non-anonymity. The main framing issue with anonymity and confidentiality is that students will be concerned about possible negative consequences for themselves, either individually or as a group, from giving low teaching ratings and hence will bias their responses upwards.

There is good reason to re-consider the applicability of previous studies to the contemporary teaching of economics and business students. First, due to the work of Becker and other labour economists, education is now viewed more strongly as an investment by students, than it was in the 1970s, when the seminal research in this area was conducted. This may cause students to be concerned not just with immediate negative retaliation by teachers but also the possible impact it might have on their life time earnings. If students are concerned about the potential impact of poor teaching evaluations on grades then students whose studies lead to the highest income occupations may be more likely to exhibit a positive bias in their SET responses. However Stone, Spool and Rabinowitz (1977, pp. 319–20) investigated bias in an evening class of jurisprudence students who already had jobs and found that although the professor was rated more positively, by students completing non-anonymous evaluations than those completing ratings anonymously, the difference was negligible. Fries and McNinch (2003) have shown that contemporary sociology students produce small but more biased responses than the Stone, Spool and Rabinowitz study, but there has been no study of economics students. We predict that the higher expected incomes of the group of economics and business students we investigate will lead them to exhibit even greater positive bias.

Second, previous studies of anonymity framing affects focus on US universities and do not concern themselves with the differing perspectives of students from international backgrounds. The economic success of a number of developing countries in recent decades has led to major changes in the global patterns and number of international students. There is a substantial literature – see Chan (1999) for an

overview – demonstrating that students from Confucian heritages have learning backgrounds which are substantially more teacher centred than those of Western students (Wong, 2004). This different educational background, plus cultural differences, potentially generate different expectations of Western university education. Chan summarises the issue nicely:

'Chinese learners have been brought up to respect wisdom, knowledge and expertise of parents, teachers and trainers. They have been socialized to respect highly those who provide the knowledge and to avoid challenging those in authority' Chan (1999, p. 298).

Whatever one concludes from the debate over cultural issues in education there is an issue relevant to our study. Specifically, since Confucian heritage students are frequently described as having a greater tendency to echo rather than challenge the opinions of those in authority, it can be hypothesised that they may respond more positively about a teachers pedagogical choice in a situation that they perceive as non-anonymous.

More pragmatically, and more independent of ethnic background, international students in Western universities are typically spending a great deal of their families' resources on an investment which is expected to lead to a higher income.[1] Thus these students may be even more sensitive to any possible negative consequence arising from a lack of anonymity in reporting a SET.

Methodologically the studies of anonymity cited above are unsatisfactorily simplistic in their statistical analysis. All the relevant data is from Likert scales, which by construction are ordinal but not cardinal. However the previous studies have all imposed a cardinal scale and analysed differences in the constructed means – an approach which is seriously flawed from a statistical point of view. We instead focus on differences in distributions caused by anonymity effects. Further more we also offer a multivariate analysis to investigate if other characteristics, especially being a foreign student, play a role in explaining the anonymity effect.

2. Empirical results –Data

In the first teaching session of 2006 we introduced an economic experiment on ultimatum bargaining into our first year undergraduate microeconomics class. We used Charlie Holt's excellent online Veconlab software to run the experiment and everything ran smoothly, as one might expect.[2] It is the student evaluations of this teaching innovation that provides the data for the following analysis.

Following their participation in the online game, students were asked to complete an online survey. The ethics information provided *before* the students completed the questionnaire indicated that the information was being collected solely for the purpose of teaching research by the author of this paper (who was not an instructor for the course), participation was voluntary, *all responses were confidential* and only aggregate results would be made available to the course instructor. No date for the release of the results was given to students.

We collected basic personal data from the students including gender, foreign/domestic status and reason for taking the course. The summary statistics for these personal data variables, which we will refer to as control variables, are given in Table 1. We also asked students about their experience of participating in the experiment. Specifically students were asked whether they 'enjoyed participating in

[1] While foreign students make up 25% of our sample of an economics principles class they are almost entirely absent from introductory humanities classes.

[2] See Meagher and Chan (2007) for a discussion of using the ultimatum bargaining experiment in an international classroom. Charles Holt's homepage and links to relevant games can be found at: http://people.virginia.edu/~cah2k/ Details of the ultimatum bargaining game can be found at this page.

the game'; the 'ease of participating in the game'; the 'clarity of instructions provided' for participating in the game; and the 'relevance of the game to their careers'. Responses were on a standard five-point Likert scale and the full distributions for the experience variables are presented in Figure 1.

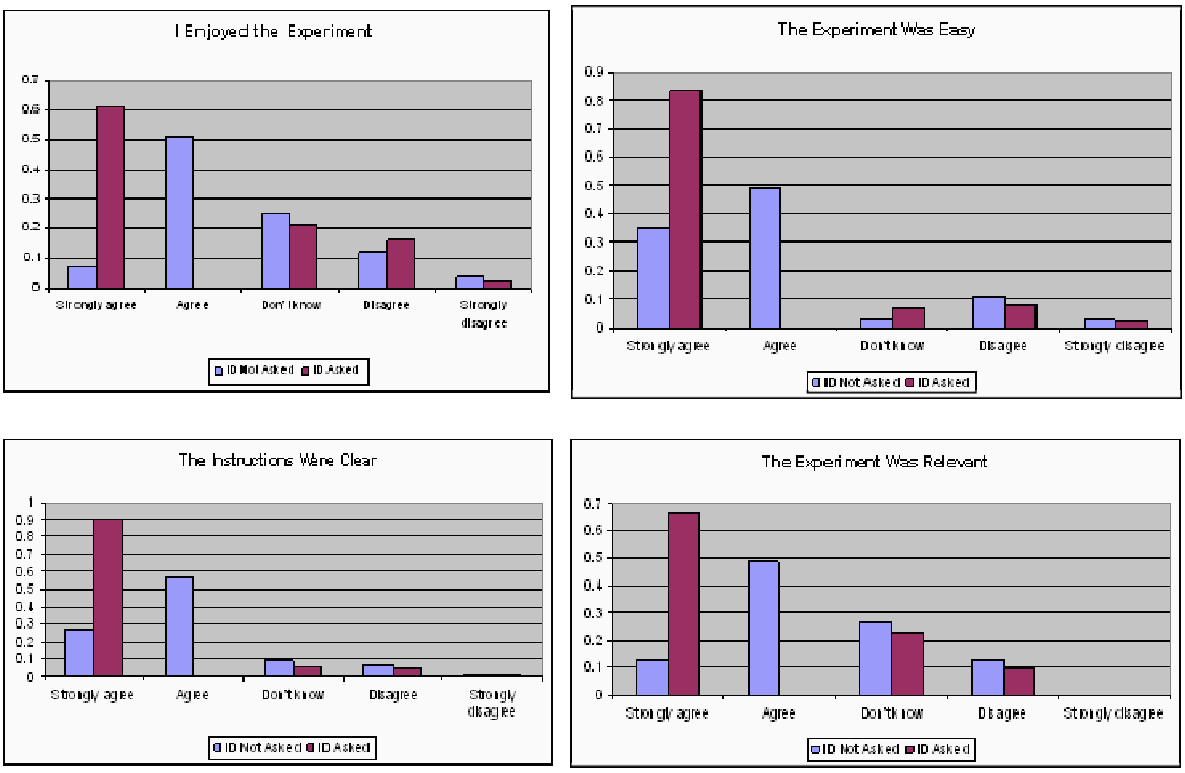
Table 1: Means of control variables (standard deviations in brackets)*

Variable	ID Not Asked	ID Asked	Pooled	Variable Definition
ID asked	0	1	0.551 (0.499)	Student ID requested in the online survey.
Male	0.550 (0.500)	0.439 (0.499)	0.489 (0.501)	Respondent is male.
Local	0.800 (0.403)	0.704 (0.459)	0.747 (0.436)	The respondent is enrolled as a local student (Australian citizenship not required).
Course compulsory	0.663 (0.476)	0.704 (0.459)	0.685 (0.466)	Reason for taking course is compulsory part of degree.
Course relevant to career	0.225 (0.420)	0.163 (0.372)	0.191 (0.394)	Reason for taking the course was relevance to career.
Course of interest	0.088 (0.284)	0.112 (0.317)	0.101 (0.302)	Reason for taking the course was interest.
Declined to give ID when asked	0	0.041 (0.199)	0.022 (0.149)	Student ID was requested in the online survey but the student left the response box blank.
N	80	98	178	

* Means and standard deviations reported to three decimal places.

It was announced that the questionnaire would be available for two weeks to complete. During the first week we did not request student identification numbers (student IDs) in the survey. *Without notification* in the second week we did request student IDs in the online survey. Thus throughout the survey students responses were always confidential but it was technically possible to identify students during the second week of data collection. *The main result of this paper is to show that despite confidentiality student responses were significantly more positive without anonymity.*

Figure 1: Distributions of student responses by question and framing method



It is important to emphasise that students were not briefed that there would be a change in the data collected and thus in particular were not aware that their choice of time to complete the survey would determine whether they would be asked for their student ID. Thus students could not have deliberately selected themselves into one or other of the treatments based on whether they were concerned about being asked for their student ID. Furthermore the exact timing of the shift in treatments was random – depending on when a research assistant (RA) updated the website late on the Thursday morning of the first week. Thus there is no natural focal point for the change in treatment either – the change did not for example occur after a reminder in a lecture. In this sense, the data generating process resembles a natural experiment in which respondents have been randomly assigned to one of two groups depending on when an RA updated the website.

While the online survey tool did not record the time of each response it did record the order of responses and we shall use this in our multi-variate analysis. In section 2.3 we report the results of ordered probit models that include a variable identifying the order in which the student entered their response to the survey. The approach is similar to the regression discontinuity design and exploits the manner in which the subjects in the data were assigned to a treatment based on the time when they participated in the survey (Thistlewaite and Campbell, 1960; Lee 2008).

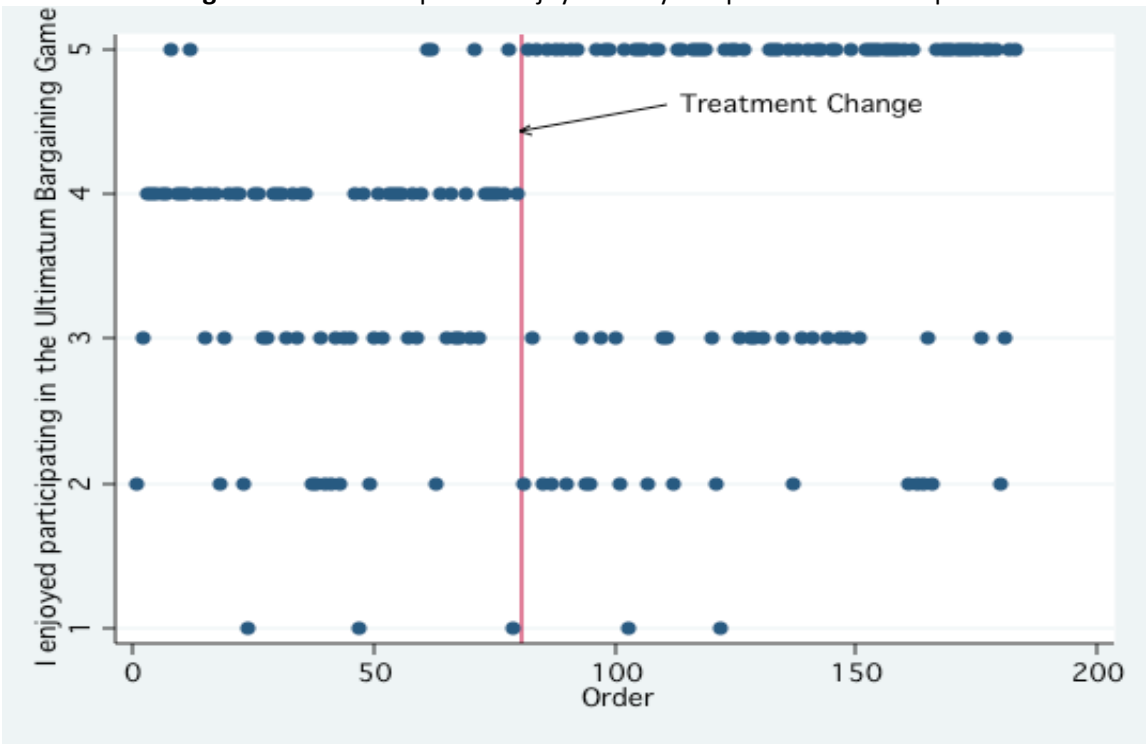
A total of 80 students responded in the first week when student ID was not requested while 103 students responded in the second week of data collection when student ID was requested. There were six students who did not provide ID when requested. Since they fell in the ID asked treatment their responses are included in that category for the construction of the sample distributions. Intuitively we interpret the behaviour of this group of six students as preferring anonymity. This issue is pursued in the ordered probit analysis below through the inclusion of a dummy variable *declined to give ID when asked.* Further, the sample is restricted to the 178 students who answered all the relevant questions rather than the 183 who answered any of the questions. There were 502 students registered for the bargaining game giving a response rate for the survey of approximately 36%. This is a typical response rate for online SET at this university.

3. Quasi random experimental design

A key point in viewing our survey as a regression discontinuity design, is the issue of whether students were able to manipulate the time of their response in order to select a specific treatment (Lee and Lemieux, 2009). This seems unlikely from the way in which the survey was constructed, thus we interpret the effect of being asked for student ID on evaluations as causal. In identifying a treatment effect we are looking for a discontinuity between the responses to the two treatments.

Figure 1 shows an apparent difference between the distributions of responses for the two treatments. Although suggestive this is not sufficient to conclude causality for two reasons: (i) responses might be a function of time independent of the treatment; and (ii) other covariates might vary between the two populations (receiving the two treatments) in some way that affects their responses.

Figure 2: Student reported enjoyment by temporal order of response



Notes: Y-axis labels, 1 = Strongly disagree, 2 = Disagree, 3 = Don't know, 4 = Agree, 5 = Strongly agree.

The scatter plot of responses based on the temporal order in which students responded to the survey in Figure 2 indicates a clear discontinuity in the positive responses (4 and 5) between the two treatments while there is no obvious change in the neutral (3) or negative responses (1 and 2). It appears that students who were inclined to 'agree' (4) that the experiment was enjoyable distorted their response upward to 'strongly agree' (5) when they were asked for their student ID in the second/right-hand half of the plot. The discontinuity is investigated more formally using an ordered probit in the next section.

An important issue when assigning a causal interpretation to differences in the responses of those students asked to complete the survey anonymously and those asked to do so non-anonymously is whether the two groups are in fact different other than for the treatment (that is, whether asked for ID) which is being analysed. The regression discontinuity approach requires that there should not be a discontinuity in the covariates associated with the change in treatments since this would suggest that

students might have been able to manipulate assignment to a treatment. Recall that whether a student was asked his or her ID depended on when the survey was completed. Reassuringly the *t*-tests in Table 2 show there is no statistically significant difference between the means of any of the covariate means between the two treatment groups. Nonetheless, we investigate whether the covariates are important for understanding the student responses by including a variety of control variables in the ordered probit regressions in the next section.

Table 2: t-test of difference in means[1] of control variables across framing[2]

Variable	Difference[3]	Std. Error	Critical Value	p-value[4]
Male	0.111	0.75	1.477	0.141
Local	0.096	0.065	1.465	0.145
Course compulsory	-0.042	0.070	-0.592	0.555
Course relevant to career	0.062	0.060	1.040	0.300
Course of interest	-0.023	0.046	-0.542	0.588

[1] H_0: means equal; H_1: means not equal (two sided test).

[2] All values reported to 3 decimal places.

[3] Difference = mean(ID not asked) – mean(ID asked).

[4] Degrees of freedom = 176.

4. Empirical results

The sample distributions in Figure 1 tell a consistent story: student responses were more positive, on average, to every question when they were also asked to provide their student ID. The variation in the neutral and negative responses is reasonably small, most of the change in the distributions is due to the increased weight on the *strongly agree* category compared to the *agree* category. A series of chi-squared goodness of fit tests, reported in Table 3, confirm that there is a very highly statistically significant difference between the distribution when ID was not asked compared to when ID was asked. Although student responses were confidential and were not supplied to a course instructor there appears to be strong evidence that the framing effect caused by asking for student IDs had a significant effect on responses between the two treatments.

Table 3: Chi-squared goodness of fit test for constant distributions across framing[a]

Question	Test Statistic	1% Critical Value
I enjoyed the experiment	435.41	χ^2(4 df) = 13.28
The experiment was easy	126.87	χ^2(4 df) = 13.28
The instructions were clear	202.66	χ^2(4 df) = 13.28
The experiment was relevant to my studies[b]	284.18	χ^2(3 df) = 11.34

H_0: With ID distribution is the same as the Without ID Distribution

H_1: With ID distribution is different to the Without ID Distribution

Right Tail Test at 1% Significance Level

[a]Expected frequencies are low in some categories but do satisfy the weak criteria of Doane and Seward (2007, p.668). Furthermore the test results on difference in distribution are driven by the *strongly agree* category in which the expected frequencies are high.

[b]For the relevance question only four categories were used in the test because there were no responses in the *strongly disagree* category.

The multi-variate analysis uses an ordered probit framework in which responses to questions about participation in the online game was ordered from strongly disagree (1) to strongly agree (5). That is, a more positive response was characterised by a higher value and don't know was considered neutral and coded as a 3. The actual estimating equation reported in Table 4 is given by:

$$y^* = x'\beta + \varepsilon \qquad (1)$$

Given that y^* is unobserved, what is observed is the responses of individuals (y) where:

$$y = 1 \; if \; y^* \le 0$$
$$y = 2 \; if \; 0 < y^* \le \mu_2$$
$$y = 3 \; if \; \mu_2 < y$$
M
$$y = J \; if \; \mu_{J-1} \le y^*$$

Where the $\mu's$ and the coefficients β are to be estimated (Greene, 2008). All estimations are undertaken in Stata using maximum likelihood. We first allow all the coefficients to vary between the two treatments by estimating two separate regressions for each treatment group. The results are reported in columns (1) and (2) of Table 4. The key result here is that the order variable is statistically insignificant, suggesting that for each of the treatment groups, the time at which individuals completed the survey (proxied by the order in which the survey is completed) had no impact on the responses. One might conjecture, for example, that 'good' students respond early in a positive way or perhaps that students with a negative experience go early because of their strong emotional response or perhaps

later because of a lack of engagement with the process. There is no evidence from these regressions to support these conjectures.

In column (3), we report the results from a model using the complete sample and which includes a dummy variable for the treatment (student *ID asked).* The key result of the paper is that the coefficient of *ID asked* is significant and positive while the coefficient on *order* is insignificant. The marginal effects from the specification reported in column (3) of Table 4 are set out in Table 5. The clear implication of the empirical analysis is that student responses are more positive when students are asked for their ID. In column (4) of Table 4 we include in the specification the *order* variable. Again, the *order* variable is statistically insignificant, while the *ID asked* variable remains marginally significant (p-value of 0.10). Again, this suggests that the non-anonymity associated with the request for student identification led to a more positive response to the question whether the student enjoyed participating in the bargaining game, rather than a continuous change in responses over time.

The multivariate analysis also indicates that students who chose not to supply identifying information, despite being in the non-anonymous treatment, gave more negative responses (columns 2-5 of Table 4). The negative responses of this group give further independent evidence of the relationship between anonymity and bias in the evaluation of teaching.

The second issue explored in this paper relates to differences in the responses of local and non-local students. In specification (4) (column 5 of Table 4) we include an interaction term between *ID asked* and *local* student status (denoted *IDlocal*). The results indicate that the term is negative and statistically significant (p-value of 0.07). The results suggest that local students when asked for identifying information are less likely to respond positively, that is non-local students respond more positively. This result is consistent with the hypothesis about international students identified in Section 1. It is not possible with our data to allocate the differences in responses for international students between economic, cultural or other causes. Nonetheless, the evidence presented in this paper suggests that the large (and in many cases growing) number of international students in Western universities mean that teaching evaluation policies based on research conducted prior to this major demographic shift may need to be re-evaluated.

Table 4: Ordered probit results for regression discontinuity model of student evaluation of enjoyment of experiment (standard errors in parenthesis)

	Coefficient Estimates				
	Model 1		**Model 2**	**Model 3**	**Model 4**
Variable	**No ID**	**ID asked**			
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
Male	-0.225	-0.313	-0.230	-0.234	-0.275
	(0.261)	(0.265)	(0.169)	(0.169)	(0.171)
Local	0.147	-0.541*	-0.284	-0.279	0.100
	(0.310)	(0.301)	(0.197)	(0.197)	(0.289)
Course compulsory	-0.526	0.722	0.301	0.309	0.386
	(0.821)	(0.741)	(0.520)	(0.520)	(0.522)
Course relevant to career	-0.655	1.094	0.437	0.437	0.514
	(0.853)	(0.808)	(0.545)	(0.545)	(0.548)
Course of interest	-0.663	0.768	0.306	0.301	0.388
	(0.907)	(0.816)	(0.575)	(0.575)	(0.577)
Declined to give ID		-1.531***	-1.573***	-1.553***	-1.575***
		(0.596)	(0.562)	(0.564)	(0.565)
Order	0.002	0.002		0.001	
	(0.006)	(0.004)		(0.003)	
ID asked			0.683***	0.548	1.243***
			(0.170)	(0.336)	(0.354)
ID*local					-0.729*
					(0.402)
N	80	98	178	178	178
Pseudo R^2	0.010	0.07	0.06	0.06	0.06

Table 5: Ordered probit results for student evaluation of enjoyment of experiment (Standard errors in parenthesis)

Coefficient Estimates		**Marginal Effect of a One Unit Change in ID asked**	
Variable	**Coefficient**	**Category**	**Marginal Effect**
Male	-0.230 (0.169)	Strongly agree	0.251*** (0.061)
Local	-0.284 (0.197)	Agree	0.007 (0.014)
Course compulsory	0.301 (0.520)	Don't know	-0.086*** (0.025)
Course relevant to career	0.437 (0.545)	Disagree	-0.133*** (0.037)
Course of interest	0.306 (0.575)	Strongly disagree	-0.038** (0.018)
Declined to give ID	-1.573*** (0.562)		
ID asked	0.683*** (0.170)		
N	178		
Pseudo R^2	0.06		

Marginal effects evaluated at the means of the independent variables. ***, ** indicates significance at the 1 and 5 per cent levels respectively

5. Conclusion

A student evaluation of teaching applied to the use of an ultimatum bargaining experiment in a first year microeconomics principles class was conducted by a third party with strong confidentiality guarantees. Student responses were found to be systematically, significantly more positive when their responses were confidential but not anonymous.

The evidence suggests that contemporary economics and business students, a group for whom the anonymity issue has not been previously investigated, may be more concerned about possible negative outcomes of giving bad SETs than are the groups studied in the existing literature. This result is consistent with the prevailing view of education as an investment and the greater income streams at risk for business and economics students.

The results of this study suggest that anonymity concerns can, contrary to the prevailing wisdom in the education literature, have a large impact on student responses. The positive bias introduced by confidentiality without anonymity suggests that the additional information available through focus groups and other personal interactions may be significantly tainted. Furthermore, the techniques involving third party data collection used in this study do not provide sufficient insulation to remove the bias in student responses. Finally, the differential response of local and non-local students is significant and suggests current beliefs about the use and validity of SET may need to be re-examined in light of

the large and growing number of students from non-Western cultures in Western universities, especially in business and vocational programmes.

References

Becker, W.E. and M. Watts (1999). 'How departments of economics evaluate teaching', *The American Economic Review*, Vol. 89(2), Papers and Proceedings of the 111th Annual Meeting of the American Economic Association (May, 1999), pp. 344–49.

CAUT, (2006). 'Policy on the use of anonymous student questionnaires(1) in the evaluation of teaching', Canadian Association of University Teacher (CAUT), http://www.caut.ca/en/policies/questionnaires.asp (retrieved 22 January 2007).

Chan, S. (1999). 'The Chinese learner – a question of style', *Education & Training*, Vol. 41(6/7), 294–304).

Doane, D.P. and L.E. Seward (2007). *Applied Statistics in Business and Economics*, New York: McGraw-Hill Irwin.

Feldman, K.A. (1979). 'The significance of circumstances for college students' ratings of the teachers and courses', *Research in Higher Education,* Vol. 10(2), pp.149–72.

Fries, C.J. and R.J. McNinch (2003). 'Signed versus unsigned student evaluations of teaching: a comparison', *Teaching Sociology,* Vol. 31(3), pp. 333–44.

Greene, W.H. (2008), *Econometric Analysis*, New Jersey: Pearson.

Hammermesh, D. S. and A. Parker (2004). 'Beauty in the classroom: instructors' pulchritude and putative pedagogical productivity', *Economics of Education Review*, Vol. 24, 369–76.

Harvey, J. (ed.) (1998). *Evaluation Cookbook*, Edinburgh: Learning Technology Dissemination Initiative.

Katz, D.A. (1973). 'Faculty salaries, promotions, and productivity at a large university', *The American Economic Review*, Vol. 63(3), pp. 469–77.

Lawson, R. A. and E. F. Stephenson (2005). 'Easiness, attractiveness and faculty evaluations: evidence from RateMyProfessor.com', *Atlantic Economic Journal*, Vol. 33, 485–6.

Lee, D.S. (2008). 'Randomized experiments from non-random selection in U.S. House Elections', *Journal of Econometrics*, Vol. 142(2), 675–97.

Lee, D. S. and T. Lemieux (2009). 'Regression discontinuity designs in economics', NBER Working Paper 14723, Cambridge, MA.

McPherson, M. A. and R. T. Jewell (2007). 'Leveling the playing field: should student evaluation scores be adjusted?', *Social Science Quarterly*, Vol. 88(3), pp. 868–81.

Meagher, K.J. and A. Chan (2007). 'Online economic experiments: student experiences in an international classroom?', mimeo, University of New South Wales.

Moore, W.J., R. J. Newman and G. K. Turnbull (1998). 'Do academic salaries decline with seniority?', *Journal of Labor Economics*, Vol. 16(2), pp. 352–66.

Siegfried, John J., and White, Kenneth J. "Financial Rewards to Research and Teaching: A Case Study of Academic Economists." American Economic Review 63 (May 1973): 309-15.

Stone, E.F., M.D. Spool and S. Rabinowitz (1977). 'Effects of anonymity and retaliatory potential on student evaluations of faculty performance', *Research in Higher Education,* Vol. 6, pp. 313–25.

Thistlethwaite, D.L. and D. T. Campbell (1960). 'Regression-discontinuity analysis: an alternative to the ex-post facto experiment', *Journal of Educational Psychology*, Vol. 51, pp. 309–17.

Wong, J. (2004). 'Are the learning styles of Asian international students culturally or contextually based?', *International Education Journal,* Vol. 4(4), pp. 154–66.

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Comment on Chen and Lin 'Does Downloading Power-Point Slides Before the Lecture Lead to Better Student Achievement?'

Edmund Cannon

Abstract

Chen and Lin (2008) is an interesting attempt to measure the effect of students having access to PowerPoint slides before a lecture. They argue that such access leads to better learning outcomes as measured by higher exam marks. While their empirical results shed some light on students' use of PowerPoint slides, I argue that they have not succeeded in isolating the treatment effect and the correlations cannot be interpreted as causal.

1. Introduction

Chen and Lin (2008a) is an interesting attempt to measure the benefits of a new teaching technology, namely the effect of downloading a lecture's PowerPoint slides by students. To do this the authors report the correlation of downloading PowerPoint slides with exam performance. Their data set allows them to control for student and question fixed effects and they claim that this allows them to remove endogeneity bias and hence identify the treatment effect. They conclude that downloading the relevant PowerPoint slides results in a student being 3.48 per cent more likely to answer a right or wrong question correctly.[1]

In this comment I argue that there are good reasons to believe that the treatment effect has not been isolated. An extension of the OLS analysis suggests that there is virtually no benefit in going to lectures for a student who downloads PowerPoint lecture slides: this (strange) result contradicts other analysis of lecture attendance (e.g. Stanca, 2006; Chen and Lin, 2008b) and is corroboratory evidence that there may be something wrong in using OLS. I suggest a possible test for endogeneity in this context and show that the null hypothesis of exogeneity is rejected. I speculate that the endogeneity of regressors then explains the OLS results.

In the next section I discuss formally the issue of endogeneity and suggest a test for its presence in this context. Then I re-analyse Chen and Lin's data which they have kindly provided. The final section discusses the results and concludes.

[1] The parameter estimate on the indicator for downloading the PowerPoint slides is 0.0348 and most questions receive marks of either zero or one (some questions receive marks in between as I discuss below).

2. Analysis

A detailed description of Chen and Lin's data can be found in the original article and I do not repeat all of that information here. They have information on a variety of variables about each student (prior exam attainment, gender, family background) that are not used in the regression analysis of Chen and Lin (2008a). The reason for this is that student fixed effects are used in the analysis and hence the other variables could not be included since they would be perfectly collinear with the fixed effects. Since the information on the students is not really needed for this comment and since the authors are concerned about anonymity I have not been provided with these data.

The data which I have re-analysed consists of information on lecture attendance, PowerPoint slide download and exam performance at question level. There are a total of 126 students each of whom has been allocated marks for up to 40 questions.[2] For each question data are available on whether the student attended the lecture in which the material was taught and also whether the student downloaded the associated PowerPoint slide.

Changing Chen and Lin's notation slightly, I use $p_{ij} \in \{0,1\}$ to denote the binary variable showing that the PowerPoint slides have been downloaded by student *i* for the lecture corresponding to question *j*. Similarly I use $l_{ij} \in \{0,1\}$ to denote lecture attendance. The mark given to the question is denoted Y_{ij} and this can take on 18 different values, ranging from zero to one. Of the 5005 observations in the full data set, 1375 (27 per cent) of the marks are zero and 2573 (51 per cent) are one, so only 1057 (21 per cent) take on the intermediate values. For this reason, the ideal specification strategy would use ordered probit or censored regression. However, I was unable to obtain convergence using these estimation procedures and so my analysis follows Chen and Lin in using a linear probability model.

The specification that Chen and Lin estimate is

$$(1) \qquad Y_{ij} = \theta p_{ij} + \alpha_i + \gamma_j + \varepsilon_{ij} \qquad \varepsilon_{ij} \perp \{p_{ij}, \alpha_i, \gamma_j\}.$$

Although this is followed by $i = 1,\ldots,I, \quad j = 1,\ldots,J$, the text makes it clear that the regression is estimated not for all $IJ = 5006$ observations but only for the 3675 observations where the student attended the lecture $l_{ij} = 1$. This specification can be contrasted with a more general specification

$$(2) \qquad Y_{ij} = \theta p_{ij} + \phi l_{ij} + \psi p_{ij} l_{ij} + \lambda_{ij} + \alpha_i + \gamma_j + \varepsilon_{ij} \qquad \varepsilon_{ij} \perp \{p_{ij}, l_{ij}, p_{ij} l_{ij}, \lambda_{ij}, \alpha_i, \gamma_j\}$$

which can only be estimated for the full sample. In this specification I have allowed explicitly that lecture attendance can have an effect on exam performance (through the parameter ϕ) and that the effect of downloading PowerPoint slides depends on lecture attendance: the effect of downloading PowerPoint slides for those who attend lectures is $\theta + \psi$, whereas for those who are absent it is only θ.

I have also introduced a new explanatory variable λ_{ij} which is the unobserved question-*j* specific determinant for student *i*. There are several possible interpretations of this:

[2] This suggests that there should be 5040 observations but in fact there are only 5005, since not all students have marks for all 40 questions. The 126 student codes range from 2 to 150, but I was not told whether another 24 students were missing.

(i) A student's prior ability varies *horizontally* across topics. Example: a student is innately good at interpreting supply and demand curves which are taught graphically, but struggles with price indices which are taught algebraically.

(ii) A student's ability to answer questions depends *vertically* on the interaction of the difficulty of the question and the ability of the student. Example: there is an easy question which all students answer correctly, and a difficult question which only clever students can answer correctly.

(iii) A student's allocation of effort between topics is chosen endogenously. Example: a student decides to skip one particular topic to save time and concentrate on studying something else.

(iv) The student's total effort is chosen endogenously. Example: a student can either compensate for missing a lecture by working harder on the topic in private study or can take the time as leisure.

Either individually or in combination these interpretations of λ_{ij} suggest that it may be correlated with p_{ij} or l_{ij}, which are themselves correlated with each other, and hence OLS estimation of

$$\begin{aligned} Y_{ij} &= \theta p_{ij} + \phi l_{ij} + \psi p_{ij} l_{ij} + \alpha_i + \gamma_j + \xi_{ij} \\ \xi_{ij} &\equiv \varepsilon_{ij} + \lambda_{ij} \end{aligned} \tag{3}$$

will yield inconsistent estimates of the parameters θ, ϕ and ψ. In principle it might be possible to design tests which deal with the issues in (i) and (ii), but collecting information on students' total effort and allocation of effort is likely to be impossible. In any event, such information is not available in the data set used here.

What are the implications of using Chen and Lin's strategy of estimating η from the sub-sample of the data where $l_{ij} = 1$? If λ_{ij} were in fact orthogonal to the other regressors, then the parameter estimates should be consistent. In a conventional panel with small *J*, the consistency result would be of little help for the cross-section fixed effects, but here we have $J = 40$, which is just large enough to suggest that we might obtain useable parameter estimates for α_i. Then I estimate Chen and Lin's model twice, once for those observations where the student attended the relevant lecture and once where they did not, so that:

$$\begin{aligned} Y_{ij} &= \theta p_{ij} + \alpha_i + \gamma_j + \varepsilon_{ij} \qquad l_{ij} = 1 \\ Y_{ij} &= \theta' p_{ij} + \alpha'_i + \gamma'_j + \varepsilon_{ij} \qquad l_{ij} = 0 \end{aligned} \tag{4}$$

where the first equation is Chen and Lin's model (and just repeats equation 1). If attendance at the lecture is genuinely exogenous then it should be uncorrelated with other explanatory variables. In particular whether or not a student attends should be uncorrelated with that student's ability and hence

$$\alpha_i = \alpha'_i \qquad \gamma_j = \gamma'_j \tag{5}$$

Working on the slightly dubious assumption that $J = 40$ is a sufficiently large data set to obtain reliable estimates for the fixed effects, this can be tested with a Chow test to determine the validity of the assumption that $\xi_{ij} \perp \left\{ p_{ij}, l_{ij}, p_{ij} l_{ij}, \lambda_{ij}, \alpha_i, \gamma_j \right\}$. Alternatively one might like to test whether

downloading PowerPoint slides is correlated with the fixed effects and hence consider an analogous Chow test splitting the data according to

$$\begin{aligned} Y_{ij} &= \phi l_{ij} + \alpha_i + \gamma_j + \varepsilon_{ij} \qquad p_{ij} = 1 \\ Y_{ij} &= \phi' l_{ij} + \alpha_i' + \gamma_j' + \varepsilon_{ij} \qquad p_{ij} = 0 \end{aligned} \tag{6}$$

and conducting the same test as in (5).

The final consideration is the calculation of the standard errors. The exam taken by the students had 40 questions but there were only 12 lectures. Clearly this means that the material for more than one question was covered in each lecture, so on average about three or four questions belong to each lecture. So one would expect the disturbances for each group of questions to be correlated and hence the standard errors should be adjusted to reflect this. To complicate matters, the material for some questions was covered in more than one lecture, so it is necessary to separate questions covered in lecture 1, questions covered in lecture 2 and questions covered in both lectures 1 and 2. Using the underlying data sent to me by Chen and Lin I have attempted to do this and have identified 23 groups of questions (many of which only contain one question). With this many groups and large numbers of fixed effects the degrees of freedom are reduced considerably for some tests and so I report tests using both conventional and clustered standard errors. Note that the easiest way to implement the test in (5) with clustered standard errors in most software packages is to estimate

$$Y_{ij} = \theta p_{ij} + \phi l_{ij} + \psi p_{ij} l_{ij} + \alpha_i + \left(\alpha_i' - \alpha_i\right) l_i + \gamma_j + \left(\gamma_j' - \gamma_j\right) l_i + \xi_{ij} \tag{7}$$

and test $\widehat{\alpha_i' - \alpha_i} = \widehat{\gamma_j' - \gamma_j} = 0$, i.e. by testing the significance of the interaction of the student fixed-effects with the lecture attendance variable.

An obvious way to interpret the clusters is as topics. Clearly some students may be better at some topics than others and hence a further possibility is to consider fixed effects for each student on each topic. Denote the fixed effect for student *i* on topic *k* as $\delta_{ik}, \quad k = 1, \ldots, 23.$ Since the number of topics is fewer than the number of questions it might be possible to estimate the relationship

$$Y_{ij} = \theta p_{ij} + \phi l_{ij} + \psi p_{ij} l_{ij} + \delta_{ik} + \gamma_j + \xi_{ij} \tag{8}$$

In practice, however, I was unable to estimate this due to collinearity.

3. Results

Table 1 OLS estimates **1**

	A	B	C
p_{ij}	0.0348 (0.0165) [0.0189]	0.0851 (0.0334) [0.0295]	0.0641 (0.0260) [0.0291]
l_{ij}			0.0228 (0.0186) [0.0149]
$p_{ij}l_{ij}$			-0.0194 (0.0296) [0.0316]
Sample used	$l_{ij}=1$	$l_{ij}=0$	Whole sample
Sample size	3,675	1,330	5,005

OLS regression results from regressions including student and question fixed effects. White's heteroskedasticity-robust standard errors in parentheses; standard errors also robust to clustering in square brackets.

Table 1 reports the results of my OLS regressions. Column A replicates the fixed-effects results of Chen and Lin (p. 16). However, when the standard errors are calculated correctly the t-statistic is only 1.84 resulting in statistical significance lower than conventionally used.

It is instructive to look at the results from using the data where students did not go to lectures, reported in column B. The effect here is more than twice as large. Taken at face value this suggests that students who do not go to lectures get much more benefit from downloading PowerPoint slides than students who do go to lectures.

Chen and Lin suggest two reasons why having PowerPoint slides may enhance students' understanding: it provides reference material in the lecture and it enhances note taking in the lecture. Clearly neither of these mechanisms are working when students are not in the lecture, so it is necessary to find alternative suggestions. One possibility is that students who do not attend lectures have difficulty reading textbooks – or indeed any conventional document – and find the summaries in PowerPoint slides a useful complement (or, more pessimistically, a useful substitute). However, to interpret the parameter estimates as reflecting this explanation alone would rely upon the joint combination of downloading PowerPoint slides and absence from lectures being exogenous.

Column C shows the results when the data are pooled. The standard errors of the parameter estimates for both lecture attendance and the interactive term are large: there is insufficient evidence that lecture attendance has any beneficial impact at all, since the test for joint significance of the two lecture variables is F(2,22) = 1.34 [p = 0.28] . The point estimate for the benefit of downloading slides conditional on attending the lecture is $\widehat{\theta+\psi}=0.0433$ whereas the marginal effect of attending a lecture conditional on downloading the slides is $\widehat{\phi+\psi}=0.0034$. Taken at face value the obvious conclusion from this is that lecture attendance is a waste of time: university administrators will be pleased to know that they can save money by scrapping costly lectures, selling the lecture rooms and relying upon students to download material from the web.

In the previous section I noted that testing the orthogonality of a student's ability to his or her exam performance is the same as testing $\widehat{\alpha_i'-\alpha_i}=\widehat{\gamma_j'-\gamma_j}=0$ in either equations (4) or equation (6). Using tests based on clustering, these tests yield results of F(22,22) = 24.91 [p = 0.000] and F(22,22) = 69.96 [p = 0.000] respectively: the results are qualitatively the same with conventionally-calculated

standard errors or for tests of $\widehat{\alpha_i' - \alpha_i} = 0$ or $\widehat{\gamma_j' - \gamma_j} = 0$ individually. This suggests that unobserved variation is correlated with the explanators of interest and that the OLS estimates are inconsistent.

4. Conclusions

The arrival of technology such as PowerPoint and the web have excited teachers who believe that it may enhance student learning. To the extent that the latter is measured by exam performance this would mean that students exposed to new technology would get higher marks. However, one does not need to be a complete Luddite to be concerned that new technology might have negative effects which would attenuate or even overwhelm the benefits. One possibility is that students suffering from problems of motivation would attend lectures less when PowerPoint slides are available. And while there may be short-run benefits in students having structured PowerPoint notes available, their availability may reduce students' long-run progress in learning to make their own notes and reduce the benefits from lecture attendance by making the experience more passive. Macedo-Rouet *et al*. (2009) suggest that the benefits of new versus old technology depend upon the type of material being taught and this may explain why research hitherto has provided apparently inconsistent results.

Chen and Lin (2008) is an interesting attempt to measure the net benefits of students downloading PowerPoint slides. As always, the problem is identifying the treatment effect when there is unobserved heterogeneity. This issue is particularly acute because lecture attendance and PowerPoint download are endogenous choices of the students.

In this paper I have proposed a test for endogeneity and concluded that the data suggest that OLS is inconsistent. The OLS estimates themselves suggest that downloading PowerPoint slides has larger benefits for students who do not attend the lecture, so the data undermine the hypothesis that PowerPoint slides benefit students in lectures. Why do we obtain such strange OLS estimates?

Various narratives could be constructed that are consistent with this paradoxical result. Suppose that sometimes missing a lecture is an exogenous event (perhaps due to illness). Having missed a lecture for this reason, the students who are most likely to try to catch up on the work are those who are most hard-working (and this may correlate with other positive attributes). So the combination of missing a lecture and downloading the PowerPoint slides may merely indicate a 'good' student who will tend to do better anyway. But this line of argument relies on attendance being exogenous: probably many absences are endogenous choices of the students. Students' choices are partly irrational and partly rational – but with an objective that includes more than maximising exam mark. With such unobserved heterogeneity in both ability and behaviour, identifying treatment effects is very difficult.

Notes

This analysis was undertaken while I was visiting the University of Verona, whose financial support and hospitality are gratefully acknowledged. I thank the authors of the original paper for making data available. I have received useful comments from two anonymous referees. Any remaining errors are my own.

References

Chen, J., and Lin, T-F. (2008a). 'Does downloading PowerPoint slides before the lecture lead to better student achievement?' *International Review of Economic Education,* Vol. 7(2)*,* pp. 9–18.

Chen,J., and Lin, T-F. (2008b) 'Class attendance and exam performance: a randomised experiment', *Journal of Economic Education,* Vol 39(3), pp.213–27.

Macedo-Rouet, M., Ney, M., Charles, S. and Lallich-Boidin, G. (2009). 'Students' performance and satisfaction with web versus paper-based practice quizzes and lecture notes', *Computers and Education,* Vol. 53, pp. 375–84.

Stanca, L. (2006). 'The Effects of Attendance on Academic Performance: Panel Data Evidence for Introductory Microeconomics', *Journal of Economic Education,* Vol. 37(3), pp. 251–66.

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Does Downloading PowerPoint Slides Before the Lecture Lead to Better Student Achievement?: Reply

Jennjou Chen and Tsui-Fang Lin

Abstract

This reply responds to a comment by Cannon (2011) that opens the debate on consistency of the effect of downloading PowerPoint slides before lectures on students' exam performance. Cannon (2011) points out potential endogeneity problems in Chen and Lin (2008) and attempts to explore the unconditional mean effect of downloading PowerPoint slides for the full sample. In this reply, we firstly argue that the estimates in our original article are consistent since the effect of interest is the "conditional" treatment effect but not the unconditional mean effect. We provide explanations for our rationale of estimating the "conditional" treatment effect. Secondly, we propose a modified downloading variable to replicate Cannon's analysis. Our results suggest that downloading PowerPoint slides before the exam does not produce a significant effect on absent students' exam performance which is different from the results in Cannon (2011). Our analysis does support Cannon's argument that students fixed effects are different across different attendance status.

JEL classification: A22, I21

1. Introduction

Edmund Cannon (2011) points out an endogeneity problem in Chen and Lin (2008), and opens the debate on consistency of the effect of downloading PowerPoint slides before lectures on students' exam performance. Cannon (2011) argues that an unobserved question-*j* specific determinant for student *i* may be correlated with download decision and attendance decision. Cannon (2011) proposes a test for endogeneity and takes into account clustered standard errors; the estimation results indicate that the OLS estimates are inconsistent.

2. Unconditional vs. Conditional Effects

We agree with Cannon (2011) that the endogeneity problem stemming from both attendance and download choices could lead to biased estimates. As pointed out, in the case of unobserved heterogeneity, identifying the average treatment effect is very difficult. However, what Chen and Lin (2008) aimed to identify was a conditional mean effect, i.e. not an unconditional mean effect. In Chen and Lin's paper, only attendees' data were used to analyse the lecture slides download effect (2008, pp. 10, 13 and 15). By making it conditional on attending lectures, to obtain consistent lecture slides estimates, our concern is whether a student's download decision is exogenous. Estimates of conditional treatment effects in Chen and Lin (2008) are consistent as long as endogeneity of students'

downloading PowerPoint slide choices is properly taken care of. A fixed effects model is used to solve part of the endogeneity problem of students' downloading decision (2008, p. 16).

Why did Chen and Lin (2008) not focus on estimation of the unconditional mean effect (i.e. average downloading lecture slides effect for all students regardless of their attendance records)? First, one of our major interests was to investigate whether or not downloading PowerPoint slides before lectures helps students learn and perform better in examinations. The channel through which downloading PowerPoint slides enhances students' learning is that printed lecture slides complement note taking and help students to preview lecture materials. These two effects mainly apply to students who choose to attend lectures. Second, our data is not generated by a random experiment, nor do we have proper instruments for attendance choice variable to estimate the unconditional mean effect properly. As recognised by Cannon (2011), the potential endogeneity problem of attendance choices makes it difficult to estimate the unconditional mean effect consistently. As a result, we focus our estimation on the conditional mean effect.

Cannon (2011) sheds light on the investigation of the unconditional mean effect of downloading PowerPoint slides on students' exam performance and attempts to estimate the effects of downloading PowerPoint slides for the full sample. We recognise that estimating the unconditional mean effect of instructor provided PowerPoint slides is also interesting and important since all students could potentially benefit from downloading the slides. The potential downloading benefits might be different for different groups of students. For instance, the benefit may depend on whether or not students attend lectures. The lecture slides could be downloaded by students before or after class meetings. For those who download slides and then attend a lecture, the benefit from printed slides is previewing class material, better note taking during the lecture, and using these slides as good references for exam preparation. Those who did not attend the lecture can use the downloaded slides only as a reference for exam preparation.

Estimation results from Cannon (Column B in Table 1) suggest that absent students benefit more than attendees from downloading PowerPoint slides. This strange OLS result may imply the existence of endogeneity of attendance choice. We agree with Cannon regarding the potential problem of engodenous attendance choice. However, it is worth noting that the variable of downloading PowerPoint slides may not be properly defined for the purpose of estimating lecture slides effects for students who choose not to attend lectures, and for the full sample. In Chen and Lin (2008) and Cannon (2011), the downloading variable is coded as 1 if a student downloaded lecture slides before the lecture was taught. And, it is coded as 0 if a student did not download slides before the lecture was taught. In order to properly measure the downloading effect on students' exam performance for absent students, and the full sample, we propose to redefine the downloading slides variable.

We use the same data source, and construct a new variable which measures whether or not a student downloaded lecture slides before the examination (not before the lecture) to estimate the lecture slides effect for absent students, and for the entire sample. The sample mean of this variable is 0.867. We estimate the same models as in Cannon (2011), using the modified downloading variable. In addition, two types of cluster designs are considered: by lecture and by chapter. Twelve lectures and nine chapters were covered during the sample semester. Estimation results with different clustering methods are similar. Here, we report results with clustered standard errors by chapter. Under the new definition of the download variable, none of the coefficients is statistically significantly different from 0. In this case, the downloading variable does not produce a significant effect on students' exam performance.

Also, we perform the same test as Cannon (2011) and obtain $F(8, 8) = 13.64$ with clustering and $F(81, 4757) = 10.13$ without clustering. The F test results suggest that the interaction of the lecture attendance variable and student fixed effects should be incorporated when estimating the downloading

effect for the entire sample. It also implies that student fixed effects are different across different attendance status. Therefore, to estimate the lecture slides effect for the full sample, we need to take into account the endogeneity bias from the attending decision.

3. Conclusion

It is important to assess the effectiveness of new information technology on college students' learning outcomes. Chen and Lin (2008) attempt to explore the lecture slides effect for attendees and find a nontrivial effect of downloading PowerPoint slides before the lecture on students' examination performance. Cannon (2011) has demonstrated that it is difficult to isolate the unconditional treatment effect given the complicated endogeneity nature associated with attendance and downloading decisions. We have explained the rationale of estimating the conditional treatment effect in Chen and Lin (2008) and argued that our fixed effects estimates have dealt with part of the endogeneity bias resulting from the downloading decision.

In addition, to properly estimate the lecture slides effect for absent students and the full sample, we employ a modified downloading variable to replicate Cannon's analysis. Our results suggest that downloading PowerPoint slides before the exam does not produce a significant impact on absent students' exam performance. Furthermore, our results support the argument that student fixed effects are different across different attendance status as demonstrated in Cannon (2011). As a result, to estimate the lecture slides effect for the full sample, one needs to take the potential endogeneity bias into account in order to estimate the unconditional treatment effect consistently.

Table 1: OLS estimates with new definition of download variable

	A	B	C
p_{ij}	0.0029 (0.0232) [0.0361]	-0.0126 (0.0405) [0.0351]	0.0340 (0.0336) [0.0339]
l_{ij}			0.0479 (0.0370) [0.0461]
$p_{ij}l_{ij}$			-0.0243 (0.0390) [0.0511]
Sample used	$l_{ij} = 1$	$l_{ij} = 0$	Whole sample
Sample size	3,675	1,331	5,006

Notes: OLS regression results include student and question fixed effects. White's heteroskedasticity-robust standard errors in parentheses; standard errors also robust to clustering in square brackets.

References

Chen, J. and Lin, T-F. (2008). 'Does downloading PowerPoint slides before the lecture lead to better student achievement?' *International Review of Economic Education*, Vol. 7(2), pp. 9–18.

Cannon, E. (2011). 'Comment on Chen and Lin "Does downloading PowerPoint slides before the lecture lead to better student achievement?"', *International Review of Economic Education*, Vol. 10(1), pp. 83-89.

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TSP in Spreadsheets – a Guided Tour

Rasmus Rasmussen

Abstract

The travelling salesman problem (TSP) is a well-known business problem, and variants like the *m*aximum benefit TSP or the price collecting TSP may have numerous economic applications. We are looking at several different variants of TSP; all solved in spreadsheets, not using tailored solvers for TSP. As these problems are NP hard, solving those using standard LP/MIP solvers has been regarded feasible only for very small sized problems. However, a careful consideration of the spreadsheet layout may facilitate efficient software utilisation. For real world problems this can have considerable effects, and with the recent advancements in solver engines, problems previously regarded as big are now easily solvable in spreadsheets. This paper shows you how; and how the flexibility of spreadsheets makes it a convenient tool solving many variants of TSP, where tailored solvers simply would not fit.

JEL classification: C61, Z00

1. Introduction

After a formal statement of the problem, three different spreadsheet models will be illustrated. The flexibility of spreadsheets will also be demonstrated, as will how spreadsheet layout may help in making an efficient problem formulation, in addition to helping to clearly communicate and display the solution. The direct permutation approach is presented first, applying integer variables to describe the sequence of the visits. The direct permutation approach fits small problems well, and requires very little work after data has been obtained. No constraints to eliminate subtours are needed, but the problem is non-linear and non-smooth, requiring heuristic solvers. Second, a network formulation is presented, where binary variables are used to make a linear formulation of the problem. An efficient spreadsheet layout is presented for non-complete graphs. Thirdly an assignment formulation is presented, applying a spreadsheet layout more suitable for complete graphs.

Variants of TSP not fitting tailored TSP software are also solved. In addition some confining side effects of common subtour eliminating constraints are discussed, particularly when multiple visits are required.

2. The standard TSP

Travelling salesman problems (TSP) are easy to describe: a salesman needs to visit all his customers located in different cities in his region, and he would like to find the cheapest tour that will assure that all cities have been visited. Unfortunately TSP is not so easy to formulate, and relatively hard to solve. When making a mathematical formulation of these problems we will for the most part use a network framework. The cities are then called nodes, and the roads connecting the cities are called arcs. See Gutin and Punnen (2007) for a full treatment of TSP and its variants.

The set of nodes to be visited are defined as $N = \{1, 2, ..., n\}$ where n is the total number of nodes (referred to as the *size* of a TSP), and the set of arcs connecting the nodes is defined as $A = \{(i,j) : i, j \in N,$

$i \neq j\}$, where the pair (i,j) indicates the arc between node i and j. A standard assumption in TSP is to assume *direct links between every pair of nodes*, usually referred to as a *complete graph*. The graph consisting of the nodes N and arcs A is then *connected*; there is a *connection* or path from any node to any other node in the graph. The basic standard assumption is to restrict the number of visits to exactly one for each node. Why the salesman is not allowed to visit a node more than once is not obvious. One can speculate that such a requirement makes it easier to develop solution procedures, thereby fitting the problem to the tools at hand. A common definition of the set of decision variables is $X \equiv \{x_{ij} : i, j \in N, i \neq j\}$ where $x_{ij} = 1$ if the salesman travels from node i to j (node i is visited immediately before node j), and 0 otherwise. The cost matrix is defined as $C = \{c_{ij} : i, j \in N, i \neq j\}$ and usually assumed to be positive, where c_{ij} represents the cost of traversing from node i to node j. In standard TSP a common assumption is that the square cost matrix is symmetric, $c_{ij} = c_{ji}$, the cost is the same in both directions. Another standard assumption is to assume the triangle inequality; $c_{ij} + c_{jk} \geq c_{ik} \ \forall i, j, k \in N$, the direct connection between two nodes is always the cheapest.

One basic assumption in TSP is to assume that the salesman has to return to the node where he starts the tour; this node is usually referred to as the *base city* or *depot*. This assumption is called a *closed tour*. For a closed tour any node can be selected as the starting node, but for practical reasons node 1 is set to be the starting node. *Node 1 is then the base city or depot*.

For a standard TSP there is always a feasible solution (as a complete graph is always connected), and we can choose any node to start (as the tour is closed and all nodes are visited). There are always alternative optimal solutions; the tour can go in either direction (as the costs are symmetric). And in the optimal tour(s) every node is visited only once (because of the triangle inequality, and the objective is always minimisation).

3. Variants of TSP

Quite a lot of real life problems do not fit these assumptions. Often we must allow for the set A not being complete, in cases where some nodes do not have direct links to all other nodes. Graphs that are not complete are no longer guaranteed to be *connected,* and for *disconnected graphs* there is *no feasible solution.* In real life we also have to allow for $c_{ij} \neq c_{ji}$, the cost of travelling from node i to j may not be the same as travelling from j to node i. This represents the *asymmetric travelling salesman problem (ATSP),* and implies *directed arcs.* Similarly it is not always cheapest to travel the direct link from node i to node k, sometimes it may be cheaper to travel via node j. Thus we must allow for the triangle inequality not to apply. The basic standard assumption to restrict the visits to exactly one for each node may also be skipped; TSP with multiple visits is referred to as TSPM, as in Gutin and Punnen (2007).

Of course the reason for the salesman to make the tour is to derive some benefit from visiting the nodes. Then let $B = \{b_j : j \in N\}$, where b_j is the benefit from visiting node j. For such problems we have the *maximum benefit travelling salesman problem (MBTSP);* see Malandraki and Daskin (1993). Another variant is the price collecting TSP (or PCTSP), see Gutin (2007).

Sometimes the salesman does not have to return to the base, and relaxing such a requirement is called an *open tour*. For an open tour it may be advantageous to be able to select the ending node as part of the problem solution, but this may increase the problem size for some types of formulations, except for the direct permutation approach.

There is a wide selection of literature on these problems, and several variants of problem formulations. We will group the formulations in two classes: the *assignment formulations* and the *flow formulations*. Further, in each group the models vary according to which assumptions are made, most notably whether a complete graph is assumed.

4. Assignment formulation of TSP

For the closed tour an assignment formulation could be of the following form:

$$Minimize \sum_{i=1}^{n} \sum_{j=1}^{n} c_{ij} x_{ij} \quad (1)$$

$$\sum_{i=1}^{n} x_{ij} = 1 \ , \ \forall \ j \in N \quad (2)$$

$$\sum_{j=1}^{n} x_{ij} = 1 \ , \ \forall \ i \in N \quad (3)$$

$$x_{ij} \in \{0,1\} \ , \ \forall \ i, j \in N \quad (4)$$

In addition *subtour elimination constraints* (SECs) are needed. Constraints (2) and (3) are the standard assignment constraints. The objective in (1) will minimise the total cost along all the arcs used to complete the tour. However, as written this formulation assumes a complete graph, and if the data are being arranged in a square matrix will also include the diagonal. For a complete graph the only arcs that do not exist are related to the *self-loop variable* $x_{i,i}$ (along the diagonal). Therefore it usually is more convenient to exclude these variables by a new constraint (5), instead of excluding them in the definition of the *set X*. This convenience comes at the cost of increased problem size (both in terms of variables and constraints). For a complete graph the following constraint will fix the diagonal in a square *n* matrix of the binary variables x_{ij} equal to zero:

$$x_{i,i} = 0 \ \ \forall \ \ i \in N \quad (5)$$

A different approach to rectify this, and allow for instances of non-complete graphs; is to set the cost c_{ij} sufficiently large for non-existing arcs, thereby preventing them from entering the final solution. However this is not a foolproof trick. In a *connected graph* there is a path from any node to any other node in the graph, and a complete graph is always connected, and thus has a feasible solution. Non-complete graphs may not be connected (*disconnected*), and will as such have no feasible solution. A high cost for non-existing arcs is then no guarantee for theses arcs to be excluded in the final solution. Therefore another strategy is to set a new parameter: $e_{ij} = 1$ if node *i* is directly connected to node *j*, otherwise 0; and replace constraint (5) with (6):

$$x_{ij} \leq e_{ij} \ , \ \forall \ i, j \in N \quad (6)$$

This formulation does not require a complete graph and allows for asymmetric costs and also for the triangle inequality not to apply, but unfortunately it has some flaws. If the assumption of a complete graph is not satisfied (and therefore constraint (6) is required), then a feasible solution for a closed tour may require some nodes to be visited twice, breaking the '=' requirement in constraint (2).

The limitation of visiting each node exactly once may also cause difficulties even for problems with a complete graph, if the triangle inequality is not satisfied. This requirement will effectively prohibit hub-like solutions, even when such solutions are the most cost-effective. A problem formulation that excludes such possible optimal solutions is generally not recommended.

5. Flow formulation of TSP

A flow formulation of the closed tour, that explicitly considers valid connections only, can be made after redefining $C = \{c_{i,j} : (i, j) \in A\}$ and $X \equiv \{x_{i,j} : (i, j) \in A\}$. This formulation will thus work even when the graph is not complete:

$$Minimize \sum_{(i,j)\in A} c_{i,j} \cdot x_{i,j} \quad (7)$$

$$\sum_{i\,:\,(i,j)\in A} x_{i,j} \geq 1 \quad \forall \quad j \in N \quad (8)$$

$$\sum_{i\,:\,(i,k)\in A} x_{i,k} = \sum_{j\,:\,(k,j)\in A} x_{k,j} \quad \forall\ k \in N \quad (9)$$

$$x_{i,j} \in \{0,1\} \quad \forall\ (i,j) \in A \quad (10)$$

Of course SECs are also required. The objective (7) will minimise the total cost of the tour, only considering valid arcs. Constraint (8) states that the salesman has to arrive each node at least once. Constraint (9) states that the salesman has to leave each node as many times as he arrive the node. By using '≥' instead of '=' in (8), we avoid the possibility of making the problem infeasible for non-complete graphs where some nodes need to be visited twice, and we do not exclude 'hub-like' optimal solutions if the triangle inequality does not apply.

6. Flow formulation of open tour TSP

For the open tour formulation we add the parameters $D = \{d_i : i \in N\}$ where d_i is the 'net demand' in node i; and $d_i = -1$ for the start node (the base city is numbered node 1); $d_i = +1$ for the end node, for the transit or intermediate nodes $d_i = 0$. The open tour formulation can then be stated as:

$$Minimize \sum_{(i,j)\in A} c_{i,j} \cdot x_{i,j} \quad (11)$$

$$\sum_{i\,:\,(i,j)\in A} x_{i,j} \geq 1 \quad \forall\ j > 1 \in N \quad (12)$$

$$\sum_{i\,:\,(i,k)\in A} x_{i,k} - \sum_{j\,:\,(k,j)\in A} x_{k,j} = d_k \quad \forall\ k \in N \quad (13)$$

$$x_{i,j} \in \{0,1\} \quad \forall\ (i,j) \in A \quad (14)$$

We must add SECs to complete the TSP formulation. The objective in (11) is identical to (7). Constraint (12) is similar to (8), except that we do not require the salesman to arrive/return to the starting node 1. Constraints (13) require the salesman to leave the starting node one more time than entering, enter the stopping node one more time than leaving, and leave any intermediate node as often as arriving the node. By removing constraint (12) we have the common *shortest path problem*. If the end node is not specified, the d_i parameters may be converted to binary variables (except for the start node), requiring their sum to equal 1.

7. Subtour eliminating constraints (SECs)

A key part of a TSP is to make sure the tour is continuous, that the arcs are linked from the base city all the way to every city visited. Without such constraints we quite often will get solutions containing degenerate tours between intermediate nodes and not connected to the base city. The originally SECs was formed in 1954 by Dantzig-Fulkerson-Johnson (DFJ) (see Dantzig, Fulkerson and Johnson, 1954):

$$\sum_{i\in S}\sum_{j\in S} x_{i,j} \le |S| - 1, \quad \forall\ S \subseteq N \setminus \{1\},\ S \neq\ \varnothing \qquad (15)$$

Unfortunately this introduces an exponential number of constraints, and becomes impractical even for small sized problems. A different SEC proposed in 1960 by Miller-Tucker-Zemlin (MTZ) (see Miller, Tucker and Zemlin, 1960) introduces only a maximum[1] of $(n-2)^2$ constraints, at the disadvantage of a weak LP relaxation:

$$u_i - u_j + 1 \le (n-1)\left(1 - x_{i,j}\right) \quad \forall (i,j) \in A,\ : i, j \neq 1 \qquad (16)$$

In (16) a new set of variables $U = \{u_i : i \in N, i \neq 1\}$ is required. The u_i are arbitrary real numbers, but can be ranked to non-negative integers, representing the sequence the nodes are being visited. For convenience we may add $u_1 \equiv 1$ (node 1 is the base city), and limit the range of u_i, thus helping the optimisation software (see also Pataki (2003)):

$$2 \le u_i \le n \quad \forall\ i > 1\ \in N \qquad (17)$$

The MTZ SECs will be used in this paper, and have the following properties:

- node 1 is required to be the base city;
- they make sure that every city visited belongs to a tour connected to the base city, thereby eliminating subtours;
- they allow nodes to be visited more than once (unless other constraints prevent such a solution);
- they do not require all nodes being visited (unless other constraints make such requirements);
- they allow unidirectional arcs to be utilised in both directions on the same tour.

For a closed tour visiting all nodes the base node can always be chosen arbitrarily. A fundamental weakness of MTZ SECs is that feasibility and final solution may depend on which node is selected as the base city. The MTZ SECs may fail to find a feasible solution even if such exists, and they may fail to find the global optimal solution. Problems with feasibility may occur in non-complete graphs, where all feasible solutions require some nodes to be visited twice. Problems finding the global optimal solution may occur in complete graphs where the triangle inequality does not apply, and where the global optimal solution requires some nodes to be visited more than once. It is therefore important to be aware of these two situations where applying the MTZ SECs may make the final solution sensitive as to which node is selected as the starting node. They will never fail if the global optimal solution visits each node only once.

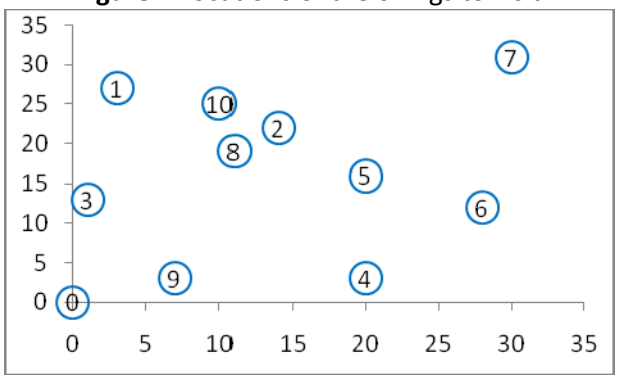
8. Closed TSP in a complete graph

As an example of a TSP in a complete graph we shall use the following example. A supply ship is serving 10 oil rigs at sea. The base is located at coordinates (0,0), and the rigs are located as displayed in Figure

[1] In a square $n \times n$ matrix; the first row, first column and the diagonal are excluded.

1. Assuming open sea the distances between any pair of nodes (oil rigs) can be calculated as straight lines (ignoring the fact that the sea level is not flat). This is a standard symmetric TSP with a complete graph where the triangle inequality applies. Data is taken from Ragsdale (2001).

Figure 1 Locations of the oil rigs to visit



9. A direct permutation approach

In this simple form the problem is to find the order for each node in the sequence of the tour that minimises the total distance (cost). If the supply ship takes the tour based on the rig numbers: 0-1-2-...-9-10-0; the total distance is 205.67. We seek the order or permutation that minimises the total distance. This direct approach is very easy to implement in spreadsheets, as displayed in Figure 2.

Figure 2 Spreadsheet for direct permutation of TSP

Rig	x	y
0	0	0
1	3	27
2	14	22
3	1	13
4	20	3
5	20	16
6	28	12
7	30	31
8	11	19
9	7	3
10	10	25

c_{ij}	0	1	2	3	4	5	6	7	8	9	10
0	0,0	27,2	26,1	13,0	20,2	25,6	30,5	43,1	22,0	7,6	26,9
1	27,2	0,0	12,1	14,1	29,4	20,2	29,2	27,3	11,3	24,3	7,3
2	26,1	12,1	0,0	15,8	19,9	8,5	17,2	18,4	4,2	20,2	5,0
3	13,0	14,1	15,8	0,0	21,5	19,2	27,0	34,1	11,7	11,7	15,0
4	20,2	29,4	19,9	21,5	0,0	13,0	12,0	29,7	18,4	13,0	24,2
5	25,6	20,2	8,5	19,2	13,0	0,0	8,9	18,0	9,5	18,4	13,5
6	30,5	29,2	17,2	27,0	12,0	8,9	0,0	19,1	18,4	22,8	22,2
7	43,1	27,3	18,4	34,1	29,7	18,0	19,1	0,0	22,5	36,2	20,9
8	22,0	11,3	4,2	11,7	18,4	9,5	18,4	22,5	0,0	16,5	6,1
9	7,6	24,3	20,2	11,7	13,0	18,4	22,8	36,2	16,5	0,0	22,2
10	26,9	7,3	5,0	15,0	24,2	13,5	22,2	20,9	6,1	22,2	0,0

Sequence	c_{ij}
0	
3	13,04
1	14,14
10	7,28
8	6,08
2	4,24
7	18,36
5	18,03
6	8,94
4	12,04
9	13,00
0	7,62
Total cost	122,77

x	y
0	0
1	13
3	27
10	25
11	19
14	22
30	31
20	16
28	12
20	3
7	3
0	0

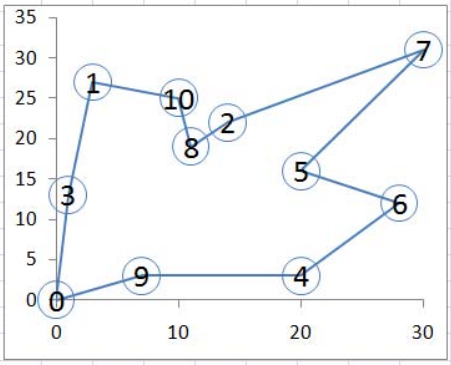
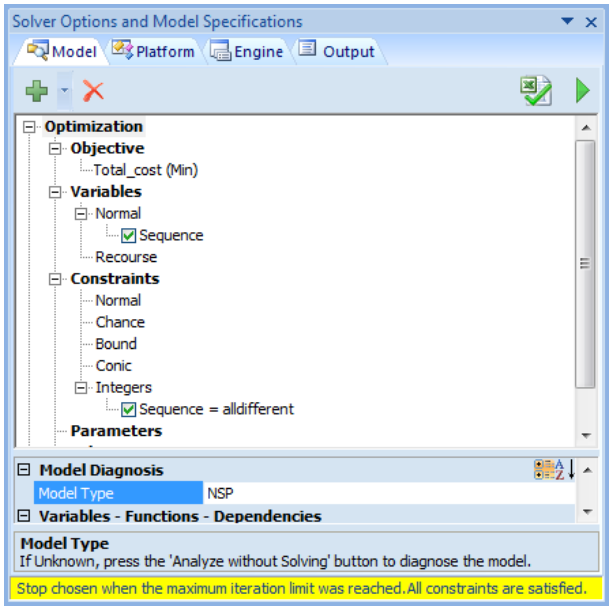


Table 1: Formulas for spreadsheet in Figure 2

Cell	Formula	Copied to	Name / Task
G3	=SQRT((INDEX($C$3:$D$13;$F3+1;1) -INDEX($C$3:$D$13;G$2+1;1))^2 +(INDEX($C$3:$D$13;$F3+1;2) -INDEX($C$3:$D$13;G$2+1;2))^2)	G3:Q13	Calculate Eucledian distances between any pair of nodes
D17	=INDEX($G$3:$Q$13;C16+1;C17+1)	D18:D27	Cost on a leg
D28	=SUM(D17:D27)	-	*Total cost*
C17:C26			*Sequence*
G16	=INDEX($B$3:$D$13;$C16+1;2)	G17:G27	A visited node's x-coordinate
H16	=INDEX($B$3:$D$13;$F16+1;3)	H17:H27	A visited node's y-coordinate

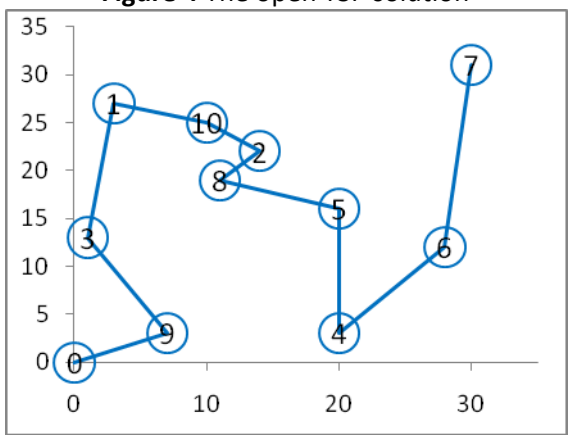
Figure 3 Solver settings for the spreadsheet in Figure 2



The spreadsheet is organised in two parts. The upper part holds a table of the coordinates for the nodes, and a corresponding table calculating the distances. The lower part holds a table of the tour sequence and the cost of each leg, and a corresponding table with the coordinates of each leg, to facilitate a plot of the tour. The table of the tour sequence starts at the base. Note that node number 0 is used for the depot in this example, to facilitate use of the *Alldifferent* constraint in Solver. (A trial version of Solver is available at www.solver.com.) The problem is to select which node to go to next in the sequence (heading 'Sequence' in Figure 2). The last leg has to return to the base. The minimum total distance/cost of 122.77 is achieved by the tour sequence 0-9-4-6-5-7-2-8-10-1-3-0 (or reverse). To model an open tour simply delete row 27 in the sheet. Figure 4 displays the optimal open tour, which has a cost of 103.58.

The scatter plot consists of two series. One series is a plot of the nodes (C3:D13 in Figure 2), with markers but no line. The second series is the tour (G13:H27 in Figure 2), with no markers and a line.

Figure 4 The open TSP solution



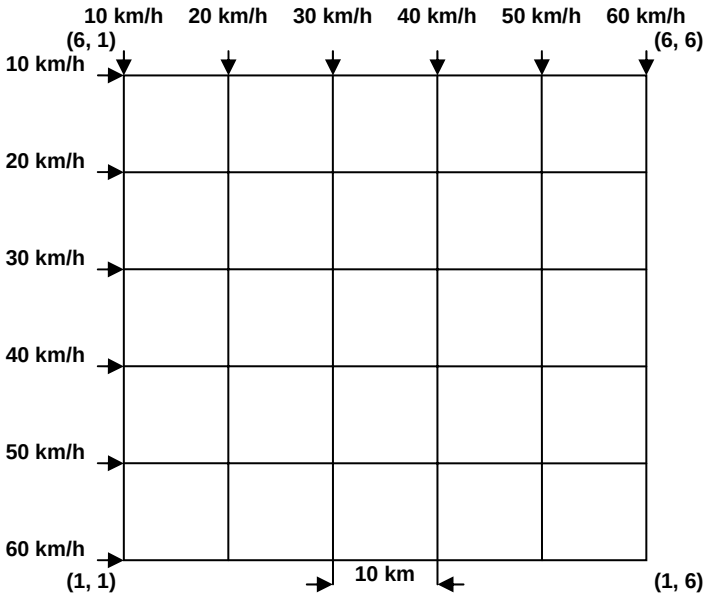
Both the spreadsheet and the Solver settings are very simple. We have 10 decision variables (number of nodes less the depot), named '*Sequence*' in the spreadsheet. The objective in the Solver settings is to minimise the value in the cell named '*Total_cost*', and the only constraint is that the variables must be all different. The **alldifferent** constraint sets the variables to integers ranging from 1 to the number of variables, and all are different. (This type of constraint is not available in the Standard Solver that ships with Excel prior to Excel 2010, but is introduced in the educational version of Solver, included in many textbooks.)

The use of the **Index** function in Excel to look up the cost at each leg makes the objective function non-smooth, because the decision variables are used as arguments in the Index function. An integer non-smooth problem is not easy to solve, and is definitely not the preferred form for large problems. In this case the *Premium Solver Platform* (PSP) selects the *OptQuest* solver engine, and Solver spends less than two seconds in finding the optimal tour (the *AutoStop* option for *OptQuest* was increased from 100 to 1000 iterations to avoid a premature ending). As this solver engine applies heuristics, it cannot guarantee that a global optimal solution has been found. When such problems become large, this non-linear approach is no longer efficient. We will therefore introduce the linear formulation, which will be applied in the rest of the paper. Also note that the direct permutation approach does not allow for multiple visits.

10. TSP in a non-complete graph, flow formulation

As an introductory example for a non-complete graph the 'Gridspeed' puzzle will be used, taken from Chlond (2008). Figure 5 presents the puzzle, based on a rectangular grid street plan, where the distance between any two intersections is 10 kilometres. (I have taken the liberty to transform the data to the metric system.) The speed along all north-south streets and all east-west avenues is constant. However the speed on the north-south streets is highest on the east end of the grid, and for the avenues east-west the speed is highest in the south end of the grid. The fastest area is therefore at the south-east edges of the grid, and slowest in north-west.

Figure 5 Street plan



One puzzle related to Figure 5 is to find the fastest route from intersection (6,1) (north-west) to intersection (1,1) (south-west), but visiting each intersection at least once. The original problem is to visit each intersection once and only once. However this is more restricted than required. Since it obviously will take more time to visit an intersection more than once, and we want to spend as short time as possible on the tour, it is sufficient to use the requirement to visit each intersection at least once.

It is necessary to transform the problem by numbering the intersections and calculate the travelling time between each (directly connected node), to facilitate a mathematical formulation. The numbered intersections are the nodes, and the lines connecting the nodes are the arcs. The travelling time (in minutes) along each arc is calculated as shown in Figure 6.

Figure 6 Relabelled street plan

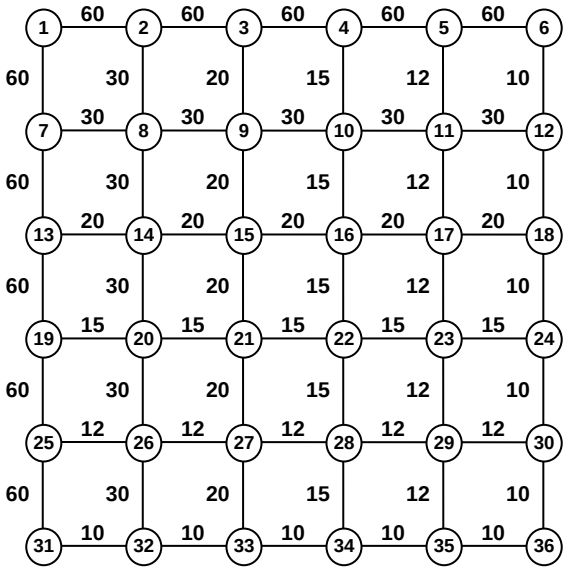


Figure 7 Spreadsheet of open TSP, non-complete graph (rows 66-121 are hidden)

	Set A		c_{ij}	x_{ij}	Eq 18	Eq 16		Set N	u_i	Eq 12	Out	Eq 13	d_i		Sequence	Tour	x	y		Node	x	y
3	1	2	60	1		0		1	1		1	-1	-1		1	1	1	6		1	1	6
4	2	3	60	0		-7		2	2	1	1	0	0		2	2	2	6		2	2	6
5	3	4	60	1		34		3	9	1	1	0	0		9	8	2	5		3	3	6
6	4	5	60	0		-15		4	10	1	1	0	0		10	7	1	5		4	4	6
7	5	6	60	1		34		5	25	1	1	0	0		25	13	1	4		5	5	6
8	7	8	30	0		1		6	26	1	1	0	0		26	14	2	4		6	6	6
9	8	9	30	0		-5		7	4	1	1	0	0		4	15	3	4		7	1	5
10	9	10	30	0		-3		8	3	1	1	0	0		3	9	3	5		8	2	5
11	10	11	30	0		-13		9	8	1	1	0	0		8	3	3	6		9	3	5
12	11	12	30	0		-3		10	11	1	1	0	0		11	4	4	6		10	4	5
13	13	14	20	1		34		11	24	1	1	0	0		24	10	4	5		11	5	5
14	14	15	20	1		34		12	27	1	1	0	0		27	16	4	4		12	6	5
15	15	16	20	0		-5		13	5	1	1	0	0		5	22	4	3		13	1	4
16	16	17	20	0		-11		14	6	1	1	0	0		6	21	3	3		14	2	4
17	17	18	20	0		-5		15	7	1	1	0	0		7	20	2	3		15	3	4
18	19	20	15	0		1		16	12	1	1	0	0		12	19	1	3		16	4	4
19	20	21	15	0		1		17	23	1	1	0	0		23	25	1	2		17	5	4
20	21	22	15	0		1		18	28	1	1	0	0		28	26	2	2		18	6	4
21	22	23	15	0		-9		19	16	1	1	0	0		16	27	3	2		19	1	3
22	23	24	15	0		-7		20	15	1	1	0	0		15	28	4	2		20	2	3
23	25	26	12	1		34		21	14	1	1	0	0		14	29	5	2		21	3	3
24	26	27	12	1		34		22	13	1	1	0	0		13	23	5	3		22	4	3
25	27	28	12	1		34		23	22	1	1	0	0		22	17	5	4		23	5	3
26	28	29	12	1		34		24	29	1	1	0	0		29	11	5	5		24	6	3
27	29	30	12	0		-9		25	17	1	1	0	0		17	5	5	6		25	1	2
28	31	32	10	0		1		26	18	1	1	0	0		18	6	6	6		26	2	2
29	32	33	10	0		1		27	19	1	1	0	0		19	12	6	5		27	3	2
30	33	34	10	0		1		28	20	1	1	0	0		20	18	6	4		28	4	2
31	34	35	10	0		1		29	21	1	1	0	0		21	24	6	3		29	5	2
32	35	36	10	0		1		30	30	1	1	0	0		30	30	6	2		30	6	2
33	1	7	60	0		0		31	36	1	0	1	1		36	36	6	1		31	1	1
34	7	13	60	1		34		32	35	1	1	0	0		35	35	5	1		32	2	1
35	13	19	60	0		-11		33	34	1	1	0	0		34	34	4	1		33	3	1
36	19	25	60	1		34	n-2	34	33	1	1	0	0		33	33	3	1		34	4	1
37	25	31	60	0		-19	n-1	35	32	1	1	0	0		32	32	2	1		35	5	1
38	2	8	30	1		34	n	36	31	1	1	0	0		31	31	1	1		36	6	1
39	8	14	30	0		-3																
40	14	20	30	0		-9																
41	20	26	30	0		-3																
42	26	32	30	0		-17																
43	3	9	20	0		1																
44	9	15	20	0		1																
45	15	21	20	0		-7																
46	21	27	20	0		-5																
47	27	33	20	0		-15																
48	4	10	15	1		34																
49	10	16	15	1		34																
50	16	22	15	1		34																
51	22	28	15	0		-7																
52	28	34	15	0		-13																
53	5	11	12	0		1																
54	11	17	12	0		1																
55	17	23	12	0		1																
56	23	29	12	0		1																
57	29	35	12	0		-11																
58	6	12	10	1		34																
59	12	18	10	1		34																
60	18	24	10	1		34																
61	24	30	10	1		34																
62	30	36	10	1		34																
63	2	1	60	0	1	0																
64	3	2	60	0	0	7																
65	4	3	60	0	1	1																
122	36	30	10	0	1	1																
123	Eq 11		726																			

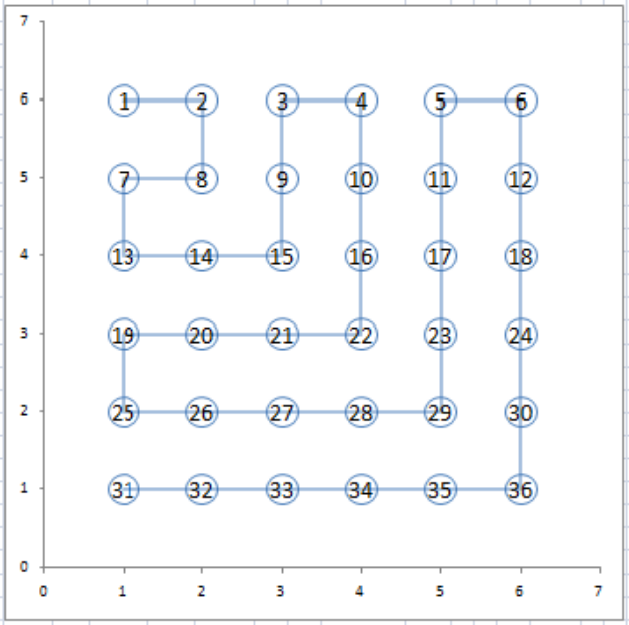


Table 2 Formulas for the spreadsheet in Figure 7

Cell	Formula	Copied to	Name / Task
B63	=C3	B64:B122	Reverse arcs: stop→start
C63	=B3	C64:C122	Reverse arcs: start→stop
D63	=D3	D64:D122	Reverse arcs: copy costs
D123	=SUMPRODUCT(D3:D122;E3:E122)	-	*Eq 11*
F63	=E3+E63	F64:F122	*Eq 18* (LHS)
G3	=IF(OR(B3=1;C3=1);0;INDEX($J$3:$J$38;B3) -INDEX($J$3:$J$38;C3) +($I$37*E3))	G4:G122	*Eq 16* (LHS)
K4	=SUMIF($C$3:$C$122;$I$3:$I$38;$E$3:$E$122)	K5:K38	*Eq 12* (LHS)
L3	=SUMIF($B$3:$B$122;$I$3:$I$38;$E$3:$E$122)	L4:L38	First part of Eq 13
M3	=K3-L3	M4:M38	*Eq 13* (LHS)
E3:E122			*Var_x*
I36			*Param_n_2*
I38			*Param_n*
J4:J38			*Var_u*
N3:N38			*Param_d*
P3	=RANK(J3;$J$3:$J$38;1)	P4:P38	The rank of a node
Q3	=MATCH(U3;$P$3:$P$38;0)	Q4:Q38	Visiting sequence
R3	=INDEX($U$3:$W$38;$Q3;2)	R4:R38	A visited node's x-coordinate
S3	=INDEX($U$3:$W$38;$Q3;3)	S4:S38	A visited node's y-coordinate

11. The open tour

We will first have a look at the open tour variant of the puzzle. An efficient layout of this network in a spreadsheet would be to organise the problem in two tables, one table for the arcs and the binary decision variables, and another table for the nodes and the continuous variables (as in Ragsdale, 2001). This will facilitate the entry of the equations (11) – (14), (16) and (17), and also make a solution easy to understand. Once the data has been entered in the spreadsheet, the model can easily be built around the data. Notice that for non-directed arcs it is sufficient to enter them in one direction, and use simple formulas to mirror the other direction. A third table has been added to the spreadsheet to facilitate a plot of the tour, which of course is not needed for solving the problem, but handy for displaying the solution.

A new constraint has been added, to speed up the solution process:

$$x_{i,j} + x_{j,i} \le 1 \quad \forall \ (i,j) \in A \qquad (18)$$

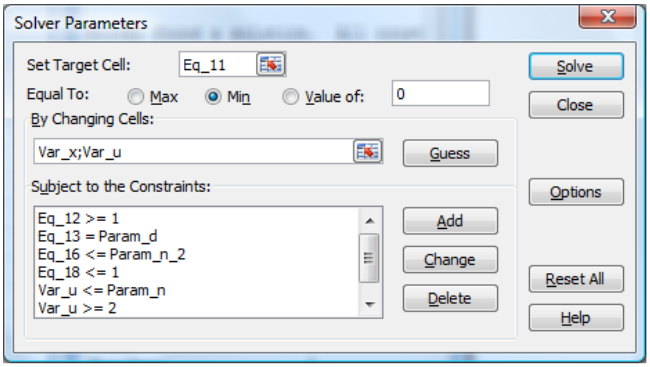
Constraint (18) simply states that no arc will be used in both directions, which is quite obvious for this problem. Such bounds on the variables are very helpful for the optimisation process, particularly so for binary variables. However they should be used with care, since adding them can make some problems infeasible.

In Figure 7 the table for the arcs is listed first; then the table for the nodes and finally the table for facilitating a plot of the tour. The first half of the arcs are listed (all arcs in one direction) and a few of the rest, together with the objective. (The rest of the arcs are in the hidden rows 66–121.) We see that

the optimal value of the objective (11) is 726; the fastest open tour from node 1 to node 31 takes a minimum of 726 minutes. The formulas in the spreadsheet are displayed in Table 2, and the Solver settings are listed in Figure 8.

The first three rows in Table 2 are purely for easy data entry. The optimisation model consists of the next six rows. The following five rows are used for naming some key cells, making the model easier to read. The last four rows facilitate a plot of the solution, assuming only *n* legs in the tour (each node is visited only once). The scatter plot in Figure 7 consists of two data series. One series is the *xy* coordinates of the nodes (in column V and W), with no line, and a circle (size 20) as marker.[2] The second series is the *xy* coordinates of the tour (in column R and S), with no marker and a line. For a closed tour a final leg is added at the end (by referring to the first leg in column Q).

Figure 8 Solver settings for Figure 7



The Standard Solver Parameter Dialog Box displayed in Figure 8 has a scroll bar to display the constraints not fitting the fixed size of the box. Here constraint (14) is not displayed; this is the declaration of the x_{ij} variable being binary. Observe that constraint (14) and (17) is entered directly in Solver, involving no formulas in the spreadsheet. Constraints (17) are the last two visible constraints in the Solver Parameter Dialog Box.

This model has 120 binary variables and 35 continuous variables, 155 bounds on the variables and 191 constraints. The number of constraints can be reduced by 4 if we group the four arcs connected to node 1 and list them first, then not include them in constraints (16). In the spreadsheet the formula for (16) include these arcs, but fix their value to 0, thereby satisfying the constraint.

Excel and the Standard Solver take less than five seconds to find the optimal solution for the open tour. (The solution time will of course depend on the version of Excel, the operating system, and the computer.) This spreadsheet design is quite versatile for many types of network problems. If we drop (12), (16), (17) and (18) we have the shortest path problem. (We may then delete column F, G, J and P – W.)

12. A closed TSP in a non-complete graph, assignment formulation

We will now rephrase the problem to a closed tour, requiring the salesman to return to the base. We will implement the assignment formulation and compare it with a flow formulation (not shown). We will also demonstrate an efficient layout for the spreadsheet of a TSP in a complete graph, even though this particular example is non-complete. For a TSP in a complete graph, it is more efficient to group the problem in three tables; one table for the cost matrix and the objective (1), a second table for the x_{ij}

[2] The labels of the scatter plot were made by the XY Chart Labeler add-in for Excel, free at www.appspro.com.

binary decision variables and constraint (2) and (3), and a third table for the SECs and the related u_i variables. For convenience a table of the coordinates of the nodes can be added to facilitate a plot of the tour. For large problems these matrixes may be entered in different sheets in the workbook. (It is more effective though for Solver to have the objective, constraints and variables in one sheet. The cost matrix and the plot data can be stored in a separate sheet.)

A matrix layout of the costs is very efficient for a complete graph, when there are direct links between any node to every other node. However, it is also very common to use the same approach for non-complete graphs, maybe because it is considered handier for data entry, at least in the preferred software tools most commonly used.

Unfortunately this convenience has a trade off. Adding enormous amount of non-existing variables and correcting this by adding an equal amount of non-existing constraints, makes a substantial burden on the software. In contrast, entering the data in a spreadsheet may actually be easier for non-complete graph situations, using only two tables instead of three.

Figure 9 Matrix of costs for TSP non-complete graph, assignment formulation

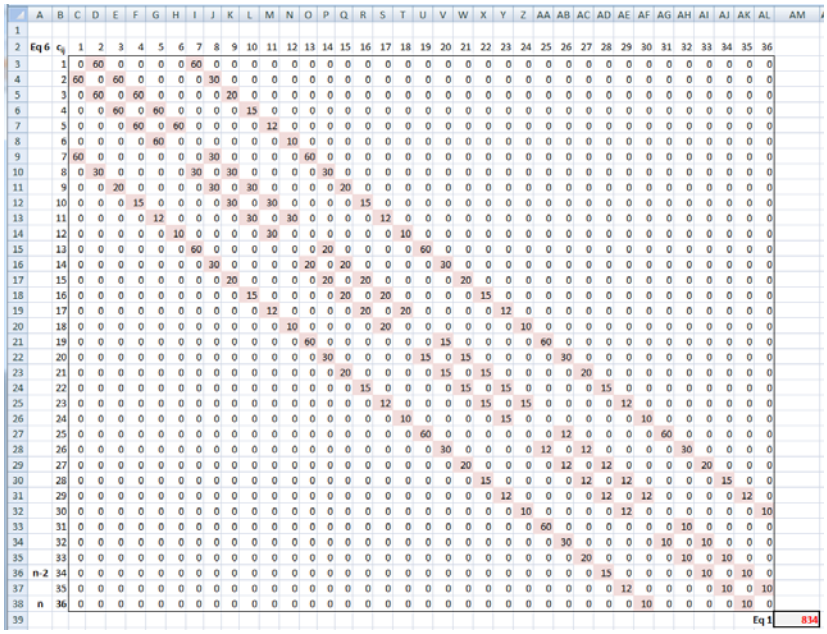


Figure 10 Matrix of binary variables for TSP non-complete graph, assignment formulation

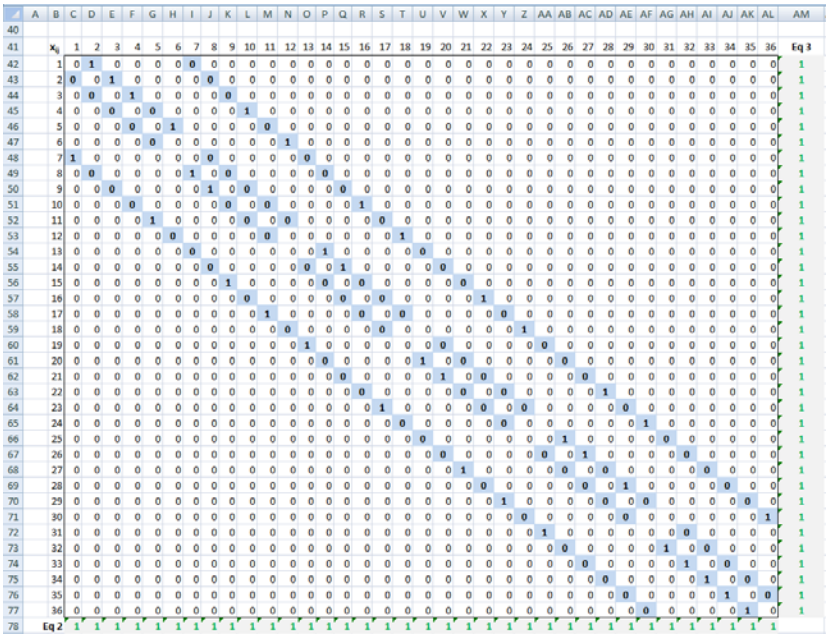
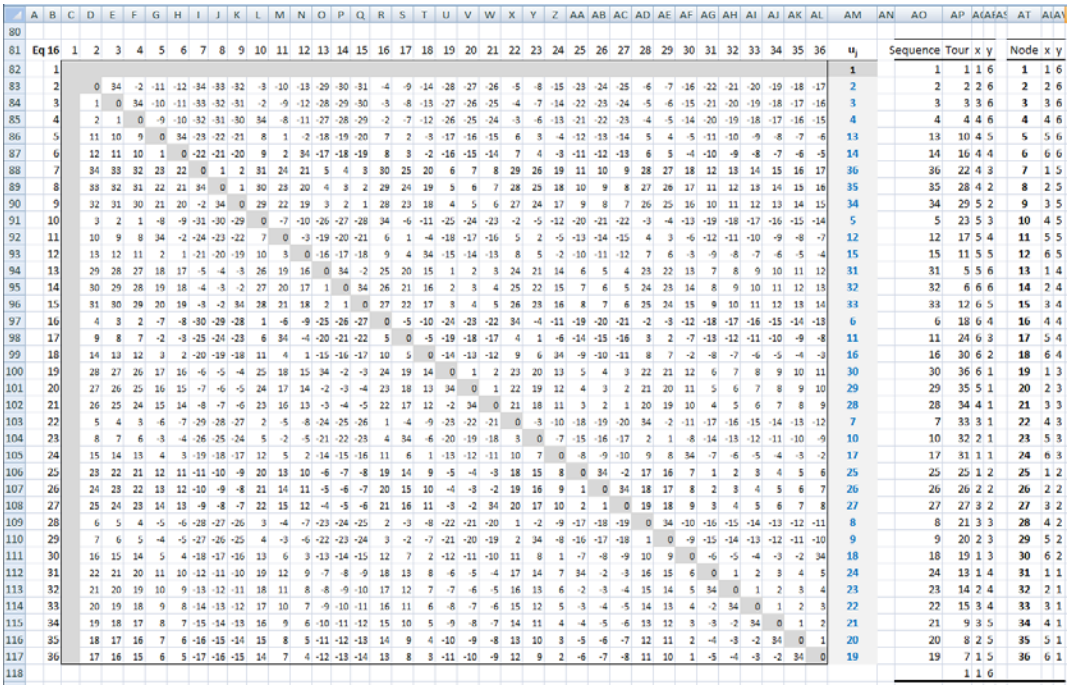


Figure 11 Matrix of SECs and plot data for TSP non-complete graph, assignment formulation



Eq	16	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	u_j
1																																							1
2		0	34	-2	-11	-12	-34	-33	-32	-3	-10	-13	-29	-30	-31	-4	-9	-14	-28	-27	-26	-5	-8	-15	-23	-24	-25	-6	-7	-16	-22	-21	-20	-19	-18	-17		2
3		1	0	34	-10	-11	-33	-32	-31	-2	-9	-12	-28	-29	-30	-3	-8	-13	-27	-26	-25	-4	-7	-14	-22	-23	-24	-5	-6	-15	-21	-20	-19	-18	-17	-16		3
4		2	1	0	-9	-10	-32	-31	-30	34	-8	-11	-27	-28	-29	-2	-7	-12	-26	-25	-24	-3	-6	-13	-21	-22	-23	-4	-5	-14	-20	-19	-18	-17	-16	-15		4
5		11	10	9	0	34	-23	-22	-21	8	1	-2	-18	-19	-20	7	2	-3	-17	-16	-15	6	3	-4	-12	-13	-14	5	4	-5	-11	-10	-9	-8	-7	-6		13
6		12	11	10	1	0	-22	-21	-20	9	2	34	-17	-18	-19	8	3	-2	-16	-15	-14	7	4	-3	-11	-12	-13	6	5	-4	-10	-9	-8	-7	-6	-5		14
7		34	33	32	23	22	0	1	2	31	24	21	5	4	3	30	25	20	6	7	8	29	26	19	11	10	9	28	27	18	12	13	14	15	16	17		36
8		33	32	31	22	21	34	0	1	30	23	20	4	3	2	29	24	19	5	6	7	28	25	18	10	9	8	27	26	17	11	12	13	14	15	16		35
9		32	31	30	21	20	-2	34	0	29	22	19	3	2	1	28	23	18	4	5	6	27	24	17	9	8	7	26	25	16	10	11	12	13	14	15		34
10		3	2	1	-8	-9	-31	-30	-29	0	-7	-10	-26	-27	-28	34	-6	-11	-25	-24	-23	-2	-5	-12	-20	-21	-22	-3	-4	-13	-19	-18	-17	-16	-15	-14		5
11		10	9	8	34	-2	-24	-23	-22	7	0	-3	-19	-20	-21	6	1	-4	-18	-17	-16	5	2	-5	-13	-14	-15	4	3	-6	-12	-11	-10	-9	-8	-7		12
12		13	12	11	2	1	-21	-20	-19	10	3	0	-16	-17	-18	9	4	34	-15	-14	-13	8	5	-2	-10	-11	-12	7	6	-3	-9	-8	-7	-6	-5	-4		15
13		29	28	27	18	17	-5	-4	-3	26	19	16	0	34	-2	25	20	15	1	2	3	24	21	14	6	5	4	23	22	13	7	8	9	10	11	12		31
14		30	29	28	19	18	-4	-3	-2	27	20	17	1	0	34	26	21	16	2	3	4	25	22	15	7	6	5	24	23	14	8	9	10	11	12	13		32
15		31	30	29	20	19	-3	-2	34	28	21	18	2	1	0	27	22	17	3	4	5	26	23	16	8	7	6	25	24	15	9	10	11	12	13	14		33
16		4	3	2	-7	-8	-30	-29	-28	1	-6	-9	-25	-26	-27	0	-5	-10	-24	-23	-22	34	-4	-11	-19	-20	-21	-2	-3	-12	-18	-17	-16	-15	-14	-13		6
17		9	8	7	-2	-3	-25	-24	-23	6	34	-4	-20	-21	-22	5	0	-5	-19	-18	-17	4	1	-6	-14	-15	-16	3	2	-7	-13	-12	-11	-10	-9	-8		11
18		14	13	12	3	2	-20	-19	-18	11	4	1	-15	-16	-17	10	5	0	-14	-13	-12	9	6	34	-9	-10	-11	8	7	-2	-8	-7	-6	-5	-4	-3		16
19		28	27	26	17	16	-6	-5	-4	25	18	15	34	-2	-3	24	19	14	0	1	2	23	20	13	5	4	3	22	21	12	6	7	8	9	10	11		30
20		27	26	25	16	15	-7	-6	-5	24	17	14	-2	-3	-4	23	18	13	34	0	1	22	19	12	4	3	2	21	20	11	5	6	7	8	9	10		29
21		26	25	24	15	14	-8	-7	-6	23	16	13	-3	-4	-5	22	17	12	-2	34	0	21	18	11	3	2	1	20	19	10	4	5	6	7	8	9		28
22		5	4	3	-6	-7	-29	-28	-27	2	-5	-8	-24	-25	-26	1	-4	-9	-23	-22	-21	0	-3	-10	-18	-19	-20	34	-2	-11	-17	-16	-15	-14	-13	-12		7
23		8	7	6	-3	-4	-26	-25	-24	5	-2	-5	-21	-22	-23	4	34	-6	-20	-19	-18	3	0	-7	-15	-16	-17	2	1	-8	-14	-13	-12	-11	-10	-9		10
24		15	14	13	4	3	-19	-18	-17	12	5	2	-14	-15	-16	11	6	1	-13	-12	-11	10	7	0	-8	-9	-10	9	8	34	-7	-6	-5	-4	-3	-2		17
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26		24	23	22	13	12	-10	-9	-8	21	14	11	-5	-6	-7	20	15	10	-4	-3	-2	19	16	9	1	0	34	18	17	8	2	3	4	5	6	7		26
27		25	24	23	14	13	-9	-8	-7	22	15	12	-4	-5	-6	21	16	11	-3	-2	34	20	17	10	2	1	0	19	18	9	3	4	5	6	7	8		27
28		6	5	4	-5	-6	-28	-27	-26	3	-4	-7	-23	-24	-25	2	-3	-8	-22	-21	-20	1	-2	-9	-17	-18	-19	0	34	-10	-16	-15	-14	-13	-12	-11		8
29		7	6	5	-4	-5	-27	-26	-25	4	-3	-6	-22	-23	-24	3	-2	-7	-21	-20	-19	2	34	-8	-16	-17	-18	1	0	-9	-15	-14	-13	-12	-11	-10		9
30		16	15	14	5	4	-18	-17	-16	13	6	3	-13	-14	-15	12	7	2	-12	-11	-10	11	8	1	-7	-8	-9	10	9	0	-6	-5	-4	-3	-2	34		18
31		22	21	20	11	10	-12	-11	-10	19	12	9	-7	-8	-9	18	13	8	-6	-5	-4	17	14	7	34	-2	-3	16	15	6	0	1	2	3	4	5		24
32		21	20	19	10	9	-13	-12	-11	18	11	8	-8	-9	-10	17	12	7	-7	-6	-5	16	13	6	-2	-3	-4	15	14	5	34	0	1	2	3	4		23
33		20	19	18	9	8	-14	-13	-12	17	10	7	-9	-10	-11	16	11	6	-8	-7	-6	15	12	5	-3	-4	-5	14	13	4	-2	34	0	1	2	3		22
34		19	18	17	8	7	-15	-14	-13	16	9	6	-10	-11	-12	15	10	5	-9	-8	-7	14	11	4	-4	-5	-6	13	12	3	-3	-2	34	0	1	2		21
35		18	17	16	7	6	-16	-15	-14	15	8	5	-11	-12	-13	14	9	4	-10	-9	-8	13	10	3	-5	-6	-7	12	11	2	-4	-3	-2	34	0	1		20
36		17	16	15	6	5	-17	-16	-15	14	7	4	-12	-13	-14	13	8	3	-11	-10	-9	12	9	2	-6	-7	-8	11	10	1	-5	-4	-3	-2	34	0		19

Sequence	Tour	x	y
1	1	1	6
2	2	2	6
3	3	3	6
4	4	4	6
13	10	4	5
14	16	4	4
36	22	4	3
35	28	4	2
34	29	5	2
5	23	5	3
12	17	5	4
15	11	5	5
31	5	5	6
32	6	6	6
33	12	6	5
6	18	6	4
11	24	6	3
16	30	6	2
30	36	6	1
29	35	5	1
28	34	4	1
7	33	3	1
10	32	2	1
17	31	1	1
25	25	1	2
26	26	2	2
27	27	3	2
8	21	3	3
9	20	2	3
18	19	1	3
24	13	1	4
23	14	2	4
22	15	3	4
21	9	3	5
20	8	2	5
19	7	1	5
		1	6

Node	x	y
1	1	6
2	2	6
3	3	6
4	4	6
5	5	6
6	6	6
7	1	5
8	2	5
9	3	5
10	4	5
11	5	5
12	6	5
13	1	4
14	2	4
15	3	4
16	4	4
17	5	4
18	6	4
19	1	3
20	2	3
21	3	3
22	4	3
23	5	3
24	6	3
25	1	2
26	2	2
27	3	2
28	4	2
29	5	2
30	6	2
31	1	1
32	2	1
33	3	1
34	4	1
35	5	1
36	6	1

Figure 12 The plot of the closed TSP in a non-complete graph, assignment formulation

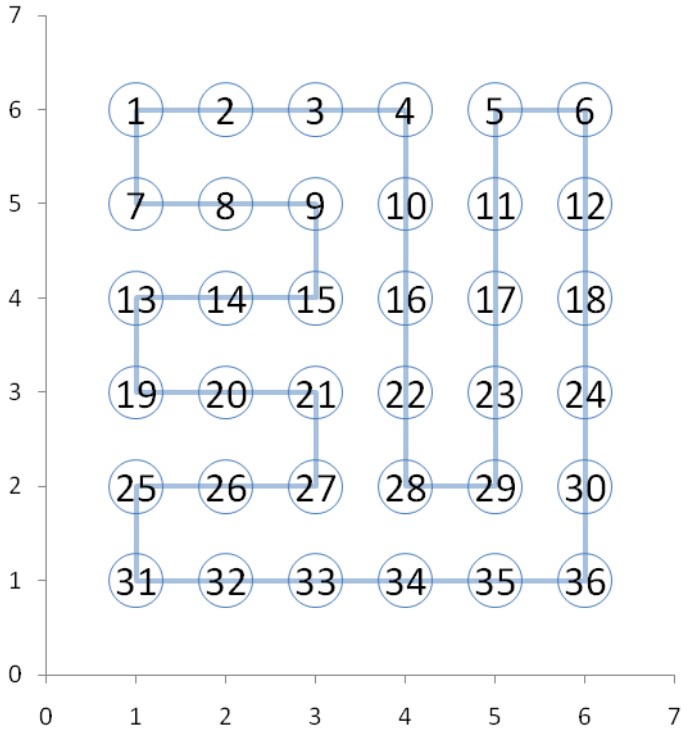


Figure 13 Solver settings for Figures 9 to 11

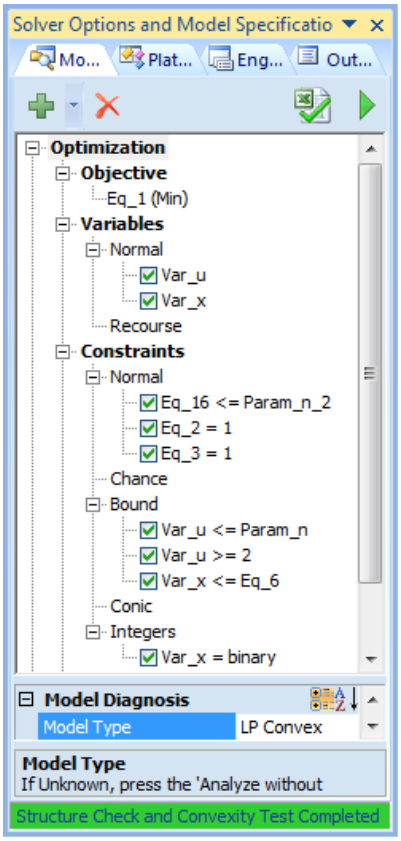


Table 3: Formulas for spreadsheet in Figures 9 to 11

Cell	Formula	Copied to	Name / Task
AM39	=SUMPRODUCT(C3:AL38;C42:AL77)	-	*Eq 1*
AM42	=SUM(C42:AL42)	AM43:AM77	*Eq 3* (LHS)
C78	=SUM(C42:C77)	D78:AL78	*Eq 2* (LHS)
D83	=INDEX($AM$82:$AM$117;$B83) -INDEX($AM$82:$AM$117;D$81) +INDEX($C$42:$AL$77;$B83;D$81)*$B$37	D83:AL117	*Eq 15* (LHS)
C3:AL38			*Eq 6* (RHS)
C42:AL77			*Var_x*
B36			*Param_n_2*
B38			*Param_n*
AM83:AM117			*Var_u*
AO82	=RANK(AM82;$AM$82:$AM$117;1)	AO83:AO117	The rank of a node
AP82	=MATCH(AT82;$AO$82:$AO$117;0)	AP83:AP117	Visiting sequence
AP118	=AP82	-	Last leg, return to base
AQ82	=INDEX($AT$82:$AV$117;$AP82;2)	AQ83:AQ118	A visited node's x-coordinate
AR82	=INDEX($AT$82:$AV$117;$AP82;3)	AR83:AR118	A visited node's y-coordinate

Due to its size this formulation cannot be solved by the Standard Solver in Excel, which has a limit of 200 variables. We see from Figure 9 that the minimum time to complete a closed tour is 834, the value for the objective (1).

In Table 4 the model in Figure 7, a closed network version (not shown), and the closed assignment version in Figures 9 to 11 are compared. The solution time for the assignment formulation of the closed tour is more than 6.2 times the solution time for the flow formulation (using the Gurobi Solver Engine in RSP V9.04 for Excel).

Table 4: Key features of the models

Models of TSP	**Figure 7**	**Not shown**	**Figure 9-11**
Type, model	Open, network	Closed, network	Closed, assignment
Integer variables	155	155	1296
Continuous variables	35	35	35
Constraints	248	249	1297
Bounds on variables	70	70	1331
Solution time (seconds)	0.44	3.84	24.01
Time Standard Solver	≈5	≈Over night	Not solvable

Lessons learned from this small example are that formulation matters. Avoid using non-existing variables rectified by non-existing constraints. However, adding constraints may have a great impact, even when not changing the optimal solution. Constraints that are tightening the feasible space may speed up the solution time (or the contrary), but such constraints must not eliminate an otherwise optimal solution.

13. A closed MBTSP in a non-complete graph, flow formulation

The ultimate minimum cost for any problem is zero; simply do nothing. So there must be a reason for doing something (presumably there is a null alternative). Minimising costs can often turn out to be solving the wrong problem. Unless any revenues are completely unaffected by the decisions at hand we cannot be sure that minimising costs is a valid model that accurately represents the relevant characteristics of the problem.

Let us assume there are some revenues or benefits b_j by visiting node j; where $j \in N$. Also introduce the set $Y = \{y_j : j \in N, j \neq 1, y_j \in \{0,1\}\}$ where the binary decision variable $y_j = 1$ if the salesman visits node j, else 0. Define the parameter $y_1 = 1$ as the requirement to visit/return to the depot (node 1), a consequence of our SECs.

The objective now is to maximise the total net benefit (total benefits minus total costs):

$$\text{maximize} \sum_{j \in N} b_j \cdot y_j - \sum_{(i,j) \in A} c_{i,j} \cdot x_{i,j} \qquad (19)$$

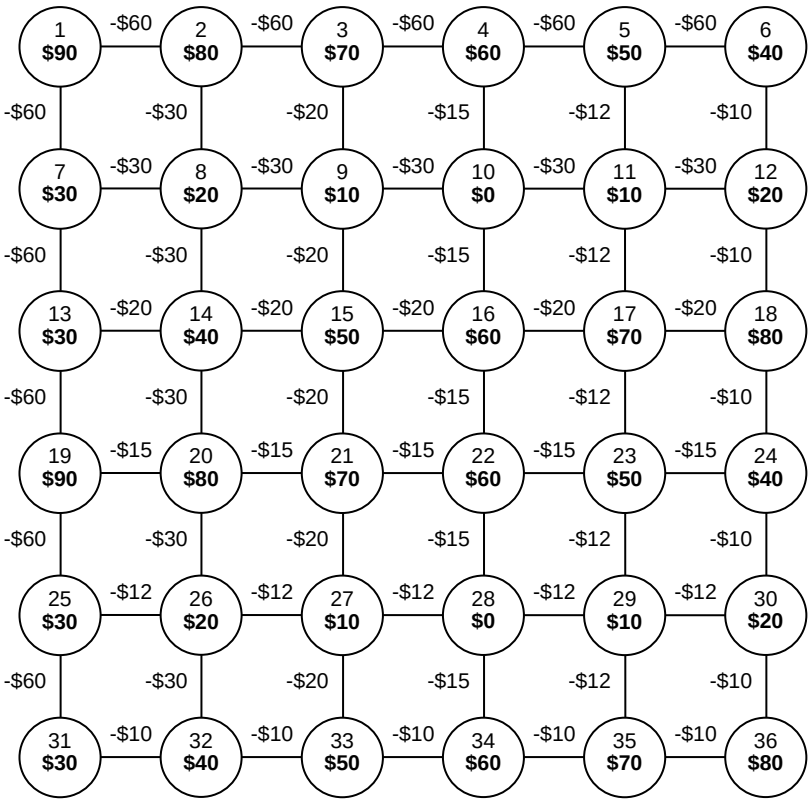
The salesman has to arrive (at least) once each node he decides to visit:

$$\sum_{i:(i,j) \in A} x_{i,j} \geq y_j \quad \forall \quad j \in N \qquad (20)$$

In addition the balance constraint (9) and binary conditions (10) apply, as well as the SECs (16) and the corresponding bounds (17). Here (19) and (20) replace the original objective (7) and constraint (8), when compared to the closed TSP flow formulation.

The revised problem is presented in Figure 14. The revenues are entered with $ symbols under each node number, indicating the revenue if the node is being visited. The cost is assumed to be 1$ for each minute of travel time, so we have a common unit of measurement in the objective. Observe that node 10 and node 28 have no revenues, and are therefore obvious candidates for no visits.

Figure 14 Relabelled street plan for MBTSP



This is a variation of the Price Collecting TSP. The common feature of these problems in this category is the combination of two kinds of decisions, the selection of some nodes, and the ordering of the nodes selected for the tour (see Gutin, 2007).

Figure 15 Closed MBTSP flow formulation in a spreadsheet, rows 66–119 are hidden

	Set A		c_{ij}	x_{ij}	Eq 16
3	1	2	60	0	0
4	2	3	60	0	1
5	3	4	60	0	1
6	4	5	60	0	13
7	5	6	60	0	1
8	7	8	30	1	34
9	8	9	30	0	1
10	9	10	30	0	-31
11	10	11	30	0	11
12	11	12	30	0	3
13	13	14	20	0	-2
14	14	15	20	1	34
15	15	16	20	0	-21
16	16	17	20	0	3
17	17	18	20	0	5
18	19	20	15	0	1
19	20	21	15	0	1
20	21	22	15	0	-19
21	22	23	15	0	1
22	23	24	15	0	7
23	25	26	12	1	34
24	26	27	12	0	8
25	27	28	12	0	-34
26	28	29	12	0	0
27	29	30	12	0	20
28	31	32	10	0	25
29	32	33	10	1	34
30	33	34	10	1	34
31	34	35	10	1	34
32	35	36	10	1	34
33	1	7	60	1	0
34	7	13	60	0	0
35	13	19	60	0	-6
36	19	25	60	1	34
37	25	31	60	0	-27
38	2	8	30	0	33
39	8	14	30	1	34
40	14	20	30	0	-3
41	20	26	30	0	-3
42	26	32	30	1	34
43	3	9	20	0	33
44	9	15	20	0	-3
45	15	21	20	1	34
46	21	27	20	0	4
47	27	33	20	0	-10
48	4	10	15	0	1
49	10	16	15	0	7
50	16	22	15	0	1
51	22	28	15	0	-11
52	28	34	15	0	23
53	5	11	12	1	34
54	11	17	12	1	34
55	17	23	12	1	34
56	23	29	12	0	-12
57	29	35	12	0	22
58	6	12	10	0	1
59	12	18	10	0	1
60	18	24	10	0	1
61	24	30	10	0	1
62	30	36	10	0	1
63	2	1	60	1	0
64	3	2	60	1	34
65	4	3	60	1	34
120	24	18	10	1	34
121	30	24	10	1	34
122	36	30	10	1	34
123	Costs		718		

	Set N	b_j	y_j	u_j	Eq 20	Eq 9
	1	90	1	1	1	1
	2	80	1	36	1	1
	3	70	1	35	1	1
	4	60	1	34	1	1
	5	50	1	21	1	1
	6	40	1	20	1	1
	7	30	1	2	1	1
	8	20	1	3	1	1
	9	10	0	2	0	0
	10	0	1	33	1	1
	11	10	1	22	1	1
	12	20	1	19	1	1
	13	30	0	2	0	0
	14	40	1	4	1	1
	15	50	1	5	1	1
	16	60	1	26	1	1
	17	70	1	23	1	1
	18	80	1	18	1	1
	19	90	1	8	1	1
	20	80	1	7	1	1
	21	70	1	6	1	1
	22	60	1	25	1	1
	23	50	1	24	1	1
	24	40	1	17	1	1
	25	30	1	9	1	1
	26	20	1	10	1	1
	27	10	0	2	0	0
	28	0	0	36	0	0
	29	10	0	36	0	0
	30	20	1	16	1	1
	31	30	0	36	0	0
	32	40	1	11	1	1
	33	50	1	12	1	1
n-2	34	60	1	13	1	1
	35	70	1	14	1	1
n	36	80	1	15	1	1
	Revenues	1530	30			
	Eq 19	**812**				

	Sequence	Tour	x	y
1	1	1	1	6
33	30	7	1	5
32	29	8	2	5
31	28	14	2	4
24	21	15	3	4
23	20	21	3	3
2	2	20	2	3
6	3	19	1	3
		25	1	2
30	27	26	2	2
25	22	32	2	1
22	19	33	3	1
		34	4	1
7	4	35	5	1
8	5	36	6	1
29	26	30	6	2
26	23	24	6	3
21	18	18	6	4
11	8	12	6	5
10	7	6	6	6
9	6	5	5	6
28	25	11	5	5
27	24	17	5	4
20	17	23	5	3
12	9	22	4	3
13	10	16	4	4
		10	4	5
		4	4	6
		3	3	6
19	16	2	2	6
		#N/A	#N/A	###
14	11	#N/A	#N/A	###
15	12	#N/A	#N/A	###
16	13	#N/A	#N/A	###
17	14	#N/A	#N/A	###
18	15	#N/A	#N/A	###
		1	1	6

	Node	x	y
	1	1	6
	2	2	6
	3	3	6
	4	4	6
	5	5	6
	6	6	6
	7	1	5
	8	2	5
	9	3	5
	10	4	5
	11	5	5
	12	6	5
	13	1	4
	14	2	4
	15	3	4
	16	4	4
	17	5	4
	18	6	4
	19	1	3
	20	2	3
	21	3	3
	22	4	3
	23	5	3
	24	6	3
	25	1	2
	26	2	2
	27	3	2
	28	4	2
	29	5	2
	30	6	2
	31	1	1
	32	2	1
	33	3	1
	34	4	1
	35	5	1
	36	6	1

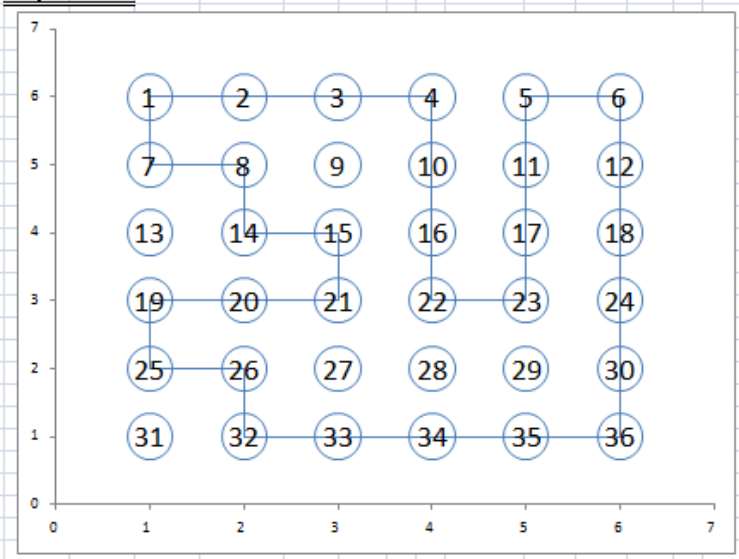
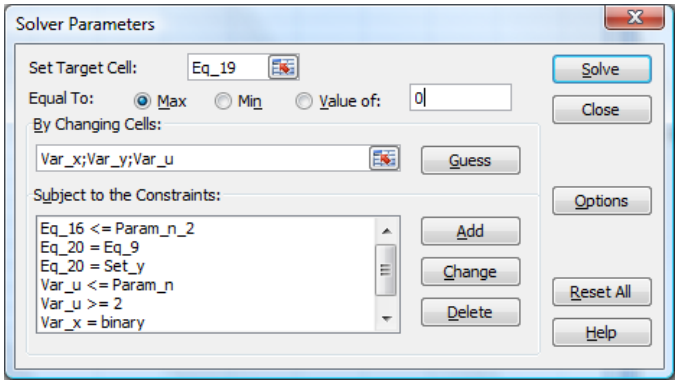


Table 5: Formulas for spreadsheet in Figure 15

Cell	Formula	Copied to	Name / Task
B63	=C3	B64:B122	Reverse arcs: stop→start
C63	=B3	C64:C122	Reverse arcs: start→stop
D63	=D3	D64:D122	Reverse arcs: copy costs
D123	=SUMPRODUCT(D3:D122;E3:E122)	-	*Computing costs*
F3	=IF(OR(B3=1;C3=1);0;INDEX($K$3:$K$38;B3)-INDEX($K$3:$K$38;C3) +$H$37*E3)	F4:F122	*Eq 16* (LHS)
I39	=SUMPRODUCT(I3:I38;J3:J38)	-	*Computing revenues*
I40	=I39-D123	-	*Eq 19*
L3	=SUMIF($C$3:$C$122;$H$3:$H$38;$E$3:$E$122)	L4:L38	*Eq 20* (LHS)
M3	=SUMIF($B$3:$B$122;$H$3:$H$38;$E$3:$E$122)	M4:M38	*Eq 9* (RHS)
E3:E122			*Var_x*
H36			*Param_n_2*
H38			*Param_n*
K4:K38			*Var_u*
J4:J38			*Var_y*
O3	=IF(J3=0;"";RANK(K3;$K$3:$K$38;1))	O4:O38	A preliminary rank of nodes
P3	=IF(J3=0;"";RANK(O3;$O$3:$O$38;1))	P4:P38	Rank of a node in the tour
Q3	=MATCH(U3;$P$3:$P$38;0)	Q4:Q38	Visiting sequence
Q39	=Q3	-	Last leg, return to depot
R3	=INDEX($U$3:$W$38;$Q3;2)	R4:R39	A visited node's x-coordinate
S3	=INDEX($U$3:$W$38;$Q3;3)	S4:S39	A visited node's y-coordinate

Figure 16 Solver settings for spreadsheet in Figure 15



From Figure 15 we see that the salesman visits only 30 of the 36 nodes, with a net profit of $812. Notice that the tour actually includes node 10 with $0 benefits, but skip node 13 with $30 in benefits. Using the Standard Solver it takes more than a full weekend to find the optimal solution. An early test version of Excel 2010 (Technical Preview) with the new Standard Solver finished during an overnight run. Again, an assignment formulation applying a full *n*×*n* matrix of the *x* variables would include too many variables for the Standard Solver. Using the commercial PSP V9.04, the solution time in Excel is 9.06 seconds for the flow formulation. This also reveals an alternative optimal solution, visiting 32 nodes. The solution time when the assignment formulation is implemented is 11.45 seconds, on the same

computer. In the assignment formulation a complete graph is assumed, and the extra variables are eliminated by extra constraints, thereby increasing the solution time.

Unfortunately the MTZ SEQs used (16) – (17) assumes node 1 to be the depot. Therefore we cannot apply this type of SEC if our goal is to find the optimal location for the depot.

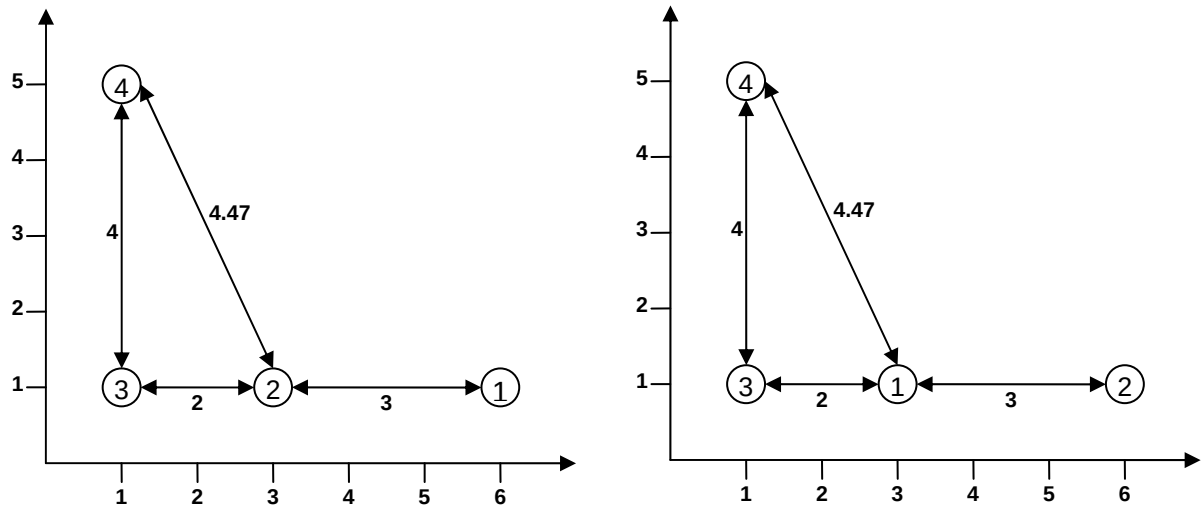
14. Pitfalls using MTZ SECs

For a closed tour the starting node can always be chosen arbitrarily, if all nodes have to be visited. Unfortunately, when applying the MTZ SECs, the solution may depend upon which node has been selected as the start node. When do we need to stay alert?

15. Non-complete graphs requiring multiple visits

Take a look at Figure 17. Two identical graphs are displayed, except that node 1 and 2 have been renumbered. You can easily find the optimal solution by visual inspection. Trying to solve one of them fails, whereas the other succeeds, if the MTZ SECs are applied in a closed TSP. There are two other nodes that could be renumbered as number 1. None of them will succeed if we try to solve using the MTZ SECs.

Figure 17 TSP in a non-complete graph, requiring multiple visits in a closed tour



Since this is a non-complete graph, a spreadsheet layout similar to Figure 7 is probably most efficient, skipping equation (18), as it is hardly needed.

16. The triangle inequality is not always satisfied

Have a look at the cost matrixes in Table 6. The only difference is that once more the nodes 1 and 2 have been renumbered. This is a complete graph, as there is a direct link between any node to every other node.

Table 6: Identical cost matrixes of a complete graph, the triangle inequality does not apply

c_{ij}	1	2	3	4	5
1	-	2	3	4	5
2	5	-	130	140	150
3	4	123	-	40	50
4	3	124	34	-	45
5	2	135	35	54	-

c_{ij}	1	2	3	4	5
1	-	5	130	140	150
2	2	-	3	4	5
3	123	4	-	40	50
4	124	3	34	-	45
5	135	2	35	54	-

Solving one of them using the flow formulation (7) – (10) and the MTZ SECs (16) – (17) returns a solution with a minimal cost of 209, visiting every node once. Solving the other returns a minimum cost of 28, visiting four of the nodes once and visiting one node four times. The numbering of the nodes has thus a great impact on which solution is obtained. The assignment formulation would return a minimum cost of 209 instead of 28. See also Lee and Raffensperger (2006) for using AMPL teaching TSP, where the DFJ SECs are being implemented.

For a complete graph a spreadsheet layout similar to Figures 9 to 11 is probably most efficient, skipping columns AO – AR and the plot, since no coordinates are given in this example.

17. Conclusion

Solving TSP using general purpose optimisation tools like MIP solvers in spreadsheets has been regarded practical only for problems of a 'small' size. Recent advancements in these types of software have increased this limit; problems of size 358 of non-complete graphs have been solved in less than 10 minutes.

Such general purpose optimisation tools also allow for a greater variety of types of TSP, whereas procedures designed specifically for TSP often restrict the problem to a limited number of variants. In fact, we may overlook the best solution by applying the 'standard' approach using the assignment formulation or these specific tools for solving TSP. We must be absolutely sure our problem formulation is valid – all relevant costs and revenues have to be considered, and the constraints must not be too limiting. Otherwise we may end up solving the wrong problem. Anticipating a specific type of solution when formulating the problem is like starting at the wrong end, and may lead to a poor result.

However, the SECs needed in a TSP formulation may have unfortunate consequences and limitations. When using the MTZ SECs, the selection of the base node can be critical, even for a closed tour in a complete graph. It may also prohibit a solution, even in a connected graph.

We have further seen that formulation matters – including non-existing variables and eliminating them by adding non-existing constraints – can both increase solution time and cause problems in finding the optimal solution (the number of variables or constraints may even become too big for the solver). A 'wide' formulation will always include the optimal solution. A 'tight' formulation may help finding the optimal solution, but may also exclude the optimal solution. A 'tight' formulation may reduce or increase the solution time, this depends on the type of solver used and the problem at hand.

To play safe a 'wide' formulation seems like a good strategy. If the graph is not complete or the triangle inequality does not apply, both imply situations where multiple visits may be required, then a replacement of the cost matrix may be advisable. Then the costs should be replaced by a minimum cost matrix (you can use the shortest path formulation $(n-1)^2$ times), which for many links may involve a lengthy tour visiting many nodes from node *i* to node *j*. The TSP model can then be 'tight', which may or may not be helpful for some solvers. Unfortunately the TSP model will then also be blind-eyed; it has no

real track of the tour or how many visits are actually being made at each node. The TSP solution then only indicates the sequence of the visits, and ignores any revisits.

References

Chlond, M. J. (2008). 'Shasha's gridspeed puzzle', *INFORMS Transactions of Education*, Vol. 9(1), pp. 46–52. Available online at http://ite.pubs.informs.org/.

Dantzig, G., Fulkerson, D. and Johnson, S. (1954). 'Solution of a large scale traveling salesman problem', *Operations Research*, Vol. 2, pp.393–410.

Gutin, G. and Punnen, A. P. (eds) (2007). *The traveling salesman problem and its variations*, New York: Springer.

Lee J., and J.F. Raffensperger: (2006). 'Using AMPL for teaching the TSP', *INFORMS Transactions on Education*, Vol. 7(1), pp. 37-69. http://archive.ite.journal.informs.org/Vol7No1/LeeRaffensperger/

Malandraki, C. and Daskin, M. S. (1993). 'The maximum benefit Chinese postman problem and the maximum benefit traveling salesman problem', *European Journal of Operational Research*, Vol. 65, pp. 218–34.

Miller, C. E., Tucker, A.. W. and Zemlin, R. A. (1960). 'Integer programming formulation of traveling salesman problems', *Journal of ACM*, Vol. 7, pp.326–9.

Pataki, G (2003). 'Teaching integer programming formulations using the traveling salesman problem', *SIAM Review*, Vol. 45(1), pp. 116–23.

Ragsdale, C. T. (2001). *Spreadsheet Modeling and Decision Analysis*, Cincinatti: South-Western College Publishing.

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Using Excel to Illustrate Hannah and Kay's Concentration Axioms

Paul L. Latreille and James Mackley

Abstract

Most courses in industrial economics/industrial organisation cover the measurement of industry concentration. In a classic paper Hannah and Kay (1977) propose a set of desirable criteria against which any of the numerous concentration measures may be judged. We describe how these criteria can be illustrated for students for several of the most popular measures using an Excel spreadsheet and an exercise sheet developed by the authors and freely available from the HEA Economics Network website.

JEL classification: A22, B41, C88, L11

1. Introduction

Most courses in industrial economics/industrial organisation typically discuss the issue of how to measure the extent of industrial/market concentration. This is fundamental to discussion of the structure-conduct-performance (SCP) paradigm and of empirical studies in relation to topics such as advertising and R&D, and also to an appreciation of the approach adopted by the competition authorities[1] to addressing the welfare implications of monopoly power and its regulation.

There are however, many alternative measures of concentration extant (see Table 1 below), and the question naturally arises as to as to whether one measure is 'superior' to another and hence should be preferred. Of course, in some instances the choice may be determined by data considerations (availability, decomposability) or with reference to relevant theory (Saving, 1970; Cowling and Waterson, 1976; see also Sleuwaegen and Dehandschutter, 1986). In a classic paper, Hannah and Kay (1977) instead propose an axiomatic approach – that is, a set of desirable criteria a 'good' concentration measure should possess[2] (see below). Some of the textbooks provide illustrations of different market share distributions and how these impact on the main measures of concentration, and accordingly discuss some of their strengths and weaknesses, including in relation to the criteria (see for example Ferguson and Ferguson, 1994; Lipczynski, Wilson and Goddard, 2009). However, while the criteria themselves are straightforward, and the above illustrations are useful, students do not always find it easy to relate these criteria to specific concentration measures, and hence to appreciate which are most likely to fail against particular criteria. The present paper describes how a simple Excel spreadsheet and guided simulation exercise may be used to illustrate some of the issues arising from the axiomatic approach for several of the most commonly used concentration measures. Both of these resources are freely available from the Economics Network website (http://www.economicsnetwork.ac.uk/archive/latreille_concentration).

[1] In the UK aspects of this function are fulfilled by the Office for Fair Trading and the Competition Commission.

[2] While the most popular, this is not the only set of criteria extant – see Marfels (1971) and Hause (1977) for alternatives, the latter also showing how several of the measures are related.

The remainder of the paper is set out as follows. In the next section 2 we briefly describe the main measures of concentration in the literature, followed by an outline of the Hannah-Kay axioms. We then outline the resources available focusing on the Excel spreadsheet, its interface and capabilities, while the final section 5 concludes.

2. Measures of concentration

As is well-known, there are two main types of concentration measure extant:

'Absolute' measures, which essentially use information on both the number of firms (N) and the variance of firm sizes (σ^2);

Relative measures (or inequality representations), which use information on σ^2 only.

The main statistical measures in the literature are summarised in Table 1 below, which also sets out special cases where appropriate. These measures (and one or two others) are discussed in more detail in Curry and George (1983), who examine some of their strengths and weaknesses. We do not repeat this discussion here: suffice it to say that, as is well-known, the widely used concentration ratio and the 'relative' measures more commonly fail the axioms than many of the others. These authors also provide a useful account of some of the other conceptual problems associated with measuring concentration such as the appropriate definition of the 'industry'/'market', the treatment of exports and imports, and of multi-product firms, etc. (from which we abstract in our simulations described below).

Table 1: Summary of the main statistical measures of concentration

Measure	Formula	Special cases
Absolute measures:		
Concentration ratio (x-firms)	$CR_x = \sum_{i=1}^{x} S_i$	
Hirschman-Herfindahl index[3]	$H = \sum_{i=1}^{N} S_i^2$	
Numbers equivalent Herfindahl index	$H_{NE} = \frac{1}{H}$	
(First order) Entropy	$E = -\sum_{i=1}^{N} S_i \log S_i$	
Relative entropy	$RE = \frac{E}{\log N}$	
Hannah-Kay index	$HK(\alpha) = \sum_{i=1}^{N} S_i^{\alpha}$	$\alpha = 2 : HK = H$
Hannah-Kay numbers equivalent index	$HK_{NE}(\alpha) = \left(\sum_{i=1}^{N} S_i^{\alpha} \right)^{\frac{1}{1-\alpha}}$	$\alpha = 2 : HK = H_{NE}$ $\alpha \to 1 : \log(HK) \to E$
Rosenbluth/Hall-Tideman index	$RHT = \frac{1}{2\sum_{i=1}^{N} iS_i - 1}$	
Relative measures:		
Gini coefficient	$G = \frac{N + 1 - 2\sum_{i=1}^{N} iS_i}{N}$	$G = 1 - \frac{1}{N(RHT)}$
Variance of logs of firm size	$V = \frac{1}{N}\sum_{i=1}^{N} (\log S_i)^2 - \frac{1}{N^2}\left(\sum_{i=1}^{N} \log S_i \right)^2$	$S_i = \frac{1}{N} (\forall i) : V = H$

Notes: S_i is the market share of firm i and x is the number of firms defining a particular index (often the x largest firms). The (first order) entropy measure is usually calculated with base 2.

[3] Note that this measure is sometimes expressed using market share percentages rather than proportions, and is then typically denoted by HHI. This form of the index is used by the US Department of Justice in guidelines for evaluating mergers, where HHI values below 1000 are seen as indicating relatively 'low' concentration, 1000–1800 'moderate' concentration, and those in excess of 1800 'high' concentration.

3. The Hannah-Kay axioms

The seven criteria proposed by Hannah and Kay (1977) for evaluating measures of concentration are reported in several of the main industrial economics texts and are as follows (of which the first four are generally regarded as being the most important):

1. If the concentration curve[4] for one industry/market lies everywhere above that for another industry, then the former should rank as being more concentrated (the 'concentration curve ranking criterion').[5]

2. The transfer of sales from smaller to larger firms should increase measured concentration (the 'sales transfer principle').

3. The entry of new firms of a size below that of the incumbent average should reduce measured concentration, while the exit of firms below that threshold should increase measured concentration (the 'entry condition').

4. Mergers should result in an increase in measured concentration (the 'merger condition').

5. Random brand switching (by consumers) should reduce measured concentration.

6. A smaller scale of entry should have less effect on measured concentration than a larger scale of entry.

7. Random factors in the growth of firms should increase measured concentration ('Gibrat's Law').

8. Not all measures satisfy all of these criteria, and in practice most are highly correlated with each other. Nonetheless, several of the measures fail to meet many of the criteria, something the simulations described in the exercise accompanying the spreadsheet are designed to illustrate.

4. The Excel spreadsheet and simulation exercise

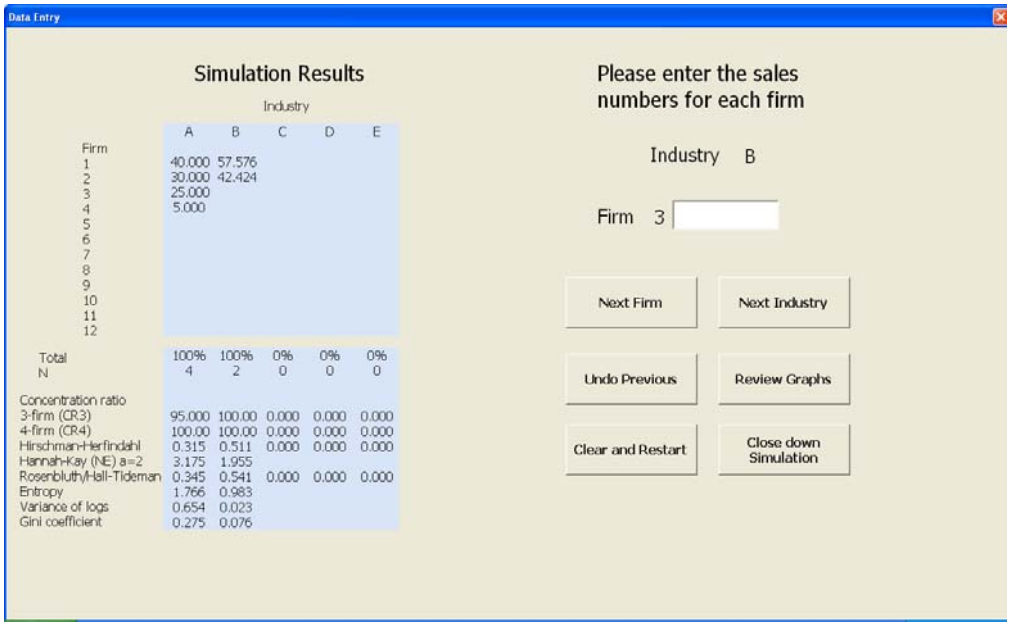
The Excel spreadsheet freely available from the Economics Network website (http://www.economicsnetwork.ac.uk/archive/latreille_concentration)[6] allows the user to enter data on market sales by firm for up to 12 firms and up to five industries/markets (see Figure 1 which shows a screen capture of the data entry/results screen). These are automatically converted to market shares and various of the main measures of industrial concentration calculated by the program.

[4] A concentration curve plots cumulative market share on the vertical against the number of firms ranked from largest to smallest on the horizontal.

[5] Where the curves intersect, the ranking of industries/ markets will depend on the weight accorded to large/small firms.

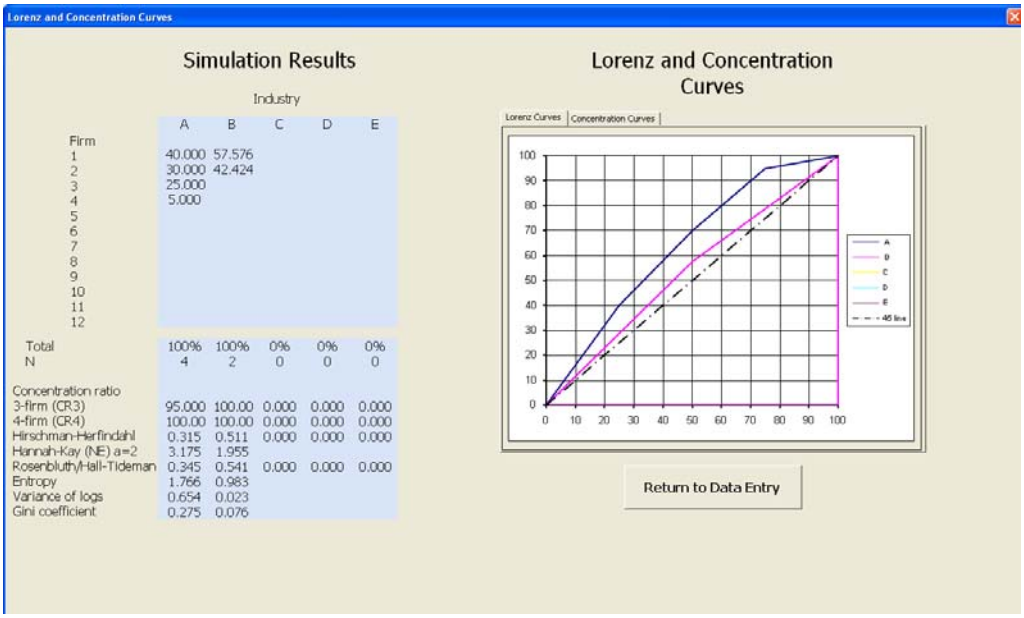
[6] The website also contains a short technical guide to using the spreadsheet, dealing for example with macros in Excel.

Figure 1 The data entry/simulation results screen



Once the data have been entered for each of the firms in a particular industry, clicking 'Next Industry' then allows data for the next industry to be entered. For each industry entered, the spreadsheet not only calculates the values of each of the concentration measures listed in Table 1 as noted, but also draws the associated Lorenz curve for each industry/market, the latter being obtained by clicking the 'Review Graphs' button (see Figure 2). This facilitates both statistical and graphical comparisons of the chosen markets.

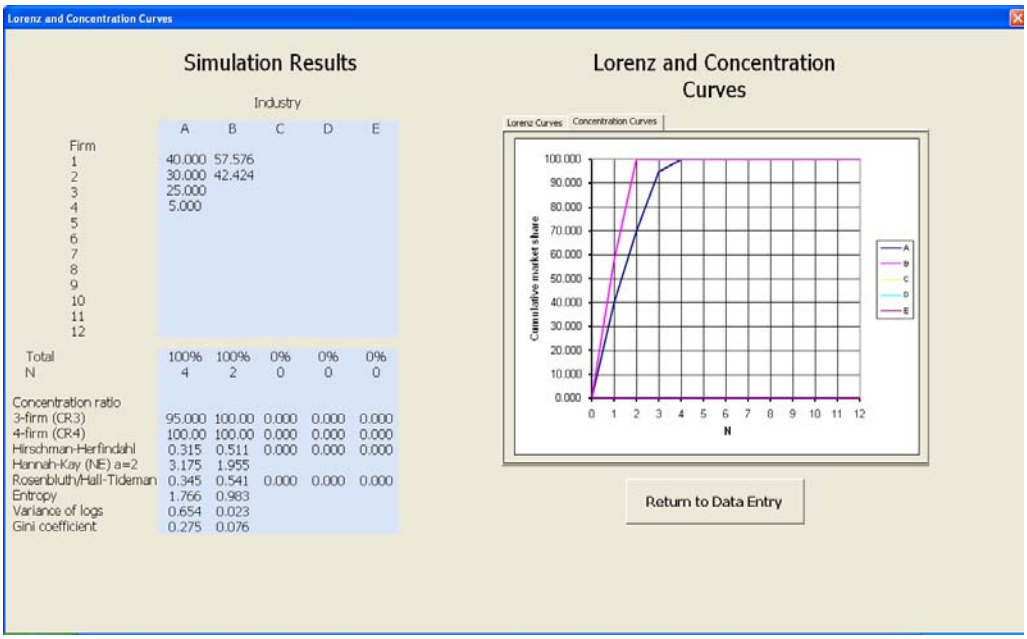
Figure 2 Lorenz curves



The simulation is further programmed to chart the accompanying concentration curves associated with each industry/market on a single diagram (see Figure 3), which are obtained by clicking the relevant tab

in 'Review Graphs' and thereby enables a straightforward comparison of two or more industries on this basis. This enables ready examination of the first of the Hannah-Kay criteria.

Figure 3 Concentration curves



In addition to the spreadsheet and user guide, as noted, the materials on the Network website also include a short exercise sheet describing a set of suggested simulations designed to illustrate each of the Hannah-Kay axioms and enabling students to explore which measures are more likely to fail a particular criterion. This can be used as a self-contained exercise for students to complete in their own time, and/or as the basis of class (or even on-line forum/wiki) discussion. Staff and students can, of course, also experiment with their own values for market shares, for example verifying those in their chosen course text.[7] The key point is that students get a better feel for how different market share distributions are encapsulated in the various measures of concentration, and which measures are likely to prove problematic in terms of particular criteria.

5. Conclusions

This short paper describes a set of resources freely available from the Economics Network's website that can be used to explore how different market share distributions are summarised by each of the main measures of industrial concentration extant, and how these measures perform in the context of the axiomatic criteria proposed by Hannah and Kay (1977). We believe this active learning tool is likely to give students an improved understanding of some of the strengths and limitations of a range of the commonly used statistical measures, and hence of their value in underpinning policy/regulation.

[7] An interesting aside is that the software sometimes produces different values from those in some of the popular textbooks, for example due to the use of different bases in calculating logarithms. This too can be deployed as a useful discussion point.

References

Cowling, K. and Waterson, M. (1976). 'Price-cost margins and market structure', *Economica*, Vol. 43, pp. 267–74.

Curry, B. and George, K.D. (1983). 'Industrial concentration: a survey', *Journal of Industrial Economics*, Vol. 31(3), pp. 203–55.

Ferguson, P.R. and Ferguson, G.J. (1994). *Industrial Economics: Issues and Perspectives* (2nd edn), London: Macmillan.

Hannah, L. and Kay, J.A. (1977). *Concentration in Modern Industry: Theory, Measurement and the UK Experience*, London: Macmillan.

Hause, J.C. (1977). 'The measurement of concentrated industrial structure and the size distribution of firms', *Annals of Economic and Social Measurement*, Vol. 6(1), pp. 73–107.

Marfels, C. (1971). 'Absolute and relative measures of concentration reconsidered', *Kyklos*, Vol. 24(4), pp. 753–66.

Lipczynski, J., Wilson, J. and Goddard, J. (2009). *Industrial Organization: Competition, Strategy, Policy* (3rd edn), Harlow: FT/Prentice Hall.

Saving, T. (1970). 'Concentration ratios and the degree of monopoly', *International Economic Review*, Vol. 11, pp. 139–45.

Sleuwaegen, L. and Dehandschutter, W. (1986). 'The critical choice between the concentration ratio and the *H*-index in assessing industry performance', *Journal of Industrial Economics*, Vol. 35(2), pp. 193–208.

Appendix

1. Industry Concentration and the Hannah-Kay axioms: a Simulation Exercise

The following simulations are suggestions based on Table 3.1 of Ferguson and Ferguson (1994) and also Lipczynski, Wilson and Goddard (2009) that are designed to illustrate the performance of some of the standard industry concentration measures in terms of the Hannah-Kay (1977) axioms.[8] In each case, the simulations can be undertaken using the Excel spreadsheet provided.

[8] The seven criteria are as follows (the first four being regarded as he more important):

1. If the concentration curve for one industry lies everywhere above that for another industry, then the former should rank as being more concentrated; where curves intersect, the ranking depends on the weight accorded to large/small firms (the 'concentration curve ranking criterion').
2. The transfer of sales from smaller to larger firms should increase measured concentration (the 'sales transfer principle').
3. The entry of new firms of size below that of the incumbent average should reduce measured concentration, while the exit of firms below that threshold should increase measured concentration (the 'entry condition').
4. Mergers should result in an increase in measured concentration (the 'merger condition').
5. Random brand switching should reduce concentration (since more consumers leave large firms to go to

The simulations consider the axioms in turn (letters in [ ] brackets refer to the industry in Ferguson and Ferguson); in each case compare the results from varying the market shares as suggested against the baseline results. At the end of each simulation, clear and reset before proceeding to the next simulation.

Of course you do not need to stick to the illustrations above, and are welcome to vary the market shares in other ways to see the effect on the various measures.

Simulation 1: Concentration curve ranking criterion

For this axiom, compare an industry [E] where the firms have sales of 4000, 3000, 2500 and 500 with a second industry [G] where the sales are 3800, 2800, 1300, 1000, 500, plus six firms each with sales of 100. Begin by comparing the concentration curves for these two industries by clicking on the 'Review graphs' button. Do the concentration curves cross? Which curve is higher and therefore ranked as more concentrated?

Now compare the data on the concentration measures in the bottom panel of the data sheet. Which measures are consistent with the rankings of the two industries as shown by the concentration curve and which are not (and therefore fail this axiom)? Suggest why.

Simulation 2: Sales transfer principle

For this axiom, consider an industry where the firms' sales are 4000, 3000, 1500, 1000 and 500 [F]. Compare this with an industry where half the sales of the smallest firm are now transferred to the fourth largest firm. What happens to the various measures of concentration? Which rise (in accordance with the axiom) and which do not (and thus fail it)? In the case of the failures, consider why.

Simulation 3: Entry condition

For this axiom, consider the first industry in Simulation 1 [E]. The average size (market share) of the firms in this industry is 25% (100%÷4 firms). Suppose a new entrant joins this industry taking 5% of each existing firm's sales (i.e. 0·05×4000=200 from Firm 1, 0·05×3000=150 from Firm 2, 0·05×2500=125 from Firm 3 and 0·05×500=25 from Firm 4), making a total market share for the entrant of 5% (<25% average market share for the industry prior to entry). The ranked sales are now: 3800, 2850, 2375, 500 (the new firm) and 475. Compare the concentration measures before and after entry. Is it true that the relative measures are most likely to fail? Which measures seem most sensitive to this entry?

Simulation 4a: Merger condition

For this axiom, consider merging the top two firms in the second of the markets in Simulation 1 [G], so that sales are now, in descending order: 6600, 1300, 1000, 500 and six firms with 100 (now 10 firms in total as compared with 11 pre-merger). Compare the concentration measures with the original values. Do all the measures satisfy the criterion in this case?

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smaller firms than vice versa).

6. A smaller scale of entry should have less effect on measured concentration than a larger scale of entry.
7. Random factors in the growth of firms should increase measured concentration (Gibrat's Law).

Simulation 4b: Merger condition

What happens if the merger is instead between the fifth and sixth largest firms originally, so that sales are now 3800, 2800, 1300, 1000, 600 and then five firms with 100 each? Which measures now appear to fail? Why is there a difference between the results of simulations 4a and 4b?

Simulation 5: Random brand switching

Starting from the sales figures in simulation 1 [E], suppose 30% of each firm's customers in the next period now switch randomly to other suppliers. This means that the largest firm loses sales of 0·3×4000=1200, the second largest 0·3×3000=900 and so on giving 750 and 150 respectively for the remaining two firms. This means that the total volume of sales switching is 3000. Suppose also that the largest firm *acquires* an equal share of the sales switching from other firms, i.e. $^1/_3$×1800=600, while the next largest acquires an equal share of the sales switching from firms 1, 3 and 4, i.e. $^1/_3$×2100=700. The third and fourth largest firms will similarly acquire sales of 750 and 950. The firms' new sales are therefore now: 4000–1200+600=3400; 3000–900+700=2800; 2500–750+750=2500; and 500–150+950=1300 respectively. Do all the measures satisfy this criterion, i.e. does measured concentration fall? Comment.

Simulation 6: Scale of entry

Compare the concentration values in simulation 3 with a larger scale of entry where instead of taking 5% of each firm's existing market share, the entrant now takes 10% (i.e. 0·1×40% from Firm 1, etc.) so that it emerges with a 10% market share. Do the concentration measures reflect that the scale of entry here is larger? Which measures do not and so appear to fail this criterion?

Simulation 7: Random growth factors (Gibrat's Law)

The following considers the operation of Gibrat's Law using the data from Lipczynski, Wilson and Goddard (2009) Table 9.1. The basic idea is that in each period, a firm has a 50:50 chance of either doubling in size or halving. The key is to watch what happens to measured concentration. Start with eight firms all with sales equal to 100. Then compare with a second period (use the new industry feature in the spreadsheet to compare the two) in which four firms double their sales while the remaining four see their sales halved (so four firms have sales of 200 while four have sales of 50). In the next period, allow half of the firms of each size to double their sales, while the remainder halve their sales (so sales are now 400, 400, 100, 100, 100, 100, 25 and 25). In the final period, repeat this so sales are 800, 200, 200, 200, 50, 50, 50 and 12.5. What happens to the measures? Do any not pass the criterion in this case?[9]

The evaluation

Do any measures appear to satisfy *all* of the above criteria, at least for the examples considered? Which fail most often and thus appear less suitable as measures of concentration? Why do the numbers for some of the measures differ from those in the books?

Of course you do not need to stick to the illustrations above, and are welcome to vary the market shares in other ways to see the effect on the various measures.

[9] Students interested in following up on this topic are referred to section 9.3 in Lipczynski, Wilson and Goddard (2009) to consider some extensions to this very simple example and see a summary of some of the extensive empirical literature in relation to Gibrat's Law (also known as the 'Law of Proportionate Effect').

2. User Guide: Industry Concentration Simulations

It is best to download and save this application before you begin. Depending on your settings, the application may not work in your web browser.

Starting the application

Note: It is possible that your Excel security settings are set too high to run the application, so you should check your macro security settings before opening the file.

In order to undo this in Excel 2003:

Open Excel and click on "Tools" in the menu bar.

Select "macro", and then from the drop down box select "security".

Make sure the setting is no higher than medium.

In order to undo this in Excel 2007:

Before opening the file, open Excel and click on the "Developer" tab in the ribbon. (If this is not showing, click the Microsoft Office Button (top left corner), and select Excel Options. On the Populat tab, click the Show Developer tab in the Ribbon check box.)

Click Macro Security and select Enable all macros. You can ignore the warning about this being potentially unsafe – the macros used in the simulations are safe – but you should reset the security level once you have finished.

When you are ready to start the game double click to open the Industry Concentration Simulations (Excel) file. If requested, click 'enable macros'.

The game should begin on start-up. If the application does not start, press "Ctrl g".

You will be welcomed by an opening screen which will close after five seconds. A welcome screen will then open.

Using the application

The Welcome Screen:

Click the "Begin Simulation" button when you are ready to start the simulation.

The Data Entry Screen:

From this screen you can enter the sales figures for each firm in a particular industry. You will start with Firm 1 in Industry A. Enter the sales figures for Firm 1; then click "Next Firm". You can now enter the sales figures for Firm 2. The percentage of the industry that each firm takes up is automatically calculated and shown in the table on the left-hand side. As you enter more data you will see the concentration ratios changing at the bottom of the table. You can enter data for a maximum of 12 firms. (If you attempt to enter data for more than 12 firms, you will see an error message.) Once you are happy with the number of firms in Industry A, click "Next Industry". You will now be able to enter data for Industry B. You can enter data for a maximum of five industries. If at any time you wish to view the Lorenz and Concentration curves, click "Review Graphs".

The Lorenz and Concentration Curves Screen.

From this screen you can review the Lorenz Curves and Concentration Curves. Select the graph you wish to view by clicking on the appropriate tab. To return to the Data Entry Screen, click “Return to Data Entry”.

Restart or Close Down.

If you wish to restart the simulation and enter different data, click “Clear and Restart”. This will clear all the data you have entered and take you back to the beginning of the simulation. If you are finished with the simulation, click “Close Down Simulation”. The application will shut down and you will be returned to your desktop.

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This Time is Different: Eight Centuries of Financial Folly

Carmen M. Reinhart and Kenneth S. Rogoff. Princeton University Press, 2009; 463 pages; £19.95
Reviewed by Stephen Buckles

Carmen Reinhart and Kenneth Rogoff have put together a fascinating tour of world financial history over the past eight centuries. The contribution of the work is to place a variety of financial crises in perspective. The text is completely convincing that financial cycles are normal and to be expected.

The work is one-fourth data appendices and a variety of brief summaries of past financial crises. Those data and crises descriptions provide researchers, paper writers and teachers with a wide variety of source material, examples and references.

The theme is met early on when the writers state and then eventually show that 'all the red lights were blinking in the run-up' to the current crisis, but were ignored due to widespread assumptions that this time is different. They demonstrate convincingly that 'this time is different' is a common theme and assumption among financial institutions, investors, economists and policy makers.

Reinhart and Rogoff divide their work into discussions of sovereign defaults, both domestic and foreign, exchange rate crises, inflation crises and banking crises. The financial crisis of the late 2000s is only the latest manifestation of the theme. Their clear explanations of shared causes and common traits of all of the types of crises make it much easier for a researcher, writer or teacher to understand the commonality. If you ever catch yourself thinking or saying that this time is different, pick up this book again. Look through the summary tables. You will quickly remember how common that thought has been, and how foolish the thought is and will continue to be.

Many readers will at first be overwhelmed by the number of examples and the data summaries; do not let that stop you. I recommend that you do not read the entire book straight through. Instead, you should read chapters for a specific type of financial crises – banking, currency, external and internal sovereign debt, or inflation. The currency debasement discussions in the early parts of the book are also instructive.

If you are interested only in the current crisis, then chapters 13 and 14 are 'must read' chapters. They are relatively self-contained and bring a fresh look at what led up to the current crisis, the warning signs and the so obviously wrong 'this time is different'. The chapters are clear about who sent warning signals and why they did. The authors are just as clear as why more observers and participants argued that this time is different, clearly demonstrating just how seductive that trap can be.

This reviewer has been perplexed as to how the economics and financial professions largely missed understanding the events leading up to the most recent crisis. The authors answer those concerns clearly and convincingly.

When a reader finishes this work, he or she will not be surprised to learn that the Greece/European Union sovereign default issues of 2010 were preceded by Greece being in default for 100 of the past 200 years. But maybe this time is different. Perhaps, we should not worry because of the reduction in risk provided by the existence of credit default swaps on Greek sovereign debt.

The book is a rich source of analogies and explanations for faculty writing and lecturing at a wide variety of levels, particularly for those teaching macroeconomic policy, trade policy and economic development courses. I cannot imagine discussing macroeconomic policy or financial markets at the introductory economic level or within advanced courses for majors without using some of the analysis and historical examples found in Reinhart and Rogoff. It should be a great historical example source for students who are writing research papers and honours theses on current and past financial crises. The data sources and past research reviews are a goldmine for interested student writers.

The book itself is not appropriate for most undergraduate courses nor do I believe that it was intended to be. Some chapters or sections may well be useful and appropriate for more advanced policy courses. An advanced undergraduate course focusing on sovereign debt, currency, banking and inflation crises could successfully use the work as a primary text. But be forewarned; the book is comprehensive and will be challenging for many undergraduates.

For faculty teaching those courses and for graduate students considering writing in these areas, the book is essential. It will help readers understand the causes of economic crises, the warning signs that a crisis just might be developing, and perhaps most importantly, that this time is not different.

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The Myth of the Rational Market: A History of Risk, Reward, and Delusion on Wall Street

By Justin Fox, HarperBusiness, 2009; 382 pages; ISBN 978 0 06 059899 0
Reviewed by John Brock

Abstract

Justin Fox, a former *Time* magazine business journalist and current Editorial Editor for the Harvard Business Review Group, started *The Myth* well before the current financial crisis erupted, but its release in 2009 could hardly have been better timed. The book is a masterfully documented and engaging history of the rise and the fall of the efficient market hypothesis (EMH). The history spans from the early 20th Century insights of mathematician Louis Bachelier and economist Irving Fisher to the recent sparring among economists – notably the University of Chicago's Eugene Fama and Dick Thaler.

The book explains the evolution of EMH from the early attempts to clarify the apparently random movements in the stock market, to Fama's EMH formulation in the 1960s (the price of a financial asset reflects all publicly-available information that is relevant to its value) to Michael Jensen's bold 1978 declaration that 'there is no other proposition in economics which has more solid empirical evidence supporting it than the Efficient Market Hypothesis' (p. 107). From its earliest characterisation, the powerful and mathematically eloquent theory of EMH has developed into a broader set of conclusions. Fox describes how EMH progressed from the observation that stock price movements were random, to the claim that it was impossible to predict stock prices and, finally, to the conviction that 'stock prices were in some fundamental sense *right*' (p. xiv). The author also keeps an eye on the skeptics, from Herbert Simon in the 1950s and psychologists Daniel Kahneman and Amos Tversky in the 1960s, to present-day behavioral economists such as Richard Thaler. The final chapter, 'The Anatomy of a Financial Crisis', provides an interesting account of the genesis of the crisis, concluding with Alan Greenspan's admission in Congressional testimony that he used to think that he was not smarter than the market, but then 'the whole intellectual edifice [of rational market theory] collapsed' (p. xii). While EMH may have spawned overconfidence in markets and paved the way for deregulation and *laissez-faire* policy, the recession of 2007–09 will probably inspire a pendulum swing in the other direction.

Economists as well as professional investors will find the *Myth of the Rational Market* an enjoyable, stimulating and worthwhile read. Undergraduate or graduate students, particularly business and economics majors enrolled in a History of Economic Thought or Personal Finance course, will take pleasure in reading this fascinating and very thoroughly documented story (particularly after the first half, which could be a little slow for the uninitiated). The beauty of the book is that Fox has integrated a great deal of economic and finance theory into a summary of the contributions by many of the key contributors of the past century. He not only discusses their academic contributions, he cleverly infuses interesting personal anecdotes along the way. For example, he begins the book with the story of Irving Fisher, who had already overcome many personal tragedies, suffering the theft of the only copy of his

manuscript of *The Nature of Capital and Income* (stolen in 1905 while he was talking in a phone booth). Thankfully, Fisher was not one to quit, and he entirely rewrote 'one of the principal building blocks of all present-day economic theory' (p. 4). Another story is of Alan Greenspan's classic trademark phrase 'irrational exuberance', which Greenspan thought of while taking a bath. Readers will discover that prominent economists are people, too!

In addition to the enjoyable narrative, *The Myth* provides some worthwhile insights for students of economics. Beyond learning about the historical chronology and interconnections that form the basis of our current economic and financial theories, readers will discover an important message about the methodology of the discipline. While mathematics provides a very useful tool, it is no more powerful than the assumptions that form the basis for its application. In classroom instruction, economists use assumptions not because they are always accurate representations of reality, but because they help students grasp the underlying logic of a situation. However, in the real world of financial markets, invalid assumptions sometimes generate dramatic failures. The author's discussion of the 1998 Long Term Capital Management (LCTM) debacle is not only captivating, but will serve as an eye opener for students. As Robert Merton, LCTM partner and 1997 Nobel Prize winning economist, so aptly acknowledged: 'The mathematics of financial models can be applied precisely, but the models are not at all precise in their application to the complicated real world' (p. 236).

From the first chapter to the last, readers will learn about how theories evolve – a continuous battle of ideas between academic leaders at the forefront of the discipline. The author discusses Thomas Kuhn's introduction of paradigm shifts in his classic, *The Structure of Scientific Revolutions*. Without realising it, students will be immersed in a story that generates an appreciation and better understanding of the scientific method – another reason to adopt this book in a college economics or finance course. Mr. Fox goes beyond merely discussing the basic logic of the models by addressing the personal attachment that many of those involved (understandably) acquire toward the theories they were instrumental in developing. It is hard to change one's position once a reputation and career have been built upon it. As John Maynard Keynes so appropriately stated: 'The difficulty lies, not in the new ideas, but in escaping from the old ones' (Keynes, viii). One such example Fox cites is how University of Chicago Merton Miller began his finance class one day in the early 1960s: 'He drew a vertical line on the blackboard, wrote "M&M" [for Modigliani-Miller] as a heading to the left of the line and "T" to the right. A student raised his hand and asked what the *T* stood for. "Them", Miller responded' (p. 95–6). Throughout the book Fox provides interesting anecdotes that help elucidate how fervently the players in the efficient markets evolution fought for their ideas. (By the way, for those who have an aversion to mathematics, the book has no graphs or equations.)

Fox ends his story with a prognosis from Robert Shiller, the Yale University economist well known for predicting both the stock market crash in 2000 and the recent housing bubble. Replying to Fox's question about the future of finance, Shiller replies: 'I think we're less than halfway through the development of financial markets. Maybe there's no end to it' (p. 321). It may be entirely coincidental that until the University of Chicago Booth School of Business moved to a new building in 2004, Fama occupied the office directly above Thaler's. A quick directory search shows that their offices are now both on the 4th floor of the new building. Is this a portent of the future of economics and finance theory? Could it be that future models will balance Eugene Fama's views of the rational and efficient market with the behaviouralist theories of Dick Thaler? Now that Fama and Thaler are on equal footing – as it were – will economics continue its movement from *homo economicus* to *homo sapiens*? The *Myth of the Rational Market* does not explore these questions, but instead focuses on Edmund Burke's sage advice: 'Those who don't know history are destined to repeat it.'

References

Keynes, John Maynard (1935). *The General Theory of Employment, Interest, and Money*, New York: Harcourt, Brace & World, Inc. (reprint 1965).

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Intermediate Macro Texts and the Economic Crisis of 2008-09

Jerry D. Gray and J. Michael Miller

Abstract

The authors use quantitative and qualitative analyses to examine how well 12 leading intermediate macroeconomic textbooks would have prepared students for understanding the economic crisis and stabilisation policies implemented in 2008-09. Evaluations distinguish between topical coverage of relevant concepts and theoretical underpinnings of interventionist policy.

The authors find heavy emphasis on content associated with macro stability but significantly less content that would have been useful in comprehending informed public warnings about instability and the interventionist policies that were actually implemented. Examples from the texts are offered to support their analyses. While not objecting to thorough treatment of arguments related to macro stability, the authors suggest students would be better served by texts that integrate more serious coverage of crises, potential causes, and policy responses.

JEL classification: A22, E00 and A10

1. Introduction

How well would popular intermediate macro texts have prepared students for comprehending the economic crisis of 2008-09 and the remarkable policy responses by the Federal Reserve, Treasury, and Congress? To address this question, we reviewed 12 widely used texts to assess the emphasis given to concepts, theories, and historical events that would have been helpful in this regard.

The general structure of our review emerges from agreement with Froyen that "recent developments [in intermediate level macroeconomics] remain within the two traditions of business cycle theory research: classical and Keynesian. The classical, or self-adjusting, school believes that markets generally work well when left free of government intervention, and where they do not, government is not likely to help" (1996, p. 113). The Keynesian school follows from the first page of *The General Theory* in which Keynes asserts that full employment is simply "a limiting point of the possible positions of equilibrium" (1936, p.3). In this view, crises and underemployment of resources are possible and potentially reinforcing so government intervention is appropriate, at least in some cases. Our review draws upon these characterisations to evaluate textbook content relating to these two traditions with regard to the possibility of crises and the appropriateness of government policy responses. We will refer to the school that views rational, individual maximising responses to shocks as stabilising and government intervention as ineffectual at best as the "non-interventionist" tradition. The tradition that allows for the possibility of vicious cycles and reinforcing effects that sometimes require stabilisation policy will be referred to as the "interventionist" view.

Our analysis rests on several fundamental premises. First, the 2008-09 crisis is the latest, but probably not the last, in a long history of crises in capitalist economies.[1] Second, competition between interventionist and non-interventionist traditions is longstanding, ongoing, and unlikely to be ultimately resolved. Arguments about the fundamental cause of crises will also remain unresolved, in part because it will always be possible to argue government policy is the cause rather than the cure.[2] Third, governments have frequently adopted interventionist policy prescriptions in economic downturns and crises. No textbook author, regardless of their view of macroeconomics, could have been surprised by calls for discretionary monetary and fiscal policies such as those implemented in response to the most recent crisis. Fourth, intermediate macro texts should prepare students to understand premises one through three by offering serious coverage of the underlying assumptions and theoretical structures of *both* interventionist and non-interventionist views.

It is important to stress that we are not interested in joining debates about the correctness of interventionist or non-interventionist views. We simply believe a strong intermediate text should prepare students to understand and critically evaluate the sort of macroeconomic events and policies seen recently, especially economic analyses and commentary intended for the general public. Evidence from quantitative and qualitative reviews leads us to conclude that while most intermediate texts thoroughly present non-interventionist theories, they should do more to prepare students for comprehending arguments about the possibility of crises and interventionist policy responses.

We begin with a section outlining a sample of economic analyses intended for the general public. We hope this short section conjures broader images of the events, public commentary, and policy responses that students were likely to confront. We then turn to a description of methods used to select texts and to conduct both quantitative and qualitative analyses. Qualitative findings are reported both in terms of the coverage accorded to simple analytical concepts and to more significant development of underlying theory. We conclude with a discussion of the apparent trajectory of textbook development.

2. A Case for Macroeconomic Literacy

Examples of informed commentary and policy responses that an intermediate text should have prepared students to understand and evaluate are ubiquitous. We focus on the period of September 2008 through the summer of 2009, drawing upon examples from the 2008 Nobel laureate in economics, members of the Federal Open Market Committee (FOMC), the business press, and headline-grabbing policies.

Paul Krugman repeatedly made arguments that one might expect intermediate students to easily recognise and assess. As early as September 2008, Krugman used his op-ed to remind readers about the vicious cycle of debt deflation and the severe recessions that can result from dramatic changes in liquidity preferences (2008). He also warned that the "current U.S. financial crisis bears a strong resemblance to the crisis that hit Japan at the end of the 1980s and led to a decade-long slump…". By the following May, Krugman's op-ed column argued that wage and price deflation, rational for each individual, may worsen rather than ameliorate the slump, especially if businesses and consumers expect deflation to continue in the future (2009). After quoting Keynes on the danger of falling prices, he went on to suggest the risk "America will turn into Japan – that we'll face years of deflation and stagnation – seems, if anything, to be rising".

[1] Historical precedents to the recent crisis have been the subject of much recent attention. See, for example, Roubini and Mihm (2010). In their opening chapter entitled "The White Swan," these authors suggest, "In the history of modern capitalism, crises are the norm, not the exception" (15).

[2] For example, John Taylor made this case for the recent crisis in *Getting Off Track: How Government Actions and Interventions Caused, Prolonged, and Worsened the Financial Crisis* (2009).

Widely distributed comments by members of the FOMC were also strikingly consistent with interventionist views that recessions can persist in the absence of stabilising monetary, and even fiscal, policy. In October 2008, Federal Reserve Chairman Ben Bernanke offered support for a second fiscal stimulus package in testimony before the House Budget Committee (Bernanke, 2008). At the American Economic Association meetings in January 2009, Janet Yellen noted that FOMC policy decisions in December 2008 resulted in the federal funds rate "effectively hitting the "zero bound" for the first time since the Great Depression" (Yellen 2009, p. 2). After arguing that in the current context she did not think that "existing automatic stabilizers – of whatever size – are likely to provide a sufficient boost to aggregate demand" (Ibid., p. 6), she concluded that, "If ever, in my professional career, there was a time for active, discretionary fiscal stimulus, it is now" (Ibid,. p. 11).

Students reading popular business press outlets would also have regularly confronted concerns about economic collapse and arguments in favor of interventionist policy. *Wall Street Journal* readers learned in October 2008 that Paul Ashworth, chief US economist at Capital Economics, was warning, "pretty much everything points toward deflation" and suggesting "The only thing you can hope for is that the prompt action of policy makers can maybe head this off first" (Reddy, 2008). *BusinessWeek* warned that "deflation is a nasty situation" (Cooper, 2008a) and suggested "the Fed is trying to ensure [the economy] will be strong enough to avoid deflation" (Cooper, 2008b). In November 2008, *Forbes* suggested to readers that the US economy was facing "a serious risk of deflation as the slack in goods, labor and commodity markets becomes deeper; the risk that we will end in a deflationary liquidity trap as the Fed is fast approaching the zero-bound constraint for the Fed funds rate; the risk of a severe debt deflation as the real value of nominal liabilities will rise, given price deflation, while the value of financial assets is still plunging" (Roubini, 2008).

Finally, it is difficult to imagine an intermediate macro student remaining unaware of the frequency, variety, and magnitude of policy efforts taken to stabilise the economy in this period. Of the long list of policies implemented, we highlight two examples that intermediate students may have found particularly jarring.[3] First, the FOMC slashed the federal funds target rate to 0-0.25 percent in December 2008 – continuing a period of 17 months in which the rate was lowered 10 times, including seven cuts of a half-point or more. Second, the $787bn discretionary fiscal stimulus package was approved by Congress and signed by the President.

Again, it is important to note that the macro events of the recent crisis are *not* unprecedented and that it is reasonable to expect textbooks to include pertinent historical examples. The Great Depression is the obvious precedent, particularly in magnitude and worldwide scale, but financial crises that quickly spread to the real sector of economies have been disturbingly frequent. Macroeconomists are familiar with numerous examples from the past two decades alone, including Mexico, Argentina, Russia, the broad Asian crisis, and Japan's "lost decade." The Japanese case is particularly notable because in a prosperous, developed country, the collapse in real estate and stock markets led to a *prolonged* recession in which monetary policy was limited by the zero lower bound. Even more recently, then-Fed Chairman Alan Greenspan publicly ruminated over the possibility of monetary policy ineffectiveness in the US economy (Greenspan, 2002).

Macroeconomics as an area of study emerged from the crisis of the Great Depression and subsequent interventionist arguments hold that discretionary monetary and sometimes even fiscal policies are necessary to stabilise the economy. Recalling our starting premises, it seems fair to expect intermediate macro texts to include content that would help students appreciate arguments for and against discretionary stimulus in times of crisis. We are not suggesting texts should *advocate* the interventionist

[3] The New York Federal Reserve Bank offers a useful "Financial Turmoil Timeline" that lists policies regarding the crisis taken from mid-2007 through mid-2010; the timeline can be accessed via http://www.newyorkfed.org/research/global_economy/Crisis_Timeline.pdf

understanding of macroeconomics, but simply that they should expose students to serious coverage of historical examples of crises as well as the interventionist approach to these macro events. It is from this view that our study reviews currently popular texts.

3. Methodology

3.1 Textbook Selection

Publishers are unwilling to release sales figures so truly definitive top-seller lists do not exist (Hoaas and Madigan 1999, p. 526). Attempting to compile a sample of influential texts, we reviewed syllabi from intermediate macro courses at leading American undergraduate economics programmes and then browsed bestselling macro textbook lists of online textbook vendors. We selected those that appeared most frequently, yielding a set of 12 books that we consider representative of the texts used across the country at the intermediate level. The texts used in this study are listed in Table 1.

Table 1: Textbooks included in this study

Title	Authors	Edition	Pages	Year
Macroeconomics	Andrew B. Abel, Ben S. Bernanke and Dean Croushore	6	609	2008
Macroeconomics: A Modern Approach	Robert J. Barro	n/a	466	2008
Macroeconomics	J. Bradford DeLong and Martha L. Olney	2	515	2006
Macroeconomics	Rudiger Dornbusch, Stanley Fischer and Richard Startz	10	580	2008
Macroeconomics: Theories and Policies	Richard T. Froyen	9	424	2008
Macroeconomics	Robert J. Gordon	11	603	2008
Macroeconomics	Robert E. Hall and David H. Papell	6	521	2005
Macroeconomics	Charles I. Jones	1	423	2008
Macroeconomics	N. Gregory Mankiw	6	554	2007
Macroeconomics: Theories, Policies and International Applications	Roger LeRoy Miller and David D. VanHoose	3	513	2004
Advanced Macroeconomics	David Romer	3	618	2006
Macroeconomics	Stephen D. Williamson	3	650	2008

3.2 Quantitative Analysis

Our quantitative review focused attention on percentage of text devoted to certain concepts, extent to which topics were discussed, and placement of content. We began our review by developing a rubric for standardised analysis (Bethune, 1992; Kalmi, 2007; Lopus, Paringer and Leet 2008). This rubric was split into two groups of eight topics each. The first group of topics was designed to reflect "interventionist" views that crises can (and do) occur and persist absent government action. Informed public commentary that students were likely to confront – highlighted briefly in the preceding "Case for Macroeconomic Literacy" section – guided the framing of these terms. The second group of topics was designed to reflect "non-interventionist" views that the economy is stable, that the business cycle is an equilibrium phenomenon, or that the economy automatically and quickly adjusts to full employment.

Table 2: Topics included in quantitative analysis

"Interventionist" Topics	"Non-interventionist" Topics
liquidity traps	"optimal" policy rules
zero lower bound on nominal interest rates	inflation targeting
debt deflation	quantity theory of money
deflation	wage-price spirals and hyperinflation
liquidity preferences	rational expectations
the Great Depression	real business cycles
Japan's "lost decade" in the 1990s	long-run fixed levels of potential output (vertical LRAS)
financial crises in general	natural rate of unemployment/ NAIRU

Distilling the competing approaches to crises and policy responses into eight terms each inevitably yields imperfect lists. Findings of a review structured in this way are necessarily a function of the topics, ideas, and concepts selected before assessing the texts, so our quantitative results will reflect our initial choices. Naturally, arguments could be made for framing the topics and concepts in different ways. For example, consider two alternative approaches to the interventionist view of crises. First, one could select terms more specifically related to the recent crisis and responses, using such concepts as subprime lending and quantitative easing. Alternatively, one could use broader terms associated with the interventionist view that are not as directly related to the possibility of crises, such as the Keynesian multiplier or fiscal policy in general. The first alternative would likely find significantly less content while the second would likely find more. Similarly, alternative approaches to the non-interventionist tradition may have found more or less content. As mentioned above, our choices for interventionist topics were simply made to assess content related to concepts and precedents widely cited in policy debates and the business press, while our non-interventionist choices reflect notions of macro stability and government interventions as ineffectual at best.

Recognising the necessarily arguable nature of this type of review, we offer the quantitative component of our analysis as simply a standardised, numerical heuristic of the texts' relative treatments. It is also important to understand that these lists do not adequately capture the work we did, as our analysis went well beyond simply looking for these words and phrases to investigate all closely linked concepts. For example, all pages that indicated a connection between policy and rules, whether they were explicit arguments for a certain monetary approach, discretion vs. rule debates, the Taylor rule, etc., were examined to determine if content on those pages should be included in the counts for "optimal" policy rules. Indeed, there is no unassailable way of quantifying this information, and we intend the lists of

terms to be viewed as one component or illustration of our review rather than as the essence of our analysis.

The next step in designing our rubric was to acknowledge that many instructors do not cover every chapter in a text and that the coverage devoted to later chapters may be less comprehensive. Therefore, to evaluate the relative placement of topics, we split each text into four equal sections by page number. Then, reviewing each text page by page, we recorded whether and where each topic was discussed or simply mentioned. In a technique derived in part from work by Bethune (1992) and Kalmi (2007), page counts for each topic in quarter-page units were recorded for all four quarters of each text. A brief but explicit mention of a topic was recorded as a quarter page. While this method does not provide insight into the quality of coverage, it does allow for comparisons of focus across topics, texts, and relative location (Bethune, 1992). To prevent a potential double-counting bias among related ideas, a total for any of the topics in each group was recorded as well. For example, if a half-page discussion of liquidity traps also explicitly mentions the zero lower bound, we counted it as a half-page for liquidity traps and a quarter-page for the zero lower bound, but also as just a half-page for interventionist topics in that section of the text.

Then, drawing on a technique used by Lopus, Paringer, and Leet (2008), we noted whether each quarter of the text omitted, simply mentioned or discussed each individual topic. This methodology was designed to evaluate if, where and to what extent each of the texts incorporated the chosen concepts. To illustrate our methodology, consider DeLong and Olney's quarter-page, yet thorough, discussion of deflation that quotes Keynes at length. This section explains "we have not had experience with deflation – falling prices in general – since the Great Depression of the 1930s" (2006, p. 226). Our analysis incorporates this passage as a quarter-page on interventionist topics as well as both a discussion of deflation and a mention of the Great Depression in the second quartile of this text.

In our quantitative analysis, we chose to include all content related to our topics, regardless of how it was presented. There were many instances where terms appeared but were treated in dismissive ways. All judgments about tone and treatment were reserved for our qualitative analysis and did not influence our counting methods.

3.3 Qualitative Analysis

Following Reardon (2007), we perused each chapter of the 12 texts to evaluate the broad approach each takes in treating the topics identified. This process consisted of scanning each page, reading relevant passages, and noting presentation of the concepts and the context in which they appear. This process also allowed us to monitor the accuracy of our quantitative findings and to check for use of less common vocabulary when referring to our selected concepts.

4. Results and Findings

4.1 Quantitative Analysis

Our quantitative findings indicate a consistent emphasis on selected non-interventionist topics and concepts across the set of texts, both in terms of the proportion of space allocated and the placement and treatment of topics. The space allocated to our selected groups of topics favours non-interventionist topics by a ratio of over three-and-a-half to one overall; this emphasis is particularly pronounced in the first half of the texts where this ratio is nearly four-and-a-half to one.[4] Table 3

[4] Our presentation of proportions and percentages in this section does not imply that we have optimal figures in mind. Rather, these observations illustrate the dominance of non-interventionist approaches found in our review.

illustrates the average percentage of the texts allocated to each group of topics by halves of textbook and overall.

Table 3: Mean percentage by topic group and location in texts

Section	Interventionist	Non-interventionist	Ratio
1st half	1.14%	5.14%	4.49
2nd half	2.27%	7.28%	3.21
Entire book	1.73%	6.21%	3.58

The texts allocated 6.21 percent of their space to our selected non-interventionist topics, while selected interventionist content constituted 1.73 percent of the books. In other words, 1 of every 16 pages examined covers the non-interventionist topics while 1 in every 58 covers the interventionist content. Those that included the most coverage of the interventionist ideas as a percentage were Mankiw at 3.38 percent and Froyen at 2.95 percent. At the other end of the spectrum, three texts devoted less than 1 percent to the interventionist ideas: Jones at 0.83 percent, Williamson at 0.38 percent, and Barro at 0.32 percent. In contrast, seven texts allocate 5.5 percent or more of their space to the non-interventionist ideas, led by Froyen at 14.39 percent and Romer at 10.60 percent.

Not a single text devotes more space to selected interventionist topics than non-interventionist content. This may not be surprising given the recent dominance of the non-interventionist view. Considering our fundamental premises, however, the gap between the relative attention given to each is disconcerting. When we sort the percentage of textbook space allocated to each group of topics for all 12 books, the highest 11 percentages are all from the non-interventionist group.

Table 4 summarises findings on the number of texts that omitted, simply mentioned or discussed each of our 16 topics. Non-interventionist topics are included in more texts and presented at length with much more frequency. Only one of the eight non-interventionist topics was omitted from more than two textbooks while all eight were discussed in at least half of the books. In fact, whenever non-interventionist topics were included, they were almost always discussed at some length rather than simply mentioned. In contrast, of the interventionist topics, only the Great Depression and deflation were included in 10 or more texts. Interventionist topics were much more likely to be found as passing or brief mentions rather than as a focal point of any sort of discussion or analysis.

Finally, we excluded mere mentions to assess the number of texts that discuss each topic and the placement of these discussions. Table 5 confirms the prominent focus allocated to the non-interventionist concepts as a whole. Seven of the eight non-interventionist terms are discussed in some detail in at least nine of the texts, while the only interventionist topic that receives equivalent attention by this measure is the Great Depression. The emphasis on non-interventionist topics is similar across the set of books and over different sections. Discussions of interventionist topics tend to come later in the books.

Our quantitative findings all support the conclusion that the non-interventionist ideas receive superior attention in the texts. Percentage of text, the extent to which topics are covered and placement of content all reflect dominant attention given to the non-interventionist concepts. Our qualitative analysis largely echoes these observations.

Table 4: Treatment of topics in texts reviewed

	Topic	Omitted	Only mentioned	Discussed	Total including topic
Interventionist topics	Great Depression	0	1	11	12
	Japan/ "lost decade"	0	5	7	12
	deflation	2	6	4	10
	liquidity trap	3	2	7	9
	financial crisis (broad)	5	3	4	7
	liquidity preferences	6	2	4	6
	zero lower bound	6	2	4	6
	debt deflation	9	1	2	3
Non- interventionist topics	inflation targeting	0	1	11	12
	rational expectations	0	1	11	12
	real business cycles	0	1	11	12
	"optimal" policy rules	1	0	11	11
	NR of unemployment/ NAIRU	1	0	11	11
	wage-price spirals and hyperinflation	1	2	9	11
	QTM	2	0	10	10
	vertical LRAS	5	1	6	7

Table 5: Texts discussing topic by location

	Topic	1st half	2nd half	Entire book
Interventionist topics	Great Depression	7	10	11
	Japan/ "lost decade"	3	6	7
	deflation	1	2	3
	liquidity trap	3	4	7
	financial crisis (broad)	0	4	4
	liquidity preferences	2	2	4
	zero lower bound	1	3	4
	debt deflation	1	1	2
	Mean	**2.25**	**4.00**	**5.25**
Non- interventionist topics	inflation targeting	0	11	11
	rational expectations	3	10	11
	real business cycles	3	9	11
	"optimal" policy rules	1	10	11
	NR of unemployment/ NAIRU	8	7	11
	wage-price spirals and	5	4	9
	QTM	9	4	10
	vertical LRAS	5	4	6
	Mean	**4.25**	**7.38**	**10.00**

4.2 Qualitative Analysis

Given the events of Autumn 2008 and the ensuing public discussions and policy implementations, appealing macroeconomic texts would offer two related but somewhat distinct elements. The less ambitious element would be to identify and clearly explain concepts that have traditionally been linked to crises. As noted in the "Case for Macroeconomic Literacy" section above, several of these concepts – such as the liquidity trap, Japan's "lost decade" and deflation – were commonly referenced among informed commentary regarding the recent crisis and policy actions. A second, more ambitious element would be to offer serious *theoretical* support for the possibility of persistent recession and the resulting need for discretionary monetary and fiscal policy. We address both of these distinct but closely related elements here. Reading relevant passages and noting the presentation of concepts helped us assess the depth, clarity and sophistication of selected interventionist arguments that are particularly relevant to understanding recent events. We will address the topical coverage before moving to theoretical treatments.

4.2.1 Concepts

Most texts presented topics that have been associated with severe macroeconomic downturns such as the Great Depression and Japan's "lost decade" but the quality of these treatments varies significantly. DeLong and Olney is probably the strongest text in terms of devoting significant attention to concepts associated with financial and economic crises. Early in their text they provide a useful discussion of the 1929 stock market crash, the important role of expectations and reinforcing effects, and the Great Depression (pp. 59-60). The authors provide useful illustrations, such as, "If you thought the economic future might be bad, you had a powerful incentive to avoid debt. And in the short run the easiest way to avoid debt is to refrain from purchasing large consumer durables on credit" (p. 59). In the middle of their text, they mention deflation and note we are fortunate there has been no deflation since the Great Depression (p. 226). Later, there is a strong treatment of financial crises and flight to safe, liquid assets (p. 409).

Mankiw's text also fared better than most in terms of identifying and discussing concepts important to understanding recent macroeconomic issues. In fact, Mankiw is the only author to include all eight interventionist topics from the quantitative analysis. On page 321, Mankiw devotes attention to the destabilising effects of deflation, telling students, "Many economists blame this deflation for the severity of the Great Depression. They argue that the deflation may have turned what in 1931 was a typical economic downturn into an unprecedented period of high unemployment and depressed income." In explaining this, he mentions the dangers of debt deflation and links this to a decrease in investment spending: "When firms come to expect deflation, they become reluctant to borrow money to buy investment goods because they believe they will have to repay these loans later in more valuable dollars" (p. 323). These discussions are quickly paired with a "case study" section on the "Japanese Slump of the 1990s" (pp. 324-5). This thorough, full-page discussion concludes that "although economists differed about whether fiscal or monetary policy was more likely to be effective, there was wide agreement that the solution to Japan's slump, like the solution to the Great Depression, rested in more aggressive expansion of aggregate demand". Mankiw proceeds to discuss the liquidity trap and explains that nominal interest rates are limited by the zero lower bound.

Three other texts also provide adequate coverage of related topics. The Abel, Bernanke and Croushore (2008, pp. 424-7) and Dornbusch, Fischer and Startz (2008, pp. 254-5) texts discuss the possibility of a liquidity trap in similar ways, but both treatments might be judged overly sanguine. A useful illustration is Dornbusch, Fischer and Startz's passage that suggests a zero lower bound situation is "unlikely" in the US (2008, p. 255). Gordon's text also links Japan's difficulties to deflation (2008, pp. 118-9) and mentions the possibility of a liquidity trap and monetary policy ineffectiveness. At best, his approach probably sends a mixed message to students about the dangers of falling price levels. In a section on Keynesian arguments about the failure of self-correction (pp. 216-8), he writes, "Unfortunately, the

stimulative effects of price deflation are not always favorable, even when the Pigou Effect or real balance effect is in operation" (p. 218). Students may have difficulty reconciling Gordon's characterisation of deflation as "not always favourable" with the gravity of the business articles that warned "deflation can choke a weak economy and spiral out of control" (Reddy, 2008).

The remaining texts all offer what we judge to be inadequate treatments of concepts relating to the recent crisis. Romer includes nearly every selected interventionist topic, but they are not featured as important concepts for students to think about and the tone in which they are presented is often rather dismissive. Hall and Papell (2005) do mention the zero lower bound (p. 398) and discuss Japan's problems with deflation (pp. 511-7), but these topics are marginalised – to the last 10 pages of the text in the case of Japan. They also stress that one of five central ideas gleaned from "recent developments in macroeconomics" (p. 464) is that the "economy is basically stable" (p. 466). Barro (2008) and Jones (2008) include the fewest number of relevant concepts and our qualitative review confirms this lack of attention. Neither provides explanations of monetary policy ineffectiveness, and Barro discusses the Laffer curve (pp. 335-6) with significantly more seriousness than the Keynesian multiplier (pp.400-1). Finally, students using Williamson's text might be particularly confused by the alarm expressed over a falling price level when deflation is covered only in a feature-box titled "Should the Fed Reduce the Inflation Rate to Zero or Less?" (2008, p. 575). This box begins by telling students, "Our monetary intertemporal model tells us that the optimal rate of inflation is negative, which implies that the Fed should engineer a rate of growth in the money supply that would give permanent deflation".

In summary, DeLong and Olney (2006) and Mankiw (2009) offer the strongest coverage of relevant concepts, while Abel, Bernanke and Croushore (2008), Dornbusch, Fischer and Startz (2008) and Gordon (2008) offer adequate presentations. We identified this topical coverage of concepts as a less ambitious element because a more beneficial textbook treatment would not only familiarise students with relevant concepts, but also offer an opportunity to understand the theoretical underpinnings of arguments for and against the dramatic policy actions that were taken.

4.2.2 Theory

Our review found considerable variation in the treatment of the theoretical motivations behind interventionist responses to crises. We judge several to be generally effective in developing interventionist analysis in a serious way, but five were found to be particularly weak. Froyen offers the most robust treatment of interventionist theory. As mentioned before, this derives from his commitment to incorporating both recent developments and ongoing fundamental disagreements between macroeconomists. His success in presenting interventionist analysis is even more notable in light of the fact that he unambiguously devotes the largest share of his text to our selected non-interventionist topics.

Froyen's approach to investment is distinctive. He quotes revealing sections from Keynes to highlight his arguments related to the volatility of investment: "Knowing that our own individual judgment is worthless, we endeavor to fall back on the judgment of the rest of the world, which is perhaps better informed. That is, we endeavor to conform with the behavior of the majority or the average" (pp. 79-80; citing Keynes 1937, p. 214). Froyen nicely summarises some of the key insights in writing that "expectations of the future profitability of investment projects rested on a precarious base of knowledge, and Keynes felt that such expectations could shift frequently, at times drastically, in response to new information and events" (2008, p. 80). In this way, Froyen offers a foundation for reinforcing effects in consumption, investment and income that can create significant demand volatility.

Froyen does more than mention historical examples of a liquidity trap, augmenting them with theoretical foundations. He traces through Keynes's three motives for holding money (2008, p. 103) and devotes two pages to speculative demand for money. This analysis culminates in the possibility of a liquidity trap. Froyen's text provides a helpful framework for understanding recent events and policy

because he does not simply present interventionist arguments and then abandon or largely ignore them later. Rather, throughout his text, Froyen treats the interventionist approach as one of two general, ongoing traditions of macro theory.

We found Miller and VanHoose to offer the second-best theoretical development of interventionist concepts. Like most others, they include the basic mathematics of the multiplier, but also provide an intuitive understanding of the reinforcing relationship between consumption and income. They connect this to potentially sharp changes in investment spending (Miller and VanHoose, 2004, pp. 158-9). These ideas are quickly reinforced with discussions of the 2001 recession in the United States. The text also explicitly develops the portfolio motive for holding money (Ibid., pp. 199-200).

Three other texts offer generally effective treatment of theoretical concepts. Dornbusch, Fischer and Startz offer a significant treatment of multiplier concepts (pp. 202-5, 244) after a thorough early discussion of business cycles. Their text devotes roughly one full page to a sound Keynesian explanation of the causes of the Great Depression, emphasising that the "Keynesian model not only offered an explanation of what had happened but also suggested policy measures that could have been taken to prevent the Depression and that could be used to prevent future depressions" (pp. 467-8). Gordon quickly treats some of the fundamental Keynesian arguments related to the failure of self-correction and need for interventionist policy in chapter 7 of his text (2008, pp. 216-8). However, this treatment is limited to flat LM and steep IS curves with little of the underlying explanation that is developed in Froyen. Finally, Mankiw (2007) also offers a generally effective treatment of Keynesian theoretical frameworks, but it is somewhat tempered because Keynesian analysis is not introduced in a thoroughgoing way until the section on "Macroeconomic Policy Debates" in part four of a five-part text. All these authors do devote attention to Keynes and the IS-LM model, though failure of self-correction is typically presented in terms of a "sticky-prices model". It is difficult to understand how students will comprehend recessions as a result of sticky prices when the dangers of deflation and interest rate policy ineffectiveness are emphasised in informed public discourse.

Hall and Papell (2005) and Jones (2008) rarely discuss Keynesian analysis in any meaningful way, and texts that strongly commit to real business cycles (Barro, 1996 and Romer, 2006) or a strong emphasis on microfoundations (Williamson, 2008) are, as expected, weak in presenting any theoretical context for recent policy actions. The models featured in these five texts inevitably lead to the conclusion that policy rules are preferable to any discretionary policies and that fiscal policy is always ineffective, if not harmful.

5. Conclusions and Looking Forward

5.1 Summary of Findings

This review began by questioning how well textbooks would have prepared students for understanding arguments about the possibility of crises and need for policy intervention. Once again, we recognise quantitative findings will reflect choices made by reviewers and alternate choices may yield differing results. However, we are confident that any review seeking to address our opening question by comparing content regarding crises and policy responses associated with the two traditions of macro thought would reach similar conclusions.[5]

Our quantitative results reveal relatively little crisis-related interventionist content, both overall and particularly in comparison to the space allocated to non-interventionist ideas. We find the serious and

[5] We believe even a casual look at any of the twelve texts reviewed here will lend confidence to this assertion and our findings in general. Quantitative findings or relative rankings of texts may differ with alternative approaches, but the overall picture seems likely to be very similar.

thorough treatments of the non-interventionist content to overwhelm attention given to relevant interventionist material in terms of percentage allocated by each book, the extent to which topics were discussed, and the placement of content.

Our qualitative analysis approached the texts with two questions in mind. First, how well did texts expose students to key concepts associated with recent events? Second, how well did texts develop the theoretical framework necessary to understand debates about the policies that were implemented? DeLong and Olney (2006) and Mankiw (2007) devoted the most significant attention to concepts related to crises. Abel, Bernanke and Croushore (2008), Dornbusch, Fischer and Startz(2008) and Gordon (2008) also provide adequate coverage. Froyen (2008) is the strongest text in terms of developing the theories that motivate recent policies of the Fed, Treasury, and Congress. Miller and VanHoose (2004) run a relatively close second with Dornbusch, Fischer and Startz (2008), Mankiw (2007) and Gordon (2008) also providing generally adequate treatments of the Keynesian foundations for interventionist approaches.

Given our opening premises, we conclude that the overwhelming emphasis many intermediate texts give to non-interventionist approaches would not have prepared students well to either understand important historical precedents or fully comprehend the crisis, policy responses, and contemporary commentaries.

5.2 Looking Forward

In light of our findings of generally inadequate helpful coverage in our selected intermediate texts, the 2008-09 crisis would seem to call for revisions that, at a minimum, elucidate the foundations of recent policies. However, comments by prominent economists encourage little optimism. Robert Shiller writes to the *New York Times*: "I fear that there will not be much change in the basic paradigms… The rational expectations models will be tweaked to account for the current crisis. The basic curriculum will not change… I hope I am wrong" (Cohen, 2009). The same *Times* article notes that John Taylor plans to include content about the crisis, but has indicated he believes the "explanations of fundamental principles won't change".

Writing on changes to economic pedagogy necessitated by the crisis, Mankiw's May 2009 *New York Times* piece seems to validate Shiller's fears. Three of the four "subtle ways" Mankiw suggests the teaching of economics will change amount to tinkering with current treatments on "the role of financial institutions", "the effects of leverage" and "the challenge of forecasting". We consider his fourth area for potential change, "limits of monetary policy," to be more substantive. Mankiw (2009) writes:

> Only rarely in the past did students ask what would happen if the central bank cut interest rates all the way to zero and it still wasn't enough to get the economy going again. That is no surprise; after all, interest rates near zero weren't something that they, or even their parents, had ever experienced. But now, with the Federal Reserve's target interest rate at zero to 0.25 percent, that question is much more pressing.

We found this to be surprising in three ways. First, there *are* recent historical examples. Japan is the obvious case, but in the US, the FOMC lowered the federal funds rate to 1.00 percent in June 2003 and kept it there for a year. Greenspan publicly discussed a zero lower bound, even if 1.00 percent is not "near zero" (Greenspan, 2002). All of the texts reviewed here were published well after Japan's "lost decade" and popular discussions concerning the possibility of monetary policy ineffectiveness and potential deflation stemming from the 2001-02 recession in the US Second, we believe it is the role of the textbook to provide students with theories, tools and information to help them understand both past and potential future macroeconomic realities and policy options, regardless of whether students ask about such possibilities. Finally, hyperinflation is not likely to be "something they, or even their

parents, had ever experienced" or view as pressing, yet Mankiw devotes roughly five of the first 108 pages of his text to hyperinflation, its causes, costs and policy implications. Nevertheless, we do appreciate that Mankiw seems to be calling for at least one significant change in textbook treatments.

More widespread and thorough treatment of the limits of monetary policy would be a step in the right direction, but given our starting premises, we believe intermediate students would be better served by more fundamental changes. As macroeconomic crises and subsequent discretionary stimulus seem likely to recur in the future, we support changes that better prepare students for understanding both historical precedents and relevant theory. Vigorous coverage of non-interventionist arguments is useful and appropriate, but more serious treatment of long-standing interventionist ideas and approaches would have helped students understand and critically assess recent public debates and implemented policies.

References

Abel, A. B., Bernanke B. S. and Croushore, D. (2008). *Macroeconomics* (6th edn), Boston: Pearson Education, Inc.

Barro, R. J. (2008). *Macroeconomics: A Modern Approach,* Mason, OH: Thomson South-Western.

Bernanke, B. S. (2008). Economic outlook and financial markets, Testimony before Committee on the Budget, U.S. House of Representatives, 20 October. Available from: www.federalreserve.gov/newsevents/testimony/bernanke20081020a.htm

Bethune, J. J. (1992). 'History of economic thought: a survey of undergraduate textbooks', *Journal of Economic Education,* Vol. 23(2) (Spring), pp. 153–61.

Cohen, P. (2009). 'Ivory tower unswayed by crashing economy', *New York Times*, 5 March.

Cooper, J. C. (2008a). 'A real risk of deflation', *BusinessWeek*, 10 November.

Cooper, J. C. (2008b). 'A deflation maelstrom in the making', *BusinessWeek,* 29 December.

DeLong, J. B. and Olney, M. L. (2006). *Macroeconomics* (2nd edn), New York: McGraw-Hill/Irwin.

Dornbusch, R., Fischer, S. and Startz, R. (2008). *Macroeconomics* (10th edn), New York: McGraw-Hill/Irwin.

Froyen, R. T. (1996). 'The evolution of macroeconomic theory and implications for teaching intermediate macroeconomics', *Journal of Economic Education*, Vol. 27(2) (Spring), pp. 108–15.

Froyen, R. T. (2008). *Macroeconomics: Theories and Policies* (9th edn), New Jersey: Pearson Prentice Hall.

Gordon, R. J. (2008). *Macroeconomics* (11th edn), Boston: Pearson Education, Inc.

Greenspan, A. (2002). Issues for monetary policy. Remarks before the Economic Club of New York, New York City, 19 December. Available from: www.federalreserve.gov/boarddocs/speeches/2002/20021219/default.htm

Hall, R. E. and Papell, D. H. (2005). *Macroeconomics: Economic Growth, Fluctuations, and Policy* (6th edn), New York: W. W. Norton & Company, Inc.

Hoaas, D. J., and Madigan, L. J. (1999). 'A citation analysis of economists in principles of economics textbooks', *Social Science Journal,* Vol. 36(3), pp. 525–32.

Jones, C. I. (2008). *Macroeconomics*, New York: W. W. Norton & Company.

Kalmi, P. (2007). 'The disappearance of cooperatives from economics textbooks', *Cambridge Journal of Economics,* 31(4), pp. 625–47.

Keynes, J. M. (1936). *The General Theory of Employment, Interest and Money*, New York: Harcourt, Brace and World.

Keynes, J. M. (1937). 'The general theory of employment', *Quarterly Journal of Economics,* 51(2) (February), pp. 209–33.

Krugman, P. (2008). 'The power of de', *New York Times*, 8 September.

Krugman, P. (2009). 'Falling wage syndrome', *New York Times*, 4 May.

Lopus, J. S., Paringer, L. and Leet, D. R. (2008). 'The treatment of the role of government in high school economics textbooks', *Journal of Private Enterprise,* Vol. 24(1), pp. 155–63.

Mankiw, N. G. (2007). *Macroeconomics*, (6th edn), New York: Worth Publishers.

Mankiw, N. G. (2009). 'That freshman course won't be quite the same', *New York Times*, 24 May.

Miller, R. L. and VanHoose, D. D. (2004). *Macroeconomics: Theories, Policies, and International Applications* (3rd edn), Mason, OH: Thomson South-Western.

Reardon, J. (2007). 'How green are principles texts? An investigation into how mainstream economics educates students pertaining to energy, the environment, and green economics', *International Journal of Green Economics,* Vol. 1(3–4), pp. 381–93.

Reddy, S. (2008). 'U.S. news: amid pressing problems, threat of deflation looms', *Wall Street Journal*, 18 October.

Romer, D. (2006). *Advanced Macroeconomics* (3rd edn), New York: McGraw-Hill/Irwin.

Roubini, N. (2008). 'The worst is not behind us (op-ed)', *Forbes,* 13 November. Available from http://www.forbes.com/2008/11/12/recession-global-economy-oped-cx_nr_1113roubini.htm.

Roubini, N. and Mihm, S. (2010). *Crisis Economics: A Crash Course in the Future of Finance*, New York: The Penguin Press.

Taylor, J. B. (2009). *Getting Off Track: How Government Actions and Interventions Caused, Prolonged, and Worsened the Financial Crisis*, Stanford: Hoover Institution Press.

Williamson, S. D. (2008). *Macroeconomics* (3rd edn), Boston: Pearson Education, Inc.

Yellen, J. L. (2009). Comments on 'the revival of fiscal policy'. Paper presented at Annual AEA/ASSA Conference, San Francisco, CA, 4 January.

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