International Review of Economics Education 22 (2016) 34–47

Contents lists available at ScienceDirect

International Review of Economics Education

journal homepage: www.elsevier.com/locate/iree

Understanding strategic competition using numerical simulations and dynamic diagrams in Mathematica☆

Mario Pezzino

University of Manchester, Oxford Road, Manchester M13 9PL, United Kingdom

ARTICLE INFO

Article history:
Received 29 June 2015
Received in revised form 14 March 2016
Accepted 24 March 2016
Available online 26 April 2016

JEL classification:
A22
C63
D43

Keywords:
Strategic competition
Dynamic diagrams
Mathematica

ABSTRACT

The paper shows how to use Mathematica to study the properties of strategic competition models. The advantage of this software is that students can see, modify and solve the algebra behind the models. In addition the paper shows how to use the command *Manipulate* to produce dynamic diagrams and animations. Dynamic diagrams are extremely useful to help students understanding diagrammatic shifts related to comparative statics analysis. Two examples are discussed: the Cournot duopoly and the Hotelling (1929) linear city model.

1. Introduction

Strategic interdependence is at the heart of courses such as Industrial, Business and Managerial Economics. A common feature of these modules is often the large size and mixed mathematical background of the class. These features clearly create significant challenges for the convenor who intends to provide students with a deeper understanding of models of strategic competition in more advanced, say undergraduate year 3 and postgraduate, Economics courses. Even students who possess a good knowledge of basic game theoretic concepts may struggle sometimes when facing applied examples of strategic competition (such as Bertrand and Cournot models). In introductory courses students are exposed mainly to the graphical representations of the models, while in more advanced modules they may also explore the algebra. A key problem of the standard textbook approach is that the diagrams are unavoidably static. Indeed they have to represent a precise example where particular values have to be assigned to parameters. Understanding how changes in parameters affect a diagram is however a vital skill for all Economics students to have. Ultimately, an economist would like to be in a position to provide policy recommendations based on meaningful comparative statics analysis. Unfortunately a static figure, say for example a diagram showing the intersection of two best reaction curves describing a Nash equilibrium, may perhaps not be informative enough.

☆ The author is grateful for helpful comments and suggestions by the Editor and two anonymous reviewers.

http://dx.doi.org/10.1016/j.iree.2016.03.002
1477-3880/

Previous contributions have already highlighted the importance of numerical simulations in the classroom.[1] In particular, recently Gorry and Gilbert (2015) have described the advantages of simulating the Cournot quantity competition model using Excel.

The objective of this paper is to introduce the reader to the use of an alternative and extremely powerful software, Mathematica.[2]

Mathematica has significant advantages compared to other software, including Excel. It has impressive computing power that allows the use of dynamic diagrams; offers an extensive selection of built-in functions and provides easy-to-use graphical tools, including 3D diagrams. Excel, especially regarding manipulating calibrations/simulations, is more laborious and less effective in terms of dynamic computing. In addition, it does not provide the possibility of directly manipulating the algebraic expressions of economics models. The ability of Mathematica to deal algebraic and parametric expression makes the software a better alternative to the use of spreadsheets. Mathematica is now commonly used by researchers and industry practitioners. Indeed Mathematica comes now pre-installed with the new Raspberry Pi.[3] Mathematica, especially for students, has also clear fixed costs (the software may need to be purchased and students need to learn the basic code). Nonetheless fixed costs can be greatly reduced. Students can purchase the software at discounted prices and a web-based version of the software can also be freely accessed online.[4] The code is very intuitive and, for our purposes, only a handful of commands (all the essential commands to start using the software are mostly covered in this paper) are required.[5]

In general, exposing students to the use of mathematical software in the classroom in more quantitative courses is clearly pedagogically sound. It provides them with transferable skills and the ability to translate mathematical problems into software language.

For less quantitative courses, where possibly the cohort may be less mathematically inclined and lack essential technical tools (such as basic calculus, geometry, linear algebra and diagrammatic analysis), the convenor of year 3 Economics module faces a difficult challenge when trying to expose students to strategic competition models.

There are two potentially dangerous paths in front of the convenor. (1) Oversimplifying the analysis. The convenor could limit the study of strategic interdependence to simplified duopoly examples, possibly studied using simple diagrams. The advantage clearly is that this approach tends to favour intuition rather than mathematical analysis. The problem is that deep intuition and understanding of the models can only be acquired with a detailed study of the mathematical framework behind them. Surely comparative statics analysis can be implemented on a diagram, but this approach seriously limits the potential of those students who would like to deeply (and critically) understand the model. (2) Another dangerous path that a convenor may be tempted to take would be to spend a large portion (usually at the beginning) of the course "refreshing" the mathematical knowledge of the students. The problem with this approach is twofold. Some of the students will find the module too technical and will feel alienated and lose engagement. At the same time, some students (those more mathematically capable) will absorb the concept of strategic interdependence as a series of mathematical exercises, losing sight of the importance of economic intuition. In other words, for them oligopoly models will become simply mathematical exercises to test their knowledge of calculus.

The objective of this paper is to propose a third way. The use of a powerful and, at the same time, user-friendly software such as Mathematica in the classroom allows the convenor to build a bridge between the two paths that we mentioned above. To solve a standard duopoly model, students need to be taught only two commands. Students will not need to solve partial derivatives or systems of linear equations. Mathematica will do that for them. In addition visually appealing (and dynamic) diagrams can be easily produced, helping students to acquire the necessary economic intuition of the models. At the same time, the maths behind the model is not hidden from students. In order to ask Mathematica to solve the model for them, students need to know what the software needs to do. They have to identify the first and second order conditions, find the intersection of the best response functions, consider total differentiation for comparative statics analysis.

The use of the software is not advantageous only in the classroom. Indeed, say, a file with the Cournot model discussed during a lecture could be used by Teaching Assistants during tutorials, both for revision and for further study. The file can be modified to produce new examples and tests. In addition, students could be expected to use the file for their revision of the syllabus. Indeed, modifying the priors of a model is extremely simple in Mathematica, allowing students to face countless examples. As a form of assessment, students can be asked to submit Mathematica notebooks with exercises based on competition models. The advantage would be to test students on their economics intuition and knowledge of the models (and the software) rather than their mathematical skills.

The remainder of the paper is organised as follows. Section 2 introduces basic Mathematica commands. Section 3 briefly discusses two important competition models, the Cournot duopoly and the linear city model. Section 4 shows the

[1] See for example Mixon and Tohamy (2001), Gilbert and Oladi (2011), Findley (2014), Guo and Gilbert (2014).
[2] http://www.wolfram.com/mathematica/.
[3] http://www.wolfram.com/raspberry-pi/.
[4] See http://www.wolframalpha.com/.
[5] Anecdotal observation among Year 3 Business Economics students indicates that they did find Mathematica useful and accessible. In the online feedback provided on the module one students reported: "*I thought Mathematica was extremely helpful in understanding the economic intuition behind everything. Moreover, under the topic of Strategic Delegation where we had to see what happened with certain changes to the parameters, In other words when trying to understand the comparative statics of things.*"