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Evaluating a computer-based simulator program to teach the principles of macroeconomic equilibria

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A B S T R A C T

General equilibrium macroeconomic models are a basic tool for understanding how the economy functions, how the main macroeconomic variables are related, and the final outcome of economic policies. The teaching of these models is essentially achieved through a system of mathematical equations accompanied by the use of concatenated graphs representing the markets involved in the economy. However, the way these graphs are traditionally taught does not allow the learner to easily understand how they are related or for changes in a model's graphical outputs (curves) to be visualized. Here, a simulation program is presented and the effectiveness of its application to a group of macroeconomics students at the University of Seville during the 2011/12 academic year is evaluated. Analysis of variance (ANOVA) of all students' scores and some complementary statistical tests were applied with a view to distinguishing between students who used the simulator with the aid of a teacher, students who used the simulator without this assistance, and students who studied the topic in a conventional manner in the classroom. The average score obtained by the first-mentioned group in a model comprehension test was significantly higher than that of the second group, which in turn was higher than that of the third group taught using the conventional approach.

1. Introduction

Macroeconomic theory can be summarized according to three major macroeconomic models: the classical, Keynesian, and neoclassical synthesis models. The classical model cannot be attributed to a particular economist, but provides an abbreviated summary of the ideas and proposals put forward by a large number of economists since the middle of 18th century through until the 1930s (Pierce & Shaw, 1974). The General Theory of Employment, Interest and Money put forward by Keynes (1936) forms the basis of the Keynesian model. However, the expansion of Samuelson's textbook (1948) was the decisive impetus to the development of macroeconomics based on Keynes's ideas. In the intervening period, economists used simplistic models of real economic situations to explain macroeconomic relationships. In those years, Hicks (1937) and Modigliani (1944) developed the IS-LM (Investment-Saving/Liquidity preference-Money supply) model as the basis of aggregate demand. The further development of the Phillips curve by Phillips (1958) and Lipsey (1960) to account for inflation, helped develop the notion of aggregate supply, in the belief that the labor market works over the long term with a flexible wage structure. This gave rise to the neoclassical synthesis model, which is used to explain long-term economic performance.

Teaching and explaining these macroeconomic models is usually performed through mathematical modeling. However, the mathematical models used in macroeconomic analysis have become increasingly sophisticated at the intermediate and advanced levels (Blanchard, 2008; Dornbush, Fisher, & Statz, 2004; Romer, 2011), meaning that students have difficulties in understanding the mathematical functions underpinning the macroeconomic models (Pablo-Romero, Pozo-Barajas, & Gomez-Calero, 2009, 2012). An understanding of these mathematical functions and how they change and relate to others is, nevertheless, essential if the macroeconomic models are to be properly understood. Consequently, the graphical presentation of macroeconomic model outputs is often used to provide supporting explanatory information.

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The equipment used in teaching such graphs has traditionally been the black/whiteboard or, more recently, PowerPoint presentations. Such approaches have also been traditionally used to teach economic theory in undergraduate economics courses, although there is a noticeable shift towards the use of other teaching techniques (Watts & Becker, 2008).

Traditional forms of graphical representations can now be expanded upon thanks to the availability of new information technologies. In this way, as stated in Chen and Howard (2010), technology can help the scientific learning process because of its potential to support activities such as visualization, meaningful thinking, problem solving and reflection. Consider changing the sentence to: However, as indicated by Tufte (2001, 2006), Sweller (2005) and Mayer (2005a, 2005b), among others, these graphs should satisfy certain rules, principles or requirements to promote student learning, such as allowing the student to interact with the program by changing parameters, etc. (Betrancourt, 2005).

Following along from these principles, we have developed a software application which allows students to interact with the model, offering the possibility of doing as many different exercises as there are different economic situations. Within the classification of learning objects considered by Churchill (2007), this application can be included within the "contextual representations" group in the sense that a realistic scenario can be explored for any economic-specific policy.

In the university teaching context, the use of simulation programs has expanded to many areas of knowledge. Within the field of economics teaching, different simulation programs have also been implemented. Despite the importance of these teaching practices for student performance as recognized by educational researchers (Seidel & Shavelson, 2007), economists have only recently begun to analyze the impact of teaching methods on student achievement. Some studies report positive experimental results accompanying the use of particular technologies. For example, Chizmar and Walbert (1999), Pettijohn, Ragan and Ragan (2003) and Letterman (2008) reported on the utilization of web-based learning environments, while Salemi (2009) addressed the use of 'clickers' as tools with which to promote learning engagement. Nevertheless, few controlled studies have been made of the effectiveness of simulations in this area. Porter, Riley and Ruffer (2004) reported that the literature on the impact of the use of simulations on learning remains very thin in the field of economics, particularly when the small number of studies within a specific category is considered. Therefore, as stated in Grimes and Willey (1990), it is important to determine the effectiveness of the use of simulations on student learning in a specific matter. Moreover, Clark, Nelson, Sengupta, and D'Angelo (2009) suggest that researchers should take a pragmatic approach in applying findings from research done in the past, or in other contexts of their own situations, audiences, and settings. Thus, more analyses of the effectiveness of the use of simulations on student learning in the field of economics may be convenient. Rutten, Van Joolingen, & Van der Veen (2012) also proposed that it is necessary to consider the role of the teacher, the lesson scenario and the computer simulations place within cv in assessing the utility of simulators in teaching. However, most studies examining the effectiveness of simulators do not take into account the influence of the teacher and other such pedagogical factors.

This paper contributes to the literature concerning the impact of the use of simulations on student learning in the field of economics, by incorporating into the analysis the influence of the active role of the teacher on the effectiveness of the simulator. In this way, the aim of the paper is to use rigorous statistical analysis to evaluate if the introduction of the macroeconomics model simulator into the teaching of macroeconomics produces positive learning outcomes when used on a group of students enrolled in the School of Economics at the University of Seville during the 2011/12 academic year. Moreover, the paper aims to evaluate the role of the teacher in the learning process by reinforcing learned outcomes achieved with the simulator.

With this aim, a comparative analysis of the scores obtained by students in three different treatment groups was performed. The first group consisted of students who used the simulator and who received further assistance provided by a teacher actively involved in the provision of additional tutorial activities. The second group consisted of students using the simulator but who received no active input from the teacher to solve problems or help with student work. And finally, the third group consisted of students who did not use the simulator and who received tuition on the macroeconomic models via traditional class-based lectures. To perform the evaluation, an ANOVA was carried out on the scores obtained by students on one section of the exam specifically addressing the macroeconomic models.

In the second section of this paper we review the teaching techniques used to explain macroeconomic models and the use of simulators in this field. In the third section we analyze the simulator program employed in our study, while in the fourth section we discuss the operation of the simulator and explain the learning process followed by the students. In the fifth section we explain the method of analysis. Thereafter we describe the ANOVA results of the students' scores and some complementary statistical tests obtained using the Stata statistical program. This is followed by a discussion section and finally we present the main conclusions of the study.

2. The teaching of macroeconomic models and the use of new technologies. A review

The teaching and explanatory description of macroeconomic models has usually been performed through mathematical modeling and the use of graphical techniques. The use of graphics in the teaching of economics can be divided, according to Ruiz (2012), into two historical phases. The first phase concerns the descriptive graphical method, which is supported by simple tables, histograms, line graphs and scatter-plots. Playfair (1786) is considered a pioneer of this method. The second phase is the analytical graphical method. According to Maas (2005), Jevons (1862) was the first to have explored the merits of this approach to study political economics. The use of analytical graphs provides an indication of the possible nature of functions describing the relationship between variables X and Y, allowing a causal interpretation to be made of the relationship between them. In the 20th century, the use and application of analytical graphical methods among economists were often based on sophisticated mathematical and graphical techniques introduced during the development of new economic models.

The application of these techniques in the field of macroeconomics can be observed in the development of the following economic models, among others: IS-LM curve (Hansen, 1949), static and dynamic analysis (Samuelson, 1947), Phillips curve (Phillips, 1958), Okun law (Okun, 1975), economic growth theory (Solow, 1956), and monetary theory (Friedman, 1948). This expansion in the use of graphics to explain macroeconomic concepts and relationships between economic variables has been extended to textbooks used at virtually all levels of teaching of this theory.

Nevertheless, graphics are not always the most appropriate tool for understanding the relationships underlying macroeconomic theory. According to Cohn, Cohn, Balch, & Bradley (2001), if graphics are complicated and students do not have sufficient time to absorb them and understand their function, the use of such graphics can even be counterproductive to the learning process. Indeed, we have found that