

# *A Software System to Teach Economics to Secondary School and First Year Engineering Students*

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## **Abstract**

*Presentamos una interfaz gráfica desarrollada mediante Matlab diseñada para complementar el aprendizaje de los conceptos básicos de economía en Bachillerato, grado superior de ciclos formativos y cursos universitarios de introducción a la economía. La aplicación informática permite que los estudiantes varíen los parámetros de los que dependen las curvas de oferta y demanda, y visualicen el efecto sobre el equilibrio de mercado de estas variaciones. Se presentan los resultados de una primera experiencia de aplicación del programa en enseñanza secundaria en Españã.*

*In this paper, we present a graphical user interface which has been devised to teach the basic concepts of economics in secondary schools and first year engineering courses. The application allows students to vary certain parameters and visually observe the effect on the supply and demand curves. The system has been developed in Matlab and employed in a secondary school in Spain. The first results are presented.*

**Keywords:** *Graphical User Interface, Economics, Educational Software*

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## 1 Introduction

The present curriculum includes an Economics module in most secondary school and first year engineering programs. Particularly, it can be found as an independent subject in the Spanish curriculum of the first course of secondary school (Bachillerato) and as a part of the Subject Formacion y Orientacion Laboral in the Spanish curriculum of the last years of College for vocational training (Grado Superior de Ciclos Formativos). A correct understanding of supply and demand curves, and of their movements and displacements, constitutes basic ground knowledge and it is crucial to facilitate the understanding of the rest of the contents in both subjects. Nevertheless, classroom typical lectures on this topic consist of a rambling description of the variables that determine the final prices and quantities.

In this paper we present a Graphical User Interface programmed in MATLAB that simulates the behaviour of these curves when some variables vary. This Graphical User Interface allows the student to take advantage of the new technologies and experiment how variations of a number of variables affect the final result, visualizing the effect caused on the curves. This application facilitates understanding the behaviour of the curves and other concepts such as complementary goods, substitutive goods, etc. It permits a constructive learning of the topics since, after a classroom lecture on the theoretical concepts, the student can design his/her own experiments over the system under study using this software. On the other hand, it permits also a functional learning, since many different examples close to student's experience can be simulated with this software. The application has been evaluated in a secondary school classroom and the results are also provided. This software is used after the classroom lesson in two different ways: (a) in a computer lab, by letting the student to develop different examples, or (b) in classroom, by showing how it works by means of a projector.

## 2 Supply And Demand Curves

Market relations between sellers and buyers of particular goods are described by supply and demand and their graphical representation are called the supply and demand curves [1]. The demand curve describes the quantity  $Q_x$  of the goods  $x$  demanded by the consumers at each price  $P_x$ . Normally, the higher the prices the less the consumers will demand. Nevertheless, it also depends on a set of other variables:

1. The prices of the substitute goods  $P_s$ ,
2. The prices of the complementary goods  $P_c$ ,
3. The level of income  $Y$ ,
4. Personal tastes  $P$  and other factors.

Therefore, it is usually expressed as a function of all these variables:

$$P_x = D(P_x, P_s, P_c, Y, P). \quad (9.1)$$

On the other hand, the supply curve describes the quantity  $Q_x$  of the same goods that the producers would be willing to supply at each price. The higher the market price, the more goods producers would be willing to supply. It also depends on other variables:

1. The cost of factors  $C_f$ ,
2. The state of the technology  $T$ ,
3. The state of expectation  $E$ , etc.

Consequently, it is expressed mathematically as a function of all these variables:

$$P_x = S(C_f, T, E). \quad (9.2)$$

The supply and demand determine the price and quantity sold of the goods  $x$  in the market. These prices and quantities sold are known as the market equilibrium [1]. Mathematically, it is just the solution of a linear system of two equations with two variables, i.e., the price of the good and the quantity of the good that is exchanged in the market. If some of the variables described above change, the market equilibrium also changes. The goal of the model is to analyze how this equilibrium change under the variation of any of the variables that determine the two equations, i.e., the Demand and Supply curves. This is usually reflected in the form of a shift in the corresponding curve. How this equilibrium changes under variations of technology, expectations, etc., is a key concept in very sophisticated Economical Theories. The explanation of supply and demand curves normally requires a tedious descriptive lesson which requires some basic mathematics. We have developed a Graphical User Interface (GUI) with MATLAB that allows the student to visualize these shifts during the class explanations, and easily observe them by manipulating the variables in a number of different examples.

### 3 A Matlab Graphical User Interface For Simulating Supply And Demand Shifts

MATLAB is a mathematical program that facilitates designing visual GUI environments, allowing the use of a wide range of components, such as sliders, text fields or graphics. For a teaching and learning perspective it is also a useful tool, since it permits to vary parameters or functions and obtain a graphical representation of the result of any system simulated with MATLAB [2].

When explaining the supply and demand shifts, the curves described in Equations 9.1 and 9.2 are reduced to straight lines for simplicity. Then Equation 9.1 is transformed in:

$$Px = C_{P_x}P_x + C - P_sP_s + C_{P_c} * P_c + C_Y * Y + C_P * P + K, \quad (9.3)$$

where  $C_{P_x}$ ,  $C_{P_s}$ ,  $C_{P_c}$ ,  $C_Y$ ,  $C_P$ , and  $K$  are constants. On the other hand, Equation 9.2 is written as:

$$Px = C'_{P_x}P_x + C_{C_f}C_f + C_T T + C_E E + K', \quad (9.4)$$

where  $C'_{P_x}$ ,  $C_{C_f}$ ,  $C_T$ ,  $C_E$ , and  $K'$  are constants. The shift of the demand curve is due to variations in variables  $P_s$ ,  $P_c$ ,  $Y$ , and  $P$ . We represent their variation as  $\Delta P_s$ ,  $\Delta P_c$ ,  $\Delta Y$ , and  $\Delta P$ . The shift of the supply curve is due to variations in variables  $C_f$ ,  $T$ , and  $E$ . We represent these variations as  $\Delta C_f$ ,  $\Delta T$  and  $\Delta E$ .

Using a series of editable text boxes, the GUI permits the introduction of the following values:

- The eleven constants  $C_{P_x}$ ,  $C_{P_s}$ ,  $C_{P_c}$ ,  $C_Y$ ,  $C_P$ ,  $K$ ,  $C'_{P_x}$ ,  $C_{C_f}$ ,  $C_T$ ,  $C_E$ , and  $K'$ .

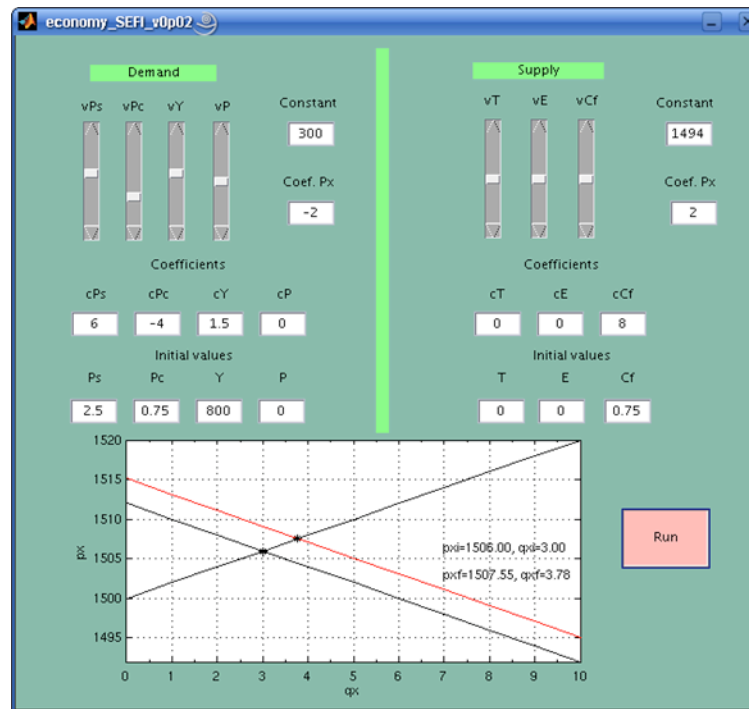


Figure 9.1: Demand curve shift

- The initial values of all the variables that influence the demand, i.e.,  $P_s$ ,  $P_c$ ,  $Y$ , and  $P$ .
- The Initial values of all the variables which have an effect on the supply, i.e.,  $C_f$ ,  $T$ , and  $E$ .

Slide bars allow varying the values of some variables which affect the curves, namely:

- $P_s$ ,  $P_c$ ,  $Y$ , and  $P$ , which produce a shift on the demand curve
- $C_f$ ,  $T$ , and  $E$ , which produce a shift on the supply curve.

At the push of a button, the GUI offers the graphical representation of the initial curves (using black lines) and the final curves (in red). It also provides the initial and final market equilibrium,  $(P_{x_i}, Q_{x_i})$  and  $(Q_{x_f}, P_{x_f})$  respectively.

## 4 Some Examples

Let us present some examples simulated with this GUI. In all the examples the constants have been initialized with the following values:  $C_{P_x} = -2$ ,  $C_{P_s} = 6$ ,  $C_{P_c} = -4$ ,  $C_Y = 1.5$ ,  $C_P = 0$ ,  $K = 300$ ,  $C'_{P_x} = 2$ ,  $C_{C_f} = 8$ ,  $C_T = 0$ ,  $C_E = 0$ , and  $K' = 1494$ .

In our first example we vary the parameters  $\Delta P_s$ ,  $\Delta P_c$ ,  $\Delta Y$ , and  $\Delta P$  so as to cause an expansion of the demand curve. We give values  $\Delta P_s > 0$ ,  $\Delta P_c < 0$ ,  $\Delta Y > 0$ , and  $\Delta P = 0$ , and observe the effect. The execution of this experiment can be observed in Figure 3, resulting in an increment of the quantity produced and a decrease in price.

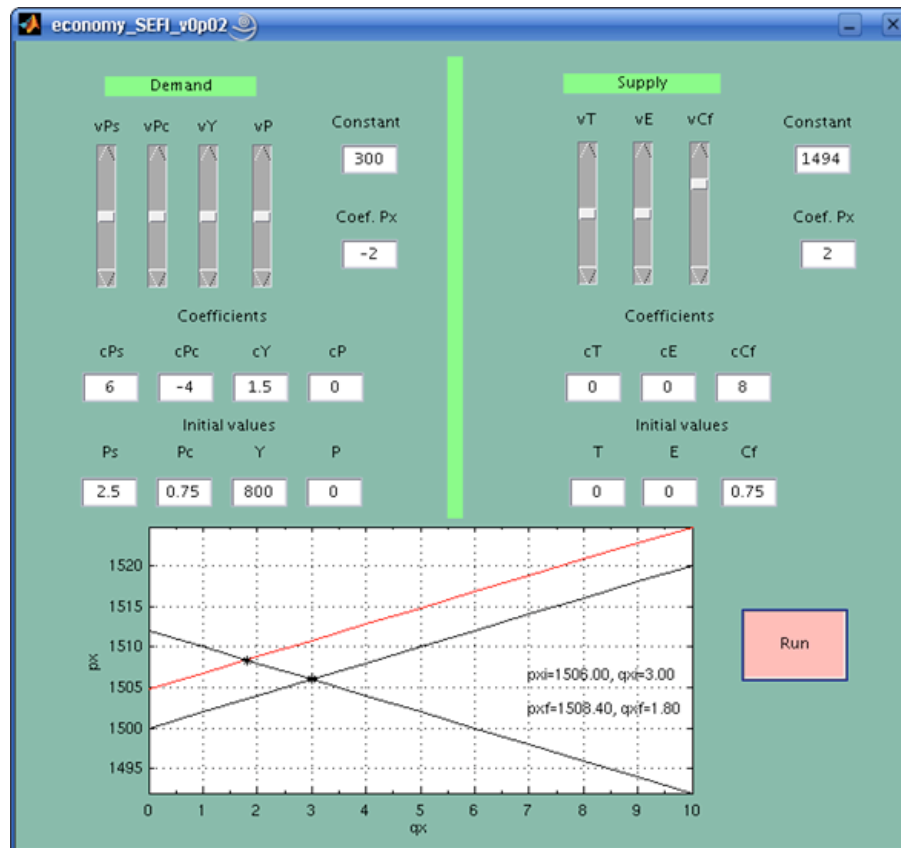


Figure 9.2: Supply curve shift

In Figure 4 we force a shift in the supply curve, choosing the parameters so that  $\Delta C_f > 0$ ,  $\Delta T = 0$  and  $\Delta E = 0$ . This results in a contraction of the supply curve and as a consequence, an increment in price and a reduction in the quantity of goods produced.

As a last example, we force a shift in both curves. In the one hand, we choose  $\Delta P_s = 0$ ,  $\Delta P_c > 0$ ,  $\Delta Y = 0$  and  $\Delta P = 0$  to shift the demand curve. In the other, we choose  $\Delta C_f > 0$ ,  $\Delta T = 0$  and  $\Delta E = 0$  to shift the supply curve. The result shows a decrease in the quantity of goods produced and, in this case, an increase in price. This is illustrated in Figure 4.

## 5 Applicability In Classroom Lessons

This software has been used in a first experience in classroom lessons of economics delivered to secondary school students at the I.E.S. Josep Maria Llopart (Spain) in the subject "Economy" of first year of secondary school (Bachillerato de ciencias sociales) during course 2007-2008. The group was composed of 20 students, 12 boys and 8 girls, of ages between 16 and 17, and medium standard of living. In a first lesson in the computer lab, the software was introduced to the students, and some simple examples designed by the professor were developed. This was based in a constructive learning approach. In a second lesson, also in the computer lab, the students were encouraged to design their own simulations based in their common experiences and develop a short explanation of what they conclude. This second lesson was based in a functional learning approach. There were no control group, so the conclusions of the experience were based in direct

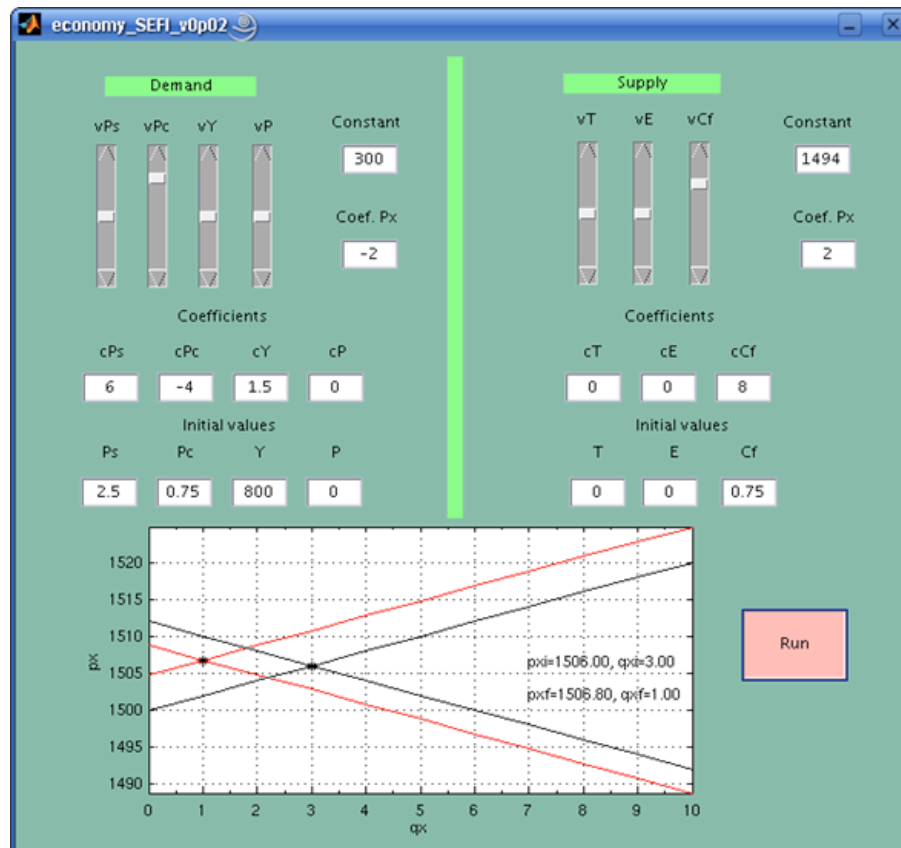


Figure 9.3: Supply and demand curves shifts

interviews to the students. Most students believed that the use of the application was a positive experience and helped them understand the most important concepts. They also appreciate that it also helped them to visualize the shifts, to remember what the variables that influence the curves are, and, in general, they appreciate that it was a change in daily routine. However, they remarked that it was not easy to identify which variable was responsible for the shifts and suggested that the colours of the curves be changed so that they matched the variable which caused them.

This software will be used in the future to achieve a deeper understanding of the concepts explained in conventional lessons. A number of practical sessions which will take place in the computer laboratory are being designed. In these, students will be required to solve a wide range of classical problems using this graphical user interface.

## 6 Conclusions

A GUI which permits the study of the shifts of the supply and demand curves has been presented. This software is useful for explaining fundamental economics principles which are needed to understand other more complex models. The application has been used in a classroom and practical lessons in a computer laboratory. Software tools are a requirement for modern learning. They permit to maintain the learning process closer to the student's daily experience, which is deeply conditioned by visual and interactive information and to attract

their attention. On the other hand, computing software offers a range of opportunities to improve teaching process, being a perfect complement to blackboard work. Indeed, there are a growing number of such experiences. For instance, at the I.E.S. Josep Maria Llompart there is currently an effort to use courses based in moodle, which has been enthusiastically supported by the students. The new GUI introduced in this paper is contextualized in this effort, and definitively permits, on the one hand, to complement blackboard explanations with a functional and constructive learning based on this software tool, while on the other, to attract students' attention with a tool closer their daily experience. In the future the functionality provided by this program will be extended to include the computation of elasticities and other interesting concepts which are relevant to an introductory course in economics





# Referencias

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