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Study on Effect Theory of Price Changes with MathCAD

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Abstract

By the computation and plotting of MathCAD, the effect theory of pricing changes is further studied, and an important conclusion is proved: Hicks demand curve and Slutsky demand curve move with the initial price changes, whereas Marshall demand curve remains invariably. This result enriches the effect theory of price changes. Moreover, MathCAD offers an auxiliary tool for practical researches, and realizes the perfect integration of economy, mathematics and computer science.

Index Terms: Economics; Effect of Price Changes; Demand Curves; MathCAD

1. Introduction

The Marshall, Hicks and Slutsky demand curves are derived from the effect analysis of price changes. They reflect the relations between demand and price of a certain commodity in different views. The Marshall demand curves shows the total effect on demand with the price changes, whereas the Hicks and Slutsky demand curves reflect the substitute effect on demand by eliminating the corresponding income effect. Nicholson (2008) addressed the effect analysis theory with price changes of Hicks and Slutsky, and presented the solution of their demand curves. However, no literature discussed whether these three curves move with the commodity's initial price.

The effect analysis of price changes is discussed in details in this paper. By MathCAD, an important result is found that the Hicks and Slutsky demand curves move with the initial price changes, whereas Marshall demand curve remains invariably. The mathematical software MathCAD plays an important role in many fields because of its strong computation and plotting capability. However, its functions in economics research are ignored. MathCAD has its unique advantages on theory depiction, mathematical expression, geometrical graph demonstration and computation, etc, which is proved once again from the research process of this paper.

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This paper is organized as follows. In section 2, three assumptions are given and three demand curves are computed by way of MathCAD. Some important results are addressed in details in section 3. We conclude the paper in section 4.

2. Basic Assumptions and Determination of Three Demand Curves

In this section, three assumptions are firstly given as follows.

(A) Monthly household consumption budget is 600.

(B) Only two kinds of normal commodity *X*, *Y* are consumed for simplification, and P_Y=1 denotes the price of commodity, *Y*.

(C) The utility function of *X*, *Y* is assumed to be $U(X, Y) = (XY)^{1/2}$.

With the price of *X* decreasing from P_{X1}=6 to P_{X2}=1.5, we separately calculated Hicks and Slutsky substitution effect, income effect and total effect values as shown in Fig. 1-A. And in Fig. 1-B, d_M, d_H and d_S respectively denotes the Marshall, Hicks, and Slutsky linear demand curves, while D_M, D_H and D_S as the nonlinear ones. In Fig. 1-A, the consumer's optimal choice $E_1(X_1, Y_1)$ is determined by P_{X1}=6, which is called the reference point. And F_1 in Fig. 1-B can also be derived as the reference point.

Notice that the budget constraint and utility function can be changed, which would not affect the conclusions. According to three assumptions, the utility curve bundle remains invariably as shown in all figures.

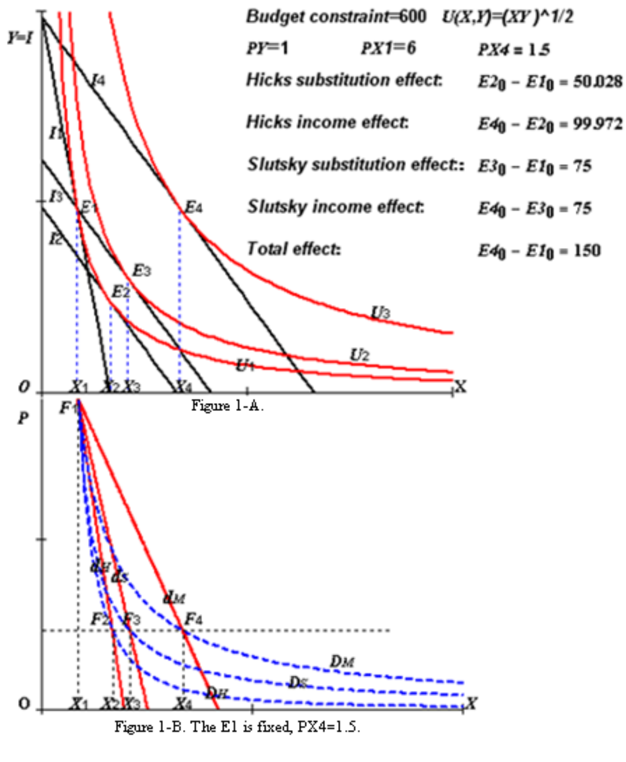

Fig. 1. (a) 1-A; (b) 1-B

In Fig. 1, the coordinates E_1(50, 300), E_2(100.28,149.958), E_3(125, 187.5), and E_4(200, 300) are computed by MathCAD. So F_1(50, 6), F_2(100.28,1.5), F_3(125, 1.5), and F_4(200, 1.5) are deduced. Here F_i(i=1,2,3,4) in

Fig. 1-B corresponds respectively with E_i(i=1,2,3,4) in Fig. 1-A， and F_2, F_3 and F_4 are at the same level. With three assumptions and price decreasing from P_{X1}=6 to P_{X2}=1.5, MathCAD calculates the linear and nonlinear equations of three demand curves.

The linear Marshall demand curve gets through F_1 and F_4, so it is easy to obtain the equation d_M:P=-0.03X+7.5. Similarly, we get the linear Hicks demand curve's equation as d_H:P=-0.09X+10.50, and linear Slutsky demand curve's equation a d_S:P=-0.06X+9. These three lines intersect at F_1.

To obtain the nonlinear demand curve equation, we assume that F_1 is fixed, *i.e.* P_{X1}=6. By repeatedly changing the price P_{X2}, the corresponding coordinates are collected according to various effect values. The curve equation can be derived by fitting these coordinates by econometric method, whereas it is not accurate. By subtle use of MathCAD, three nonlinear demand curve equations are precisely derived by optimization method, and also get some important results.

The Marshall nonlinear demand curve considers the total effect and it does not rely on the reference point E_1 or F_1. Suppose that the price of commodity X is P, we get the utility function $U=[X(600-PX)]^{1/2}$ from $PX+Y=600$. By $\partial U/\partial X=0$, the Marshall nonlinear demand curve equation is obtained as D_M:P=300/X.

For Hicks nonlinear demand curve, P_{X1}=6 determines the reference point E_1. Hicks points out that the constant real purchasing power refers to the original utility level unchanged. In Fig. 1-A, the original utility level, *i.e.* the utility curve U_1, is determined with E_1 given. And then E_4 is computed from P_{X2}. With E_1 identified, corresponding to E_4, E_2 is uniquely determined, which is the intersection of the Hicks substitute effect and income effect. Therefore, the X-coordinate X_2, is uniquely determined from commodity X's price $P=P_{X2}$ at E_4 (P_{X2} is now changeable). Now the Hicks nonlinear demand curve is obtained as above. It can be seen that the Hicks nonlinear demand curve relies on the reference point E_1.

The equivalent utility curve equation across E_1(50, 300) is $(XY)^{1/2}=U(50, 300)=122.474$, so Y=15000/X. Provided that the price P is changeable, *i.e.* E_4 is movable, budget constraint equation is $I=PX+Y$, then $I=PX+15000/X$. By $\partial I/\partial X=0$, the Hicks nonlinear demand curve equation is derived as D_H:$P=15000/X^2$.

Similarly, the Slutsky nonlinear demand curve equation is D_S:P=150/(X-25). In Fig. 1-B, the precise Marshall, Hicks and Slutsky nonlinear demand curves are also plotted as D_M, D_H and D_S, and they intersect at F_1.

3. Important Results

In this section, some important results are presented. By MathCAD, the linear and nonlinear demand curves are listed in the same graph for comparison analysis.

Proposition 1: If the reference point E_1 is fixed, these three linear demand curves rotate around F_1. So a misunderstanding may come forth: there is not a believable demand curve in economic society. In fact, three nonlinear demand curves are the true demand curves, however, the condition that the reference point E_1 is fixed cannot be ignored.

In Fig. 1 to 2, because the E_1 is fixed, three nonlinear demand curves are unchanged.

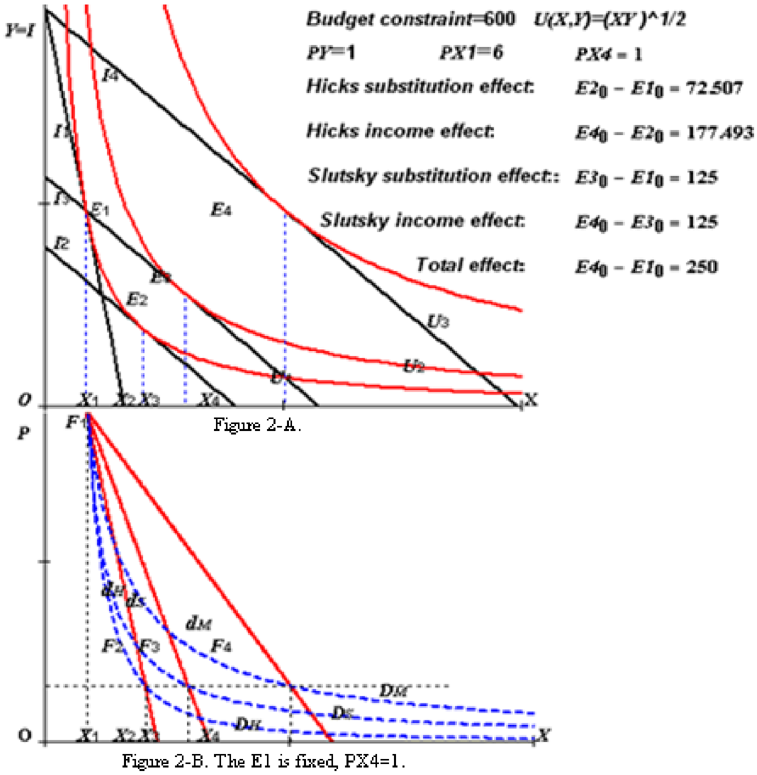

Fig. 2. (a) 2-A; (b) 2-B

Proposition 2: If the reference point E_1 is changed, the Hicks and Slutsky nonlinear demand curves will move accordingly.

To verify this proposition, we use MathCAD to compute these three demand curves. Given $E_1(50, 300)$ (i.e. P_{X1}=6) as the reference point, the Marshall, Hicks and Slutsky nonlinear demand curve equations are D_M:P=300/X, D_H:P=15000/X^2, D_S:P=150/(X-25). Similarly, with a new reference point $E'_1(83.333, 300)$ (i.e. P'_{X1}=3.6), the Marshall, Hicks and Slutsky nonlinear demand curve equations are D_M:P=300/X ,D_H:P=25000/X^2 and D_S:P=25000/(2X-83.333). For details please refer to Fig. 3 to 4. It can be seen from these figures that the Hicks and Slutsky demand curve equations change with different reference points, whereas the Marshall's remains invariable. The reason underlying is that the Hicks and Slutsky analysis eliminates the income effect. The eliminated amount is up to the position of E_1, so E_1 plays a crucial role on the demand curve equations and its' position.

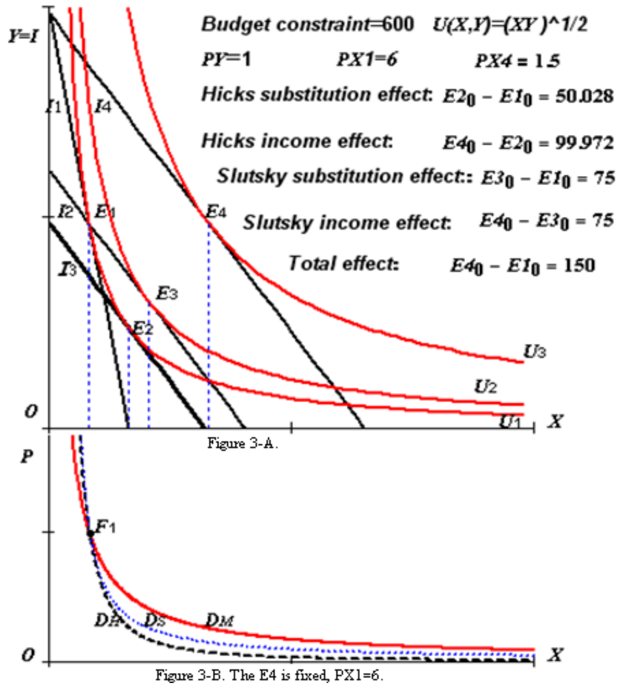

Fig. 3. (a) 3-A; (b) 3-B

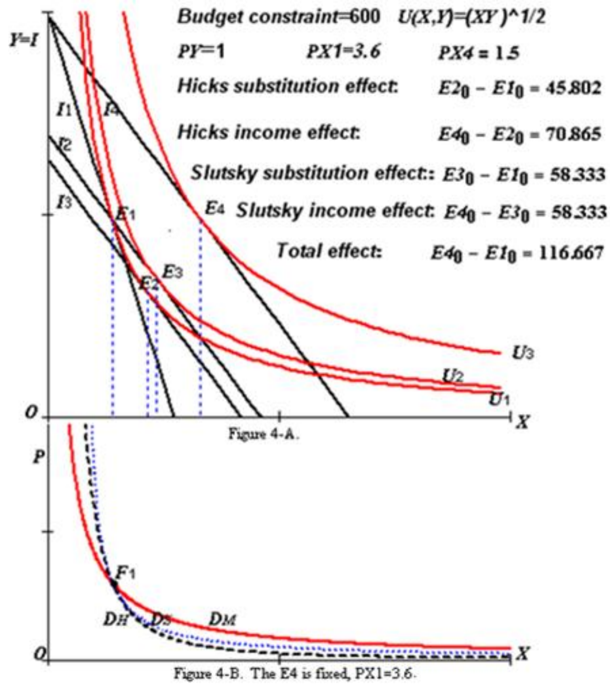

Fig. 4. (a) 4-A; (b) 4-B

Integrating proposition 1 and 2, it shows that Marshall nonlinear demand curve equation is always P=300/X, so we get the following proposition.

Proposition 3: The nonlinear Marshall demand curve is unchanged, and it does not rely on the reference point E_1. Provided that the consumer's preferences, consumer budget, and the price Y remain unchanged, there exists a certain Marshall demand curve in economic reality. Of course, it will changes accordingly if one of these three factors changes.

Proposition 4: By setting strict assumptions (*i.e.* the reference point is fixed), the Hicks and Slutsky demand curves exhibit some important results, whereas the Marshall demand curve does not for its loose conditions. So the scientific analysis, such as the tax effect, can be carried on by the Hicks and Slutsky demand curves. Even if the conditions are appended, the Marshall demand curve has no capability for further research. From another view, the Marshall demand curve is widely applied for its loose conditions, while the application of Hicks and Slutsky demand curves is restricted.

4. Conclusions

In this paper, the price effect analysis is discussed in details by way of MathCAD. Three nonlinear demand curve equations are derived and their graphs are precisely plotted. Some important results are obtained from comparison analysis. It is firstly found that the Hicks and Slutsky nonlinear demand curves move accordingly with the initial reference point, while the Marshall demand curve does not. This important result profits from the skillful use of MathCAD.

In many research fields, MathCAD plays an important role because of its strong computation and plotting capability. However, it is ignored in economics research. MathCAD has its unique advantages on theory depiction, mathematical expression, geometrical graph demonstration and computation, *etc*, which is proved once again from the research process of this paper. The main functions of MathCAD are as follows.

4.1. MathCAD promotes economics for further scientificity

Economic model is established to describe the relations between variables in concise form. Only when these abstractive relations are visualized, the signification of the model exhibits explicitly. It is MathCAD that realizes the integration of the concise model and visual demonstration. If Professor J. Viner had the chance to use MathCAD, he would not have made the mistake about *LAC*, which was not detected until 1950. So by static plotting and dynamic demonstration, MathCAD helps us to profoundly understand the model's principles, limitations and defects.

4.2. MathCAD provides a new method for empirical analysis

In empirical analysis by MathCAD, the traditional economic model can be explained from the view of mathematics, such as linear and nonlinear, derivative, inflexion, intersection, etc. And the derived conclusions are once again translated into economics language to describe the economic theories. We may possibly achieve valuable information from this process. The results in this paper provide a sufficient evidence of MathCAD's advantages.

4.3. *MathCAD can help us to understand the economics conceptions and concise theories*

MathCAD can easily produce a variety of beautiful, accurate and comprehensive graphics, and also can animate the dynamic process of economic variables, which will efficiently help us to understand what we have learned. So MathCAD can be used to establish a media library for us to visually learn the abstract theories and economics conceptions.

MathCAD has strong functions and provides an important tool for scientific research. MathCAD can help to improve the research efficiency, boost the development of economics, and realize the perfect integration of economic theories, mathematics and computer science. So we should strengthen its application in economics research and empirical analysis.

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