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**FEA Working Paper No. 2007-16**

**Beyond the *Ceteris Paribus* Assumption:  
Modeling Demand and Supply Assuming  
*Omnia Mobilis***

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*Omnia Mobilis***

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August 2007

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**Beyond the *Ceteris Paribus* Assumption:  
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Keywords

*Ceteris paribus, omnia mobilis*, demand and supply, multi-dimensional graphs,  
Econographicology

JEL Code

B41

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## **Acknowledgments**

We are grateful for comments and suggestions from Sir Clive W.J. Granger, Rajah Rasiah, Goh Kim Leng, Anthony T. H. Chin, Ritter Diaz and Chong Chin Sieng.

## Abstract

In this paper we are concerned with the application of multi-dimensional graphs (or Cartesian Spaces) in visualizing and modeling total change in a dependent variable in response to changes in any or all of the (many) independent variables affecting it. Previous literature has used the *ceteris paribus* assumption to investigate and visualize the effect of each independent variable and obtains total change as a cumulative effect of the parts. The multi-dimensional graph allows the visualization of the *omnia mobilis* (everything is moving) assumption and further provides an alternative to modeling total change in a dependent variable. The application of this approach to demand and supply is shown. The approach shows that quantity sold in the market is not necessarily equal to the quantity demanded and supplied once the effect of independent variables other than just price is taken into account. Quantity demanded and supplied are mostly in disequilibrium and the quantity sold is a joint function of all the independent variables that affect supply and demand.

## 1. Introduction

The *ceteris paribus* assumption can be considered a vital tool in the process of building economic models to explain complex economic phenomenon. This assumption translated from Latin means “all other things [being] the same”. It facilitates the description of how a variable of interest changes in response to changes in other variables by examining the effect of one variable at a time. An extremely important contribution of Alfred Marshall, it supports the understanding of the application of *ceteris paribus* assumption in economic models. According to Marshall (1890, v.v.10):

“The element of time is a chief cause of those difficulties in economic investigations which make it necessary for man with his limited powers to go step by step; breaking up a complex question, studying one bit at a time, and at last combining his partial solutions into a more or less complete solution of the whole riddle. In breaking it up, he segregates those disturbing causes, whose wanderings happen to be inconvenient, for the time in a pound called *Ceteris Paribus*. The study of some group of tendencies is isolated by the assumption *other things being equal*: the existence of other tendencies is not denied, but their disturbing effect is neglected for a time. The more the issue is thus narrowed, the more exactly can it be handled: but also the less closely does it correspond to real life. Each exact and firm handling of a narrow issue, however, helps towards treating broader issues, in which that narrow issue is contained, more exactly than would otherwise have been possible.”

Marshall’s approach thus allows the analyses of complex economic phenomena by parts where each part of the economic model can be joined to generate an approximation of the real world. This approach can be termed the Isolation Approach and according to Marshall (Schlicht, 1985, p.18) originates from two possible Isolation clauses. First the *ceteris paribus* assumption allows some variables to be considered unimportant. This clause is called Substantive Isolation. Substantive Isolation considers that some unimportant variables cannot significantly affect the final result of the economic model. Second, the *ceteris paribus* assumption allows the influence of some important factors to be disregarded. The application of the *ceteris paribus* assumption in this case is purely hypothetical; therefore the second clause is called Hypothetical Isolation. It allows parts of the model to be managed more easily.

In other words, to explain a complex economic phenomenon, the *ceteris paribus* approach considers the effect partially of each variable in a set of  $m$  variables (termed usually independent variables,  $X_j$ ,  $j = 1, 2, \dots, m$ ) upon a variable of interest (usually termed the dependent variable,  $Y$ ). From a mathematical point of view, the *ceteris paribus* assumption in an economic model is equivalent to the partial derivative, which explains how one independent variable, say  $X_k$ , in a set of independent variables can affect the dependent variable  $Y$  while the other independent variables are being held constant. From a graphical point of view, the *ceteris paribus* assumption supports the elaboration of scenarios that can be visualized on 2-Dimensional ( $X, Y$ ) space. More precisely if  $Y$  is a function of, say,  $X_1$  and  $X_2$ , the (partial) relationship between  $Y$  and  $X_1$  can be visualized in the 2-D space describing  $Y$  and  $X_1$ , assuming  $X_2$  is held constant. In order to approximate real world, Marshall (1890, v.v.10) goes on to propose that “With each step more things can be let out of the pound; exact discussions can be made less abstract, realistic discussions can be made less inexact than was possible at an earlier stage.” The real-world scenario is thus approximated by the cumulative effect of the partial effects of the  $X$  variables on  $Y$ .

With the availability of multi-dimensional graphs based on the application of Cartesian Spaces (Ruiz, 2007, p.5), it is possible to visualize what we call the Omnia Mobilis (everything is moving) assumption. The Cartesian space is used to generate is used to generate multi-dimensional-graphs with different dimensions that can be shown to move with time. But more than that, the multi-dimensional graph provides an alternative to the Marshall view of step-by-step cumulative partial approach to modeling a complex economic phenomenon.

In this paper we are concerned with the application of multi-dimensional graphs in visualizing and modeling total change in an independent in response to changes in any or all of the (many) independent variables affecting it within the same framework of space and time. The multidimensional-graph can also be used to describe dynamic and multi-functional analyses that represent changes within the total function of an economic variable. The next section discusses the application of multi-dimensional graphs to model demand and supply. The third section concludes the paper.

## **2. Visualizing and Modeling Demand and Supply Surfaces**

Concerning the graphical methods for modeling demand and supply, it is necessary to mention the significant contributions of Antoine Augustin Cournot. Cournot (1897, p.427) derived the first formula for the rule of supply and demand as a function of price. He was also the first economist to draw supply and demand curves on a graph (2-Dimensional view). Cournot believed that economists should utilize graphs only to establish probable limits and express less stable facts in more absolute terms. He further held that the practical use of mathematics in economics involves not only strict numerical precision, but also graphical visualization. Besides Cournot, other innovative economists who contributed to the analytical graph system in economic models over time were William Stanley Jevons, Marie-Esprit-Léon Walras, Vilfredo Pareto, Alfred Marshall and Francis Ysidro Edgeworth (McClelland, 1976, p. 97).

In this section, we describe the application of multi-dimensional graphs to the analysis of demand and supply. The supply and demand model determines the quantity sold in the market. The usual model predicts that in a competitive market, price will function to equalize the quantity demanded by consumers and the quantity supplied by producers, resulting in an economic equilibrium of quantity. The application of multi-dimensional graphs allows the visualization and modeling of the effect of other variables on quantity demanded and supplied. With this application, the quantity sold in the market will equal quantity demanded and quantity supplied only under certain circumstances. In other cases, the quantity sold in the market will be a balance between the demand and supply quantities.

The application of the Infinity Cartesian Space (I-Cartesian Space) (Ruiz, 2006, p.3) is used to obtain demand and supply surfaces that replace the usual 2-Dimensional (and 3-Dimensional) demand and supply lines. The general function to build demand and supply cylinders is given below by:

$$Y_{C:L} = f_C ([X_{C:L;j}, P_{C:L;j}, R_{C:L;j}], j = 1, \dots, m_C)$$

**Where:**

$C = \{1, 2\}$  is the Cylinder,  $C = 1$  for the demand cylinder and  $C = 2$  for the supply cylinder

$L = \{1, 2, 3, \dots, n\}$ ,  $n \rightarrow \infty$ , is the Level

$m_C$ ,  $m_C \rightarrow \infty$ , is the number of independent variables in cylinder  $C$

$X_{C:L;j}$  is the independent variable  $j$  in cylinder  $C$  at level  $L$  lying in position  $P_{C:L;j}$  with value  $R_{C:L;j}$ ;

$P_{C:L;j}$ ,  $0^\circ \leq P_{C:L;j} < 360^\circ$ , is the position of  $X_{C:L;j}$  in cylinder  $C$  at level  $L$ ;

$R_{C:L;j}$  is the radius corresponding to the  $X_{C:L;j}$  in cylinder  $C$  at level  $L$

$Y_{C:L}$  is the dependent variable, quantity demanded ( $C=1$ ) and quantity supplied ( $C=2$ ) at level  $L$

**Assumptions**

1. Application of *omnia mobilis* assumption.
2. The set of independent variables affecting demand are not necessarily the same as that for supply; however price is common to both sets.
3. The set of independent variables for demand and for supply are available for the same number of levels, that is, “ $n$ ”. Usually the level represents time.
4. The unit of measurements of all variables is the same. For example, all variables can be measured in terms of growth.
5. Price is the independent variable  $X_{C:L;1}$ , located at position  $P_{C:L;1} = 1^\circ$  in both cylinders and for all levels. Since price in the demand cylinder must equal price in the supply cylinder, the radius  $R_{1:L;1} = R_{2:L;1}$

**Definitions**

1. The Balance Line,  $BL_L$ , is the line that joins  $Y_{1:L}$  and  $Y_{2:L}$  at level  $L$ .
2. The Balance Point is a point on  $BL_L$  that indicates the quantity sold at level  $L$ .
3. The Balance Quantity Line (BQL) is the vertical line that connects all the Balance Points,  $L = 1, \dots, n$ . It forms the hinge between the demand and supply cylinders and at each level  $L$  and in each cylinder it is located at  $P_{C:L;0} = 0^\circ$ .

**The Demand Cylinder**

As seen from Figure 1, the demand cylinder is a series of  $n$  sub-cylinders, one for each level. For a given sub-cylinder, say for  $L=1$ , the values of the  $m_1$  independent variables  $X_{1:L;j}$  affecting demand  $Y_{1:L}$  are plotted on the base of the sub-cylinder as the radii. The value of a specific independent variable at time point 1, say  $X_{1:1;1}$  is plotted as  $R_{1:1;1}$  the radius pictured lying on a flat surface at angle  $P_{1:1;1}$  measured from  $1^\circ$  line used for price as its reference line. The points from the end of the radii are joined to meet in a single point on the top of each sub-cylinder at height  $Y_{1:1}$ , the quantity demanded at time  $L$ . The diameter of the sub-cylinder is twice the maximum radius. The demand function is expressed as:

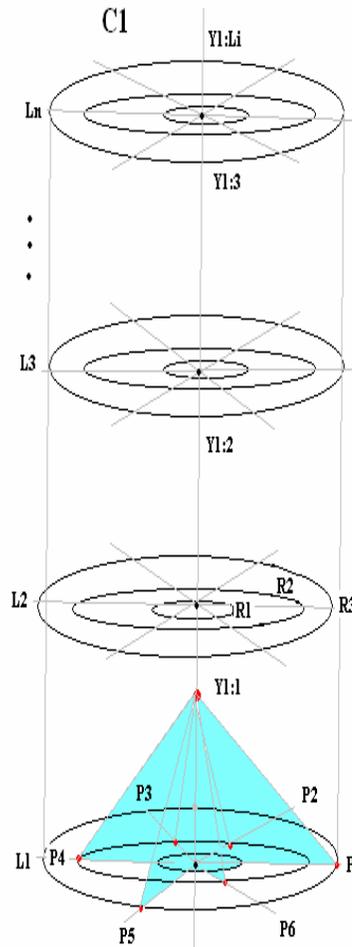
$$Y_{1:L} = f_1 ([X_{1:L;j}, P_{1:L;j}, R_{1:L;j}], j = 1, \dots, m_1)$$

### The Supply Cylinder

Similarly, the supply cylinder is a series of n sub-cylinders, one for each level. For a given sub-cylinder, say for  $L=1$ , the values of the  $m_2$  independent variables  $X_{2:L;j}$  affecting demand  $Y_{2:L}$  are plotted on the base of the sub-cylinder as the radii. The value of a specific independent variable at time point 1, say  $X_{2:1:1}$  is plotted as  $R_{2:1:1}$  the radius pictured lying on a flat surface at angle  $P_{2:1:1}$  measured from  $1^\circ$  line used for price as its reference line. The points from the end of the radii are joined to meet in a single point on the top of each sub-cylinder at height  $Y_{2:1}$ , quantity supplied at time L. The diameter of the sub-cylinder is twice the maximum radius. The supply function is expressed as

$$Y_{2:L} = f_2 ([X_{2:L;j}, P_{2:L;j}, R_{2:L;j}], j = 1, \dots, m_2)$$

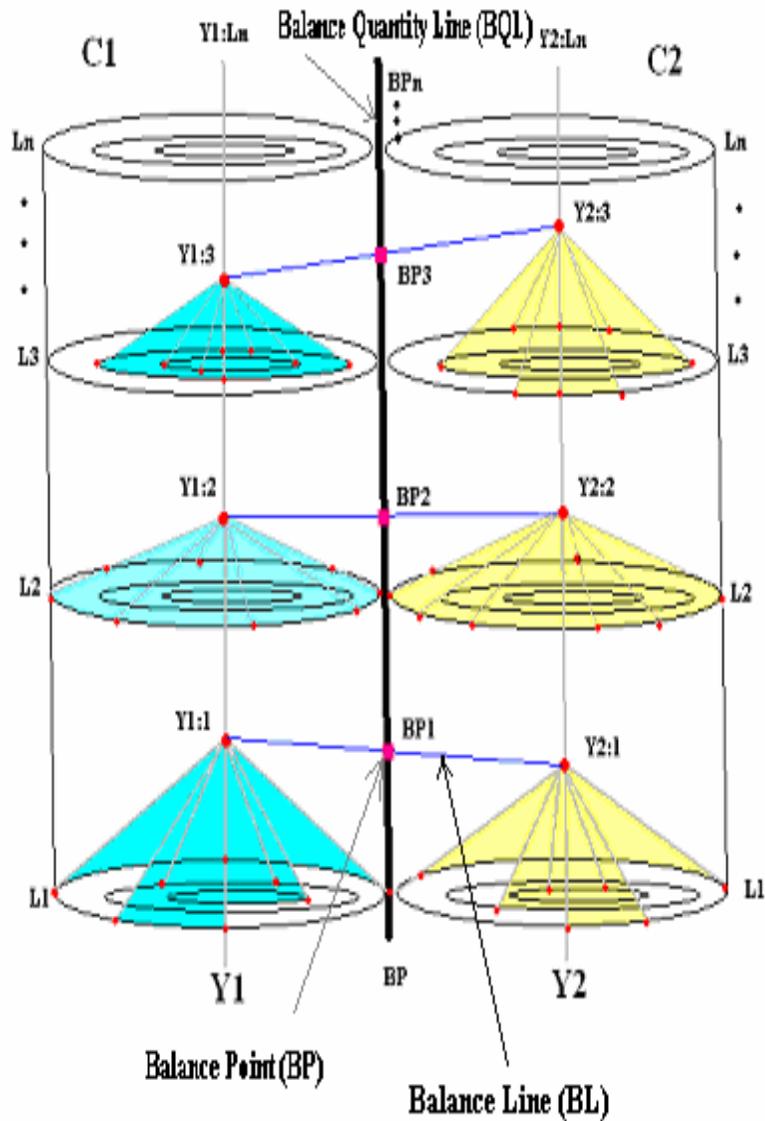
**Figure 1:**  
Demand Cylinder



**The Demand and Supply Surfaces**

The demand and supply surfaces are placed side by side as shown in Figure 2, the sub-cylinder for level L for demand being adjacent to the sub-cylinder for level L for supply. The maximum height of the sub-cylinders at level L will be the maximum of  $Y_{1:L}$  and  $Y_{2:L}$ . The demand and supply surfaces are then two oblique cylinders consisting of sub-cylinders of varying diameters. The two cylinders are hinged on a common line located at position  $P_{C:L:0} = 0^\circ$ . This common line is called the Balance Quantity Line (BQL) and connects all the Balance Points which show the quantities sold in the market at all the different levels.

**Figure 2:**  
Demand and Supply Cylinders



***The Balance Line, Balance Point and Changes in Demand and Supply***

The balance line,  $BL_L$ , is the line that connects  $Y_{1:L}$  and  $Y_{2:L}$  in sub-cylinder L. This line may be linear as shown in Figure 3 or non-linear. The quantity sold in the market lies somewhere on this line given by the Balance Point,  $BP_L$ . The quantity sold is thus viewed as a “balance” between demand and supply quantities. Thus,

$$BP_L = g(Y_{1:L}, Y_{2:L})$$

In other words, the quantity sold in the market is a function not only of the common price but also of all the factors that affect supply and demand. This suggests that demand and supply quantities can remain in disequilibrium at time L.

**Example**

If we assume that  $BL_L$  is a straight line, then its slope is given by

$$S_L = \left| Y_{1:L} - Y_{2:L} \right| / \left| \max_j \{R_{1:L;j}\} + \max_j \{R_{1:L;j}\} \right|$$

As demand or supply changes from one level to the next, the slope of the line will change. The Balance Point, however, may or may not change as that depends on the joint effect of all variables that affect quantity. In order to understand the Balance Line, it is useful to consider three scenarios:

- Scenario 1: Only one independent variable, price; demand equals supply
- Scenario 2: More than one independent variable; demand equals supply
- Scenario 3: More than one independent variable; demand does not equal supply

Figure 3 shows the demand and supply surfaces for each of these scenarios for levels  $L=1, 2$  and  $3$  with assumed data.

***Scenario 1***

In this case, the two cylinders will be of same diameter and will be straight cylinders, that is, the mid-points of the cross-sectional circles will be on the same line. Quantity demanded equals quantity supplied, and the quantity sold in the market is the equilibrium quantity under the *ceteris paribus* assumption. With  $Y_{1:1} = Y_{2:1}$ ,  $S_L = 0$ . The Balance Line is thus a horizontal line (See figure 3).

The demand and supply functions are

$$Y_{1:1} = f_1 ([X_{1:1:1}, P_{1:1:1}, R_{1:1:1}]) \quad Y_{2:1} = f_2 ([X_{2:1:1}, P_{2:1:1}, R_{2:1:1}])$$

The graph for level  $L=1$  is:

Demand Cylinder	Supply Cylinder
$Y_{1:1} = 4$	$Y_{2:1} = 4$
$R_{1:1:1} = 3$ (price)	$R_{2:1:1} = 3$ (price)

The slope of the Balance Line is

$$S_L = (4-4)/(3+3) = 0/9 = 0$$

The Balance Point showing the quantity sold in the market at level 1 is

$$BP_1 = Y_{1:1} = Y_{2:1} = 4$$

### ***Scenario 2***

Since  $Y_{1:2} = Y_{2:2}$ , the slope of the Balance Line will be zero and quantity demanded equals quantity supplied and the quantity sold in the market equals the equilibrium quantity under the *ceteris paribus* assumption. In this situation, the quantity sold under the *omnia mobilis* assumption does not differ from that under the *ceteris paribus* assumption. That is, the other variables besides price have the same effect as price on the quantity supplied or demanded (see figure 3).

The demand and supply functions are

$$Y_{1:2} = f_1 ([X_{1:2:j}, P_{1:2:j}, R_{1:2:j}], j = 1, \dots, 9) \quad Y_{2:2} = f_2 (X_{2:2:j}, P_{2:2:j}, R_{2:2:j}], j = 1, \dots, 9)$$

The graph for level L=2 is:

Demand Cylinder

Supply Cylinder

$$Y_{1:2} = 5$$

$$Y_{2:2} = 5$$

$$R_{1:2:1} = 5 \text{ (price)}$$

$$R_{2:2:1} = 5 \text{ (price)}$$

$$R_{1:2:2} = 5$$

$$R_{2:2:2} = 5$$

$$R_{1:2:3} = 5$$

$$R_{2:2:3} = 5$$

$$R_{1:2:4} = 5$$

$$R_{2:2:4} = 5$$

$$R_{1:2:5} = 5$$

$$R_{2:2:5} = 5$$

$$R_{1:2:6} = 5$$

$$R_{2:2:6} = 5$$

$$R_{1:2:7} = 5$$

$$R_{2:2:7} = 5$$

$$R_{1:2:8} = 5$$

$$R_{2:2:8} = 5$$

$$R_{1:2:9} = 5$$

$$R_{2:2:9} = 5$$

The slope of the Balance Line is

$$S_L = (5-5)/(5+5) = 0/10 = 0$$

The Balance Point showing the quantity sold in the market at level 2 is

$$BP_2 = Y_{1:2} = Y_{2:2} = 5$$

### Scenario 3

Finally consider Scenario 3, where  $Y_{1:3} \neq Y_{2:3}$ . In this case, the diameters of each sub-cylinder for the two cylinders would be different; the cylinders become oblique. Then the Balance Line will slope down towards the sub-cylinder with the lower quantity. The quantity sold will be shown by the Balance Point, a point on this line determined by all the independent variables in both the demand and supply cylinders. In this situation, the quantity sold under the *omnia mobilis* assumption differs from that under the *ceteris paribus* assumption (see figure 3).

The demand and supply functions are

$$Y_{1:L} = f_1 ([X_{1:3:j}, P_{1:3:j}, R_{1:3:j}], j = 1, \dots, 9) \quad Y_{2:L} = f_2 (X_{2:3:j}, P_{2:3:j}, R_{2:3:j}], j = 1, \dots, 9)$$

The graph for level L=3 is:

Demand Cylinder	Supply Cylinder
$Y_{1:3} = 5$	$Y_{2:3} = 4$
$X_{1:3:1} = 5$ (price)	$X_{2:3:1} = 5$ (price)
$X_{1:3:2} = 3$	$X_{2:3:2} = 4$
$X_{1:3:3} = 5$	$X_{2:3:3} = 2$
$X_{1:3:4} = 5$	$X_{2:3:4} = 4$
$X_{1:3:5} = 6$	$X_{2:3:5} = 4$
$X_{1:3:6} = 3$	$X_{2:3:6} = 4$
$X_{1:3:7} = 5$	$X_{2:3:7} = 5$
$X_{1:3:8} = 5$	$X_{2:3:8} = 6$
$X_{1:3:9} = 6$	$X_{2:3:9} = 5$

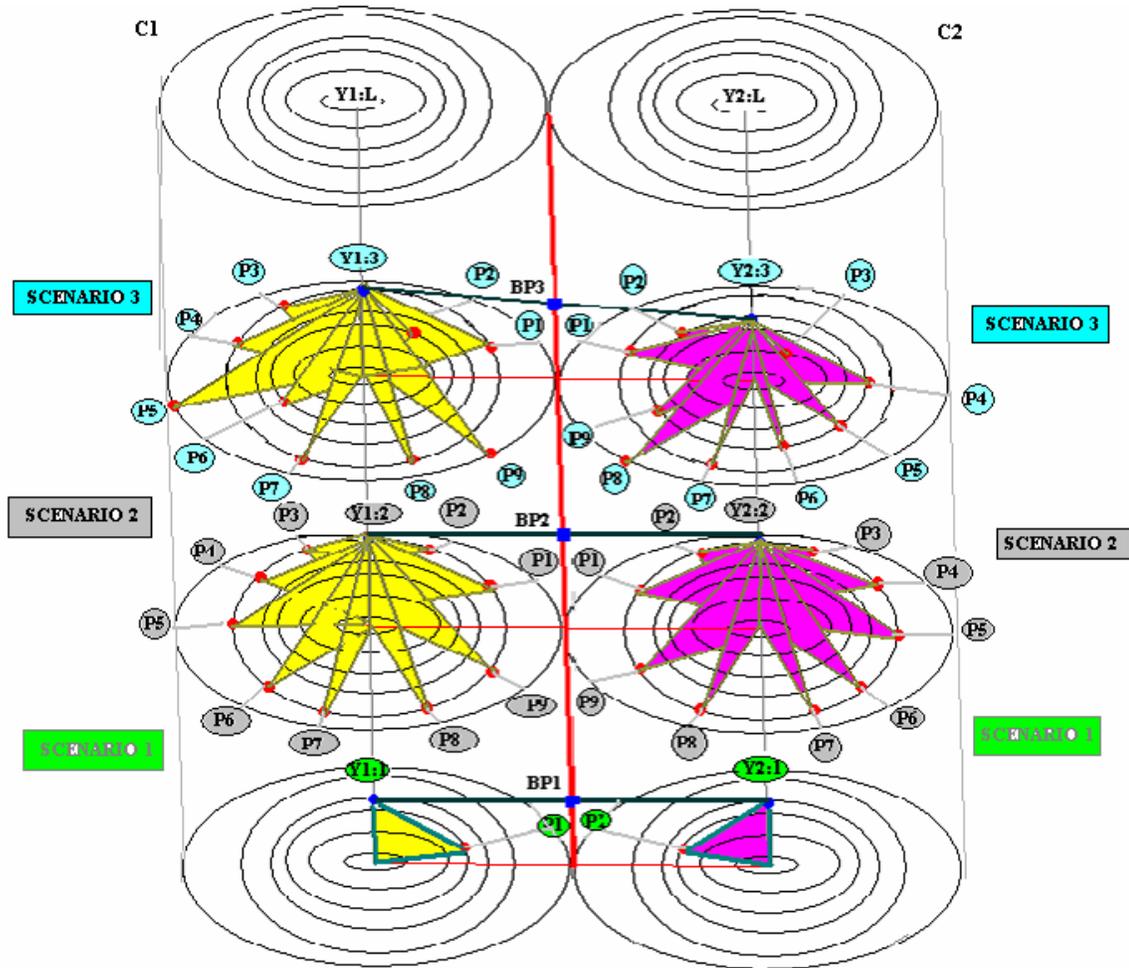
The slope of the Balance Line is

$$S_L = (5-4)/(6+6) = 1/12$$

The Balance Point showing the quantity sold in the market at level 3 will lie between 4 and 5.

$$BP_3 \neq Y_{1:3} = 5 \text{ and } BP_3 \neq Y_{2:3} = 4$$

**Figure 3:  
Demand and Supply Surfaces Application**



### 3. Conclusion:

The use of the *ceteris paribus* assumption is linked to the type of graphs used such as 2-Dimensional and conventional 3-Dimensional graphs. The multi-dimensional graph goes beyond the traditional approach to allow the visualization of the *omnia mobilis* (everything is moving) assumption and further provides an alternative to modeling total change in a dependent variable. In order to demonstrate the applicability of multi-dimensional graphs we have used it in the context of demand and supply. The approach shows that quantity sold in the market is not necessarily equal to the quantity demanded or supplied when the effect of independent variables other than just price is taken into account. Quantity demanded and supplied are mostly in disequilibrium and the quantity sold is a joint function of all the independent variables that affect supply and demand.

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