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Regional Tourism Development using Linear Programming and Vector Analysis

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Abstract

This paper describes a linear programming formulation and vector analysis which aims at presenting an evaluation of the available tourism forms of Dirfis area as part of a greater development planning for altering the tourism development in the area. The target of the present paper is to investigate the contribution of three different tourism forms (conference, ecotourism and pilgrim) in the local tourism economy given the available resources. The model introduced is a LP maximization model under the constraints of cost and space allocation. The final results of the model indicate an overall contribution to profits only of two tourism forms (conference and pilgrim) hence ecotourism is criticized from the model as unprofitable.

Keywords: *Linear Programming (LP), vector analysis, tourist forms, tourism development*

Introduction

Tourism is undoubtedly one of the major social and economic phenomena of modern times. The opportunity to participate in touristic growth has been widely available since the early 1900s, despite tourism being a social activity limited to a privileged minority at the time. Nevertheless, tourism is not just a social phenomenon; it is a major undertaking/venture.

«Mobility, holidays and travel are social victories» with significant impact all around the world. [1] Links between tourism and local communities are crucial and as a result so is the role of a local community in the decision making process over touristic development. For tourism to grow in a supportive way, it is important to use local resources. Forecasts assume that international tourism will continue to grow in the 21st century, with projected arrivals of 1.6 billion and returns that would reach 2 trillion U.S. dollars by 2020 [2].

The types of tourism that can be developed in a specific region are differentiations of the general tourism system. According to Professors P. BERNECKER and C. KASPAR (based on external phenomena and the effects of participating in tourism) these are some of the categories: leisure tourism, therapeutic/spa tourism, conference tourism, political tourism, sports/recreational tourism. [3] Based on the choice/expectations of tourists, a brief classification of the different types of tourism can also be made as follows: nature tourism, cultural tourism, social tourism, conference tourism, recreational tourism, sports tourism, religious tourism, health tourism, etc. [4]

Euboea, including Paradirfies Communities as well, is the largest island (after Crete) throughout Greece and the seventh prefecture in length. The length of Euboea comes up to 4.170 sq.km. The climate is mild, with several variations in each area. The temperature remains almost the same during the day and during the year, except from some mountainous areas.

The municipality of Dirfyon in Evia are faced with the following dilemma: a hotel complex that could be potentially turned into a conference centre already exists. However, the area offers resources for the development and growth of spa as well as religious tourism. The authority need to determine which category should be given development priority. Using linear programming and vector analysis we'll try to find which tourism category is most likely to be followed/developed.

Programming Methods

More useful methods for the examination of problems of production in the sector of travel and tourism are these of linear or non linear programming. These techniques give the possibility for constant relations between the surges in the sort term as well as for the distribution of surges in the production of more than one products or services. This is important for enterprises such as city hotels, which should distribute money resources, human resources, space and equipment between services to the customers, participants in congresses, in various other operations etc., or in a program of maintenance of a railway line that serves the needs of the educational tourism, the objective of maintenance of heritage, and the recreational tourism (Bull 1985).
Linear programming can be viewed as part of a great revolutionary development which has given mankind the ability to state general goals and to lay out a path of detailed decisions to take in order to "best" achieve its goals when faced with practical situations of great complexity. Our tools for doing this are ways to formulate real-world problems in detailed mathematical terms (models), techniques for solving the models (algorithms), and engines for executing the steps of algorithms (computers and software).[6]
A programming method takes into consideration the subjects of constant capacities as restrictions of system. The constant capacity is characteristic mark of enterprises in the sector of transports, where the offer of capacity in the sort term presents a `"boom" and is limited. As an example a vehicle allocates X places and it can be used only with one way each time. If no more vehicles are exist, then the capacity is X if exist also other vehicles, then the marginal increases of flows can be in sizes equal with X places.
A simple linear program begins with the determination of interrelation of an objective function, as the maximization of profits, for one or more products.

This can take the form:

Objective: Maximization of $P= aX_1 + bX_2$

where **P** = profit

$\mathbf{X_1}$ and $\mathbf{X_2}$ are products

a and **b** is the gross profit margin per product unit.

The production relations between the surges and the flows are determined with the form of restrictions, which determines the quantity of surges that are required for the production of certain flows, as well as the capacity of the available surges. These can have the form:

Under the restrictions:

$$i_1X_1 + i_2X_2 + S_1 = C_1$$
$$j_1X_1 + j_2X_2 + S_2 = C_2$$

where $\mathbf{i_1}$, $\mathbf{i_2}$, $\mathbf{j_1}$ and $\mathbf{j_2}$ are the quantities of surges i and j that are required in order to produce one unit of products X1 and X2 respectively,

$\mathbf{C_1}$ and $\mathbf{C_2}$ are the capacities of these available resources,

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$\mathbf{S_1}$ and $\mathbf{S_2}$ are the unused capacity that has remained from the surges (that usually characterized as stochastic variables).

Moreover, all variables should be positive or equal with zero (the restriction of non negativity). The enterprise cannot offer negative quantities of product.

This simple form of linear programming supposes constant output of scale and constant relations between the various uses of surges. Alternative relations and altered marginal output can be analyzed with more complex non linear programming.
Similarly, the interrelation of objective function in this case is the maximization of profits under constant conditions (that is to say, with constant prices in a region of flows) - a situation that are likely to exist only with perfect competition.
A more realistic picture, that of incomplete competition in the travel and tourism sector and the alternative objectives, they presuppose non linear interrelations of objectives.
The long-term analysis of production is even more complex:

- the production scale can be changed and the capacities can be altered with methods such as the further increase of financing, the extension of hotel building installations, the concession of more extent areas in National Parks or the acquisition of new vehicles.
- the methods of production can be changed in order to reflect the altered relative cost of surges. More specifically, labour it is possible to be substituted with capital in the whole system of production, but only marginal.
- the characteristics of the products can be changed. As an example, a thematic park can add a new pole of attraction or a restaurant can change cooking style - not as a result from demand, but as a choice of the management.

Model Development

The municipal development company needs to define its developmental policy based on the tourist resources available [8]. Assume the following:

1. Number of conference venues infrastructures x_1
2. Number of ecotourism sites infrastructures x_2
3. Number of pilgrimage sites infrastructures x_3

Profits per sector are:

Conference tourism: 6 monetary units
Eco Tourism: 4mu
Pilgrimage Tourism: 3mu

The company's goal is to maximise profit i.e. maximise : $\mathbf{6x_1+4x_2+3x_3}$

We assume the following:

1. The area available for the development of the "logistics" infrastructure is 50000m2. The requirements for each category are as follows:

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- Conference tourism: 800 τ.μ.
- Eco Tourism: 600 τ.μ.
- Pilgrimage Tourism: 500 τ.μ.

1. The total maintenance cost for the premises should not exceed the 36 mu. The actual cost per category is:

   - Conference tourism: 1 mu
   - Eco Tourism: 0,8 mu
   - Pilgrimage Tourism: 0,3 mu

In mathematical terms the above are:

$$8x_1+6x_2+5x_3 \leq 500$$
$$10x_1+8x_2+3x_3 \leq 360$$

Two independent variables x4 and x5 are introduced for the maximisation of the following linear function:

$$f(x_1, x_2, x_3, x_4) = 6x_1 + 4x_2 + 3x_3 + 0x_4 + 0x_5$$

where:

$$8x_1+6x_2+5x_3+x_4+0x_5=500$$
$$10x_1+8x_2+3x_3+0x_4+x_5=360$$
$$x_1, x_2, x_3, x_4, x_5 \geq 0$$

Assume, matrix $A=\begin{pmatrix} 8 & 6 & 5 & 1 & 0 \\ 10 & 8 & 3 & 0 & 1 \end{pmatrix}$ and vector $b=\begin{pmatrix} 500 \\ 360 \end{pmatrix}$. According to the optimization theory, function f takes its maximum value at the extreme points of the compact and closed set $E=\left\{x \in R_+^5 \mid Ax=b\right\}$. Also assume matrix Ax for every $x \in E$, where Ax consists of A's columns corresponding to the non-zero coordinates of x. Thus, x is the outermost point of R when Ax has linearly independent columns. Since A has a max of two linearly independent columns, the possible Ax 2x2s are as follows:

1. $A_x = \begin{pmatrix} 8 & 6 \\ 10 & 8 \end{pmatrix}$: Solving the system $A_x \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} = b$ the result is $\begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \end{pmatrix} = \begin{pmatrix} 460 \\ -530 \\ 0 \\ 0 \\ 0 \end{pmatrix}$. This is rejected.

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2. $A_x = \begin{pmatrix} 8 & 5 \\ 10 & 3 \end{pmatrix}$: Solving the system $A_x \begin{pmatrix} x_1 \\ x_3 \end{pmatrix} = b$ the result is $\begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \end{pmatrix} = \begin{pmatrix} 11{,}53 \\ 0 \\ 81{,}53 \\ 0 \\ 0 \end{pmatrix}$ which is an extreme point of E.

3. $A_x = \begin{pmatrix} 8 & 1 \\ 10 & 0 \end{pmatrix}$: Solving the system $A_x \begin{pmatrix} x_1 \\ x_4 \end{pmatrix} = b$ the result is $\begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \end{pmatrix} = \begin{pmatrix} 36 \\ 0 \\ 0 \\ 212 \\ 0 \end{pmatrix}$ which is an extreme point of E.

4. $A_x = \begin{pmatrix} 8 & 0 \\ 10 & 1 \end{pmatrix}$: Solving the system $A_x \begin{pmatrix} x_1 \\ x_5 \end{pmatrix} = b$ the result is $\begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \end{pmatrix} = \begin{pmatrix} 62{,}5 \\ 0 \\ 0 \\ 0 \\ -265 \end{pmatrix}$. This is rejected

5. $A_x = \begin{pmatrix} 6 & 5 \\ 8 & 3 \end{pmatrix}$: Solving the system $A_x \begin{pmatrix} x_2 \\ x_3 \end{pmatrix} = b$ the result is $\begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \end{pmatrix} = \begin{pmatrix} 0 \\ 13{,}63 \\ 83{,}63 \\ 0 \\ 0 \end{pmatrix}$ which is an extreme point of E.

6. $A_x = \begin{pmatrix} 6 & 1 \\ 8 & 0 \end{pmatrix}$: Solving the system $A_x \begin{pmatrix} x_2 \\ x_4 \end{pmatrix} = b$ the result is $\begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \end{pmatrix} = \begin{pmatrix} 0 \\ 45 \\ 0 \\ 230 \\ 0 \end{pmatrix}$ which is an extreme point of E.

7. $A_x = \begin{pmatrix} 6 & 0 \\ 8 & 1 \end{pmatrix}$: Solving the system $A_x \begin{pmatrix} x_2 \\ x_5 \end{pmatrix} = b$ the result is $\begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \end{pmatrix} = \begin{pmatrix} 0 \\ 83{,}33 \\ 0 \\ 0 \\ -306{,}6 \end{pmatrix}$. This is rejected.

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8. $A_x = \begin{pmatrix} 5 & 1 \\ 3 & 0 \end{pmatrix}$: Solving the system $A_x \begin{pmatrix} x_3 \\ x_4 \end{pmatrix} = b$ the result is $\begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 120 \\ 0 \\ -100 \end{pmatrix}$. This is rejected.

9. $A_x = \begin{pmatrix} 5 & 0 \\ 3 & 1 \end{pmatrix}$: Solving the system $A_x \begin{pmatrix} x_3 \\ x_5 \end{pmatrix} = b$ the result is $\begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 100 \\ 0 \\ 60 \end{pmatrix}$ which is an extreme point of E.

10. $A_x = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$: Solving the system $A_x \begin{pmatrix} x_4 \\ x_5 \end{pmatrix} = b$ the result is $\begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 500 \\ 360 \end{pmatrix}$ which is an extreme point of E

The solution that maximises $f(x_1, x_2, x_3, x_4) = 6x_1 + 4x_2 + 3x_3 + 0x_4 + 0x_5$ is $\begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \end{pmatrix} = \begin{pmatrix} 11{,}53 \\ 0 \\ 81{,}53 \\ 0 \\ 0 \end{pmatrix}$.

Hence, profit maximisation occurs when x_1=11,53 (i.e. when there are 11 conference venues), x_2=0 (i.e. there are no eco tourism venues) and x_3=81,53 (i.e 81 pilgrimage areas). This means that eco tourism will not contribute to profit maximisation and is therefore not necessary.

Conclusion

The conclusion is that we receive seriously under consideration the results of our example. Also with the restrictions that we have at the moment, Municipality of Dirfis should not invest for the tourist model of ecotourism, since there are not exist sites for eco tourism in the region, and therefore if the Municipality wants to proceed with this tourist form after all, would be a wrong investment and in particular without developmental prospects for the area and the local community.

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