CONSTANTINE PORPHYROGENETUS INTERNATIONAL ASSOCIATION

Journal of Management Sciences and Regional Development
Issue 5, July 2005
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http://www.stt.aegean.gr/geopolab/GEOPOL%20PROFILE.htm
ISSN 1107-9819
Editor-in-Chief: John Karkazis

THE ROLE OF ENVIRONMENT IN A REGION'S SUSTAINABLE DEVELOPMENT

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Abstract. Mankind's relationship with the environment has gone through several stages, starting with primitive times, in which human beings lived in a state of symbiosis with nature, followed by a period of increasing mastery over nature up to industrial age and culminating in the rapid material-intensive growth pattern of the twentieth century, which adversely affected natural resources in many ways, thus becoming a serious impediment to further growth. The present paper outlines the changing role of environment in a region's development, presents a measure of a region's overall attractiveness and incorporates environmental factors into it.

Keywords: Image of an Area, Sustainable Development, Economic Factors, Social Factors, Environmental Factors

1. INTRODUCTION

The development of an area depends on its ability to attract business activity. Business mobility, however, is largely a voluntary process. Business units move into or out of a given area on the basis of their perception of the area's relative attractiveness. Their mobility is a function of a multitude of factors. In the early stages of a country's industrialization the dominant factors are economic. However, as the industrialization process progresses, the role of the social factors is gradually strengthened and in some cases becomes decisive. Environmental factors are usually the last to be considered when people realize that the rapid growth of the socioeconomic subsystem has begun to overload some of the capabilities of the ecosystem locally as well as globally.

Environmental assets provide various types of services to human society, ranging from simple amenities to irreplaceable life support functions and there is an urgent need for the people to incorporate the consequences of those assets' degradation into their decision making process.

The present paper focuses on the environmental factors and its scope is to:

- Outline the changing role of environment in the process of an area's development over time
- Present a measure of an area's overall attractiveness
- Incorporate and quantify the effect of environment in this measure

2. THE CHANGING ROLE OF ENVIRONMENT IN SUSTAINABLE DEVELOPMENT: A BRIEF OVERVIEW

As it has been mentioned already, environmental degradation is one of the basic problems facing most countries around the world. Furthermore it has been found that one of the main causes of this problem is their fast economic growth. Obviously this finding raises a very important point as economic growth and indeed fast economic growth has for many years been considered as the centerpiece of a country's progress. Hence the concept of development has to be reconsidered. A new environmental aspect of development may be added to the economic and social ones and the blending of all three dimensions in defining sustainable development over time should be examined.

The relationship between environment and development is complex, dynamic and multidimensional. Various studies (Angelis et al (1999)) have shown that sustainable development is still a rather ill defined concept seeking a compromise between the preservation of natural environment and the achievement of economic and social development. The relationships between the three dimensions (economic, social, environmental) of sustainable development and their interconnections are given in Figure 2.1 below (Munasinghe (1993), Svedin (1991)).

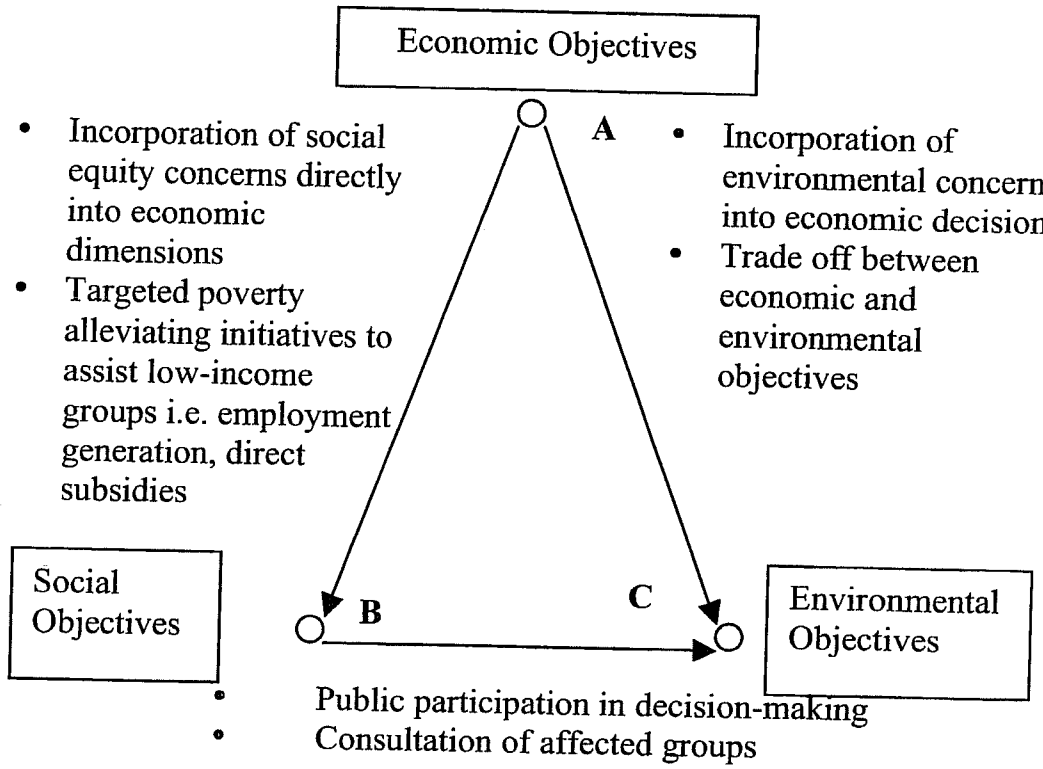

Figure 2.1 The three dimensions of sustainable development and their interconnections

In the 1950's and 1960's the focus of economic progress was on growth and increase in output based mainly on the concept of economic efficiency (Point A in Figure 2.1). Environment was not yet taken into account since it did not seem to affect the economic results.

By the early 1970's the large and growing numbers of poor in the developing world led to greater efforts of directly improving income distribution. The development paradigm shifted towards equitable growth where social objectives were recognized as distinct from and as important as economic efficiency (Point B in Figure 2.1) and issues like cultural interrelations in regional development started to draw attention (Higgins (1995)). The end of this decade also marked the appearance of

environment as a new factor affecting economic activity but with limited importance. Environmental threats were conceived of as local in time and space and hence easy to overcome.

Protection of the environment was the emerging strong new concern in the next decade. By the early 1980's protection of the environment has become the third objective of development (Munasinghe (1993), Svedin (1991)) showing that environmental degradation was a major barrier to progress (Point C in Figure 2.1). New fields of research like environmental modeling (Jorgensen et al (1996)) and landscape ecology (Turner et al (2001)) started to developed and the concept of sustainable development has evolved to encompass three major points of view economic, social and environmental. Furthermore by the end of the decade environmental concern was for the first time integrated into the business decision-making process.

In the 1990's environmental matters were considered to be the major component of the wider economic activity. Furthermore, environmental threats were perceived as emerging on a very large scale, often related to socio-economic turbulent factors and requiring corrective actions.

Finally in the first years of the 21st century the crucial role of environmental factors and their increasing contribution to an area's sustainable development was further established not only in the more developed European countries (Storper and Scott (1996)) but also in Greece (Skourtos and Sofoulis (1995)).

3. THE CONCEPT OF AN AREA'S IMAGE.

The growth or decline of an area depends on its power to "pull" both industries and the right blend of people to run them; this pulling trend depends on what we call the Image of an area. At each time instant the area "sends" out its image and depending on its impact on the people (both employers and employees) the area may be considered Attractive or Repulsive.

One may argue that since people "receiving" the Image of an area belong to various distinct groups (i.e. employers, unskilled workers, skilled workers etc) and are sensitive to different factors, the impact of the area's Image on the members of each particular groups will differ. Whilst this is plausible empirical evidence suggests that all groups of potential movers react similarly to a basic set of factors; more precisely, a set of minimum standards, largely common to all groups, must be satisfied if the area is to be considered as potential choice by any of them. To reconcile those two views we refine the concept of an area's Image by introducing the concepts of Basic Image (*BI*) and Specific Image (*SPI*).

The Basic Image of an area measures the degree to which this area satisfies a set of basic criteria common to all prospective movers. An area satisfying those criteria is considered, by all prospective movers, as worth a closer examination and as a potential final choice.

The Specific Image of an area, as perceived by a particular group of potential movers, measures the degree to which movers belonging to that particular group consider this area as their final choice.

At this point it should be mentioned that the development of an area may be expressed in both absolute and relative terms. In the latter

and more interesting case the development pattern of the given area is compared to that of a hypothetical area, which is referred to as the "typical area" and expresses, as far as possible, an "average" of the main areas of a similar type to that under study. In this paper we shall be looking at the relative development patterns of an area. Hence, all factors affecting its Images (Basic and Specific) must express relative values as compared to the corresponding values of the typical area.

The concepts of Basic and Specific Images have been discussed in full detail in some earlier papers (Angelis (1981) and (1990), Angelis and Dimopoulou (1991)). Summarizing the main findings about Basic Image we could say it may be expressed as a multitude of factors (Cullingworth (1969), Hunter and Reid (1968), Rhodes and Khan (1971), Townroe (1971), Townroe (1979)). Moreover, those factors may be divided into two groups according to which of the two conflicting functions of an area, economic or social, they concern. The factors of the first group (Accessibility to Materials and Markets, Land Availability, Financial Conditions) properly quantified and scaled give a measure of the area's potential for economic development. This measure is called the Economic Indicator (*EI*) of the area. Similarly the factors of the second group (Housing Conditions, Environmental Conditions, Social Conditions) properly quantified and scaled give a measure of the area's social conditions and quality of life. This measure is called the Social Indicator (*SI*) of the area. Concluding therefore, we could say that the Basic Image of an area may be expressed as a function of two conflicting indicators, Economic and Social. Hence,

$$BI = f(EI, SI)$$

Furthermore:

$$EI = \frac{\sqrt[3]{(LOCM)(LAVM)(FICM)}}{2}$$

$$SI = \frac{\sqrt[3]{(HSCM)(ENCM)(SOCM)}}{2}$$

where
LOCM: Location Multiplier
LAVM: Land Availability Multiplier
FICM: Financial Conditions Multiplier
HSCM: Housing Multiplier
ENCM: Environnemental Conditions Multiplier
SOCM: Social Conditions Multiplier

The expression of the Basic Image as a function of these two Indicators is not accidental; on the contrary, it is consistent with the concept of an area as a socio economic unit. The main advantage of such an expression is that it may be used to underline, and eventually describe, the basic conflict that characterizes the development of an area (Perloff and Wingo (1971), Zolotas (1981)).

Furthermore there seems to be evidence to suggest that the Basic Image function is non- linear and its graph discontinuous. To study this function Catastrophe, a mathematical theory particularly applicable to cases where continuous forces in discontinuous phenomena, was used (Postle (1980), Poston and Steward (1978), Woodcock and David (1978)). The theory is derived from topology and classifies the ways in which discontinuities occur in terms of a few archetypal forms called elementary catastrophes. According to this theory in the case of a process expressed through a behavior variable and depending on two control variables we can define a 3- dimensional surface, known as the

Cusp Surface, showing all the ways in which a discontinuity of the behavior variable may occur.

Returning to our case it is reminded that the Basic Image of an area has been expressed as a function of two conflicting Indicators, Economic and Social respectively. Hence, we can define the Cusp Surface for the area's Basic Image showing all its possible discontinuities. This surface is defined as

$$S_c = \left\{(X, A, B) \in \square^3 / X^3 - BX - A = 0\right\}$$

where A and B are functions of the area's Economic and Social Indicators respectively.

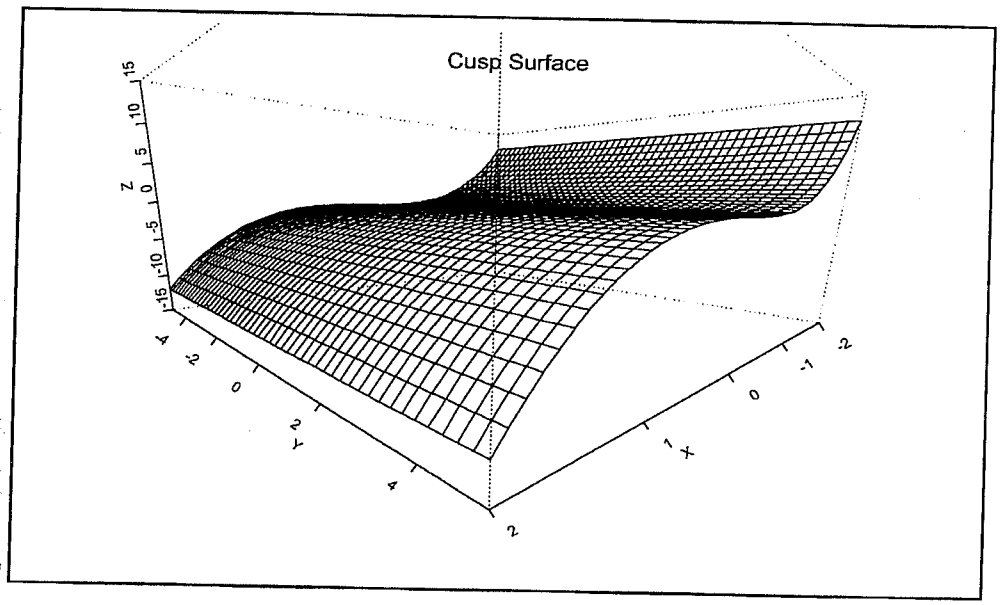

Figure 3.1: Cusp Surface

The Cusp Surface is shown in Figure 3.1 where the x, y and z-axes correspond to the Basic Image, the control variable B and the control variable A respectively. As we can see there is a single folding of the surface near the axes' origin.

On the basis of the above we can say that the value of an area's Basic Image (BI=X) at each point in time is given as a solution of the equation

$$X^3 - BX - A = 0,\ X \in [-1,+1]\ A, B \in R \qquad (1)$$

where

$$\left.\begin{aligned} A &= m(a-a_0)+(b-b_0) \\ B &= (a-a_0)-m(b-b_0) \end{aligned}\right\} \text{if } m \le 1 \text{ (i.e. } \theta \le 45^\circ)$$

$$\left.\begin{aligned} A &= (a-a_0)+\frac{1}{m}(b-b_0) \\ B &= \frac{1}{m}(a-a_0)-m(b-b_0) \end{aligned}\right\} \text{if } m>1 \text{ (i.e. } 90^\circ>\theta>45^\circ)$$

and

a:	The value of the area's Industrial Indicator
b:	The value of the area's Social Indicator
a_0:	The value of the typical area's Industrial Indicator
b_0:	The value of the typical area's Social Indicator
m:	A variable expressing the relative weight attached to each of the two Indicators in defining the area's Basic Image.

It must be noted that m takes positive values indicating varying degrees of contribution of each Indicator in the formation of the area's Basic Image. More specifically, as the value of m decreases the contribution of Industrial Indicator decreases as well, in favour of the Social Indicator. Especially for m=1 their contributions are equal. Furthermore, the values of both the typical area's Indicators are equal to 0.5 and the Indicators' values of any given area lie in the interval [0,1]. Finally, the value of the typical area's Basic Image is equal to zero and

the Basic Image value of any given area lies in the interval [-1,1]. Positive Basic Image indicates an attractive area that may be considered as a potential final choice by the various groups of prospective movers.

Having defined an area's Basic Image we may now go on to define its Specific Image as perceived by the various groups of potential movers. Summarizing our findings we can say that it may be expressed as a function of both the area's Basic Image and certain specific factors relevant to the particular group of movers. In other words:

$$SPIM_g = g\left(BI, SPF_{1_g}, SPF_{2_g}, \ldots, SPF_{n_g}\right)$$

where:

$SPIM_g$: The area's Specific Image as perceived by the members of group g

BI: The area's Basic Image

$SPFi_g$: The Specific Factor i for the members of group g.

Obviously the specific factors differ from one group to another. In the case of investors, one of the most influential group of movers, the specific factors may include labour availability, labour quality and the provision of financial incentives.

Hence:

$$SPIMI = \sqrt[4]{(BIM)(LBAVM)(LBQLM)(FINIM)}$$

where:

SPIMI: Specific Image for Investors

BIM: Basic Image Multiplier

LBAVM: Labour Availability Multiplier

LBQLM: Labour Quality Multiplier

FINIM: Financial Incentives for Industrial Multiplier

It must be noted that for the purposes of this work all the Specific Image values of the typical area are equal to 1 and the Specific Image values for any given area lie within the interval [0,2]. Specific Image value, as perceived by a group of prospective movers, greater than 1 indicates an area with high probability of being considered as the best final choice by the members of this group.

4. INCORPORATING ENVIRONMENTAL FACTORS INTO AN AREA'S IMAGE

According to the overview of the changing role of the environment in sustainable development presented in section 2 the expression of an area's Basic Image as a function of two conflicting Indicators, the use of the Cusp Catastrophe to model it and the expression of an area's Specific Images as functions of both Basic Image and the respective specific factors mentioned so far, seem valid up to the mid 1980's.

At that point in time, however, environment emerged as a new factor affecting an area's development and soon became the third objective of development interconnections (Munasinghe (1993), Svedin (1991)). In order to take into account this new factor we should modify the definitions of both an area's Basic Image and the Specific Image as perceived by investors.

The Basic Image of an area has so far been expressed as a function of the Economic Indicator (*EI*) and Social Indicator (*SI*) with environment being one of the factors comprising the Social Indicator. However as environment becomes increasingly important there is a

growing need to isolate it and treat it separately as a third Indicator which may be referred to as Environmental Indicator (*ENI*). Hence,

$$BI = f(EI, SI, ENI)$$

The first two Indicators, which may also be referred to as the socioeconomic plane Indicators, have already been defined. The third Indicator expresses the environmental conditions in a given area. It may be measured as a function of air pollution, water pollution and solid waste levels in the given area. Alternatively, in case such data is not available, it can be measured indirectly as a function of population health problems as well as of agricultural production and stock breeding problems due to environmental reasons.

For the purposes of this work and in order to be in line with the definitions of Economic Indicator and Social Indicator, the Environmental Indicator (ENI) will be defined as follows

$$ENI = \frac{\sqrt[3]{(AQM)(WQM)(SWLM)}}{2}$$

where

AQM: Air Quality multiplier

WQM: Water Quality Multiplier

SWLM: Solid Waste Level Multiplier.

In this case too, there is evidence suggesting that the Basic Image function is non-linear and its graph discontinuous. Hence, Catastrophe Theory will again be employed for its study. According to this theory in the case of a process expressed through a behavior variable and depending on three control variables, we can define a four-dimensional surface, known as the Swallowtail Surface, showing all the ways in which a discontinuity of the behavior variable may occur. Returning to

our case it is reminded that the Basic Image of an area has been expressed as a function of three indicators; Economic, Social and Environmental. Hence, we can define the Swallowtail Surface for the area's Basic Image showing all its possible discontinuities. This surface is defined as

$$S_{SW} = \left\{(X, A, B, C) \in R^4 / X^4 - BX^2 - AX - C = 0\right\}$$

where A, B and C are functions of the area's Economic, Social and Environmental Indicators respectively.

A 3-dimensional part of the Swallowtail Surface is shown in Figure 4.1 where the x,y and z axes correspond to the Basic Image, the control variable B and the control variable A respectively. As we can see there is a double folding of the surface near the axes' origin and a single folding towards the edges.

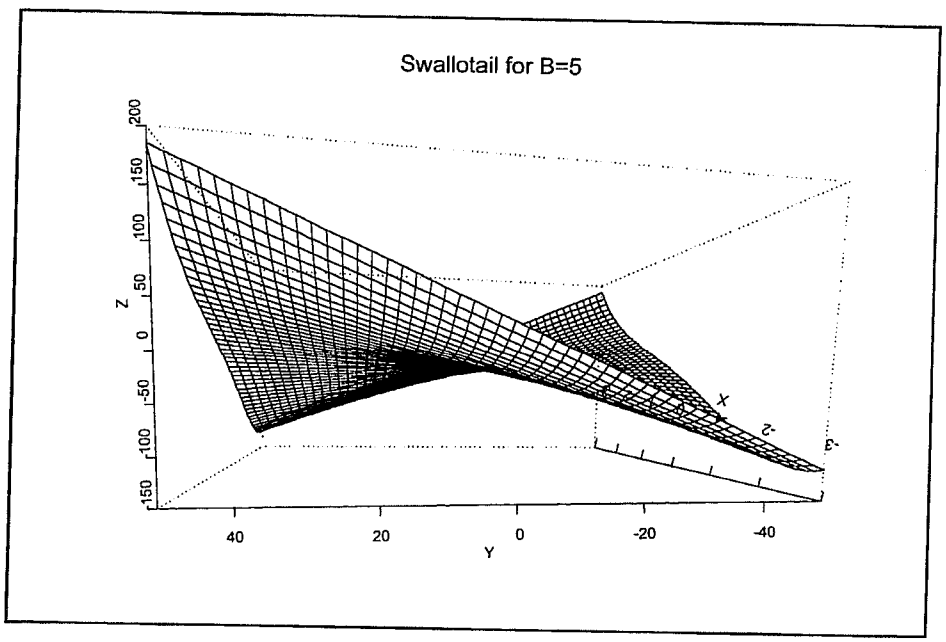

Figure 4.1: Swallowtail Surface

On the basis of the above we may say that the value of an area's Basic Image (BI=X) at each point of time is given as a solution of the equation:

$$X^4 - BX^2 - AX - C = 0,\ X \in [-1, +1],\ A, B, C \in R \quad (2)$$

where

$$\left.\begin{aligned} A &= (a - a_0)m + (b - b_0) \\ B &= (a - a_0) - (b - b_0)m - (c - c_0)k \\ C &= (a - a_0)k - (b - b_0)mk - (c - c_0) \end{aligned}\right\},\ if\ \begin{matrix} 0 \le m \le 1 \\ 0 \le k \le 1 \end{matrix}$$

$$\left.\begin{aligned} A &= (a - a_0)m + (b - b_0) \\ B &= \frac{(a - a_0)}{k} - \frac{(b - b_0)m}{k} + (c - c_0) \\ C &= (a - a_0) - (b - b_0)m - \frac{(c - c_0)}{k} \end{aligned}\right\},\ if\ \begin{matrix} 0 \le m \le 1 \\ k > 1 \end{matrix}$$

$$\left.\begin{aligned} A &= (a - a_0) + \frac{(b - b_0)}{m} \\ B &= \frac{(a - a_0)}{m} - (b - b_0) + (c - c_0)k \\ C &= \frac{(a - a_0)k}{m} - (b - b_0)k - (c - c_0) \end{aligned}\right\},\ if\ \begin{matrix} 1 > m \\ 0 \le k \le 1 \end{matrix}$$

$$\left.\begin{aligned} A &= (a - a_0) + \frac{(b - b_0)}{m} \\ B &= \frac{(a - a_0)}{mk} - \frac{(b - b_0)}{k} + (c - c_0) \\ C &= \frac{(a - a_0)}{m} - (b - b_0) - \frac{(c - c_0)}{k} \end{aligned}\right\},\ if\ \begin{matrix} 1 < m \\ 1 < k \end{matrix}$$

and:

a: The value of the area's Industrial Indicator

b: The value of the area's Social Indicator

c: The value of the area's Environmental Indicator

a_0: The value of the typical area's Industrial Indicator

b_0: The value of the typical area's Social Indicator

c_0: The value of the typical area's Environmental Indicator

m: A variable expressing the relative weight attached to each of the two Socioeconomic plane Indicators in defining the area's Basic Image.

k: A variable expressing the relative weight attached to two Socioeconomic plane Indicators on the one hand and the Environmental Indicator on the other in defining the area's Basic Image.

It must be noted that m and k take positive values indicating varying degrees of contribution of each Indicator in the formation of an area's Basic Image. More specifically as the value of m decreases the contribution of Industrial Indicator decreases as well, in favour of the Social Indicator. Especially for m=1 the two Indicators have the same contribution. Similarly as the value of k decreases the contribution of the Socio-economic plane Indicators as a whole decreases as well in favour of the Environmental Indicators. Especially for k=1 their contributions are equal.

The Specific Image of an area as perceived by Investors (*SPIMI*) which has so far been expressed as a function of its Basic Image, its labour quality and availability and the provision of financial incentives to industries moving into it will have to be extended so as to include environmental cost as well. Hence

$$SPIMI = \sqrt[4]{(BIM)(LQAVM)(FINM)(ENCM)}$$

where

BIM:	Basic Image Multiplier
LQAVM:	Labour Quality and Availability Multiplier
FINM:	Financial Incentives Multiplier
ENCM:	Environmental Cost Multiplier

The Environmental Cost Multiplier (*ENCM*) expresses the cost of protecting, cleaning up and restoring the environment in the given area. It is measured as a function of the money spent by the private sector for protecting and restoring the environment (i.e. purchase of special filters, construction of biological cleaning units etc). In addition, it can be implicitly measured as a function of the existence and strictness of environmental regulations concerning air pollution, water pollution, and solid wastes.

5. CHANGES IN THE VALUES OF AN AREA'S BASIC IMAGE

In order to examine how the Basic Image values vary in points with high potential for change, we have simulated their trend for different values of the corresponding Indicators for both the Cusp and the Swallowtail Surfaces.

In the case of the Cusp Surface we know that the Basic Image value of an area depends on the values of its two Indicators, Economic and Social. Keeping both the typical area's Indicators equal to 0.5, setting the slope parameter m equal to 1 (indicating the same

contribution of both Indicators in defining the area's Basic Image) and letting the values of the given area's two Indicators to vary we get the results shown in Figure 6.1.

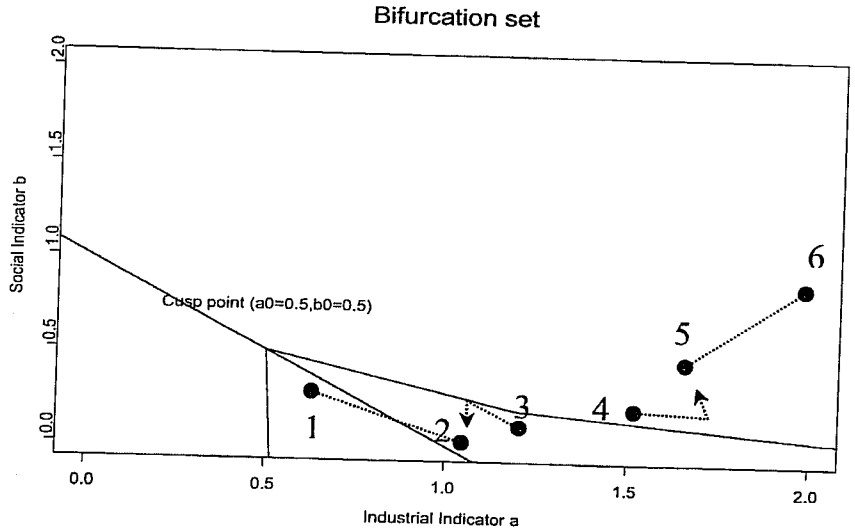

Figure 6.1: Bifurcation set for Cusp Catastrophe for m=1 and a_0=b_0=0.5 and path lines 1-2, 3-2, 4-5, 5-6

This figure is a projection of the Cusp Surface on a 2-dimensional space and it is referred to as the Bifurcation Set of the Cusp Surface. As we can see:

- When the values of both the given area's Indicators are greater than the corresponding coordinates of the right edge curve of the bifurcation set then its Basic Image values are positive and the area is attractive (i.e. Path line 5-6 in Figure 6.1)
- When the values of both the given area's Indicators are less than the corresponding coordinates of the left edge curve of the bifurcation set then its Basic Image values are negative and the area is repulsive (i.e. Path line 1-2 in Figure 6.1)

- When the coordinate vector of the values of the given area's two Indicators lies initially inside the bifurcation set and then crosses its edges as one Indicator is increasing while the other is decreasing then the area's Basic Image values may be either positive or negative and sudden changes from one mode to the other may be expected. (i.e. Path lines 3-2 and 4-5 in Figure 6.1)

In the case of the Swallowtail Surface we know that the Basic Image value of an area depends on the values of its three Indicators Economic, Social and Environmental. Keeping all three Indicators equal to 0.5, setting the slope parameter m equal to 1 (indicating the same contribution of both the Socioeconomic plane Indicators in defining the area's Basic Image), the slope parameter k equal to 0.6 (indicating a 60% contribution of the two Socioeconomic Indicators as a whole and a 40% contribution of the Environmental Indicator in defining the area's Basic Image) and letting the values of the given area's three Indicators to vary we get the results shown in Figure 6.2a. This figure is a projection of the Swallowtail Surface on a 3-dimensional space and it is referred to as the Bifurcation Set of the Swallowtail Surface. Figure 6.2b follows from Figure 6.2a as a 2-dimensional contour created by keeping c constant and letting a and b to vary.

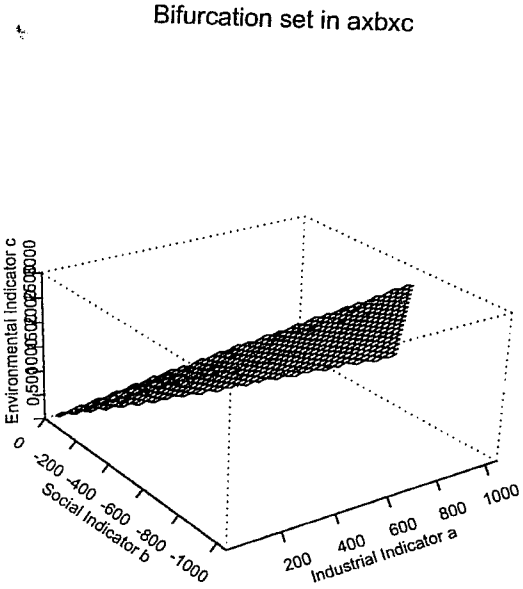

Figure 6.2a Bifurcation set in axbxc

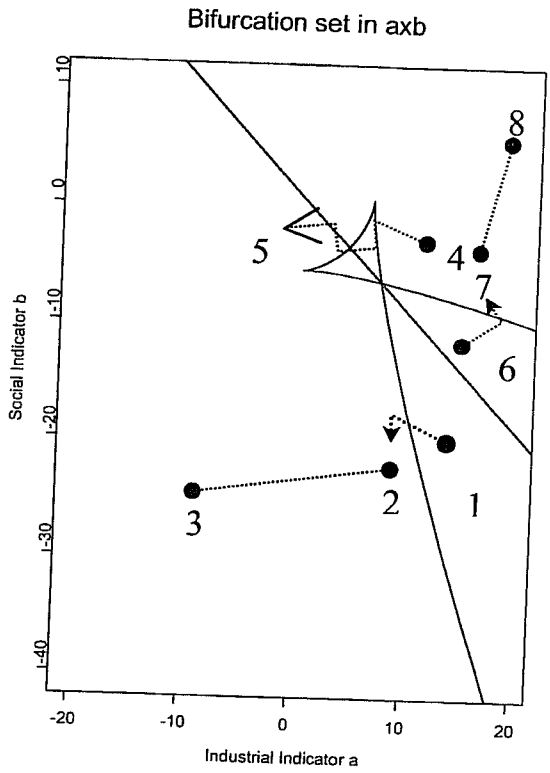

Figure 6.2b: : Bifurcation set in axb plane and paths 1-2-3, 4-5, 6-7-8

As we can see:

- When the values of all three Indicators are greater than the corresponding coordinates of the right edge of the bifurcation set then its Basic Image values are positive and the area is attractive (i.e. Path line 7-8 in Figure 6.2b)
- When the values of all three Indicators are less than the corresponding coordinates of the left edge of the bifurcation set then its Basic Image values are negative and the area is repulsive (i.e. Path line 2-3 in Figure 6.2b)

- When the coordinate vector of the values of the given area's three Indicators lies initially within the bifurcation set and then crosses its edges as one of the socioeconomic plane Indicators is increasing while the other is decreasing then sudden changes in the sign of the Basic Image values may be expected and the Environmental Indicator may play the crucial role of adjusting the Basic Image value (i.e. maintain its current sing or speed – up a change of sign). (i.e. Path lines 4-5, 1-2, 6-7 in Figure 6.2b)

6. CONCLUSIONS - SUGGESTIONS FOR FURTHER RESEARCH

The growth and decline of an area depends on its ability to attract and retain business units and the right blend of people to run them. This attraction power is expressed through a variable, which is referred to as the Image of the area and may be further analyzed into Basic Image and Specific Images.

The Basic and Specific Images have so far been defined as functions of only economic and social factors. In this paper, however, these functions have been extended so as to cover environmental factors as well. Such factors include the Air Quality Multiplier, the Water Quality Multiplier and Solid Waste Level Multiplier in the case of the area's Basic Image and Environmental Cost Multiplier in the case of its Specific Image as perceived by Investors. A first approach of quantifying those factors and thus defining an area's Image has been made but further research and elaboration is needed toward this direction. Once the quantification methodology has been fully defined it

could be applied to data drawn from 51 Greek counties over a period of time in order to calculate the values of all indicators and eventually the values of both their Basic and Specific Images.

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