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THE ROLE OF ENVIRONMENT IN A REGION'S SUSTAINABLE DEVELOPMENT AS DESCRIBED BY A BUTTERFLY CATASTROPHE MODEL

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Abstract

The territorial organisation of economies and societies is undergoing a dramatic change. Globalisation, technological innovation, migration and population ageing make it increasingly difficult to predict the future of regions. Economic change tests the ability of all regions to compete and the gap between leading and lagging regions in terms of growth, income and employment is widening. Environmental factors test the ability of national and local governments to manage resources in a sustainable manner and to maintain and improve the quality and safety of life, in areas showing both economic growth (congestion, pollution, contamination, waste generation) or decline (abandoned land, degradation of the built heritage, lack of investment, etc.). These problems have led, step by step, to a modification of the targets of development and the acceptance that the concept of development has to embody the quality of economic growth, as well as its quantity and human well being alongside with it. Sustainable development refers to the ability of our societies to meet the needs of the present without sacrificing the ability of future generations to meet their own needs. Measuring sustainable development means going beyond a purely economic description of human activities; requires integration of economic, social and environmental concerns. New techniques are required in order to benchmark performance, highlight leaders and laggards on various aspects of regional development and facilitate efforts to identify best practices. New tools have to be designed so as to make sustainability decision-making more objective, systematic and rigorous. Our aim is to outline the changing role of environment in a region's development, present a measure of a region's overall attractiveness and incorporate environmental factors into it.

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 the setting up of this measure

Keywords: Region's Image, Region's Attractiveness, Regional Development, Sustainable Development, Economic Factors, Social Factors, Environmental Factors, Butterfly Catastrophe Model.

JEL Classification: C02, C65, Q01, Q51, R58

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.

The scope of the present paper is to:

- Introduce/give a brief overview of the concept of sustainable development
- 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 economic, social and environmental factors in the setting up of this measure

2. Sustainable Development

The concept of development is used to express the achievements or the positive changes in the basic elements of human socio-economic behaviour. Those who seek for a scientific definition for development disregard the fact that development is not only a technical subject. It has an important ideological content and reflects a strong set of values. Thereby the term development is identified in the 20^{th} century with the terms economic growth and industrialisation. Economic policies have typically measured development with the growth of per capita income or consumption.

Sustainable development is not a new concept. J.S. Mill (1843), one of the great economists of the 19^{th} century, showed his concern by focusing on issues such as the ultimate point to which society is tending by its industrial progress and the conditions mankind will have to face when this progress seizes. Many years later, R. Solow (1991), another leading and Nobel prize winner economist, focusing on the same subject stated that sustainability must be understood as an obligation to conduct ourselves so that we leave to the future the option or

the capacity to be as well off as we are. Furthermore, he urged the decision makers to take all the measures needed to ensure a distributional equity between the present and the future.

Today, the territorial organisation of economies and societies is undergoing dramatic change. Sustainable development is a strategy by which communities seek economic development approaches that also benefit the local environment and quality of life.

3. The changing role of the Economic, Social and Environmental Factors in Sustainable Development

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 centrepiece 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.

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. Environment was not yet taken into account since it didn't seem to affect the economic results.

By the early 1970's the development paradigm shifted towards equitable growth where social objectives were recognized as distinct from and as important as economic efficiency. The end of this decade also marks the appearance of environment as a new factor affecting economic activity but with limited importance. Environmental threats are conceived of as local in time and space and hence easy to overcome.

Protection of the environment is the emerging strong new concern in the next decade The concept of sustainable development has therefore evolved to encompass three major points of view: economic, social and environmental. Furthermore, by the end of the decade, environmental concern is for the first time integrated into the business decision making process.

In the 1990's and at the beginning of the 21st century, the crucial role of the environmental dimension and its increasing contribution to sustainable development has been further established.

4. Measuring Sustainable Development

Measuring sustainable development means going beyond a purely economic description of human activities and integrates economic, social and environmental concerns. In other words, sustainable development means ensuring economic efficiency while respecting social equity and safeguarding ecological integrity. Many tools and methodologies have been used over the past years to measure the progress towards sustainability (Munda, 2006; Karol & Brunner , 2009; Yigitcanlar & Dur, 2010). The majority of those methodologies make use of a single indicator in order to measure separately the evolution of each component i.e. the economic, the social, the environmental. The criteria, according to which indicators are selected for measuring sustainable development, are exhausting in literature (Barrios & Komoto, 2006; Singh et al, 2009). In this paper we introduce the concept of a region's Image, a measure of its overall progress towards sustainable development which encompasses all the three dimensions economic, social and environmental and suggests ways of measuring all three dimensions as well as the region's image.

5. The Region as a Socio-economic Unit and the Process of Business and Residential Location

The growth and decline of a region depends on its ability to attract and retain business and people. The realization that places compete for investment has expanded in recent years to encompass competition among places for the attention of investors and workers (Malecki, 2004). As people and businesses become more mobile, they will move towards attractive places and evacuate unattractive places. The success of a region depends on its capability to attract and keep firms with stable, or increasing, market shares, whilst maintaining stable or increasing standards of living for those who participate in it (Storper, 1997); in other words, when the region is able to generate high profits for its businesses and high standard living conditions for its residents (Bristow, 2010). On the basis of all the above, one can say that a region should ensure livability, investibility and visitability (Kotler et al., 1999) and, in doing so, it performs a number of functions: economic, social and environmental. These functions, however, are not always compatible; on the contrary, the idea of a potential conflict between them often appears in urban literature. Concluding, it could be said that a region, as a socioeconomic system, has to achieve not only a satisfactory economic performance, but also a number of other basic social and environmental objectives. If these are not met, then, over the longer term, a conflict would arise and the situation would almost certainly not be sustainable (Llewellyn, 1996; Lovering, 2001; Bristow, 2005).

Having discussed the nature of a region as a socioeconomic unit we will now look at the location process of both business units and employees. Mobility within a state is largely a voluntary process. Hence, the growth and decline of a region depends on its ability to attract and retain business activities and the right blend of people to run them (Bristow, 2005). It is therefore important to understand how business units and employees/residents make their location decisions. Earlier papers have shown that there seem to be a set of "attraction" factors, common for both investors and employees. Those factors include economic stability, economic viability, infrastructure, financial resources, health and education facilities of high quality and good environmental conditions. Furthermore, they may be divided into three basic sets. The first set contains factors related to the economic function of the region; the second set contains factors related to the social function of the region and finally the third set contains factors related to the environmental function of the region.

6. The Concept of a Region's Image

As it has been mentioned so far, the growth or decline of a region depends on its power to "pull" and retain both business activities and the right blend of people to run them; this pulling power depends on what we call the Image of the region. It can be argued that, at each point in time, the region "sends out" its Image and, depending on its impact on the people (both employers and employees), the region may be considered attractive or non attractive. One may also argue that since people "receiving" the image of the region belong to various distinct groups (i.e. employers, unskilled workers, skilled workers etc.) and are sensitive to different factors, the impact of the region's Image on the members of each particular group will be different (Kotler et al., 1999).

Whilst this argument is plausible, the available 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 region is to be considered as a potential choice by any of them. Every community must provide some basic standards of services to attract and retain people, business and visitors. Admittedly, no uniform standards exist. Hence, every region, in order to be/remain attractive, should determine the standards pertaining each time and try to meet them (Kotler et al., 1999).

To reconcile these two views we refine the concept of a region's Image by introducing the following two concepts: the Basic Image and the Specific Image.

The **Basic Image** of a given region measures the degree to which the region satisfies a set of basic criteria, common for all movers. A region satisfying those criteria is considered by all potential movers as worth a closer examination and as a potential final choice.

The **Specific Image** of a given region, as perceived by a particular group of potential movers, measures the degree to which movers belonging to that particular group consider the region as their best final choice. This Specific Image, however, although a function of specific factors appealing mainly to members of that group, is primarily a function of the region's Basic Image.

The remainder of this paper will focus on the definition and study of a region's Basic Image. This is a rather abstract concept which expresses the actual state of the region; a physically realizable measure for the Basic image is difficult to find. What may be measured more easily is the net change of a region's population due to migration during each time period. Such a change, however, is of very little importance as a measure of the real state of the region. The perception and reaction times to any change in the state of a region's Basic Image are different for the various groups of potential movers and are particularly long for certain vulnerable minorities, who lack real choice in place to live and work. Hence, the measurable changes of the region's population due to migration may be generally considered as the delayed and considerably smoothed consequence of changes in the Basic Image.

The study of the mechanisms governing the shaping and the changes of a region's Basic Image is a task of imperative importance. Apart from simplifying the analysis of a region's behaviour, the Basic Image, as an overall measure of its attractiveness and performance, has the following two advantages:

i. It gives an early warning of any potential danger of decline.
ii. It gives the "true" picture of the region and helps decision makes to detect the causes and not only the symptoms of any existing problems.

An early and correct diagnosis of a problem is perhaps the biggest step towards its solution. In the case of regional development, however, the seeds of decay are usually planted during a period of prosperity and no action is taken against them until it is too late (Kondakis et al., 2009; Angelis, V. & Dimaki, K. 2011). Ironically, the very state of being an attractive place may unleash forces that ultimately unravel the attractiveness of a place. Many places experience a period of growth, followed by a period of decline, and the fluctuations may be repeated several times. Therefore, a monitoring device, which will alert us at the first sight of danger, is a tool of great importance (Kotler et al., 1999).

We have so far introduced the Basic Image of a region as a function of a number of factors which influence the movement of people and industries. Mobility is essentially a voluntary process and state intervention may only be passive in the sense that it can stop or influence movement but it can not direct it. Hence, any attempt to improve or sustain the attractiveness of a region must be directed towards providing the framework within which this voluntary process can flourish. The Basic Image as defined may be the basis for such a framework and the factors affecting will be the prime targets for improvement. The factors affecting the Basic Image that have been presented so far include financial conditions, employment, social conditions, health and education quality, environmental conditions, regional influence etc. Furthermore they may be divided into three groups depending on which dimension of the region's development they refer to.

In some previous papers (Angelis & Dimopoulou 1991; Angelis, V. & Dimaki, K. 2011) the factors affecting a region's Image were divided into two groups related to the economic and social dimensions of its development, providing in that way measures of its economic potential and social conditions. These measures were referred to as the Economic Indicator and the Social Indicator. Evidence was also presented to support that the Economic and Social indicators may be seen as conflicting indicators. The expression of a region's Basic Image as a function of two conflicting Indicators and the use of the Cusp Catastrophe to model it is, up to a certain point in time, in line with the overview presented in the previous section. Indeed, according to this overview, economic growth was the only concern of development until the early 1970's when social objectives gradually began to appear as distinct from and as important as economic efficiency. However, by the early 1980's protection of the environment appeared and soon became the third objective of development. (Svedin, 1991; Munashinghe, 1993). In Angelis et al. (1999) the environmental quality was one of the factors that have been considered as affecting the area's Social Indicator. However, as environmental quality becomes increasingly important, there is a growing need to isolate it and to treat it separately as a third indicator let's say Environmental Indicator (Bovolos et al., 2011). In this work, we present a novel way to model a region's Image by taking into account the effect of economic, social and environmental impact. To this end we classify the various factors affecting a region's Image into three groups according to whether they express the economic, the social or the environmental function of the region.

The **Economic Indicator** is a function of factors like *GDP per Capita, Energy Expenditure per Capita, Employment Rate, Research & Development percentage of GDP* and gives a measure of the industrial potential of the area.

The **Social Indicator** is a function of factors like *Public Expenditure on Education Persons with Upper Secondary or Tertiary Education, Healthy Life Years, Hospital Beds, Expenditure on Social Protection, People at Risk of Poverty or Social Exclusion and* gives a measure of the social conditions in the area.

The **Environmental Indicator** is a function of factors like *Share of Renewable Energy Sources (RES) in Electricity Generation, Share of Renewable Energy Sources (RES) in gross Final Energy Consumption (FEC), Energy Intensity of the Economy, Greenhouse Gas Emissions* and gives the measure of the quality of the environment in the region. Hence,

$$Basic\ Image = \varphi\ Economic\ Indicator, Social\ Indicator, Environmental\ Indicator$$

The expression of the Basic Image as a function of the Economic, Social and Environmental Indicator is not accidental; on the contrary, it is consistent with the concept of a region 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 characterises the development of a region (Llewellyn, 1996; Lovering, 2001; Bristow, 2005). Furthermore, the Environmental Indicator may be seen as a buffer limiting the decrease of attractiveness of a declining region and facilitating the reversal of its declining trend.

At this point it should be mentioned that the growth of a region may be expressed both in absolute or relative terms. In the latter and most interesting case the development pattern of a given region is compared to that of a hypothetical region, which is referred to as the "typical" region and expresses, as far as possible, an average of the main regions of a similar type to that of the study. In this paper we shall be looking at the relative development patterns of a region. Hence, all the factors affecting its images (Basic and Specific) should be expressed in relative terms as compared to the corresponding values of the "typical" region.

7. Properties of a Region's Basic Image

Let us now move a step further and concentrate on the problem of the theoretical shape of the graph of the Basic Image. In order to get a first feeling of the shape of those graphs we start by stating the following simple observations describing the way in which the two or three indicators operate.

i. The higher the Industrial Indicator of a region the more Attractive its Basic Image.
ii. The higher the Social Indicator of a region the more Attractive its Basic Image.
iii. The higher the Environmental Indicator of a region the more Attractive its Basic Image.

iv. If the Industrial Indicator of a region is continuously increasing but at the same time its Social Indicator is continuously decreasing, the Basic Image of the region may be either Attractive or Repulsive and sudden changes in its state may be expected.

Such observations although trivial and only a first approximation of the truth, they give us some useful background information and help us deduce the shape of the three-dimensional graph. Observation (iv) is the most interesting because it implies that the graph we want to draw is discontinuous. Those observations make the idea of a discontinuous graph credible and worth pursuing further (Pike et al., 2006; Capello, 2007; Capello et al., 2008).

The general mathematical theory of discontinuous and divergent behaviour from continuous underlying forces is called Catastrophe Theory (Thom, 1975; Zeeman, 1973). The theory is derived from Topology and is based upon some new theorems in the geometry of many dimensions, which classify the ways in which discontinuities may occur, in terms of a few archetypal forms called elementary catastrophes (Poston and Stewart, 1996). Although the underlying mathematics are difficult and the proofs of the theorems involved complicated, the elementary catastrophes themselves are relatively easy to understand and can be used effectively, even by non-experts in the subject (Angelis and Dimopoulou, 1991). Catastrophe theory was developed and popularized in the early 1970's. After a period of criticism, it is now well established and widely applied (Rosser, 2007). Today, the theory is very much alive and numerous nonlinear phenomena that exhibit discontinuous jumps in behavior have been modeled by using the theory, for instance in chemistry (e.g Wales, 2001), in physics (e.g. Aerts, 2003), in psychology (e.g. Van der Mass et al., 2003) in clinical studies (e.g. Smerz and Guastello, 2008) and in the social sciences (e.g. Smith et al., 2005; Dou and Ghose, 2006; Huang, 2008).

Table 1 summarizes the elementary catastrophes in the case where a process is expressed through one behaviour variable depending on one up to four control variables. In the case of a process, for example, whose behaviour depends on two control variables it is sufficient to know that a theorem exists giving the qualitative shape of a 3-dimensional surface, which shows all possible ways in which a discontinuity in the behaviour may occur. The two control variables are usually referred to as normal and splitting factor respectively.

Table 1: Some Elementary Catastrophes

Number of Behavior Variables	Number of Control Variables	Type of Catastrophe
1	1	Fold
1	2	Cusp
1	3	Swallowtail
1	4	Butterfly

Elementary Catastrophes have characteristic invariant properties and, often, even wave flags (Gilmore, 1993) to gain our attention.

- ***Modality*** arises when, for some combinations of values of the control parameters, there are two or more possible stable values for the state variable.
- ***Sudden Jumps*** take place when a small change in the values of the control parameters may result in a large change in the value of the state variable, as the system jumps from one local minimum to another.
- ***Hysteresis*** occurs whenever a physical process is not strictly reversible. That is, when the jump from one local minimum to another does not occur over the same point in the control parameter space as the reciprocal jump.
- ***Divergence*** arises when small changes in initial values of the control parameters lead to large changes in the final value of the state variable.
- ***Inaccessibility*** means that the physical system has an equilibrium state which is unstable.

Returning to the present case, our intention is to show that the process of shaping a region's Basic Image may be modeled in terms of a butterfly catastrophe. The first step towards this direction will be to show that at least some of the five invariant properties characterizing phenomena that may be described by the butterfly catastrophe (i.e. modality, sudden transitions, hysteresis, divergence and inaccessibility) are present in our particular case.

Earlier works (e.g. Angelis & Dimaki, 2011), have shown that the five properties characterizing phenomena exhibiting non-linear behaviour are present in the process of shaping a region's Basic Image.

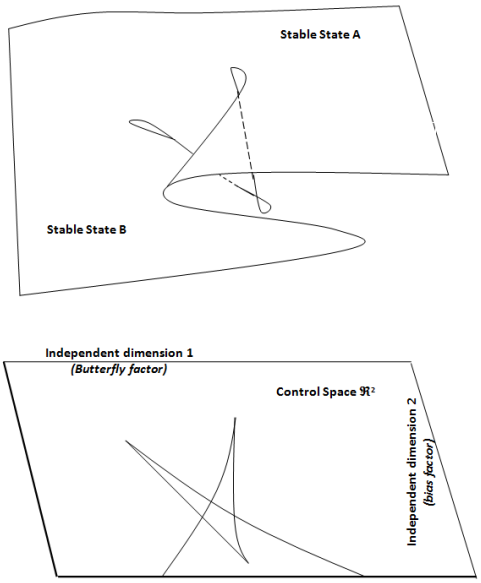
8. Modeling a Region's Basic Image

We have so far shown that the process of shaping a region's Basic Image has all the properties characterizing phenomena which may be modeled in terms of Catastrophe Theory. Hence we may now use Catastrophe Theory to estimate a region's Basic Image. It is reminded that the Basic Image of a region has been defined as a function of three indicators. Therefore, the appropriate elementary catastrophe is the butterfly which is extremely useful in qualitative modeling especially for situations where a compromise emerges between conflicting states. Consequently, the value x, of a region's Basic Image, at each point in time, is given as a solution of the equation:

$$x^5 - Cx^3 - Bx - A = 0 \qquad (1)$$

Equation (1) is referred to as the **Basic Image Equation** and its graph is qualitatively equivalent to the Butterfly Catastrophe Graph (Figure 2). The relationship (1) is a quintic equation, which describes a 4-dimensional manifold with a fold of a complicated structure, which is called pleat. Such a pleat is determined as a 3-dimensional surface with a butterfly shape.

Figure 2: The Butterfly Catastrophe Graph



It can be proved that:

$$\begin{pmatrix} A \\ B \\ C \end{pmatrix} = \begin{pmatrix} mk & k & -\sqrt{m^2+1} \\ \sqrt{k^2+1} & -m\sqrt{k^2+1} & 0 \\ m & 1 & k\sqrt{m^2+1} \end{pmatrix} \begin{pmatrix} a-a_0 \\ b-b_0 \\ c-d_0 \end{pmatrix} \text{ when } \begin{matrix} \tan\theta = m \le 1 \\ \tan\varphi = k \le 1 \end{matrix}$$

(similar relationships may be given for all the combinations of the values of m and k)

where:

a, b, c are the values of the region's Economic, Social, Environmental Indicators respectively.

a_0, b_0, c_0 are the values of the typical region's Economic, Social, Environmental Indicators respectively

$m = \tan\theta$: Variable expressing the relative weight attached between the Economic and Social Indicators in defining the area's Basic Image

$k = \tan\varphi$: Variable expressing the relative weight between the plane defined by the Social and the Economic Indicators and the Environmental Indicator.

For the purposes of this work, the values of all Indicators lie in the interval [0,1], whereas the value of its Basic Image lies in the interval [-1,1]. The value of the "typical" region's Basic Image is 0. Hence, positive Basic Image indicates an attractive region that may be considered as a potential final choice by the various groups of prospective movers.

We have so far defined a region's i Basic Image as a function of a multitude of factors, grouped into three potentially conflicting indicators. A large variety of indicators, either simple or composite, quantifying the economic, social and environmental dimension of a region may be found in the relevant literature (Hammond et al., 1995; Freudenberg, 2003; Slavova, 2008; Eurostat Regional Yearbook, 2008). For the purposes of our model, those indicators are expressed as the geometric mean of several **Sub indicators**, each of which depends on a number of factors among those affecting the region's Basic Image. The use of this geometric mean is justified by the fact that each one of the Sub indicators affecting the respective indicator is considered to be critically important for this indicator's value. Consequently,

$$IND_i^h = \sqrt[m]{\prod_{j=1}^{m} SbI_{ij}^h},\ h = 1,\ 2,\ 3;\ i = 1,\ 2, \ldots, n;\ j = 1,\ 2, \ldots, m$$

where, IND_i^h denotes the h^{th} Indicator of region i and SbI_{ij}^h denotes the j^{th} Sub indicator of region i, which is related to Indicator h. Each Sub indicator SbI_{ij}^h is defined as a non-linear function of a respective Relative Index RI_{ij}^h. This index is, in turn, a function of all variables, measured or estimated, affecting the Sub indicator and may be defined in the following two ways:

- The values of all variables, expressed in relative terms with respect to the typical region, are used to obtain directly the Relative Index RI_{ij}^h, $h = 1,\ 2,\ 3$, $i = 1,\ 2, \ldots, n$, $j = 1,\ 2, \ldots, m$.
- The variables are classified into various sets, depending on the specific component of the Sub indicator they affect. The values of all variables belonging to every set, expressed in relative terms with respect to the typical region, are used to obtain directly the respective Relative Sub indices $RSI_{ij_k}^h$, $h = 1,\ 2,\ 3$, $i = 1,\ 2, \ldots, n$, $j = 1,\ 2, \ldots, m$, $k = 1,\ 2, \ldots, r$. Finally, those Sub Indices are combined so as to give Relative Index:

$$RI_{ij}^{h} = \frac{\sum_{k=1}^{r} w_k RSI_{ij_k}^{h}}{\sum_{k=1}^{r} w_k},\ h=1,\ 2,\ 3,\ i=1,\ 2,\ldots,n,\ j=1,\ 2,\ldots,m,$$

where, $w_k, k=1, 2,\ldots,r$ are weights indicating the relative importance attached to each Sub index in defining the respective Relative Index. Once the Relative Index has been defined, its values are transformed so as to obtain the corresponding values of Sub indicator SbI_{ij}^{h}. Note that each Sub indicator and the respective Relative Index summarize the same aspect of a region's development. The transformation used works as a standardization process and it is needed to ensure that:

- all Sub indicators have the same range. For the purposes of the model, all Sub indicators have the same range values –usually [0,2]; hence, the range of their product is $[0, 2^n]$ and, consequently, the range of $IND_i^h,\ h=1,\ 2,\ 3;\ i=1,\ 2,\ldots,n$ is also [0,2]. In certain cases, however, the dominance of a particular Sub indicator needs to be emphasized. This may be done by increasing its range. In such a case, the range of the remaining Sub indicators must be modified, so that the range of their product remains the same i.e. $[0,\ 2^n]$.
- the effect of changes in the values of variables on the values of the respective Sub indicators follow the same pattern for all Sub indicators.

Table 2: The Economic, Social and Environmental Indicators of region *i*

$IND_i^1 = \sqrt[3]{\prod_{j=1}^{3} SbI_{ij}^1},\ i=1,\ 2,\ldots,n$		$IND_i^2 = \sqrt[3]{\prod_{j=1}^{3} SbI_{ij}^2},\ i=1,\ 2,\ldots,n$	
$\boldsymbol{IND_i^1}$:	**The Economic Indicator of region *i***	$\boldsymbol{IND_i^2}$:	**The Social Indicator of region *i***
SbI_{i1}^1:	The Financial Conditions Sub indicator of region *i*	SbI_{i1}^2:	The Education Sub indicator of region *i*
SbI_{i2}^1:	The Employment Sub indicator of region *i*	SbI_{i2}^2:	The Health Sub indicator of region *i*
SbI_{i3}^1:	The R & D Sub indicator of region *i*	SbI_{i3}^2:	The Social Conditions Sub indicator of region *i*

$IND_i^3 = \sqrt[3]{\prod_{j=1}^{3} SbI_{ij}^3},\ i=1,\ 2,\ldots,n$	
$\boldsymbol{IND_i^3}$:	**The Environmental Indicator of region *i***
SbI_{i1}^1:	The RES Sub indicator of region *i*
SbI_{i2}^1:	The Energy Efficiency Sub indicator of region *i*
SbI_{i3}^1:	The Climate Change Sub indicator of region *i*

Returning to the present case, it is reminded that the factors affecting a region's Basic Image may be allocated into three sets, according to whether they express the economic, the social or the environmental aspect of the region. The factors of the first set provide a measure of the region's economic development prospects. This measure is referred to as the **Economic Indicator.** Similarly, the factors of the second set provide a measure of the region's social profile. This measure is referred to as the **Social Indicator.** Finally**,** the factors of the third set provide a measure of the region's environmental profile. This measure is referred to as the **Environmental Indicator.** Furthermore, each of those Indicators is expressed as the geometric mean of several Sub indicators as shown in Table 2.

A clear overview of the variables affecting a region's Basic Image and their conversion through Sub Indices, Relative Sub indices, Relative Indices and Sub-indicators into Indicators and, finally, into the region's Basic Image is given in Table 3. One may argue that some significant variables expressing the region's power to retain/attract movers belonging to various groups are missing from Table 3. Such variables include labour availability/quality and financial incentives for investors, as well as job availability/quality, employment earnings and financial incentives for employees. This is a plausible argument but, on the other hand, it must be noted that those variables will be used in a next step, which, however, is beyond the scope of this paper, for the estimation of a region's Specific Images, as perceived by the various groups of potential movers. The Specific Images express the degree to which the members of each group consider the region as their best final choice. A physically realizable measure of those Images is the net change, over a period of time, in the number of the members of each group present in the region. As it has already been mentioned, those changes may be generally considered as the delayed and considerably smoothed consequences of the changes in the Basic Image. Hence, a region's Basic Image, as defined, gives a reliable overall estimate of the region's prospects of development and an early warning for any potential danger. Finally, it must be underlined that the choice of variables used for the estimation of a region's Basic Image depends, among other things, on the availability of data. In any way, however, our intention in this paper is to provide a generic framework for the estimation of a region's Basic Image. Within this framework, every researcher may make the appropriate modifications according to both his research requirements and the data availability.

Table 3: Conversion of the variables affecting the Basic Image of region *i*

INDICATORS, INDICES AND VARIABLES CONCERNING REGION *i*					
Indicators	**Sub indicators**	**Relative Indices**	**Relative Sub indices**	**Sub indices**	**Variables**
Economic Indicator IND_i^1	The Financial Conditions Sub indicator SbI_{i1}^1	Relative Financial Conditions Index RI_{i1}^1	Relative Sub index for Gross Domestic Product per inhabitant $RSI_{i1_1}^1$	Sub index for Gross Domestic Product per inhabitant $SI_{i1_1}^1$	Gross Domestic Product
					Population
			Relative Sub index for Energy expenditure per inhabitant $RSI_{i1_2}^1$	Sub index for Energy expenditure per inhabitant $SI_{i1_2}^1$	Energy expenditure
					Population
	The Employment Sub indicator SbI_{i2}^1	Relative Employment Index RI_{i2}^1			Persons aged 20 to 64 in employment
					Population of the same age group
	The R & D Sub indicator SbI_{i3}^1	Relative R & D Index RI_{i3}^1			Gross domestic expenditure on R&D
					Gross Domestic Product
Social Indicator IND_i^2	The Education Sub indicator SbI_{i1}^2	Relative Education Index RI_{i1}^2	Relative Sub index for Persons with upper secondary or tertiary education $RSI_{i1_1}^2$	Sub index for Persons with upper secondary or tertiary education $SI_{i1_1}^2$	Persons with upper secondary or tertiary education, 15 to 64 years
					Population of the same age group
			Relative Sub index for Public expenditure on education $RSI_{i1_2}^2$	Public expenditure on education $SI_{i1_2}^2$	Public expenditure on education
					Gross Domestic Product
	The Health Sub indicator SbI_{i2}^2	Relative Health Index RI_{i2}^2	Relative Sub index for Healthy Life years $RSI_{i2_1}^2$	Sub index for Healthy Life years $SI_{i2_1}^2$	Healthy Life years for males
					Healthy Life years for females
					Males/females in the population
			Relative Hospital beds Sub index $RSI_{i2_2}^2$	Sub index for Hospital beds $SI_{i2_2}^2$	Hospital beds (per 100,000 inhabitants)
	The Social Conditions Sub indicator SbI_{i3}^2	Relative Social Conditions Index RI_{i3}^2	Relative Sub index for Social Protection Expenditure $RSI_{i3_1}^2$	Sub index for Social Protection Expenditure $SI_{i3_1}^2$	Social Protection Expenditure
					Population
			Relative Sub index for People at risk of poverty $RSI_{i3_2}^2$	Sub index for People at risk of poverty $SI_{i3_2}^2$	People at risk of poverty
					Population
Environmental Indicator IND_i^3	The Renewable Energy Sources (RES) Sub indicator SbI_{i1}^3	Relative Renewable Energy Sources (RES) Index RI_{i1}^3	Relative Sub index for Share of RES in Electricity Generation $RSI_{i1_1}^3$	Sub index for Share of RES in Electricity Generation $SI_{i1_1}^3$	Share of RES in Electricity Generation
			Relative Sub index for Share of RES in FEC $RSI_{i1_2}^3$	Sub index for Share of RES in gross FEC $SI_{i1_2}^3$	Total RES Consumption
					Total Final Energy Consumption (FEC)
	The Energy Efficiency Sub indicator SbI_{i2}^3	Relative Energy Efficiency Index RI_{i2}^3			Gross Energy Consumption
					Gross Domestic Product
	The Climate Change Sub indicator SbI_{i3}^3	Relative Climate Change Index RI_{i3}^3			Total Greenhouse Gas Emissions
					Population

The first of the Sub indicators presented in Table 3 is defined below. The remaining Sub indicators are defined in a similar way.

The Financial Conditions Sub Indicator: The term refers to the level of geveral economic conditions prevailing in the region and somehow reflects the standard of living of its inhabitants. The Financial Conditions Sub indicator of region i, $SbI_{i_1}^1$ is a non-linear transformation of the Relative Financial Conditions Index, $RI_{i_1}^1$ which combines two aspects of the region's economic conditions: the level of Gross Domestic Product (GDP) and energy expenditure. The level of GDP is expressed through the Relative Gross Domestic Product per inhabitant Sub index, $RSI_{i_{12}}^1$, which is the ratio of the total GDP to the population, expressed in relative terms. The energy expenditure is expressed through the Relative Energy Expenditure per inhabitant Sub index, $RSI_{i_{12}}^1$ which is the ratio of energy consumption to the population, expressed in relative terms. Hence, on the basis of the above, we have that

$RSI_{i_{12}}^1 = \dfrac{w_1 RSI_{i1_i}^1 + w_2 RSI_{i1_2}^1}{w_1 + w_2}$, where w_1, w_2 are the appropriate weights

9. Application of the Proposed Model

The methodology presented in the previous section has been used for the estimation of the Basic Image of four countries in the South of Europe, Greece, Italy, Spain and Portugal, over the period 2000-2010. The Basic Image values of the "typical" country (region), which is taken as the average of those four countries, have also been calculated. The required data have been drawn from the official site of Eurostat. The results are summarized in Figures 2-5.

Figure 2 presents the values of the Economic Indicator for all four countries and the "typical" country throughout the period under study. As we san see Greece has the lowest Economic Indicator value among the four countries, which has been actually steadily decreasing over the period under study. Portugal started with an Economic Indicator value lower than those of Italy and Spain, but by the end of the period, it has surpassed them. Finally, Italy and Spain show an almost constant Economic Indicator throughout the period under study with the lead changing between them until 2008, when Portugal climbed into the first place. It must be noted that throughout the period Greece maintains an Economic Indicator value lower than that of the "typical" country, whereas Italy, Spain and Portugal exhibit values higher than that of the "typical" country, with only a few exceptions.

Figure 3 presents the values of the Social Indicator for all four countries and for the "typical" country throughout the period under study. As we can see Italy started with the

highest Social Indicator value followed by Greece which however is catching up Italy towards the end of the period. Spain shows an almost constant Social Indicator value throughout the period and the same holds for Portugal but at a lower level. It must be noted that throughout the period Portugal and Italy maintain Social Indicator values lower than that of the "typical" country, whereas Greece and Spain higher values.

Figure 2: The Economic Indicator of the European South, 2000-2010

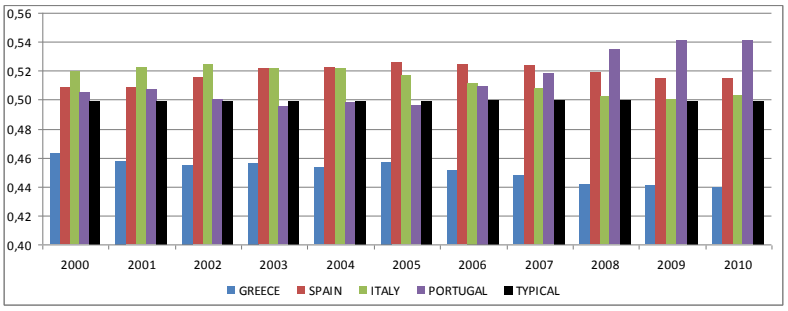


Figure 3: The Social Indicator of the European South, 2000-2010

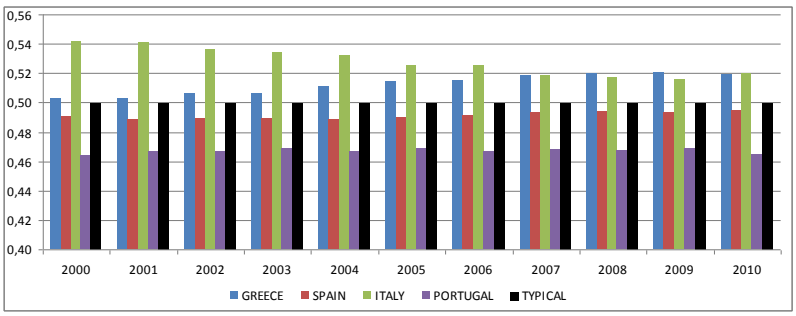


Figure 4 presents the values of the Environmental Indicator for all four countries and for the "typical" country throughout the period under study. Portugal maintains the highest Environmental Indicator value over the whole period, whereas Greece the lowest. Spain and Italy exhibit an almost constant Environmental Indicator value at a similar level throughout the period. It must be noted that throughout the period under study Greece and Spain (with a few exceptions) maintain Environmental Indicator values lower than that of the "typical" country, whereas Portugal and Italy (with a few exceptions) higher.

Figure 4: The Environmental Indicator of the European South, 2000-2010

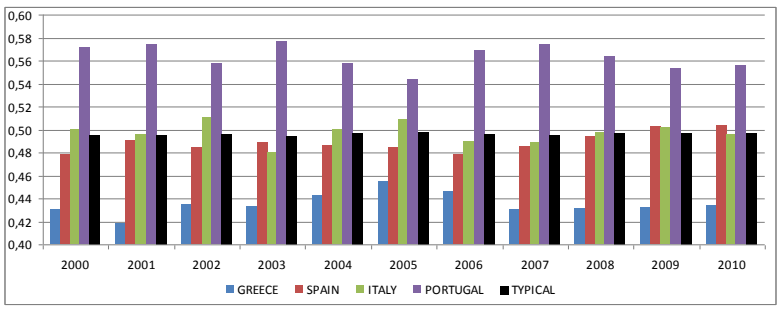
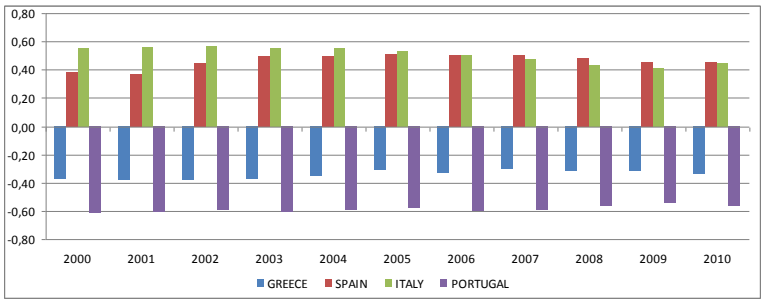


Figure 5: The Basic Image of the European South, 2000-2010



Finally, Figure 5 presents the values of Basic Image for all four countries and for the "typical" country throughout the period under study. Italy and Spain maintain an almost constant positive Image value with Italy leading in the former years and Spain in the latter. Greece and Portugal maintain a negative Basic Image value with Portugal having constantly the worse value.

10. Conclusions and Suggestions for further Research

A region's development depends on its ability to retain existing business activities and attract new ones. This ability depends on what we call the Image of a region and it is a measure expressing the region's current state of development and its future prospects. The paper introduced the concept of a region's Basic Image, developed a mathematical model for its estimation, applied the model to the case of four countries of the European South namely, Greece, Spain, Italy and Portugal and presented the results. The Basic Image gives a "true" picture of a region's development and an early warning of any future problems. Furthermore, its structure allows a researcher to identify not only the changes in the Basic Image values, but also the causes of those changes and, hence, take the necessary measures. Consequently, the Basic Image may prove to be a very useful managerial tool, which can help the authorities to improve the region's attractiveness and future prospects of development. The application results seem logical and expected. They show that the proposed model expresses a region's attractiveness in a realistic way, in the sense that it quantifies the region's appeal to the full range of its existing and potential business units and employees. The Basic Image, as defined so far, has left out a number of important variables, endogenous or exogenous. Hence, another area of further research would be to redefine a region's Basic Image, so as to include some of those variables. Such a set of variables may be those related to the prevailing socio-economic environment in which the region operates and could define a fourth indicator, which may be referred to as General Economic Climate Indicator. As it has been seen in section 7, in the case of three or four indicators the most appropriate elementary catastrophes are the

Swallowtail and the Butterfly catastrophes respectively. Hence, our task will be to examine how those elementary catastrophes may be used to model the enriched Basic Image.

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