

Angelis, Vasilis; Angelis-Dimakis, Athanasios; Dimaki, Katerina

Conference Paper

The Attractiveness Of The European South As Described By A Cusp And A Butterfly Catastrophe Model

53rd Congress of the European Regional Science Association: "Regional Integration: Europe, the Mediterranean and the World Economy", 27-31 August 2013, Palermo, Italy

Provided in Cooperation with:

European Regional Science Association (ERSA)

Suggested Citation: Angelis, Vasilis; Angelis-Dimakis, Athanasios; Dimaki, Katerina (2013) : The Attractiveness Of The European South As Described By A Cusp And A Butterfly Catastrophe Model, 53rd Congress of the European Regional Science Association: "Regional Integration: Europe, the Mediterranean and the World Economy", 27-31 August 2013, Palermo, Italy, European Regional Science Association (ERSA), Louvain-la-Neuve

This Version is available at:

<https://hdl.handle.net/10419/124030>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

THE ATTRACTIVENESS OF THE EUROPEAN SOUTH AS DESCRIBED BY A CUSP AND A BUTTERFLY CATASTROPHE MODEL

Vasilis Angelis

Quantitative Methods Laboratory
Department of Business Administration
University of the Aegean
8, Michalon str.
82100 Chios, Greece
v.angelis@aegean.gr

Athanasios Angelis-Dimakis

Environmental and Energy Management
Research Unit
School of Chemical Engineering
National Technical University of Athens
9 Herroon Polytechniou st.
Zografou Campus, 15780 Athens, Greece
angelis@chemeng.ntua.gr

Katerina Dimaki

Department of Statistics
Athens University of Economics
and Business
76, Patission str.
10434 Athens, Greece
dimaki@aueb.gr

Abstract

Over the past years a large number of regional growth theories have been developed and a number of models have been built in an effort to describe, explain and eventually predict regional development trends. However, until a few years ago, the large majority of those models assumed the existence of linear and thus regular, growth processes. Linear models are certainly able to generate unstable solutions, but the solutions of such models are restricted to certain regular standard types. This limitation has recently been overcome with the adoption of non-linear models which allow for a change in a system's dynamics generated by even small perturbations in structural forms. Structural instability entails the possible existence of significant qualitative changes in the behaviour of the system (i.e. in the state variables) closely connected with bifurcation and catastrophic phenomena that may occur if the parameter values (i.e. the control variable) reach critical values. The application of non-linear models has shown that the deterministic and well-behaved unique results achieved by the dynamic linear models are no longer guaranteed: interregional convergence determined by the traditional models collapses and opens the way to alternative possible trajectories and multiple equilibria. The non-linear models are thus able to simulate an endogenous series of complex phenomena which in the past could only be replicated by means of exogenous shocks introduced *ad hoc*.

The present paper introduces a country's Image, a variable which expresses a country's state of development and its future prospects. Furthermore, the factors affecting this variable are defined and ways of measuring them are suggested. Finally, these factors are grouped into different ways leading to two alternative non-linear models for the generation of country's image. The two models are applied to the case of the European South and the values of the two sets of images for those countries are compared and discussed.

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

JEL Classification: C02, C65, Q01, R58

1. INTRODUCTION

A country's development is a multi dimensional concept, including socio-economic ecological, technical and ethical perspectives. In the early stages of a country's development the dominant factors are economic. However as the development 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 paper introduces the concept of a country's image, a composite measure of the country's overall trend towards sustainable development. However before we go on to define a county's image we should present a number of key points concerning:

- Sustainable development
- The changing role of economic, social and environmental dimension in the process of a country's development
- Measuring sustainable development

1.1 Sustainable development

- Development is not only a technical subject. It has an important ideological content and reflects a strong set of values (Munda, 2005).
- Development is identified in the 20th century with the terms economic growth and industrialisation.
- The ancient Egyptian, Mesopotamian, Greek and Roman civilizations have dealt with environmental problems such as deforestation, salination and loss of soil fertility for sustainable development, which we would today refer to as sustainability problems (Du Pisani, 2006).
- J.S. Mill (1883), one of the great economists of the 19th 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.

- R. Solow (1991) 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.
- Sustainable development is a strategy by which communities seek economic development approaches that also benefit the local environment and quality of life. It provides a framework under which communities can use resources efficiently, create sufficient infrastructures, protect and enhance quality of life, and create new businesses to strengthen their economies.

1.2 The changing role of economic, social and environmental dimension in the process of county development

- In the 1960's the focus of economic progress was on growth and increase in output, based mainly on the concept of economic efficiency.
- 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 (Svedin, 1991).
- Protection of the environment is 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 showing that environmental degradation was a major barrier to progress. By the end of the decade, environmental concern is for the first time integrated into the business decision making process (Munashinghe, 1993).
- In the 1990's and at the beginning of 21st century, the crucial role of the environmental dimension and its increasing contribution to sustainable development has been further established. Environmental matters are considered to be a major component of the wider economic activity (Angelis et al., 1999).
- Environmental threats are now perceived as emerging on a very large scale, often related to socio-economic turbulent factors and requiring immediate corrective action.

1.3 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.
- Multi-criteria evaluation has demonstrated its usefulness in many sustainability policy and management problems (see e.g. Romero & Rehman, 1989; Nijkamp et al, 1990; Beinat & Nijkamp, 1998; Janssen, 1992; Munda, 1995; Munda et al, 1998; Ringius et al, 1998; Janssen & Munda, 1999; Hayashi, 2000; Bell et al, 2001; Munda, 2005, 2008).
- Measuring sustainable development requires at a minimum integration of economic, social and environmental concerns. This is not an easy task and requires the design of a specific tool.
- In this paper we introduce the concept of a country's image, a measure of its overall progress towards sustainable development, which encompasses all the three dimensions and suggest ways of measuring it.

2. THE CONCEPT OF A COUNTRY'S IMAGE

The term image is currently used in a variety of contexts. image is a sum of beliefs, ideas and impressions. It is the total impression an entity makes on the minds of people and exerts a powerful influence on the way people perceive things and react to them (Dowling, 1998; Dichter, 1985). Relevant literature suggests that image is important in this process and identifies different types, including projected and received entity images (Kotler et al., 1993). Projected place images can be conceived as the ideas and impressions of a place that are available for people's consideration.

This type of images reach people by an image transmission or diffusion process through various channels of communication, which themselves can alter the character of the message. The received place images are formed from the interaction between these projected messages and people's own needs, motivations, prior knowledge, experience, preferences, and other personal characteristics. In this way people create their own unique representations or mental constructs, resulting in their own personal images of a place (Ashworth and Voogd, 1990; Gartner, 1993; Bramwell and Rawding, 1996).

In this paper, image is defined in a slightly different way, as a function of objectively measured factors, which influence people. It is clear that a country's image, based on objectively measured factors and expressing its current state of development, may be improved through marketing and promotion activities. Nevertheless, it is believed that the impact of those activities on the country's image is temporary and limited and the only lasting effect is the objective improvement of the various attributes of this image.

Different people hold quite different images of the same place. Because a country consists of a number of groups of people that have a different type of interaction with it, each of these groups is likely to have a different image of the particular country. Hence, a country does not have an image, but multiple images (Dowling, 1998).

Based on the above it can be said that at each stage of the process of a country's development we can observe its image. In other words, it can be argued that, at each point in time, the country "sends out" its image and, depending on its impact on the people, the country may be considered attractive or non attractive. One may also argue that since people "receiving" the image of the country belong to various distinct groups and are sensitive to different factors, the impact of the country's image on the members of each particular group will be different (Kotler et al., 1999; Bryson & Daniels, 2007).

Whilst this argument is plausible, the available evidence suggests that all groups of people 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 country is to be considered as an attractive one.

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

- The Basic Image of a given country measures the degree to which the country satisfies a set of basic criteria, common for all people.
- The Specific Image of a given country, as perceived by a particular group of people, measures the degree to which people belonging to that particular group consider the country as their first preference.

The remainder of this paper will focus on a country's Basic Image, a summary measure of its current state of development and future prospects as perceived by all groups of people. A physically realizable measure for the Basic Image is difficult to find. What may be measured more easily, are the net changes in the values of a number of economic welfare indicators. However, those measurable changes may be generally considered as the delayed and smoothed consequence of prior changes in the Basic Image. Hence, the study of the mechanisms governing the shaping and the changes of a country's Basic Image is a task of imperative importance.

On the basis of all the above the Basic Image of a country may be defined as a function of a number of variables which may be divided into a number of groups depending on the availability of data and the level of analysis. A first approach would be to have two groups of factors (economic and social /environmental) whether a second approach would be to split the social/environmental group into social and environmental thus having three groups of factors. The factors of every group properly measured and scaled would define the respective Indicators (either Economic and Social/Environmental or Economic, Social and Environmental).

In the first approach (in the two indicators case) the *Economic Indicator of country i* (IND_i^1) is a function of factors like *GDP per Capita, Energy Expenditure per Capita, Employment Rate, Research & Development percentage of GDP* which provide a measure of the country's economic development prospects while the *Social/Environmental Indicator of country i* (IND_i^2) 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, Environmental Conditions* which provide a measure of a country's social profile. In this case a country's Basic Image is a function of those two Indicators, i.e. $Basic\ Image = \varphi(IND_i^1, IND_i^2)$.

In the second approach (in the three indicators case) the *Economic Indicator of country i* (IND_i^1) is defined as before while the Social/Environmental Indicator is split up into the *Social Indicator of country i* (IND_i^2) which 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*, provides a measure of a country's social profile and the *Environmental Indicator of country i* (IND_i^3) which is a function of factors like *Share of Renewable Energy Sources (RES) in Electricity Generation, Share of Renewable Energy Sources in gross Final Energy Consumption (FEC), Energy Intensity of the Economy, Greenhouse Gas Emissions*, provides a measure of the quality of the environment in the country. In this case a country's Basic Image is a function of those three Indicators, i.e. $Basic Image = \varphi(IND_i^1, IND_i^2, IND_i^3)$.

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

3. MEASURING A COUNTRY'S BASIC IMAGE

We have so far defined a country's Basic Image as a function of a number of indicators. In order to get a first feeling of the shape of its graph we start by stating the following simple observations describing the way in which the two indicators operate.

- i. The higher the Economic Indicator of a country the more attractive its Basic Image.
- ii. The higher the Social/Environmental Indicator of a country the more attractive its Basic Image.

- iii. If the Economic Indicator of a country is continuously increasing but, at the same time, its Social/Environmental Indicator is continuously decreasing, the Basic Image of the country may be either attractive or non attractive and sudden changes in its state may be expected.

Observation (iii) is the most interesting because it implies that the graph we want to draw may be discontinuous. Furthermore, the available evidence shows that sustainability issues are characterized by a high degree of conflict. In the 1980's, the awareness of actual and potential conflicts between economic growth, social progress and preservation of the environment led to the concept of sustainable development. Since then, all governments have declared, and still claim, their willingness to pursue economic growth under the flag of sustainable development although often development and sustainability are contradictory terms. The concept of sustainable development has wide appeal, because it carries the ideal of a harmonization or simultaneous realization of economic growth, social progress and environmental concerns (Munda, 2005). Sustainable development aims to achieve simultaneously environmental system goals (resilience, biological productivity), economic system goals (satisfaction of basic needs, enhancement of equity, increasing useful goods and services), and social system goals (cultural diversity, institutional sustainability, social justice, participation). This definition correctly points out that sustainable development is a multidimensional concept, but as our everyday life teaches us, it is generally impossible to maximize different objectives at the same time and compromised solutions must be found (Barbier, 1987).

When dealing with sustainability issues no reductionism, economic, social or environmental is possible. A reductionist approach for building a model can be defined as the use of just one measurable indicator (e.g. GDP per capita), one dimension (e.g. economic), one objective (e.g. the maximization of economic efficiency) and one time horizon. If one wants to avoid reductionism, there is a clear need to take into account incommensurable dimensions using the proper techniques so as to reach a solution.

As a tool for conflict management, multi-criteria evaluation has demonstrated its usefulness in many sustainability policy and management problems. In this paper in order to model the process of shaping a country's Basic Image involving the conflict between the various dimensions of development we use a different tool, Catastrophe

Theory. The same tool has been used in modeling the process of shaping a region's Basic Image (Angelis and Dimaki, 2011). Catastrophe Theory (Thom, 1975; Zeeman, 1973) is the general mathematical theory of discontinuous and divergent behavior from continuous underlying forces. 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. 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 et al., 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 Behaviour Variables	Number of Control Variables	Type of Catastrophe
1	1	Fold
1	2	Cusp
1	3	Swallowtail
1	4	Butterfly

Returning to the present case it must be reminded that the Basic Image of a country has been defined as a function of either two or three potentially conflicting indicators. Therefore, according to Catastrophe Theory, the appropriate elementary catastrophes

for its description are the Cusp and the Butterfly Catastrophe Models (Thom, 1975; Zeeman, 1973; Gilmore, 1993; Poston and Stewart, 1996). These two cases will be discussed in detail in the next two sections.

3.1 A Country's Basic Image as a Function of two Indicators

In this case the most appropriate elementary catastrophe is Cusp Catastrophe Model. Hence, at each point in time, the value $x_i, i = 1, 2, \dots, n$, of the i^{th} country's Basic Image is given as a solution of the equation:

$$x_i^3 - Bx_i - A = 0 \quad (1)$$

with,

$$\begin{cases} A = m(IND_i^1 - IND_0^1) + (IND_i^2 - IND_0^2) \\ B = (IND_i^1 - IND_0^1) - m(IND_i^2 - IND_0^2) \end{cases} \text{ if } m \leq 1 \quad \text{and}$$

$$\begin{cases} A = m(IND_i^1 - IND_0^1) + (1/m)(IND_i^2 - IND_0^2) \\ B = (1/m)(IND_i^1 - IND_0^1) - (IND_i^2 - IND_0^2) \end{cases} \text{ if } m > 1$$

Equation (1) is referred to as the **Basic Image Equation** and IND_i^1 and IND_i^2 express the values of the two Indicators for the i^{th} country, while IND_0^1, IND_0^2 , express the values of those two Indicators for the "typical" country. The variable m expresses the relative weights attached to each one of the two indicators in defining the Basic Image (Angelis & Dimaki, 2011).

Table 2. The Economic and Social Indicators of country i

$IND_i^1 = \sqrt[3]{\prod_{j=1}^3 Sbl_{ij}^1}, i = 1, 2, \dots, n$		$IND_i^2 = \sqrt[4]{\prod_{j=1}^4 Sbl_{ij}^2}, i = 1, 2, \dots, n$	
where			
IND_i^1	The Economic Indicator of country i	IND_i^2	The Social Indicator of country i
Sbl_{i1}^1	The Financial Conditions Sub indicator of country i	Sbl_{i1}^2	The Education Conditions Sub indicator of country i
Sbl_{i2}^1	The Employment Sub indicator of country i	Sbl_{i2}^2	The Housing Conditions Sub indicator of country i
Sbl_{i3}^1	The R & D Sub indicator of country i	Sbl_{i3}^2	The Social Conditions Sub indicator of country i
		Sbl_{i4}^2	The Environmental Conditions Sub indicator of country i

For the purposes of this work, the values of all Indicators lie in the interval $[0,1]$, whereas the value of the Basic Image lies in the interval $[-1,1]$. Table 3. Conversion of the variables affecting the Basic Image of country i .

Table 3. Conversion of the variables affecting the Basic Image of country *i*

INDICATORS, INDICES AND VARIABLES CONCERNING COUNTRY <i>i</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)	Sub index for Gross Domestic Product per inhabitant (SI_{i1}^1)	Gross Domestic Product
			Relative Sub index for Energy expenditure per inhabitant (RSI_{i2}^1)	Sub index for Energy expenditure per inhabitant (SI_{i2}^1)	Population
					Energy expenditure
	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}^2)	Sub index for Persons with upper secondary or tertiary education (SI_{i1}^2)	Persons with upper secondary or tertiary education (15 to 64 years)
			Relative Sub index for Public expenditure on education (RSI_{i2}^2)	Sub index for Public expenditure on education (SI_{i2}^2)	Population of the same age group
					Public expenditure on education
	The Health Sub indicator (SbI_{i2}^2)	Relative Health Index (RI_{i2}^2)	Relative Sub index for Public expenditure on health (RSI_{i2}^2)	Sub index for Public expenditure on health (SI_{i2}^2)	Gross Domestic Product
			Relative Sub index for Hospital beds Sub index (RSI_{i2}^2)	Sub index for Hospital beds (SI_{i2}^2)	Public expenditure on health
					Hospital beds (per 100,000 inhabitants)
	The Social Conditions Sub indicator (SbI_{i3}^2)	Relative Social Conditions Index (RI_{i3}^2)			Social Protection Expenditure
					Population
	The Environmental Conditions Sub indicator SbI_{i4}^2	Relative Renewable Energy Sources (RES) Index (RI_{i4}^2)	Relative Sub index for Share of RES in Electricity Generation (RSI_{i4}^3)	Sub index for Share of RES in Electricity Generation (SI_{i4}^3)	Share of RES in Electricity Generation
			Relative Sub index for Share of RES in gross FEC (RSI_{i4}^3)	Sub index for Share of RES in gross FEC (SI_{i4}^3)	Total RES Consumption
		Relative Energy Efficiency Index (RI_{i5}^2)			Total FEC
					Gross inland consumption of energy
Relative Climate Change Index (RI_{i6}^2)			Gross Domestic Product		
			Total Greenhouse Gas Emissions		
			Population		

The value of the "typical" country's Basic Image is 0. Hence, positive Basic Image indicates an attractive country. 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 country's Basic Image and their conversion through Sub Indices, Relative Sub indices, Relative Indices and Sub-indicators into two Indicators and, finally, into the country's Basic Image is given in Table 3.

3.2 A Country's Basic Image as a Function of three Indicators

In this case the most appropriate elementary catastrophe is the Butterfly (Angelis et al 2013). Hence, the value x_i , of the i^{th} country's Basic Image, at each point in time, is given as a solution of the equation:

$$x_i^5 - Cx_i^3 - Bx_i - A = 0 \quad (2)$$

$$\text{with: } \begin{pmatrix} A \\ B \\ C \end{pmatrix} = \begin{pmatrix} mk & k & -\sqrt{m^2+1} \\ \sqrt{k^2+1} & -m\sqrt{k^2+1} & 0 \\ m & 1 & k\sqrt{m^2+1} \end{pmatrix} \begin{pmatrix} IND_i^1 - IND_0^1 \\ IND_i^2 - IND_0^2 \\ IND_i^3 - IND_0^3 \end{pmatrix} \text{ when } \begin{matrix} m \leq 1 \\ k \leq 1 \end{matrix}$$

Similar relationships may be given for all the combinations of the values of m and k

Table 4: The Economic, Social and Environmental Indicators of country i

$IND_i^1 = \sqrt[3]{\prod_{j=1}^3 Sbl_{ij}^1}, i = 1, 2, \dots, n$		$IND_i^2 = \sqrt[3]{\prod_{j=1}^3 Sbl_{ij}^2}, i = 1, 2, \dots, n$	
where		where	
IND_i^1 :	The Economic Indicator of country i	IND_i^2 :	The Social Indicator of country i
Sbl_{i1}^1 :	The Financial Conditions Sub indicator of country i	Sbl_{i1}^2 :	The Education Sub indicator of country i
Sbl_{i2}^1 :	The Employment Sub indicator of country i	Sbl_{i2}^2 :	The Health Sub indicator of country i
Sbl_{i3}^1 :	The R & D Sub indicator of country i	Sbl_{i3}^2 :	The Social Conditions Sub indicator of country i
$IND_i^3 = \sqrt[3]{\prod_{j=1}^3 Sbl_{ij}^3}, i = 1, 2, \dots, n$			
where			
IND_i^3 :	The Environmental Indicator of country i		
Sbl_{i1}^3 :	The RES Sub indicator of country i		
Sbl_{i2}^3 :	The Energy Efficiency Sub indicator of country i		
Sbl_{i3}^3 :	The Climate Change Sub indicator of country i		

Equation (1) is referred to as the **Basic Image Equation** and IND_i^1 , IND_i^2 and IND_i^3 express the values of the three Indicators for the i^{th} country, while IND_0^1 , IND_0^2 and IND_0^3 , express the values of those three Indicators for the "typical" country. The variable m expresses the relative weight attached between the Economic and Social Indicators in defining the country's Basic Image while k expresses the relative

weight between the plane defined by the Social and the Economic Indicators on one hand and the Environmental Indicator on the other (Kondakis et al., 2010).

Table 5: Conversion of the variables affecting the Basic Image of country i

INDICATORS, INDICES AND VARIABLES CONCERNING COUNTRY 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)	Sub index for Gross Domestic Product per inhabitant (SI_{i1}^1)	Gross Domestic Product
					Population
			Relative Sub index for Energy expenditure per inhabitant (RSI_{i2}^1)	Sub index for Energy expenditure per inhabitant (SI_{i2}^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}^2)	Sub index for Persons with upper secondary or tertiary education (SI_{i1}^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_{i2}^2)	Public expenditure on education (SI_{i2}^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_{i21}^2)	Sub index for Healthy Life years (SI_{i21}^2)	Healthy Life years for males
					Healthy Life years for females
					Males/females in the population
			Relative Hospital beds Sub index (RSI_{i22}^2)	Sub index for Hospital beds (SI_{i22}^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_{i31}^2)	Sub index for Social Protection Expenditure (SI_{i31}^2)	Social Protection Expenditure
					Population
		Relative Sub index for People at risk of poverty (RSI_{i32}^2)	Sub index for People at risk of poverty (SI_{i32}^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}^3)	Sub index for Share of RES in Electricity Generation (SI_{i1}^3)	Share of RES in Electricity Generation
			Relative Sub index for Share of RES in gross FEC (RSI_{i2}^3)	Sub index for Share of RES in gross FEC (SI_{i2}^3)	Total RES Consumption
					Total FEC
	The Energy Efficiency Sub indicator (SbI_{i2}^3)	Relative Energy Efficiency Index (RI_{i2}^3)			Gross inland consumption of energy
					Gross Domestic Product
	The Climate Change Sub indicator (SbI_{i3}^3)	Relative Climate Change Index (RI_{i3}^3)			Total Greenhouse Gas Emissions
				Population	

Furthermore, the values of all Indicators lie in the interval $[0,1]$, whereas the value of the Basic Image lies in the interval $[-1,1]$. The value of the "typical" country's Basic Image is 0. Hence, positive Basic Image indicates an attractive country. For the purposes of this work, each of those Indicators is expressed as the geometric mean of several Sub indicators, as shown in Table 4. A clear overview of the variables affecting a country's Basic Image and their conversion through Sub Indices, Relative Sub indices, Relative Indices and Sub-indicators into Indicators and, finally, into the country's Basic Image is given in Table 5.

4. 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 (Figure 1), over the period 2000-2010.

Figure 1: The Map of the European South



The Basic Image values of the "typical" country, which is taken as the average of those four countries, have been also calculated. The required data have been drawn from the official site of Eurostat.

4.1 The two Indicators Case

The results are summarized in Table 6 and in Figures 2-4. Table 6 contains the values of the Basic Images and the values of the Economic and Social/Environmental Indicators for Greece, Italy, Spain and Portugal for the period under study.

Figure 2 presents the values of the Economic Indicator for all four countries and the "typical" country throughout the period under study. As we can see Greece has the lowest Economic Indicator value among the four countries, which has been actually decreasing over the period under study. Portugal started with an Economic Indicator value considerably lower than those of Italy and Spain, but by the end of the period, it

has almost reached them. Finally, Italy and Spain show an almost constant Economic Indicator throughout the period under study with the lead changing between them. It must be noted that throughout the period Greece maintains an Economic Indicator value lower than that of the “typical” country, Portugal shows lower values up to 2007 and higher thereafter whereas Italy and Spain exhibit values higher than that of the “typical” country throughout the period.

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

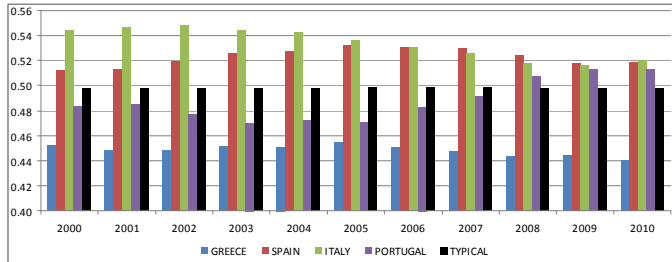


Figure 3: The Social/Environmental Indicator of the European South, 2000-2010

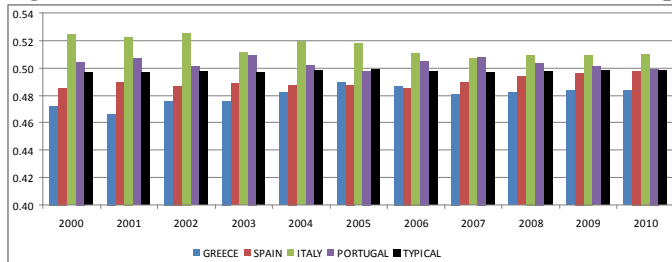
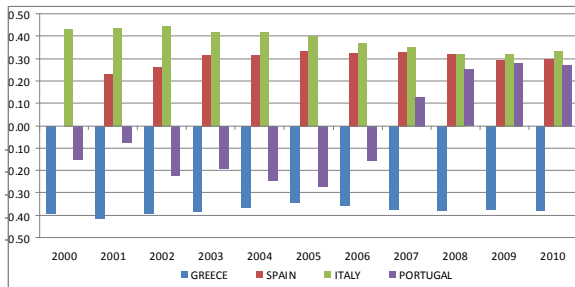


Figure 3 presents the values of the Social/Environmental Indicator for all four countries and for the “typical” country throughout the period under study. As we can see Italy retains the highest but gradually decreasing Social/Environmental Indicator throughout the period, followed by Portugal which has an almost constant Indicator. Spain and Greece exhibit lower, but gradually increasing, Social/Environmental Indicators and indeed Spain catches up Portugal at the last three years. It must be noted that throughout the period Italy and Portugal maintain a Social/Environmental Indicator value higher than that of the “typical” country. On the contrary, Greece and Spain (with the exception of one year) exhibit Social/Environmental Indicator values lower than that of the “typical” country.

Finally, Figure 4 presents the Basic Image values for all four countries and for the “typical country throughout the period under study. Italy and Spain maintain positive Basic Image values throughout the period under study with Spain gradually increasing and Italy gradually decreasing but remaining leader, for the whole period. However their difference at the end of the period is negligible. Greece exhibits negative and slightly fluctuating Basic Image values throughout the period under study. Finally

Portugal starts with a negative Basic Image value (lower than that of Greece) which in 2007 turns positive and remains positive thereafter.

Figure 4: The Basic Image of the European South, 2000-2010



4.2 The three Indicators Case

The results are summarized in Table 6 and in Figures 5-7. Table 6 contains the values of the Basic Images and the values of the Economic, Social and Environmental Indicators for Greece, Italy, Spain and Portugal for the period under study.

The Economic Indicator for all four countries and the “typical” country is identical in both the two and three Indicators cases. Hence the values presented in the previous section and the comments made are valid in this case too.

Figure 5 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 Spain maintain Social Indicator values lower than that of the “typical” country, whereas Greece and Italy higher values.

Figure 5: The Social Indicator of the European South, 2000-2010

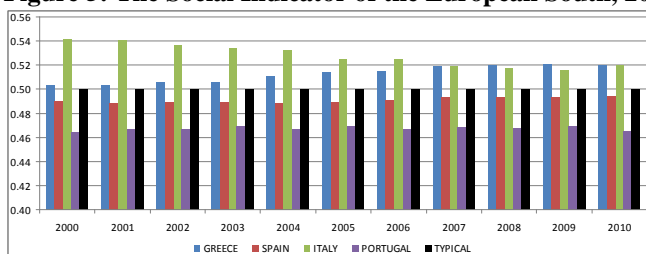
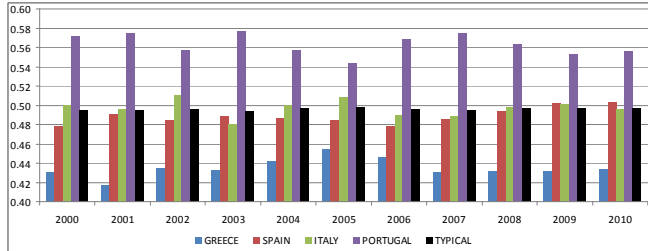


Figure 6 presents the values of the Environmental Indicator for all four countries and for the “typical” country throughout the period under study. Portugal maintains the highest Environmental Indicator value over the whole period, whereas Greece the

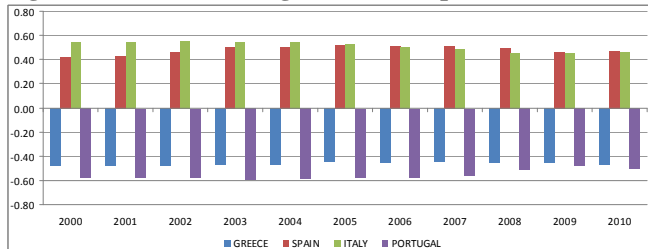
lowest. Spain and Italy exhibit almost constant and similar Environmental Indicator values over the whole period. It must be noted that throughout the period under study Greece and Spain (with a few exceptions) maintain Environmental Indicator values lower than that of the “typical” country, whereas Portugal and Italy (with a few exceptions) higher.

Figure 6: The Environmental Indicator of the European South, 2000-2010



Finally, Figure 7 presents the values of Basic Image for all four countries and for the “typical” country throughout the period under study. Italy and Spain maintain a constant positive Image value throughout the period with Italy leading in the former years, but gradually decreasing and Spain in the latter. Greece and Portugal maintain a negative Basic Image value with Portugal having constantly the worse value. However, in the last years their difference becomes negligible.

Figure 7: The Basic Image of the European South, 2000-2010



4.3 Comparison of the two Cases

Looking at the Basic Image values, as estimated by the two models, for all four countries and throughout the period under study, the following differences may be identified:

- The Basic Image values estimated using the three indicators model are, in absolute terms, higher than the respective values of the two indicators model.
- The Basic Image values of both models for Spain and Italy follow the same trend. However, in the case of two indicators Italy remains leader (but with narrowing lead) throughout the period, whereas in the three Indicators case Spain takes the lead in 2006 and keeps it thereafter.

Table 6: The Basic Image and the values of Economic, Social and Environmental Indicators of the European South, 2000-2010. Both Models

Countries	Cusp Catastrophe Model			Butterfly Catastrophe Model			
	Basic Image	Indicators		Basic Image	Indicators		
		Economic	Social		Economic	Social	Environmental
2000							
Greece	-0.394	0.4524	0.4726	-0.477	0.4524	0.503	0.431
Spain	0.199	0.5125	0.4853	0.426	0.5125	0.490	0.478
Italy	0.434	0.5444	0.5247	0.546	0.5444	0.542	0.500
Portugal	-0.153	0.4839	0.5042	-0.580	0.4839	0.464	0.572
Typical Country	0	0.4983	0.4967	0	0.4983	0.4996	0.4952
2001							
Greece	-0.414	0.4484	0.4670	-0.480	0.4484	0.503	0.418
Spain	0.231	0.5129	0.4892	0.432	0.5129	0.488	0.491
Italy	0.438	0.5467	0.5223	0.551	0.5467	0.541	0.496
Portugal	-0.075	0.4855	0.5071	-0.573	0.4855	0.467	0.574
Typical Country	0	0.4983	0.4964	0	0.4983	0.4996	0.4947
2002							
Greece	-0.393	0.4480	0.4758	-0.482	0.4480	0.506	0.434
Spain	0.267	0.5193	0.4871	0.469	0.5193	0.489	0.484
Italy	0.445	0.5484	0.5257	0.560	0.5484	0.537	0.510
Portugal	-0.226	0.4773	0.5012	-0.576	0.4773	0.467	0.557
Typical Country	0	0.4982	0.4974	0	0.4982	0.4996	0.4963
2003							
Greece	-0.385	0.4522	0.4755	-0.469	0.4522	0.506	0.433
Spain	0.316	0.5262	0.4888	0.501	0.5262	0.489	0.488
Italy	0.420	0.5442	0.5117	0.542	0.5442	0.534	0.480
Portugal	-0.191	0.4705	0.5094	-0.593	0.4705	0.469	0.577
Typical Country	0	0.4983	0.4964	0	0.4983	0.4996	0.4944
2004							
Greece	-0.370	0.4510	0.4824	-0.465	0.4510	0.511	0.443
Spain	0.315	0.5274	0.4876	0.505	0.5274	0.488	0.486
Italy	0.422	0.5427	0.5191	0.544	0.5427	0.532	0.500
Portugal	-0.245	0.4728	0.5015	-0.584	0.4728	0.467	0.558
Typical Country	0	0.4985	0.4977	0	0.4985	0.4996	0.4968
2005							
Greece	-0.343	0.4547	0.4898	-0.448	0.4547	0.515	0.454
Spain	0.336	0.5323	0.4877	0.522	0.5323	0.490	0.485
Italy	0.403	0.5368	0.5181	0.532	0.5368	0.525	0.508
Portugal	-0.275	0.4708	0.4978	-0.576	0.4708	0.469	0.544
Typical Country	0	0.4986	0.4983	0	0.4986	0.4996	0.4979
2006							
Greece	-0.356	0.4507	0.4865	-0.454	0.4507	0.515	0.446
Spain	0.329	0.5312	0.4859	0.516	0.5312	0.491	0.478
Italy	0.373	0.5305	0.5107	0.506	0.5305	0.525	0.490
Portugal	-0.159	0.4829	0.5052	-0.574	0.4829	0.467	0.569
Typical Country	0	0.4988	0.4971	0	0.4988	0.4997	0.4957
2007							
Greece	-0.375	0.4479	0.4812	-0.445	0.4479	0.519	0.430
Spain	0.333	0.5299	0.4897	0.513	0.5299	0.493	0.485
Italy	0.350	0.5257	0.5068	0.490	0.5257	0.519	0.489
Portugal	0.130	0.4917	0.5082	-0.557	0.4917	0.468	0.574
Typical Country	0	0.4988	0.4965	0	0.4988	0.4996	0.4947
2008							
Greece	-0.38	0.4433	0.4825	-0.454	0.4433	0.520	0.431
Spain	0.317	0.5242	0.4940	0.493	0.5242	0.494	0.494
Italy	0.325	0.5180	0.5095	0.459	0.5180	0.517	0.498
Portugal	0.254	0.5076	0.5036	-0.514	0.5076	0.467	0.563
Typical Country	0	0.4983	0.4974	-0.454	0.4983	0.4997	0.4966
2009							
Greece	-0.377	0.4438	0.4833	-0.450	0.4438	0.521	0.432
Spain	0.294	0.5182	0.4966	0.467	0.5182	0.493	0.502
Italy	0.320	0.5166	0.5098	0.452	0.5166	0.516	0.501
Portugal	0.28	0.5133	0.5010	-0.479	0.5133	0.469	0.553
Typical Country	0	0.4980	0.4977	0	0.4980	0.4996	0.4971
2010							
Greece	-0.382	0.4404	0.4833	-0.464	0.4404	0.519	0.434
Spain	0.300	0.5189	0.4979	0.471	0.5189	0.495	0.503
Italy	0.335	0.5200	0.5105	0.467	0.5200	0.520	0.496
Portugal	0.273	0.5134	0.4992	-0.498	0.5134	0.465	0.556
Typical Country	0	0.4982	0.4977	0	0.4982	0.4997	0.4972

- The Basic Image values of both models for Greece and Portugal follow the same trend. However in the two Indicators case Portugal is better and indeed in 2007 its Basic Image turns positive whereas in the three Indicators case Greece is better (but with narrowing lead) throughout the period.

Before proceeding to the interpretation of those differences the following comments should be made.

- In the two Indicators case the Economic and the Social/Environmental Indicators carry almost equal weight in defining the Basic Image.
- In the three Indicators case the Economic and Social Indicators are the key determinants of the Basic Image values whereas the Environmental Indicator accelerates or decelerates the changes generated by them.

Hence, the environmental factors have a more direct and increased contribution in the two Indicators case.

On the basis of the above the differences between the results of the two models may be interpreted as follows:

- The primary environmental data have a greater variation among the four countries, as compared to the economic or social data. Hence when used in the two Indicators model result in larger variations among the Basic Image values of the four countries.
- Italy has a better environmental profile than Spain. Hence in the two Indicators model (where the environmental factors have increased contribution) the superiority of the relative performance of Italy, as compared to that of Spain, appears more emphatic.
- Similarly, Portugal has a better environmental profile than Greece. Hence, in the two Indicators model the superiority of the relative performance of Portugal, as compared to that of Greece, appears more emphatic.

5. CONCLUSIONS AND SUGGESTIONS FOR FURTHER RESEARCH

A country's path of growth depends on its ability to tackle the conflicts characterizing sustainability issues. This ability is reflected on what we call the Image of a country, a measure expressing, at each point in time, the country's current state of development and its future prospects.

The paper introduced the concept of a country's Basic Image, developed two mathematical models for its estimation, applied the models to the case of four

countries of the European South, presented the results, compared them and commented on their differences. In both models the Basic Image gives a “true” picture of a country’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 country’s attractiveness and future prospects of development.

The application results, in both cases, seem logical and expected. They show that the proposed model expresses a country’s process of development in a realistic way, in the sense that it quantifies the country’s appeal to the full range of people.

An area of further research would be to apply the two models to a large variety of cases and compare their results. Based on those comparisons it may be then decided whether:

- One of the models performs better in every situation.
- Each model is more suitable for certain cases
- The two models require further fine tuning so as to give even closer results in every case.

REFERENCES

1. Aerts, D., Czachor, M., Gabora, L., Kuna, M., Posiewnik, A., Pykacz, J., Syty, M., 2003, ‘Quantum morphogenesis: a variation on Thom’s catastrophe theory’, *Physical Review E*, 67, pp. 1-13.
2. Angelis, V. and Dimaki, K., 2011. A Region’s Basic Image as a Measure of its Attractiveness, *International Journal of Economic Sciences and Applied Research*, 4(2), pp. 7-33.
3. Angelis, V., Tsetseri, M. and Dimaki, K., 1999. The Economic, Social and Environmental Dimensions of Sustainable Development. The Transition from Conflict to Synthesis and the Future Prospects. *Studies in Regional and Urban Planning*, Issue 7.
4. Angelis, V., Angelis-Dimakis, A. and Dimaki, K., 2013. A Country’s Process of Development as Described by a Butterfly Catastrophe Model. The Case of European South. *International Journal of Economic Sciences and Applied Research (to appear)*.
5. Ashworth, C. J. and Voogd, H., 1990. *Selling the City*, Belhaven Press, London.
6. Barbier, E. B., 1987. The concept of sustainable economic development, *Environmental Conservation*, 14(2), pp. 101-110.
7. Beinart, E. and Nijkamp, P., 1998. *Multicriteria Evaluation in Land-Use Management: Methodologies and Case Studies*, Kluwer Academic Publishers, Dordrecht.
8. Bell, M. L., Hobbs, B., Elliott, E. M., Ellis, H. and Robinson, Z., 2001. An evaluation of multicriteria methods in integrated assessment of climate policy, *Journal of Multi-Criteria Decision Analysis*, 10(5), pp. 229-256.
9. Bryson, J R and Daniels, P W (eds.), 2007. *The Handbook of Service Industries*. Edward Elgar, Cheltenham.
10. Bramwell, B. and Rawding, L., 1996. ‘Tourism Marketing Images of Industrial Cities’, *Annals of Tourism Research*, 23 (1), pp. 201-221.
11. Dichter, E., 1985. ‘What’s An Image’, *The Journal of Consumer Marketing*, 2, pp. 75-81.
12. Dou, E. and Ghose, W., 2006. ‘A dynamic nonlinear model of online retail competition using cusp catastrophe theory’, *Journal of Business Research*, 59, pp. 838-848.

13. Dowling, G. R., 1998. 'Measuring Corporate Images: A Review of Alternative Approaches', *Journal of Business Research*, 17, pp. 27-37.
14. Du Pisani, J. A., 2006. Sustainable development – historical roots of the concept, *Environmental Sciences*, 3 (2), pp. 83-96.
15. Gartner, W., 1993. 'Image Formation Process', *Journal of Travel and Tourism Marketing*, 2, pp. 191-215.
16. Gilmore, R., 1993. *Catastrophe Theory for scientists and engineers*. Wiley, New York.
17. Hayashi, K., 2000. Multicriteria analysis for agriculture resource management: A critical survey and future perspectives, *European Journal of operational Research*, 122, pp. 486-500.
18. Huang, Y. K., 2008. 'The study of customer segmentation examined by catastrophe model', in Olya, M. and Uda, R. (eds) *Towards Sustainable Society on Ubiquitous Networks*, Springer, Boston, pp. 37-48.
19. Janssen, R., 1992. *Multiobjective decision support for environmental management*, Kluwer Academic Publishers, Dordrecht.
20. Janssen, R. and Munda, G., 1999. Multi-criteria methods for quantitative, qualitative and fuzzy evaluation problem, in J. van den Bergh (ed.), *Handbook of Environmental and Resource Economics*, Edward Elgar, Cheltenham, pp. 837-852.
21. Karol, P. & Brunner, J., 2009. Tools for measuring progress towards sustainable neighborhood environments. *Sustainability*, 1, pp. 612-627.
22. Kondakis, M., Dimaki, K. and Angelis, V., 2010. Selecting the Optimum Path of a Region's Sustainable Development, 50th Congress of the *European Regional Science Association*, "Sustainable Regional Growth and Development in the Creative Knowledge Economy", 19-23 August, Jönköping, Sweden.
23. Kotler, P., Haider, D. H., Irving, R., 1993, *Marketing Places: Attracting Investment, Industry and Tourism to Cities, States and Nations*, Free Press, New York.
24. Kotler, P., Asplund, C., Rein, I., Haider, D. H., 1999. *Marketing Places Europe*, Prentice Hall, London.
25. Mill, J. S., 1883. *Principles of political economy, with some of their applications to social philosophy*, People's edition, London, Longmans Green.
26. Munashinghe, M., 1993. Environmental Economics and Sustainable Development, World Bank Environment Paper number 3. *The International Bank for Reconstruction and Development*, Washington D.C.
27. Munda, G., 1995. *Multicriteria Evaluation in a Fuzzy Environment –Theory and Applications in Ecological Economics*. Contributions to Economics Series, Physica - Verlag, Heidelberg.
28. Munda, G., 2005. Multiple Criteria Decision Analysis and Sustainable Development, in J. Figueira, S. Greco and M. Ehrgott (eds), *Multiple Criteria Decision Analysis: State of the Art Surveys*, Springer Verlag, Boston, Dordrecht, London.
29. Munda, G., 2006. Social multi-criteria evaluation for urban sustainability policies, *Land Use Policy*, 23, pp.86-94.
30. Munda, G., 2008. *Social multi-criteria Evaluation for a Sustainable Economy*, Springer-Verlag, Heidelberg.
31. Munda, G., Paruccini, M. and Rossi, G., 1998. Multicriteria evaluation methods in renewable resource management: The case of integrated water management under drought conditions. In E. Beinart and P. Nijkamp (eds), *Multicriteria Evaluation in Land-Use Management: Methodologies and Case Studies*, Kluwer Academic Publishers, Dordrecht, pp. 79-94.
32. Nijkamp, P., Rietveld, P. and Voogd, H., 1990. *Multicriteria Evaluation in Physical Planning*, North-Holland, Amsterdam.
33. Poston, T. and Stewart, I., 1996, *Catastrophe Theory and its Applications*, Dover, New York.
34. Ringius, L., Asbjorn, T. and Holtmark, B., 1998. Can multi-criteria rules fairly distribute climate burdens? OECD results from three burden sharing rules, *Energy Policy*, 26(10), pp. 777-793.
35. Romero, C. and Rehman, T., 1989. *Multiple Criteria Analysis for Agricultural Decisions*, Elsevier, Amsterdam.
36. Rosser, J. B., 2007. 'The rise and fall of catastrophe theory applications in economics: Was the baby thrown out with bathwater?', *Journal of Economic Dynamics and Control*, 10, pp. 3255-3280.
37. Smerz, K. E. and Guastello, S. J., 2008. 'Cusp catastrophe model for binge drinking in college population', *Nonlinear Dynamics, Psychology and Life Sciences*, 12, pp. 205-224.
38. Smith, M., Lancioni, R. A., Oliva, T. A., 2005. 'The effects of management inertia on the supply chain performance of produce-to stock firms', *Industrial Marketing Management*, 24, pp. 614-628.

39. Solow, R., 1991. Sustainability: An Economist's Perspective, *Lecture to the Marine Policy Centre, Massachusetts*.
40. Svedin U., 1991. The Economy-Ecology in Dialogue in Folke C and Kaberger T. Linking the Natural Environment and the Economy: *Essays from the Eco-Eco Group*. Kluwer Academic Publishers.
41. Thom, R., 1975. *Structural Stability and Morphogenesis: An Outline of a General Theory of Models*. Addison-Wesley, Reading M.A.
42. Van der Mass, H. L. J., Kolsteib, R., Van der Pligt, J., 2003. 'Sudden transitions in attitudes', *Sociological Methods and Research*, 32, pp. 395-417.
43. Wales, D. J., 2001. 'A microscopic basis for the global appearance of energy landscapes', *Science*, 293, pp. 602-604.
44. Yigitcanlar, T. & Dur, F., 2010. Developing a Sustainability Assessment Model: The Sustainable Infrastructure, Land-Use, Environment and Transport Model, *Sustainability*, 2, pp. 321-340
45. Zeeman, E. C., 1973. 'Applications of Catastrophe Theory', *International Conference on Manifolds*, Tokyo, Japan, pp. 11-26.