A Country's Process of Development as Described by a Butterfly Catastrophe Model: The Case of European South

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Abstract

For a long period of time a country's development has been synonymous with its economic growth. Over the last years, however, economies and societies have been undergoing dramatic changes. These changes have led to the concept of sustainable development, which 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 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. 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 and the environmental. Our objective in the present paper is to:

- *Outline the process of a country's development taking into account all its three dimensions, economic, social and environmental.*
- *Present a model for quantifying its process of development encompassing all those dimensions.*
- *Apply the model to European South countries.*
- *Discuss the results.*

Keywords: Country's Image, Country's Process of Development, Economic Social & Environmental Factors, Butterfly Catastrophe Model

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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 scope of the present paper is to:

- Outline the process of a country's development taking into account all its three dimensions, economic, social and environmental.
- Present a model for quantifying its attractiveness (process of development) encompassing all those dimensions.
- Apply the model to the countries of the European South.
- Discuss the results.

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 20th 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.A. Du Pisani (2006) points out that, as early as the ancient Egyptian, Mesopotamian, Greek and Roman civilizations, environmental problems such as deforestation, salination and loss of soil fertility occurred, which we would today refer to as sustainability problems. Plato in the 5th century BC, Strabo and Columella in the 1st century BC and Pliny the Elder in the 1st century AD discussed different types of environmental degradation resulting from human activities such as farming, logging and mining. These authors were not only aware of environmental degradation, but also recommended what we call sustainable practices to maintain the "everlasting youth" of the earth. 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. 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.

Taking sustainability seriously into account creates a need for the inclusion of the physical appraisal of the environmental impact on the socio-economic system too. Systemic approaches to sustainability issues consider the relationships between three systems: the economic system, the social system and the environmental system. The economic system includes the economic activities of people. The social system comprises all social activities. Finally, the environmental system includes both the economic and social system (O´Neill, 1993; Martinez-Alier et al., 1998; 2001).

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. 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. It can help us create healthy communities that can sustain our generation, as well as those that follow us.

3. The changing role of the Economic, Social and Environmental Dimensions of a Country's Development

Environmental degradation is one of the basic problems most countries around the world are facing today. 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 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. The changing role of these three dimensions is briefly outlined below.

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 performance.

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. 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. Furthermore, at that time, economic growth and environmental quality were largely perceived as opposing each other.

Protection of the environment is the emerging strong new concern in the next decade. At that time the importance of reconciling economic growth with the environment had come to be generally recognised providing an intellectual underpinning to efforts to elevate the

importance of environmental issues in policy making. 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. The concept of sustainable development has therefore evolved to encompass three major points of view: economic, social and environmental (Angelis et al., 1999). 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 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. Furthermore, environmental threats are now perceived as emerging on a very large scale, often related to socio-economic turbulent factors and requiring immediate corrective action. The gradual awareness of actual and potential conflicts between economic growth, social progress and preservation of the environment led to the concept of sustainable development. Hence, 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 (genetic diversity, 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).

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. 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 (Munda, 2005).

Many tools and methodologies have been used over the past years to measure the progress towards sustainability (Munda, 2006; Karol and Brunner, 2009; Yigitcanlar and 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 exhaustive in literature (Barrios and Komoto, 2006; Singh et al., 2009). As a tool for conflict management, multi-criteria evaluation has demonstrated its usefulness in many sustainability policy and management problems (see e.g. Romero and Rehman, 1989; Nijkamp et al., 1990; Beinat and Nijkamp, 1998; Janssen, 1992; Munda, 1995; Munda et al., 1998; Ringius et al., 1998; Janssen and Munda, 1999; Hayashi, 2000; Bell et al., 2001; Munda, 2005; 2008).

In conclusion, it can be said that 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.

5. 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 the 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. These types of images reach people by transmission or diffusion process through various channels of communication, which they can alter, the character of the message. The received place images are formed from the interaction between these projected messages and people' 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 three sets according to whether they express the economic, the social or the environmental function of the country.

The factors of the first set (e.g. *GDP per Capita, Energy Expenditure per Capita, Employment Rate, Research & Development percentage of GDP*) provide a measure of the country's economic development prospects. This measure is referred to as **Economic Indicator** $\left(IND_i^1\right)$. Similarly, the factors of the second set (e.g. *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*) provide a measure of a country's social profile. This measure is referred to as **Social Indicator** $\left(IND_i^2\right)$. Finally, the factors of the third set (e.g. *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)* provide a measure of the quality of the environment in the country. This measure is referred to as **Environmental Indicator** $\left(IND_i^3\right)$. Hence,

$$\text{Basic Image} = \varphi\left(IND_i^1, IND_i^2, IND_i^3\right)$$

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.

6. Modeling a Country's Basic Image

We have so far defined a country's Basic Image as a function of three 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 three indicators operate.

i. The higher the Economic Indicator of a country the more Attractive its Basic Image.
ii. The higher the Social Indicator of a country the more Attractive its Basic Image.
iii. The higher the Environmental Indicator of a country the more Attractive its Basic Image.
iv. If the Economic Indicator of a country is continuously increasing but, at the same time, its Social 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 (iv) is the most interesting because it implies that the graph we want to draw may be discontinuous with multiple equilibria. Furthermore, the recent work on resilience seems to indicate the existence of multiple equilibria in systems such as persons, firms, products or even nations (Pendall et al., 2010). According to Berkes and Folke (1998) and Gunderson et al. (2002), the important measure of resilience is the magnitude or scale of disturbance that can be absorbed before the system changes in structure by the change of variables and processes. Systems are seen to be complex, non linear, multi-equilibrium and self-organising; they are permeated by uncertainty and discontinuities. Resilience in this context is a measure of robustness and buffering capacity of the system to changing conditions. Finally, the available evidence presented so far indicates that sustainability issues are characterized by a high degree of conflict.

The study of discontinuous functions requires special mathematical tools. Such a tool is Catastrophe Theory (Thom, 1975; Zeeman, 1973) 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 terns of a few archetypal forms called elementary catastrophes (Gilmore, 1993; 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: 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

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.

Returning to the present case it must be reminded that the Basic Image of a country has been defined as a function of three potentially conflicting indicators. Therefore, according to Catastrophe Theory, the appropriate elementary catastrophe is the swallowtail and consequently the value $BI = x_i$, of a country's Basic Image is given as a solution of the equation:

$$x_i^4 - Dx_i^2 - Bx_i - A = 0$$

At this point, however, it should be mentioned that the swallowtail catastrophe is not particularly useful as a model because under a wide range of conditions no stable state can exist. This problem together with the fact that environment may, in some cases, act as a buffer delaying/accelerating the decline of a declining country or accelerating/delaying the growth of a growing country, with high or low environmental quality respectively, leads us to consider the next elementary catastrophe namely the butterfly catastrophe. The butterfly catastrophe involves four control factors and in order to use it as the basis for modeling the shaping of a country's Basic Image we need, on top of the three indicators already defined Economic, Social and Environmental, to introduce a fourth one. This indicator may be the Political Indicator (POI), which expresses the general socio-economic and political climate

in which the country is found in the period under study. Consequently, the value $BI = x_i$, of a country's Basic Image, at each point in time, is given as a solution of the equation:

$$x_i^5 - Cx_i^3 - Dx_i^2 - Bx_i - A = 0$$

For the purposes of this work, we set $D = 0$ and comments for its use in the general case are given in the final section of the paper. 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:

$$x_i^5 - Cx_i^3 - Bx_i - A = 0 \tag{1}$$

with:

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

$$\begin{pmatrix} A \\ B \\ C \end{pmatrix} = \begin{pmatrix} k & \frac{k}{m} & -\frac{\sqrt{m^2+1}}{m} \\ \frac{\sqrt{k^2+1}}{m} & -\sqrt{k^2+1} & 0 \\ 1 & \frac{1}{m} & \frac{k}{m}\sqrt{m^2+1} \end{pmatrix} \begin{pmatrix} IND_i^1 - IND_0^1 \\ IND_i^2 - IND_0^2 \\ IND_i^3 - IND_0^3 \end{pmatrix} \text{ when } \begin{matrix} m > 1 \\ k \le 1 \end{matrix}$$

$$\begin{pmatrix} A \\ B \\ C \end{pmatrix} = \begin{pmatrix} m & 1 & -\frac{\sqrt{m^2+1}}{k} \\ \frac{\sqrt{k^2+1}}{k} & -\frac{m}{k}\sqrt{k^2+1} & 0 \\ \frac{m}{k} & \frac{1}{k} & \sqrt{m^2+1} \end{pmatrix} \begin{pmatrix} IND_i^1 - IND_0^1 \\ IND_i^2 - IND_0^2 \\ IND_i^3 - IND_0^3 \end{pmatrix} \text{ when } \begin{matrix} m \le 1 \\ k > 1 \end{matrix}$$

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

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).

Composite indicators for ranking countries are very common in a variety of economic and policy domains, such as industrial competitiveness, sustainable development, globalization and innovation. As a result, there is an extensive literature on the construction of such indicators (Saisana and Tarantola, 2002; Munda and Nardo, 2005, 2009; Shen et al., 2011; Dallara and Rizzi, 2013).

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

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

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

For the purposes of this work, 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 Indicators and, finally, into the country's Basic Image is given in Table 3. 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.

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

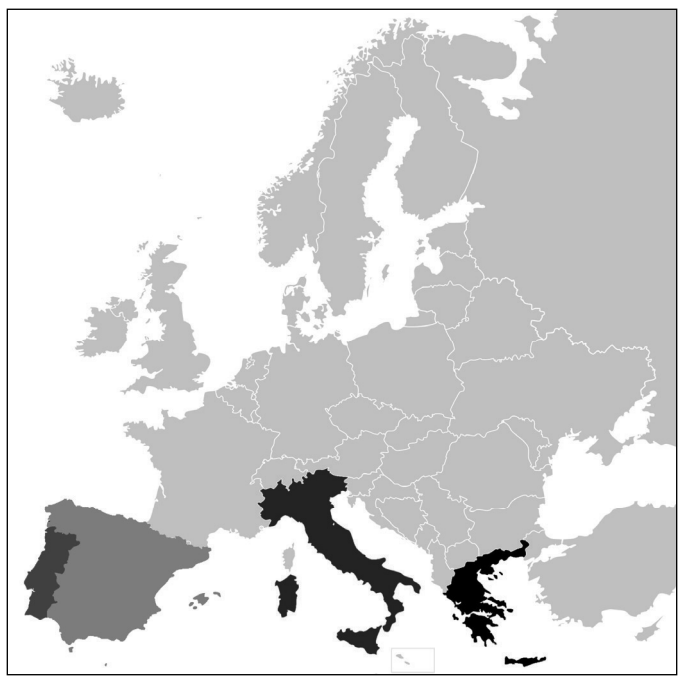
INDICATORS, INDICES AND VARIABLES CONCERNING COUNTRY *i*					
Indicators	**Sub indicators**	**Relative Indices**	**Relative Sub indices**	**Sub indices**	**Variables**
Economic Indicator $\left(IND_i^1\right)$	The Financial Conditions Sub indicator $\left(SbI_{i1}^1\right)$	Relative Financial Conditions Index $\left(RI_{i1}^1\right)$	Relative Sub index for Gross Domestic Product per inhabitant $\left(RSI_{i1_1}^1\right)$	Sub index for Gross Domestic Product per inhabitant $\left(SI_{i1_1}^1\right)$	Gross Domestic Product
					Population
			Relative Sub index for Energy expenditure per inhabitant $\left(RSI_{i1_2}^1\right)$	Sub index for Energy expenditure per inhabitant $\left(SI_{i1_2}^1\right)$	Energy expenditure
					Population
	The Employment Sub indicator $\left(SbI_{i2}^1\right)$	Relative Employment Index $\left(RI_{i2}^1\right)$			Persons aged 20 to 64 in employment
					Population of the same age group
	The R & D Sub indicator $\left(SbI_{i3}^1\right)$	Relative R & D Index $\left(RI_{i3}^1\right)$			Gross domestic expenditure on R&D
					Gross Domestic Product
Social Indicator $\left(IND_i^2\right)$	The Education Sub indicator $\left(SbI_{i1}^2\right)$	Relative Education Index $\left(RI_{i1}^2\right)$	Relative Sub index for Persons with upper secondary or tertiary education $\left(RSI_{i1_1}^2\right)$	Sub index for Persons with upper secondary or tertiary education $\left(SI_{i1_1}^2\right)$	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 $\left(RSI_{i1_2}^2\right)$	Public expenditure on education $\left(SI_{i1_2}^2\right)$	Public expenditure on education
					Gross Domestic Product
	The Health Sub indicator $\left(SbI_{i2}^2\right)$	Relative Health Index $\left(RI_{i2}^2\right)$	Relative Sub index for Healthy Life years $\left(RSI_{i2_1}^2\right)$	Sub index for Healthy Life years $\left(SI_{i2_1}^2\right)$	Healthy Life years for males
					Healthy Life years for females
					Males/females in the population
			Relative Hospital beds Sub index $\left(RSI_{i2_2}^2\right)$	Sub index for Hospital beds $\left(SI_{i2_2}^2\right)$	Hospital beds (per 100,000 inhabitants)
	The Social Conditions Sub indicator $\left(SbI_{i3}^2\right)$	Relative Social Conditions Index $\left(RI_{i3}^2\right)$	Relative Sub index for Social Protection Expenditure $\left(RSI_{i3_1}^2\right)$	Sub index for Social Protection Expenditure $\left(SI_{i3_1}^2\right)$	Social Protection Expenditure
					Population
			Relative Sub index for People at risk of poverty $\left(RSI_{i3_2}^2\right)$	Sub index for People at risk of poverty $\left(SI_{i3_2}^2\right)$	People at Risk of Poverty
					Population

Environ-mental Indicator $\left(IND_i^3\right)$	The Renewable Energy Sources (RES) Sub indicator $\left(SbI_{i1}^3\right)$	Relative Renewable Energy Sources (RES) Index $\left(RI_{i1}^3\right)$	Relative Sub index for Share of RES in Electricity Generation $\left(RSI_{i1_1}^3\right)$	Sub index for Share of RES in Electricity Generation $\left(SI_{i1_1}^3\right)$	Share of RES in Electricity Generation
			Relative Sub index for Share of RES in gross FEC $\left(RSI_{i1_2}^3\right)$	Sub index for Share of RES in gross FEC $\left(SI_{i1_2}^3\right)$	Total RES Consumption
					Total FEC
	The Energy Efficiency Sub indicator $\left(SbI_{i2}^3\right)$	Relative Energy Efficiency Index $\left(RI_{i2}^3\right)$			Gross inland consumption of energy
					Gross Domestic Product
	The Climate Change Sub indicator $\left(SbI_{i3}^3\right)$	Relative Climate Change Index $\left(RI_{i3}^3\right)$			Total Greenhouse Gas Emissions
					Population

7. 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. The required data have been drawn from the official site of Eurostat.

Figure 1: The Map of the European South



The results are summarized in Tables 4-5 and in Figures 2-5. Table 4 contains the values of the Economic, Social and Environmental Indicators for Greece, Italy, Spain and Portugal for the period under study. The values of the Economic, Social and Environmental Indicators of the "typical" country have been also calculated.

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

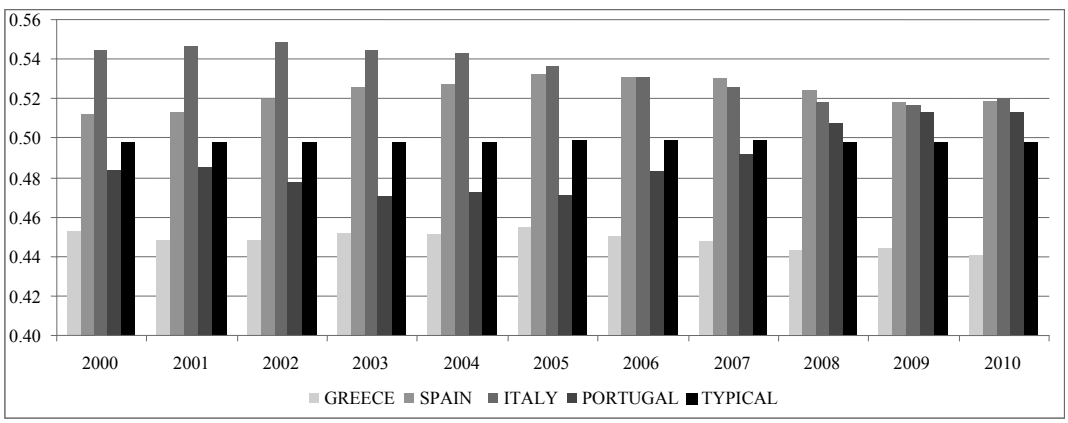


Figure 3 presents the values of the Social Indicator for all four countries and for the "typical" country throughout the period under study. As we can see Italy started with the highest Social Indicator value followed by Greece which however is catching up Italy towards the end of the period. Spain shows 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 Spain maintain Social Indicator values lower than that of the "typical" country, whereas Greece and Italy higher values.

Table 4: The values of Economic, Social and Environmental Indicators of the European South, 2000-2010

Countries	Indicators		
	Economic	Social	Environmental
2000			
Greece	0.4524	0.503	0.431
Spain	0.5125	0.490	0.478
Italy	0.5444	0.542	0.500
Portugal	0.4839	0.464	0.572
Typical Country	**0.4983**	**0.4996**	**0.4952**
2001			
Greece	0.4484	0.503	0.418
Spain	0.5129	0.488	0.491
Italy	0.5467	0.541	0.496
Portugal	0.4855	0.467	0.574
Typical Country	**0.4983**	**0.4996**	**0.4947**
2002			
Greece	0.4480	0.506	0.434
Spain	0.5193	0.489	0.484
Italy	0.5484	0.537	0.510
Portugal	0.4773	0.467	0.557
Typical Country	**0.4982**	**0.4996**	**0.4963**
2003			
Greece	0.4522	0.506	0.433
Spain	0.5262	0.489	0.488
Italy	0.5442	0.534	0.480
Portugal	0.4705	0.469	0.577
Typical Country	**0.4983**	**0.4996**	**0.4944**
2004			
Greece	0.4510	0.511	0.443
Spain	0.5274	0.488	0.486
Italy	0.5427	0.532	0.500
Portugal	0.4728	0.467	0.558
Typical Country	**0.4985**	**0.4996**	**0.4968**
2005			
Greece	0.4547	0.515	0.454
Spain	0.5323	0.490	0.485
Italy	0.5368	0.525	0.508
Portugal	0.4708	0.469	0.544
Typical Country	**0.4986**	**0.4996**	**0.4979**
2006			
Greece	0.4507	0.515	0.446
Spain	0.5312	0.491	0.478
Italy	0.5305	0.525	0.490
Portugal	0.4829	0.467	0.569
Typical Country	**0.4988**	**0.4997**	**0.4957**
2007			
Greece	0.4479	0.519	0.430
Spain	0.5299	0.493	0.485
Italy	0.5257	0.519	0.489
Portugal	0.4917	0.468	0.574
Typical Country	**0.4988**	**0.4996**	**0.4947**
2008			
Greece	0.4433	0.520	0.431
Spain	0.5242	0.494	0.494
Italy	0.5180	0.517	0.498
Portugal	0.5076	0.467	0.563
Typical Country	**0.4983**	**0.4997**	**0.4966**
2009			
Greece	0.4438	0.521	0.432
Spain	0.5182	0.493	0.502
Italy	0.5166	0.516	0.501
Portugal	0.5133	0.469	0.553
Typical Country	**0.4980**	**0.4996**	**0.4971**
2010			
Greece	0.4404	0.519	0.434
Spain	0.5189	0.495	0.503
Italy	0.5200	0.520	0.496
Portugal	0.5134	0.465	0.556
Typical Country	**0.4982**	**0.4997**	**0.4972**

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

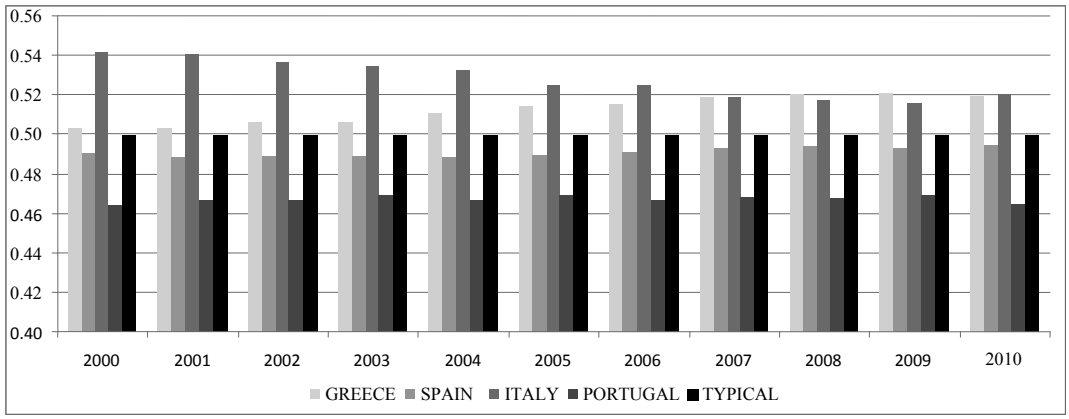


Figure 4: The Environmental Indicator of the European South, 2000-2010

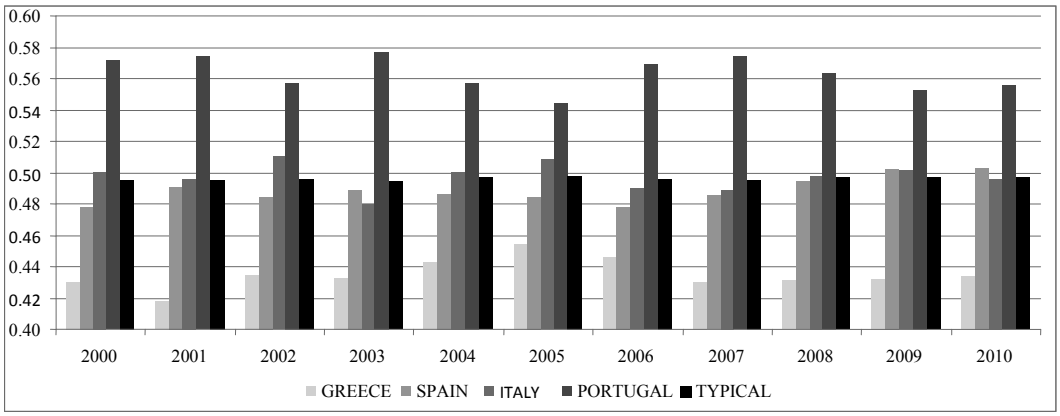
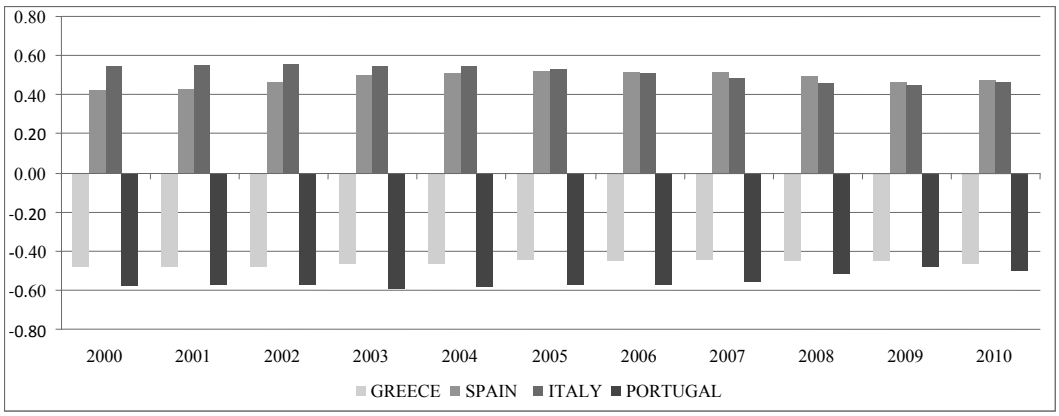


Figure 4 presents the values of the Environmental Indicator for all four countries and for the "typical" country throughout the period under study. Portugal maintains the highest Environmental Indicator value over the whole period, whereas Greece the lowest. Spain and Italy exhibit an almost constant 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.

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

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
GREECE	-0.4770	-0.4800	-0.4820	-0.4690	-0.4650	-0.4480	-0.4540	-0.4450	-0.4540	-0.4500	-0.4640
SPAIN	0.4260	0.4320	0.4690	0.5010	0.5050	0.5220	0.5160	0.5130	0.4930	0.4670	0.4710
ITALY	0.5460	0.5510	0.5600	0.5420	0.5440	0.5320	0.5060	0.4900	0.4590	0.4520	0.4670
PORTUGAL	-0.5800	-0.5730	-0.5760	-0.5930	-0.5840	-0.5760	-0.5740	-0.5570	-0.5140	-0.4790	-0.5000

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



Finally, Table 5 contains the values of the Basic Image for all four countries throughout the period under study and Figure 5 presents them graphically. 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. At a first glance this last finding seems somehow unexpected since Portugal has two out of its three Indicators (Economic and Environmental) higher than those of Greece but still its Basic Image is marginally worse than that of Greece. A closer look however reveals the following:

- The non-linear Butterfly Catastrophe model used in this paper for the estimation of a country's Basic Image value is based on three Indicators: Economic, Social and Environmental. However the key determinants of the Basic Image are the first two indicators whereas the Environmental Indicator accelerates or decelerates the changes generated by them.
- If we follow the changes in the values of all Indicators and the Basic Image values for Greece and Portugal throughout the period under study, the following observations may be made:
  - In the case of Portugal the Economic Indicator is, after a period of stagnation, continuously increasing whereas the other two Indicators remain almost constant.

Hence, its Basic Image follows the trend of the Economic Indicator and improves considerably in the second half of the period under study. Furthermore, the Social Indicator of Portugal is well **below** the Social Indicator of the "typical" country and its Economic Indicator is **below** that of the "typical" country for almost the whole period.

- In the case of Greece the Social Indicator, after a period of stagnation, increases slightly whereas the other two Indicators remain almost constant throughout the period under study. Hence, its Basic Image improves slightly in the second half of the period under study. Furthermore, the Social Indicator of Greece is **above** the Social Indicator of the "typical" country and its Economic Indicator is **below** that of the "typical" country for almost the whole period.

On the basis of all the above it is clear that in the last three years under study the key determinants of the Basic Image value, in both Greece and Portugal, are comparable and hence any relative ranking of the two countries and perhaps a sudden change may be expected. However, it is obvious that the trend of their Basic Image values has changed in favour of Portugal (which closes the gap) and if the key determinants keep moving in the same way, Portugal will soon take the lead.

8. 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 a mathematical model for its estimation, applied the model to the case of the four countries of the European South and presented the results. 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 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.

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 country**'s Basic Image, so as to include some of those variables. Such a set of variables may be those related to the** general socio-economic and political climate in which the country is found in the period under study and could define a fourth indicator, which may be referred to as the Political Indicator. This indicator has been included in the model

presented in section 6 but for simplification reasons it was set equal to zero. However, in the general case the variables affecting this indicator will be identified, measured and scaled and the indicator will be calculated along the lines used for the other three indicators. Hence, our task will be to examine how the complete Butterfly catastrophe (with $D \neq 0$) may be used to model the enriched Basic Image.

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