SOCIOECONOMIC AND ENVIRONMENTAL PERFORMANCE: A COMPOSITE INDEX APPROACH AND COMPARATIVE APPLICATION TO THE USA AND CHINA IN THE NEW MILLENNIUM*

Joanílio Rodolpho Teixeira
Department of Economics
University of Brasília

Danielle Sandi Pinheiro
Department of Administration
University of Brasília

Anna Eloyr Silveira Vilasboas
Department of Economics
University of Brasília

ABSTRACT

This paper deals with an analytical framework to provide a measure of overall performance which involves both socioeconomic activities and environmental sustainability using a recent Index of well-being. The composite indicator, created by Medrano-B & Teixeira (2013), is associated with the so called "Magic Square", a diagram stimulated by the work of Kaldor (1971). From this starting point, we introduce a robust set of four variables to measure their total impact on the sustainable development of each economy or region. They are: human development index, per capita carbon dioxide, drinkable water and sanitation, and intensity of renewable energy measured as a fraction of the total generated. This formal approach is applied to the comparative performance of the USA and China from 2002 to 2012. As expected, environmental, socioeconomic and institutional indicators affect the level of welfare. This being the case, an important lesson is that careful regulation and policy actions, not just proposals, are required to implement a sustainable and acceptable quality of life. In this article we completed the argument by suggesting that a new paradigm is required to fulfill our desirable objectives, and thus get more out of our intellectual effort, capabilities and political influence. This proposal may well be indigestible or simply ignored by many. On the other hand, now that disillusionment with the current state of affairs is setting in, perhaps this new vision will get a strong hearing at last.

KEY WORDS: Normalized Magic Square, Sustainable Development, Welfare in USA and China.

JEL CLASSIFICATION: E6, E01, E3, F1

---

*This research article is part of the research program of the group of "Growth and Distribution" from the National Council of Science and Technology" (CNPq-Brazil). For comments, contact: joanilioteixeira@hotmail.com. We thank Rodrigo Peñaloza, René Medrano-B, Wellington Carlos and Ricardo Pasini for helpful suggestions.

INTRODUCTION

Given the current immense accumulation of their negative effects on the environment, we wonder at the relative complacence worldwide with the impact of the present patterns of production and consumption. No longer is it only dreamers and visionaries who are alerting society to the deep and undesirable consequences that may yet lead to the collapse of our planet. These consequences are affecting humanity as well as other species, and future generations of these. It is actually curious to observe the relative alienation, silence and apparent indifference of many people and governments on this matter. We need urgent action to change the present situation. However, we must recognize that actions and changes, without previous thought and clear goals, are counterproductive. In this vein, the major challenge for the present generation is to develop a shared vision, both desirable to the vast majority of people and ecologically sustainable from a global perspective.

This paper is the product of a research agenda the core of which is to design a modeling framework to measure the impact of a set of variables with a new index of welfare constructed from indicators of trends over which the index is computed. The original approach is encountered in the work of Kaldor (1971), but he was only concerned with macroeconomic variables. He did not consider environmental issues nor did he introduce equations or numerical or graphical illustrations in his analysis. Here we extend his method to include aggregated socioeconomic performance, environmental indicators and sustainable development. We stress that due to the efforts of Karl Schiller and economists of the OECD, an intuitive geometric diagram was established in the 1970s in order to treat with fundamental macroeconomic variables. This representation, called 'Magic Square', is associated to the size of the area of a figure conceived in such a way that its four directions (N, S, E, and W) are expressed in percentages.

Medrano-B & Teixeira (2013) normalized the mentioned vectors to make them uniform since the area of the quadrangle could be calculated due to the non uniform scales of the axes. They produced an analytical transformation which allows the calculation of the area of the relevant quadrangle. The measure ends up as a composite index of welfare. Such an indicator captures the impact of the re-dimensioned components of the index. The new method was used by Firme & Teixeira (2014) focusing mainly on Brazil's macroeconomic performance. The formal approach is expanded here in order to integrate a set of interconnected socioeconomic and ecological measures to produce a single welfare index.

We believe that a collection of composite indexes is ideal for measuring multi-dimensional characteristics which would be hard to explain using a single variable. This is certainly the case of sustainable development. The latter concept remains somewhat elusive since it may encompass a wide set of issues over different time periods, regions and theoretical visions. Under this complex circumstance there is a widely shared consensus that the ecosystem is a non-ergodic dynamic structure. Omitting to describe development in a holistic perspective and to measure its impact for meaningful comparative work is a pressing problem worldwide.

Gasparatos, El-Haran & Horner (2007) argues against a reduced form approach for assessing sustainability of the ecological system. According to them, the use of a single metric to address the environment is a naïve approach to the serious threat confronting society. This is the main

reason why we decided to examine the problem by combining a set of composite indicators integrating socioeconomic and ecological variables. Here, special emphasis is placed on the challenges confronted by ecological states in transition.

The present article focuses, simultaneously, on the relationships among four composite key variables: Human Development Index (HDI), Per Capita Carbon Dioxide (CO2CAP), Drinking Water & Sanitation (WATSAN), and Renewable Energy Intensity as a share of national (total) generation of energy (SHARENEW). We highlight the main reasons accounting for the fragility of the environment by clarifying the meaning of the above variables and their significance in the process of sustainable development. For instance, renewable energy generation, by its very nature, tends to be highly sustainable in comparison to gas, oil- and coal-based energy. As Bergman et al (2006, p.1005) pointed out: "Renewable energy projects, as with traditional fossil fuel projects, tend to be capital intensive, so the opportunity to develop and manufacture [new] renewable energy equipment for domestic use and international export exists".

Our empirical analysis examines the comparative performance of the USA (an industrial country) and China (an emergent one). We are concerned with the conflicts between economic prosperity and welfare on the one hand, and its ensuing environmental problems on the other. We suggest that unconstrained growth is poisoning the environment in such a way that short-term economic prosperity is shaping negatively the future of human beings and their habitats worldwide. Accordingly, the somewhat prevalent feeling of increasing welfare may well be deceptive and unsustainable. Therefore solving the problems of the sustainability of development is required in order to reduce the major environmental threat to the present and future of society.

Following this introduction, the paper is subdivided as follows: Section 1 centers attention on sustainability and sustainable development. Section 2 presents a composite formulation of a normalized index which measures, simultaneously, socioeconomic and environmental performance. Section 3 estimates socioeconomic and environmental trends for the USA and China at the beginning of this millennium (2002 to 2012). Section 4 presents some concluding thoughts, summarizes policies to promote sustainable development and highlights the main comparative conclusions about the two countries.

1. SUSTAINABLE DEVELOPMENT AND SUSTAINABILITY: AN OVERVIEW

The publication of "The Limits to Growth", a report from the Club of Rome, in 1972, raised fundamental questions about the environment and the future of our planet and society. The book stimulated a vigorous debate among scholars and politicians worldwide. Actually, as explained by Giarini (2013, p.79): "The world was inundated with articles – often written or inspired by economists. Loudly and clearly, they denounced the falsity and deception of the report, even attacking the very idea of a crisis or of a slowdown in growth". It also raised the concern of many people about the risk for the ecosystem of actions motivated by orthodox views about economic growth such as the apparently unlimited accumulation of physical capital. But the original number of economists supporting the report was relatively small.

As is well known, although frequently obscured, conventional economic analysis takes for granted two twin assumptions: a) free endowments of natural resources, and b) free disposal of wastes. Accordingly, the environment is envisaged to be, simultaneously, "a horn of plenty and a bottomless sink", as pointed out by Kurz & Salvadori (1997) in the introduction to their article. From the orthodox conditions of free competition and a standard static perspective, the environment is basically irrelevant. They argue: "production can be conceptualized as a process whose inputs are only labor and produced means of production. Thus, outputs are merely commodities". Under these oversimplified conditions, it follows that the environment does not matter and the prices of exhaustible resources are not taken into account. From this standpoint they criticize such approaches and conclude that, despite the progress made in their own dynamic analytical framework, "many more steps will have to follow before one arrives at a moderately satisfactory theory of exhaustible resources".

Indeed, we do not have a complete dynamic model on sustainable development. Such a paradigm is unquestionably desirable for a proper analysis of environmental performance in a world surrounded by uncertainties. Unfortunately, most of mainstream economics literature dealing with the dynamics of the environment tends to obscure some essential points. Although market failures and externalities are mentioned, they are considered mainly and merely as exceptions. In the same vein, along with questionable propositions connecting living standards to simple productivity, the common position on efficient allocation of resources remains founded on self-interest and Pareto optimality and is inadequate for treating the complexity of the real world.

Despite not immediately recognized, the publication of "The Limits to Growth", in 1971, did mark the starting-point of an era of criticism of the unquestioned faith in the conventional analyses executed in the economics of the environment. No doubt, an expanding network of persons, worried about the effects on both nature and humankind, started to work out some re-thinking. New thought and actions led to increasing doubt and uncertainty about the sustainability of the dominant ecological and socioeconomic organization of society. Jacobs & Slaus (2013) summarize the vigorous debate between the orthodox (or standard) vision and the search for the key elements of an alternative paradigm.

Naturally, a set of seed-ideas was required to highlight the reasons that may account for the fragility of the conventional theory of growth and accumulation of capital. To do so we need to clarify the meaning of "sustainable development" and "sustainability". It is of interest to note that a neoclassical economist, Solow (2012, p.543) pointed out: "The questions that come to be connected with sustainable development or sustainable growth or just sustainability are genuine and deeply felt and very complex". Those concepts have been defined in many ways, but the most quoted one is from the Brundtland Report (1987), published by the "World Commission on Environment and Development" (WCED), with the title "Our Common Future". It states that "Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (p.43). "Sustainability", on the other hand, is currently defined as the practice of maintaining the process of productivity indefinitely—natural or manmade—by replacing resources used with resources of equal or greater value without degrading or endangering natural systems.

In our understanding the above definitions contain two underlining views: a) the concept of ***need***, is actually concerned with essential needs of the world's poor for which overriding priorities should be given; b) the idea of ***limitation*** involves serious considerations on the state of technology and social organization on the environment's possibility in such a way that thought and actions should meet both the present and future needs. Surely, such double foundations require that the physical planet and society should be looked at as a system that connects space and time. These may well be considered important formulations, but they are methodologically problematic, as also emphasized by Solow in the same article, page 544: "If we try to look far ahead, as presumably we ought to if we are trying to obey the injunction to sustainability, we realize that the tastes, the preferences of future generations are something that we don't know about. Nor do we know anything very much about the technology that will be available to people 100 years from now".

Despite the current difficulties, including the economic crisis started in 2007/08, the movement towards better socioeconomic and environmental performance produced some positive effects worldwide. For instance, one of the main outcomes at the United Nations (Rio + 20) Conference held in Rio de Janeiro, Brazil, in June 2012, was the formulation of an agreement by members states to set targets for sustainable development – the future we desire. The objective sought to include the fundamental aspirations of both people and important institutions. Sustainability and the effort towards Global Footprint Network, it may be argued, is to a large degree a 'fait accompli'. However, we need to be cautious on this matter.

Nowadays, people worldwide are more aware of global climate changes. Alarm about the increasing planetary warming is in the daily press and such global concern does not constitute a novelty anymore. The Synthesis Report of the Intergovernmental Panel on Climate Change (IPCC), in November 2014, from Copenhagen, did spread some scary statistical data and projections on the matter. In the "Approved Summary for Policymakers" (p. 3) we can read: "Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history". On the same page, it also mentions that: "Each of the last three decades has been successively warmer at Earth's surface than any preceding decade since 1850". Furthermore, as indicated in page 7: "Cumulative emissions of CO_2 largely determine global mean surface warming by the late 21st century and beyond. Projections of greenhouse gas emissions vary over a whole range, depending on both socioeconomic development and climate policy".

In December 2014 a Conference on Climate, the COP-20, took place in Lima, Peru. It was not a success, but kept open the possibility of some agreement in the important meeting, the COP-21, which will occur at the end of 2015 in Paris, France. It hopes to establish a global accord on the subject – provided that nations will look beyond their navels and their own frontiers. No doubt, to address effectively the mitigation and adaptation of the present environmental condition, and to identify the path towards the desirable one, raises fundamental issues concerning equity, justice and fairness. As we know, many of the individuals, communities, regions and countries most vulnerable to climate warming have not contributed much to such emissions. They also face varying challenges and capabilities to finance the process of sustainable development. Success on such complex matters may require some compromise

and consensus-building paths to be taken by the movement's leaders. However, as pointed out by Vitello (2014), mentioning Martin Litton: "To compromise is to lose". Also: "Shall we fail to go into battle because it is hard to win?"

Most people point to the success of some affirmative actions towards sustainability. However, it may be argued that it is possible to attribute the declining resistance to sustainable development to guilt, indifference and the fear of being accused of old-fashioned or backward thinking. It is important to realize that there is a veiled rationality, sometimes disguised, that can't be ignored. A strange paradox: Sustainable development is desirable but perhaps too costly for the investment projects of most entrepreneurs. Furthermore, it has an invisible enemy: almost no-one is apparently against sustainability but the hardest task is to change deeply held attitudes not usually articulated.

A set of points which can lead to a consensus on sustainable development and sustainability continues to remain elusive. Some of them are indicated below:

i) The two concepts, above, transcend the conventional way of thinking and leads to the study of a broader field of theoretical and empirical disciplines requiring leadership in thought that leads to action.

ii) A broader approach stimulates evolutionary changes, leading to alter the nature of the dominant economic theory, of environmental aims and economic policy. This involves a new paradigm based on a proper theoretical framework and universal values. Such a paradigm must encompass a wide set of issues over different time and spatial scales.

iii) It also requires the accommodation of views and theories from diverse branches of knowledge and expertise; a way of thinking, no doubt, profoundly worried about the natural environment and the effects on human beings and other living species.

iv) The new paradigm must effectively integrate economics, with politics, management engineering, astronomy, law, sociology, culture, ecology, modeling building (mathematics and statistics), etc. This requires strong groups of analysts sharing visions both desirable to the vast majority of people, and ecologically sustainable in a global perspective.

v) This is not a task for isolated groups but rather for international research networks which can focus on effective contributions to shape new thinking so that the planet can escape the multiple crises affecting humanity and the physical world. We need to deal with the active necessity to understand and to reshape the reality.

vi) Reality resists attempts to create utopian worlds. We are in a difficult and stormy historical period. Actually, the planet may well be on the verge of collapse—if not an ecological hecatomb, at least a period of increasing environmental uncertainty, profound doubt about the present and the future.

vii) The key to unlocking this puzzle involving the present self- interest and the collective social action to preserve the future requires a broadly accepted set of fundamental notions and values on behavioral habits, customs, investments, environmental procedures, etc, which can try to contain the harmful current tendencies.

viii) It is necessary to be worried about the blind pursuit of self-interest by ordinary people, stock holders, financial system, businessmen, fictitious capital, governmental credit and expenditure, etc.

ix) To a large extent, incremental changes in political and socioeconomic policy towards sustainability and sustainable development will not be sufficient to address the pressing problems confronting nature and society both currently and prospectively. In times of crises, deep understanding and planned actions are important for avoiding the traps and pitfalls to which conventional and utopian ways of thinking lead.

x) We need to persuade governments and international institutions to assume that a proper climate strategy should be considered a priority. To attain this aim needs sustained social action with worldwide participation.

xi) The issue of causality far exceeds this scope of an indicator of welfare. Somewhat, economic models are parables, allegories and metaphors. A set of thoughts as propositions to capture the logic of the symbolic process. Naturally, the analyses must be checked against on empiric data.

xii) It is indispensable that sound structural models be established to handle the critical issues facing the formalization, calculation and evaluation of proposals for alternative paths and transitions to both socioeconomic and sustainable development.

The deep understanding of the circumstances, past and present, as well as potential paths towards a desirable future, is not a simple matter. History, statistics, philosophy and values are all required in effective quantitative formulations to guide the decision makers. We know that to generate such models is a difficult task. For instance, the uncertainty or vulnerability of the variables involved, the creative and robust definition of each indicator being used, and the analysis of possible multiple correlations among them can make the comparative analysis of alternative paths quite complex.

We intend here to outline a proposal for a new index which can evaluate socioeconomic welfare defined to include environmental performance. As pointed out by Marien (2011, p.139): “Green growth is not a replacement for sustainable development, but should be seen as a subset, in that it is narrower in scope”. Giarini, Jacobs & Slaus (2014) in the Fall electronic edition of Cadmus journal, state that: “Efforts to date confirm the conclusion that a new paradigm must necessarily be founded on a new theoretical framework based on universal values and a trans-disciplinary perspective of social evolution”. Nagan & Arena (2014) propose what they consider to be the necessary elements of a new paradigm and they seek to locate the new paradigm of political economy in terms of its global reach. We add that, to aspire to and accomplish such an aim we need to avoid wishful thinking and utopian views. Formal models with strong analytical features are required. The resulting empirical analyses, based on both the historical record and projections, may result in propositions for research on the transitions and dynamics of sustainable development. Our composite socioeconomic and environmental Index of Welfare is presented in the next section.

2. A FORMULATION OF A COMPOSITE INDEX FOR WELFARE AND SUSTAINABILITY

We need a robust Index of Welfare which can measure both socioeconomic development and its sustainability. Such a metric should be designed to take into account the health of people of a region, nation or the world, of other species as well as the impact on the natural environment. We consider that, alone, the Gross Domestic Product (GDP) or the GDP per capita over time do not capture these features. Actually, Kuznets (1934), the inventor of the concept of GDP, indicated in his first report to the USA Department of Commerce, Senate document, that he disapproved the use of the GDP as a general indicator of welfare. He noted that "the welfare of a nation can scarcely be inferred from a measure of national income" (p. 7). Hicks (1946) also pointed out the practical difficulty of using the GDP per capita as an objective indicator of a nation's welfare.

However, supporters of the GDP as the fundamental welfare index claim that, in general, there is a sustained correlation between the GDP and other socioeconomic variables. Furthermore, several of them argue that alternative indicators are more vulnerable to political manipulation. Some econometricians also suggest, quite often, that other indexes tend to combine 'items' that are, really, commensurable or contain superposed sub-sets of variables. Accordingly, this may apply to the well-known Human Development Index (HDI) which is a summary measure of average achievement in three key dimensions: health, education and the gross national income per capita. We must pay attention to these criticisms, but point out that such composite indicators have been used worldwide.

There are an increasing number of scholars and institutions working hard on the search for how to go beyond the HDI. This is the case of initiatives by the European Union, Club of Rome, World Academy of Art and Science, OECD, etc. Surely, the relevant indexes of welfare must take into account a wider context and changes in related spheres of human knowledge. To make the required progress in this direction involves all of visions, values and methods. New theoretical formulations and empirical data are an absolute priority to capture the dynamics, complexities and sustainability of socioeconomic development. From our perspective, it makes sense to try to answer a fundamental question with regard to the sustainability of the levels of keep expanding without undermining its ability to sustain the same levels in the future? This question has been largely ignored or obscured by most orthodox economists.

Fullerton & Stavins (2012, abstract, p.3) argue that: "Economists themselves may have contributed to some misunderstandings about how they think about the environment, perhaps through enthusiasm for market solutions, perhaps by neglecting to make explicit all the necessary qualifications, and perhaps simply by the use of jargon". We state specifically that the expansion of global output is not a reliable measure of development. This indicator may encourage a search for unbounded higher productivity and consumption. It may tend to overvalue unviable expectations of sustained higher levels over time. It obscures both current and potential ecological problems. It may stimulate somewhat the expansion of the economy but frequently by degrading the environment and even the welfare of both humans as well as other species.

There is an extensive set of models dealing with the relationship between socioeconomic variables and measures of their environmental effects. Most such models are goal-oriented as

their authors take their ultimate purpose to be the search for practical ways of improving human welfare. As expected we are unable to build models which can include most of the immense number of indicators or variables that shape the interaction between human behavior, institutions and the environment. From a methodological stand point, we need to set up reasonable abstractions and simplifications of the reality. Conceptually, we need to express in simplified forms a number of different alternative representations of a complex whole. In this sense, although one should search for a more encompassing perspective, no doubt, any specific model represents a particular viewpoint. Therefore, the relevant conclusions will be the result of an emphasis on the set of particular factors being considered. Nevertheless, a formal approach is crucial and can be viewed as no more than providing some building blocks for a representation of the complex nexus of reality.

We will propose here a composite indicator of welfare which takes into account social, human and environmental criteria. We believe that our composite indicator provides insights into comparative development levels, which the current indicators, alone, cannot. It is not surprising that we have witnessed numerous attempts to construct composite indices intended either to replace or to complement both GNP per capita and HDI. Some critics argue that while generally held to be politically useful, such new indices have proved to be somewhat redundant in the sense that their values have been shown to exhibit a positive and statistically significant correlation with GDP per capita. It follows that these indices may have failed to encompass what GDP per capita cannot capture. Despite all these challenges, we believe our proposed index will be useful and we hope policy makers will look favorably on our analytical methods.

As we mentioned in the introduction, a stimulating starting point to deal with the formulation of a model encompassing the interrelationship involved in the sustainability of development is a seminal article by Kaldor (1971), in which he considers the macroeconomics of the conflicts across national policy objectives. However, he does not deal with the environment. An extended enquiry led to the introduction by Karl Schiller, in the early 1970's, of a graphical representation of Kaldor's original view. A glance at the resulting diagram reveals a diagnosis of comparative performance. This analytical instrument was called a "Magic Square" (MS) and soon after some economists from OECD began to use this geometric apparatus to evaluate economic policies. The "wonderland", which was introduced by OECD, is an ideal configuration which takes into account desirable features of a system composed of a set of variables represented by the larger area of a quadrangle. It involves the calculation of norms or values postulated as idealized references for a given accounting period. To start the procedure we need reliable information on the numerical values of the variables, and then to find the limits (bounding conditions), designated as "awful" and "desirable" for each.

A "naïve" macroeconomic representation of the MS was formulated by Bernard et alli (1988). Medrano-B & Teixeira (2013) modified this approach. The original figure is conceived in its four directions (N, S, E and W) indicated by Υ, τ, φ and ζ. All four variables (axes) are originally drawn at different scales expressed in percentages and the adjacent indexes are joined by straight lines. The original area of such figure cannot be calculated due to the non-uniform scales of the axes. To construct the new MS all four scales are arbitrarily defined to be uniform from 0 to b, where b is a numerical constant to be evaluated by normalizing the figure to a unit area. A new MS, with a larger area is drawn not as a square but a diamond-shaped figure. The

Greek symbols indicating the superior (sup) and the inferior (inf) bounding conditions, given by expressions (1). Note that the first inequality has a different sense as we explain in section3. The respective differences, expressed by (2), lead to the illustration (Figure 1):

$$\Upsilon_{inf} \geq \Upsilon \geq \Upsilon_{sup};\ \tau_{inf} \leq \tau \leq \tau_{sup};\ \varphi_{inf} \leq \varphi \leq \varphi_{sup};\ \zeta_{inf} \leq \zeta \leq \zeta_{sup}. \qquad (1)$$

$$\Upsilon_{sup} - \Upsilon_{inf} = \Gamma;\ \tau_{sup} - \tau_{inf} = T;\ \varphi_{sup} - \varphi_{inf} = \Phi;\ \zeta_{sup} - \zeta_{inf} = Z. \qquad (2)$$

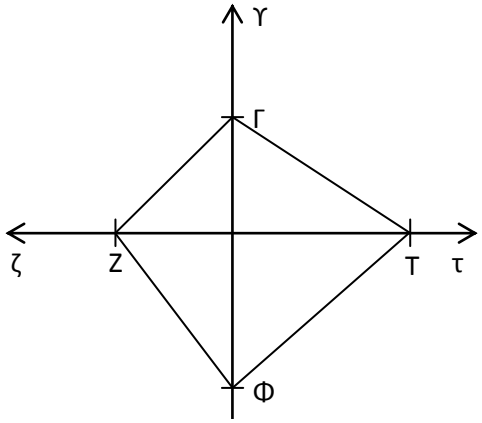


Figure 1

In the new MS, all four scales are arbitrarily defined to be uniform from zero to b, where b is a numerical constant to be evaluated by normalizing to a unit area the modified MS. Therefore, the four new corresponding indexes, indicated by prime are given by expressions (3):

$$0 \leq \Upsilon' \leq b \quad ; \quad 0 \leq \tau' \leq b \quad ; \quad 0 \leq \varphi' \leq b \quad ; \quad 0 \leq \zeta' \leq b \qquad (3)$$

By the above transformation we will create a perfect square with uniform axes. The next step is to find the transformation required from the un-primed to the primed variables. Since all original variables have linear scales, the primed is represented by a square. The algebraic transformation constitutes an orthogonal representation corresponding to the equation for a straight-line joining two points. Such straight-line is Ax + By + c = 0. Let the two points be $M_1=(x_1, y_1)$ and $M_2= (x_2, y_2)$. The relevant function is $y_2-y_1= b\ (x_2- x_1)$, where $b= (y_2 –y_1)/(x_2-x_1)$ is the angle of the function. It follows that: $(y – y_1) = \{(y_2 –y_1)/(x_2 – x_1)\}\ (x – x_1)$. The identical sides of a square are obtained by expressions (4):

$$\Upsilon' = b\ (\Upsilon - \Upsilon_{inf})/(\Upsilon_{sup} - \Upsilon_{inf}) = (b/\Gamma)\ (\Upsilon - \Upsilon_{inf}) \quad ; \quad \tau' = b\ (\tau - \tau_{inf})/(\tau_{sup} - \tau_{inf}) = (b/T)\ (\tau - \tau_{inf})$$

$$\varphi' = b\ (\varphi - \varphi_{inf})/(\varphi_{sup} - \varphi_{inf}) = (b/\Phi)\ (\varphi - \varphi_{inf}) \quad ; \quad \zeta' = b\ (\zeta - \zeta_{inf})/(\zeta_{sup} - \zeta_{inf}) = (b/Z)\ (\zeta - \zeta_{inf}) \qquad (4)$$

Now we illustrate in Figure 2 the diagram which visualizes the area of the square, rotated in 45 degrees:

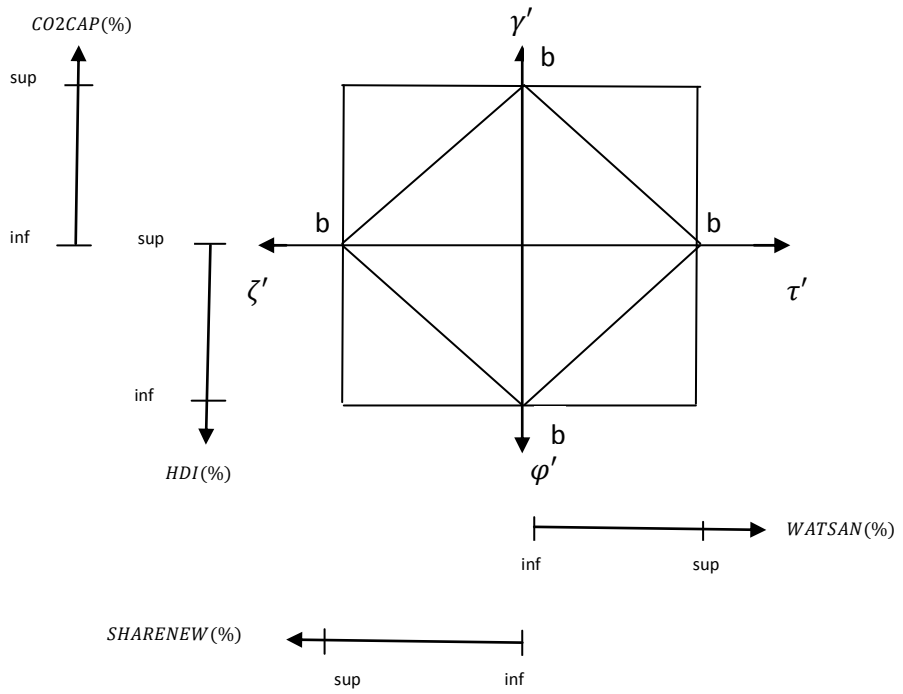


Figure 2

Certainly the area (A) of the square is the aggregation of the four triangles. Therefore, b is equal to the "square root of 2 divided by 2". And A' is the index of welfare representing the size area we have been looking forward. Notice that it is constituted by the addition of the four right-angled triangles in figure 2. A' is given by equation (5):

$$A' = \tfrac{1}{2} (\Upsilon'\tau' + \tau'\varphi' + \zeta' \varphi' + \zeta' \Upsilon') \qquad (5)$$

To calculate the real valued Index of Welfare (A') it is convenient to formulate (5) as an algebraic operation given by expression (6):

$$A' = \tfrac{1}{4} \{[(\Upsilon - \Upsilon_{inf})/\Gamma] [(\tau - \tau_{inf})/T] + [(\tau - \tau_{inf})/T] [(\varphi - \varphi_{inf})/\Phi] + [(\zeta - \zeta_{inf})/Z] [(\varphi - \varphi_{inf})/\Phi]$$

$$+ [(\zeta - \zeta_{inf})/Z] [(\Upsilon - \Upsilon_{inf})/\Gamma]\} \qquad (6)$$

In the next section we will consider the meaning of the four variables involved in the performance of the USA and China. We also include the relevant statistical data to be used as well as the construction and the result of the Index of Welfare, A', with closed boundaries set at zero and one.

3. THE USA AND CHINESE SOCIOECONOMIC AND ENVIRONMENTAL PERFORMANCE

According to the Climate Analytics (2014), the USA and China are responsible for between 35% and 45% of the current world emissions of CO_2. However, neither of these two countries is in the frontier of techniques to improve their respective patterns of energy efficiency. Of course,

their joint effort would help considerably to prevent threatening climate change, if they decide to limit the current use of conventional energy and apply an enhanced effort towards a policy of sustainable development. In both countries there is evidence of concern for finding sustainable ways to produce and consume energy. Despite this concern, however, the results have been insufficient to make a major impact on the continuing undesirable transformations of the environment.

In the last decades, China has taken a big jump in its rate of economic growth. Nowadays, its GNP is about half of the USA while the average consumption per capita of electricity of the latter is four times of the former. In the last 10 years, the annual growth rate of the GNP for China is 10.5% compared to 1.6% for the USA. Most of it is produced in these economies by burning fossil fuel. In neither is there an important economic sector leading the world in the effort in the substitution of these fuels for those which can mitigate the effects on climate change. The energy consumption of the industrial sector in China is increasing significantly and recently the national government took some steps in the direction of the use of sustainable energy, but neither China nor the USA is already adopting the more environmentally friendly standards of the European Union on this matter.

This being the case, we agree with Johnson (2011, p. 19) that: "Our world is headed into a ***perfect storm*** of an interconnected financial, ecological and social crisis. Almost all forward-looking assessments demonstrate that business as usual and incremental improvements will not be sufficient to take us to a future world blessed by equitable prosperity, safety and contentment". On the other hand, if the USA and China were to set a good example and start an immediate program of sustainable development, we should become less pessimistic about the future of the planet we share.[1]

The October issue of "Climate Analytics" (2014) indicates that, if China and the USA were to adopt, together, the most ambitious policies of efficiency used by the European Union, it would be possible by 2030 to reduce the emissions of CO_2 to 10% below the current policy projection of "Climate Action Tracker". This may well be a reasonable justification for why we decided to compare here the socioeconomic and environmental performance of these two countries, taking as a theoretical indicator the general Index of Welfare presented in the previous section.

The results of the present enquiry are somewhat preliminary. It can be considered more an illustration. We should also mention that our approach does not take into consideration that the relationship between environmental sustainability and sustainable development is to a large extent a function of long term trajectories, and that our time series of statistical data are not long enough. We contend that such long series are not available. To some extent however, it may be justified to try to draw conclusions from the data available even though they are not a totally satisfactory sample.

1 Notice that, the USA and China, after a long period of almost secret negotiations, announced, this November, 2014, in Beijing, an unprecedented compromise towards the reduction of pollutant gases in an effort to conclude a global agreement on climate change in 2015. However, there is a strong domestic tendency in both countries to postpone such objectives. Anyway, better to be pessimistic on this matter, since the result of the agreement will possibly be valid only after 2030 in China and 2025 in the USA.

As an application of the complete set of variables we will consider once again the cases of the USA and China. We will use four variables that combine the socioeconomic performance of each country with their indexes of environmental sustainability. To help the exposition in this exercise, the variables and their definitions are shown in table 1:

Table 1: Environmental Variables and Definitions

Environmental Variables				
Name	**Definition**	**Description**	**Source**	**Data Link**
CO2CAP (Υ)	Per capita dioxide emissions from the consumption of energy	Metric tons of carbon dioxide	The World Bank Group	http://data.worldbank.org/indicator/EN.ATM.CO2E.PC
WATSAN (τ)	Access to drinking water and sanitation	Percentage of population with access to improved drinking water and sanitation	Yale Center for Environmental Law and Policy (YCELP) and Center for International Earth Science Information Network (CIESIN), Columbia University	http://epi.yale.edu
HDI (φ)	Human development index	The index combines three major indicators: health, education and living standard.	United Nations Development Program (UNDP)	http://undp.org
SHARENEW (ζ)	Share of renewables in total consumption of energy	Electricity from renewable (hydro, wind, geothermal and solar) plus biomass consumption all divided by the total energy consumption.	Global statistical energy yearbook 2014	https://yearbook.enerdata.net/

Source: Own elaboration from a number of reports.

In order to calculate the index of Welfare, we use the period 2002 to 2012. It is worth mentioning that the limits (bounding conditions) we use are based to a large extent on the maximum and minimum values of the four variables **CO2CAP (Υ)**, **WATSAN (τ)**, **HDI (φ)** and **SHARENEW (ζ)**. They are expressed in percentage changes on the four axes, as indicated in table 2.

The meaning of the **CO2CAP** has been already explained above. Here, we consider CO_2 only, as a proxy for greenhouse gases (effects) which penetrate the atmosphere, absorbing and emitting radiation. Anthropogenic CO_2 emissions come from combustion of carbon-based fuels (primarily wood, coal, oil and natural gas). Since the beginning of the industrial revolution, the burning of fossil fuels and extensive devastation of native forests has contributed to a 40% increase in the atmospheric concentration of CO_2**.** The temperature in the planet went up 0.8° Celsius since 1880, on average. Furthermore, there is an acceleration of global warming since World War II. This process, if not contained, will drive the planet to a catastrophe.

Concerning **WATSAN (τ)**, its welfare implications are quite obvious. To gain access to improved drinking water and sanitation is a vital step towards improving health and well-being. Despite the progress worldwide, the planet remains off track concerning both targets, for safe water and for sanitation. The economic gains from provision of improved services of drinking water and sanitation must comply with international standards. The adoption of the Millennium Development Goals demonstrated the inadequacies of provision of these services which were carefully examined in this document. They are important with respect to their ecological, economic and social functions, and also provide important benefits to the ecosystem.

There is no need to emphasize here the importance of the Human Development Index (HDI). However we should take into consideration that in the 2010 Report a further inequality-

adjusted Human Development Index (IHDI) was introduced. Income distribution and concentration are important indicators of the real wealth of nations. The well documented book by Thomas Piketty (2014) shows that inequality is currently rising in developed countries. He also comments extensively on its harmful effects. In the present article the simple HDI remains useful, even though we still do not have a long enough statistical series for it, for an examination of the relevant impact of socioeconomic policies for changing the income distribution on the pathways to human development. For reference, see the United Nations Development Programme's Human Development Report, released in July 2014.

We explain now the **SHARENEW** indicator. Energy is a vital element in human life and to secure a sufficient and accessible supply is crucial for sustainability in contemporary societies. The demand for energy is increasing rapidly and the trend is likely to continue. Renewable energy requires appropriate policies and new technologies. It consists of solar, wind, geothermal, modern biomass and hydroelectric. Fossil fuels in their crude form, such as, wood, coal and oil have traditionally been extensively used as energy resources. Society has been acknowledging that, although they dominate the market, they present high levels of pollutants, and that a significant effort must be made to reduce their presence in the structure of the planet's economies. This is the reason why we introduce the variable, demand for renewable energy divided by the total expenditures on energy.

After the four indicators are described above, it is time to deal with the algebraic- geometry of our mathematical model. Naturally, the usefulness of the ideal bounding (wonderland) configuration requires the establishment of suitable numerical values for the four variables. Then, we need to establish the two limits, "awful" and "desirable", for each. The first is located in the center of the Figure 2 and the other in the extreme vertex of the square. Here we introduce statistical data for China and the US. We estimate the average values for the years 2002/2003 and 2011/2012 in order to compare the changes in the two countries which occurred over the interval of ten years. Such averages of the two years, for the initial and terminal periods, tend to reduce the weight of any peculiarities of an atypical year. The results are shown in Table 2.

Table 2: Environmental Variables - Calculated Data

Environmental Variables (% change)				
	China		**USA**	
	2002-2003	**2011-2012**	**2002-2003**	**2011-2012**
CO2CAP (ϒ)	11,56	8,90	0,07	-6,93
WATSAN (τ)	6,19	0,00	0,15	0,00
HDI (φ)	1,34	4,08	0,53	0,22
SHARENEW (ζ)	-12,21	1,58	6,20	1,05

Source: Our own elaboration from information of table 1

Table 3 shows the calculated superior (sup) and inferior (inf) limits given by expressions (1) and (2) as well as the Desirableland[2] configuration. The latter includes environmental economics and this is a rapidly evolving discipline. The perceptions and dimensions of global climate change may, in the long run, prove to be the most significant task in terms of both its potential damages and its cost. We will restrict the discussion to what we view as being the most salient points. Unfortunately, the empirical evidence to date has not provided overwhelming support for any configuration of the Wonderland parameters. However, from historical circumstances, we are able to represent a kind of normative limits, the bounding conditions as explained previously.

To proceed, consider first CO2CAP. We want to encounter the extreme points (awful and desirable) of the interval corresponding to that variable. In order to determine the lower limit (awful), we just take the average between the observed lower limits on both countries. Notice that, this average is taken under the assumption that the worst performance between the two countries gets weight equal to 1/3 and the best one equal to 2/3. We determine the upper limit (desirable) in a similar fashion, but we inverse the weights. In other words, we consider 2/3 for the best and 1/3 for the other. Observe that these weights were obtained through the method of "convergence of opinions in group" - graph algorithm[3]. Such weights indicate that the former has a superior performance and the latter the inferior one. We consider the upper limit (desirable) in a similar fashion. We proceed likewise for the remaining three variables.

Table 3: Bounding Conditions and Desirableland

Bounding Conditions		
China	**USA**	**Desirableland**
$11,56 \geq \Upsilon \geq 8,90$	$0,07 \geq \Upsilon \geq -6,93$	$7,72 \geq \Upsilon \geq -2,02$
$0,00 \leq \tau \leq 6,19$	$0,00 \leq \tau \leq 0,15$	$0,00 \leq \tau \leq 4,17$
$1,34 \leq \varphi \leq 4,08$	$0,22 \leq \varphi \leq 0,53$	$0,96 \leq \varphi \leq 2,90$
$-12,21 \leq \zeta \leq 1,58$	$1,05 \leq \zeta \leq 6,20$	$-7,79 \leq \zeta \leq 4,65$

Source: Our own elaboration from information of table 2.

Thus, according to expression (2):

$$\Upsilon_{sup} - \Upsilon_{inf} = -9,74 \qquad \tau_{sup} - \tau_{inf} = 4,17 \qquad \varphi_{sup} - \varphi_{inf} = 1,94 \qquad \zeta_{sup} - \zeta_{inf} = 12,44 \qquad (7)$$

2 Notice that in the configuration of the empirical data, we changed the expression Wonderland to Desirableland, due to the fact that the first is an ideal vision and the second is only concerned with the potential performance in a given the historical circumstances.

3 This technique is related to the Delphi approach, mainly developed by Dalkey & Helmer (1963), for achieving convergence of opinions concerning real-world knowledge solicited from experts. This led to a mathematical structure- the graph theory.

Since the numerical value of b was already defined (square root of 2 divided by 2), we will substitute such value in expression (4). This leads us to the transformations required to obtain the corresponding numerical values of the four original variables given by the Greek symbols. That is, the primed ones given by the set of expressions (7). As an example, we will take the transformations of ϒ and then φ.

CO2CAP ϒ:

$$\Upsilon' = \frac{b\,(\Upsilon - \Upsilon\,\mathrm{inf})}{\Gamma}$$

$$\Upsilon' = \frac{\sqrt{\frac{1}{2}}\,(\Upsilon - 7{,}72)}{-9{,}74} = \frac{\sqrt{\frac{1}{2}}\,(7{,}72 - \Upsilon)}{9{,}74} \qquad (8)$$

HDI φ:

$$\varphi' = \frac{b\,(\phi - \phi\,\mathrm{inf}))}{\Phi}$$

$$\varphi' = \frac{\sqrt{\frac{1}{2}}\,(\phi - 0{,}96)}{1{,}94} \qquad (9)$$

In the same way, we can find the scale transformations of the other two variables:

$$\tau' = \frac{\sqrt{\frac{1}{2}}\,\tau}{4{,}17} \qquad (10)$$

$$\zeta' = \frac{\sqrt{\frac{1}{2}}\,(\zeta + 7{,}79)}{12{,}44} \qquad (11)$$

Substituting the values of Table 3 in the equations (8) to (11), we obtain the following results:

Table 4: Impact of environmental variables in the index over ten years

Country	**Δ ϒ'**	**Δ τ'**	**Δ φ'**	**Δ ζ'**
China	0,019	0,104	0,100	0,078
USA	0,051	0,005	0,012	0,029

The area of the square (Desirableland), corresponding to the figure 2 is equal to 1. Now, we calculate the representative areas for the USA and China, given by expression (6).

Table 5: Magic Square's areas

Index of Economic Welfare and Sustainability(% change)		
Country	**2002-2003**	**2011-2012**
China	1,00	83,47
USA	7,00	37,75

Considering the growth rate of the index in ten years, we obtain:

CHINA:

$\frac{\Delta A'}{\Delta t} = \frac{83,47-1,00}{10}$ = 8, 24%/year

USA:

$\frac{\Delta A'}{\Delta t} = \frac{37,75-7,00}{10}$ = 3, 07%/year

Now, in Figure 3 and 4, we can visualize the results obtained through Kaldor's Magic Square.

Figure 3: China's Magic Square

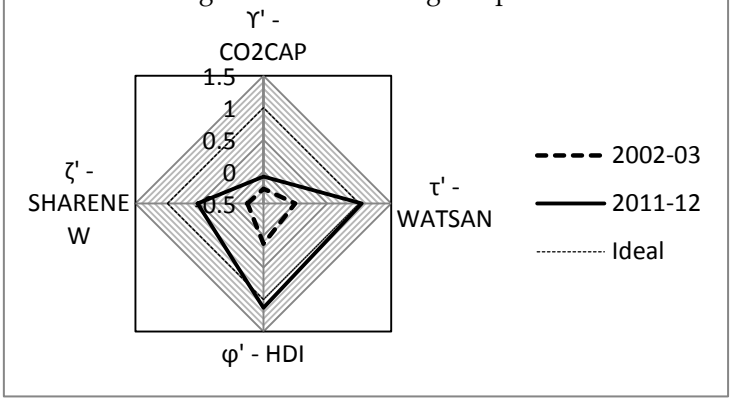
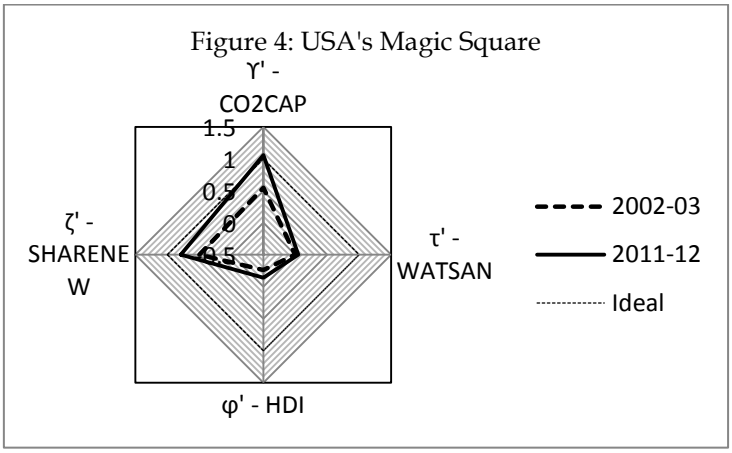


Figure 4: USA's Magic Square



In the table 4, we note that China obtained results more impressive than the USA in the majority of the variables. Analyzing HDI and WATSAN, the Asian country performed very well (Δ **φ'**=0,100; $\Delta\tau$'=0,104), which is a considerable leap forward in the social area. In compliance with United Nations Development Program (UNDP), this social improvement occurred due to the significant economic growth that achieved, especially, the income per capita. Moreover, it appears that governmental support and political willingness became the main driving force to improve the water and sanitation services.

The USA also had a good performance in these indicators (Δ **φ'**= 0,012; $\Delta\tau'$= 0,005). Since 2002, the USA showed improvements in all areas including in the HDI. Furthermore, it has one of the

best systems of basic sanitation in the planet. According to the World Bank, almost all citizens have access to treated drinking water and piped sewage.

In relation to SHARENEW, China ($\Delta\zeta'$= 0,078) and the USA ($\Delta\zeta'$= 0,029) made only timid progress in ten years. The Chinese environmental commitment is based on geopolitical and other factors. The country became a major consumer of petroleum. Consequently, the dependency on imported fossil fuels had increased, which is always a risk in the context of an emergent country. Moreover, the consumption of oil and, especially, coal had been creating negative consequences domestically. The number of cases of respiratory diseases in China's big cities grows exponentially because of the air pollution caused by the burning of coal. To solve these problems, the government is investing substantially in renewable sources of energy. This reality is captured in China's result for CO2CAP ($\Delta\Upsilon'$= 0,019). On the other hand, the USA reduced their $C0_2$ emissions significantly in the last ten years, which can be observed in the CO2CAP result ($\Delta\Upsilon'$= 0,051). According to the U.S. Energy Information Administration (EIA), the country recently started the transition to a low-carbon economy. One example of the new measures put into place by the government was the switch from coal to natural gas in energy production.

4. CONCLUDING THOUGHTS

In this paper we proposed and made use of a composite indicator of wellbeing and sustainability which took into account social, human and environmental welfare criteria. Our composite indicator provides insights into the development patterns of any given region. Such comparisons are welcome as attempts to quantify these patterns which can allow us to rethink the notions of growth, distribution and sustainability in the different regions of our planet. Here we concentrated our effort in the comparison between only the USA and China. We took as reference the period 2002-2012 and as indicators of socioeconomic and environmental performance, four composite key variables: Human Development Index (HDI), Per Capita Carbon Dioxide (CO2CAP), Drinkable Water and Sanitation (WATSAN), and Renewable Energy as a share of total energy use (SHARENEW).

We concluded that although the level of welfare and degree of sustainability is much higher in the USA in comparison with the level of the index in China, the comparative welfare performance of the latter, in the period studied, is much higher than in the USA. It means that China was exerting a stronger effort than the USA in this direction. It happens that we are not sure that such effort is sustainable.

It is reasonable to be anticipatory and prescient about the future. The motive for this remark is due to our worry that the present economic paradigm, with its conventional path, may lead to major ecological, social and economic challenges in the near future. We need a new economic paradigm involving new visions, and solutions which have to be implemented. It is necessary to understand that the fundamental problems all living species face are very severe. It is not just an economic question of increasing efficiency (productivity) in order to guarantee growth, distribution and accumulation of capital. Rethinking economics is not simply about reevaluating the historical experience from the Industrial Revolution onwards, for both its

theories and the philosophical framework it uses. Rethinking is also about rediscovering the much larger dimension of the socioeconomic process and its sustainability. As pointed out by Joan Robinson (1977, p. 1337): “These questions involve the whole political and social system of the capitalist world; they cannot be decided by economic theory, but it would be decent, at least, if economists admitted that they do not have an answer to them”.

Naturally, the transition towards a new paradigm involves an international movement which integrates the natural and social sciences in order to address the prerequisites for sustainable development. This movement requires synergy and action through interconnections across research centers at an international level. This deep cooperation is necessary to improve the data and quality of the research on topics such as low carbon transitions, global warming, environment, ecosystem services and their accompanying socioeconomic policies.

The basic problem is: in any complex chain of events, there is a fundamental asymmetry between the present (status quo) and the future. During the transition, each element of the chain may break down when it encounters an almost infinite set of uncertainties. When this happens, the narrative may become unpleasant and the prospective path to be followed doubtful. This may allow people and their governments to conclude, erroneously, that it is better to keep to the current ways. This may be ingenuous and possibly, even a foolish perception. Actually, creating this shared vision, a new paradigm of a sustainable and desirable material future is perhaps the most critical task facing humanity nowadays.

The previous paragraph may give some readers the false impression that nothing really important can be attained by a single individual dealing with the difficult problems posed by the theme of our paper. It seems the case that a number of economists and scholars had adopted this view and had sunk into complacency and ceased being concerned about sustainability. It is true that group research presents great advantages. However, it may be useful to recall the first paragraph of Hahn (1989. P. 13): “… those individuals who are endowed with a special genius for the subject and have a powerful economic intuition will often be more right in their conclusions and implicit presumptions than in their explanation and explicit statements. That is to say, their intuitions will be in advance of their analysis and their terminology. Great respect, therefore, is due to their general scheme of thought, and it is a poor thing to pester their memories with criticism which is really verbal”. [J.M. Keynes (1924) quoted by Hahn in Kaldor (1972. p.1249,n. 1)].

Environmentalism is a social and political tendency that is concerned about the conservation, improvement and sustainability of the ecosystem. This movement has now become worldwide and it is no wonder that scholars, national and international institutions are catching the “green fever”, and especially the issue of how to circumvent the global warming trap. The impulses for “going green” are now multiplying faster than was expected a few years ago. However, without a solid socioeconomic foundation, the green movement will still scare people and governments. We need a new paradigm of sustainable development, but to improve the possibility to attain success in the implementation of new visions and polices, we must be capable of measuring, analyzing and hedging the relevant variables which can help to improve the commitment of the relevant institutions. Otherwise, a number of risks will be faced by society when new programs of sustainability are implemented.

REFERENCES

Bernard, Michel; Drouet, Michel; Echaudemaison, Claude & Pinet, Nicole. (1988). “Economie et Societé Fraçaise”. Editions Nathan. Paris, France.

Bergmann, Ariel & Hanley, Nick & Wright Robert. (2006). “Valuing the Attributes of Renewable Energy Investments”. Energy Policy, 34.

Brundtland, Gro. (1987). “Report published by the “World Commission on Environment and Development” (WCED). The Organization Center for “Our Common Future”. United Nations. Washington, USA.

Dalkey, Norman & Helmer, Olaf (1963). “Na Experimental Application of the Delphi Method to the Use of Experts”. Management Science, Vol. 9, Issue 3, pp. 458-467.

Firme, Vinícius & Teixeira, Joanilio. (2014). “ Index of Macroeconomic Performance for a Subset of Countries: A Kaldorian Analysis from the Magic Square Approach Focusing on Brazilian Economy in the Period 1997 – 2012. Panoeconomicus, Vol. 5, Special Issue.

Fullerton, Don & Stavins, Robert. (2012). “How Economists See the Environment”. Chapter 1 in “Economics of the Environment”. Selected Readings. Edited by R. Stavins. 6th Edition. W. W. Norton & Company, Inc. New York, USA.

Gasparatos, Alexandros & El - Haram, Mohamed & Choi, Hyung-Jin. (2011). “International Conference on Whole Life Urban Sustainability and its Assessment”. Edited by M. Horner & C. Hardcastle & A. Price and J. Bebbington . Glasgow, Scotland.

Giarini, Orio. (2013). “The Club of Rome and the Limits to Growth”. Chapter 5 in the book published by O. Giarini. “Itinerary to the Third Age”. The Risk Institute. Special Edition. European Papers on the New Welfare. Nº 18. Trieste, Italy.

Giarini, Orio & Jacobs, Garry and Slaus, Ivo. (2014). “Presentation of the Complete Fall Electronic Edition”. Cadmus Journal. Vol.2. Issue3. November .

Hahn, Frank. (1989). “Kaldor on Growth”. Cambridge Journal of Economics, Vol. 13, pp. 47-57.

Hicks, John. (1946). “ Value and Capital”. Second Edition. Claredon Press. London, UK.

Human Development Report 2014. (2014). “Sustaining Human Progress: Reducing Vulnerabilities and Building Resilience”. China- HDI values and rank changes in the 2014 Human Development Report. United Nations.

IPCC, Fifth Assessment Synthesis Report. (2014). “Climate Change 2014”. Approved Summary for Policymakers. United Nations. Washington-DC, USA.

Jacobs, Garry & Slaus, Ivo. (2013). “From Limits to Growth to Limitless Growth”. In the Introduction to “Itinerary to the Third Age”. Published by O. Giarini. The Risk Institute. Special Edition. European Papers on the New Welfare. Nº 18. Trieste, Italy.

Johnson, Ian. (2011). “The Perfect Storm: Economics, Finance and Socio-Ecology”. A Commentary. Cadmus. Vol. I. Nº 2. April.

Kaldor, Nicholas. (1971). “Conflicts in National Economic Objectives”. The Economic Journal. Vol. 81 (321).

Kaldor, Nicholas. (1972). “The Irrelevance of Equilibrium Economics”. Economic Journal, Nº328, pp. 1237-1255.

Klugman, Jeni & Rodrigues, Francisco and Choi, Hyung-Jin. (2011). “The HDI 2011: New Controversies, Old Critiques”. Human Development Research Paper 2011/01. United Nations Development Programmes, Human Development Reports. April. Washington-DC, USA.

Kurz, Heinz & Salvadori, Neri. (1997). “Exaustible Resources in a Dynamic Input-Output Model with Classical Features”. Economic Systems Research. Vol. 9.

Kusnets, Simon. (1934). “National Income, 1929 – 1932”. 73rd US Congress. 2nd session. Senate Document N° 124, page 7. <http//library.bea.gov?/ SDD, 888>. Washington-DC, USA.

Marien, Michael. (2011). “Towards Green Growth”. Review of OECD book with the same title . Cadmus. Vol. 1. Issue 3. October.

Medrano-B, René & Teixeira, Joanilio. (2013). “A Kaldorian Macroeconomic Index of Economic Welfare”. Revista de História Econômica & Economia Regional. Vol. 8. N° 14. Jan-Jun.

Nagan, Winston & Arena, Valeen. (2014). “Towards a Global Comprehensive Context-driven and Decision-focused Theory and Method for a New Political Economy”. Cadmus. Vol. 2. Issue 2. May.

Nordhaus, William. (2007). “Critical Assumptions in the Stern Review on Climate Change”. Science 317. N°5835, pp. 2001-2002.

Piketty, Thomas. (2014). “Capital in the Twenty-First Century”. Belknap Press. Cambridge, MA.

Robinson, Joan. (1977). “What are the Questions?”. Journal of Economic Literature. Vol. 15, N°4, pp. 1318-1339.

Solow, Robert. (2012). “Sustainability: An Economist’s Perspective”. In “Economics of the Environment”. Edited by R. Stavins. Selected Readings. Sixty Edition. W. Norton & Company. New York, USA.

Stern, Nicholas. (2007). “The Economics of the Climate Change: The Stern Review”. Cambridge University Press. Cambridge, UK.

U.S. Energy Information Administration. “Monthly Energy Review”. (September 2014)

Vitello, Paul. (2014). “Martin Litton, 97, fighter for the U.S environment, is dead”. International New York Times, p. 2. December 8.