GREEN ECONOMY INDEX: WHAT REALLY MATTERS?

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ABSTRACT

In the recent decades, the global increase in resource consumption, waste production, and environmental pollution has become a core aspect of the sustainable development framework. Humanity is living in the era of global warming and faces the consequent imbalance of the climate, ecosystem and biodiversity. Significant efforts have been made in the last half century to establish proper measures to account for welfare and sustainability. This issue deserves further scrutiny, since sound policies must be based on facts, not surmises. After all, we are dealing with conflicts of socioeconomic and environmental objectives. The aim of this article is to provide a new index of sustainability, called Green Economy Index, the Magic Triangle, which is associated to Kaldorian ideas. This indicator is capable of assisting in the decision-making process towards sustainable development. For this purpose, three variables were used: GDP *per capita*, supply of renewable energy and CO2 emissions, a choice based on the three pillars of the green economy. Such index is applied here to measure the performance of Brazil. Our approach demonstrates the weak strength of the Brazilian success in the period.

**Keywords:**sustainable development, indicators of sustainability, Green Economy Index, Magic Triangle.

JEL CLASSIFICATION: E6, E01, E3, F1

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**Introduction**

The search for a balance between economic development and protection of natural resources reinforces the paradigm of green economy. Sustainability is not something that can be achieved quickly. It is a process of change, continuous improvement and structural transformation of society. According to a report to the Club of Rome, the current economic system has put the world on a treadmill that is driving society in a hopeless environmental direction, yet any conventional attempt to stop what is happening only makes the situation worse. Conventional solutions cannot reduce inequality and joblessness, or climate change. Nor will a wealth tax, boosting infrastructure spending, or encouraging more entrepreneurship. These kind of development demands a sort of transformation that has only two precedents: the formation of agrarian societies, from Neolithic groups based in hunting and harvesting; and the fast industrialization, initiated just over two centuries ago (Veiga, 2013).

Seen in these terms, the construction of a major socio-environmental model requires a wide range of data and information collection from the various aspects involved in production processes. Furthermore, it is necessary to conduct investigations that provide a better understanding of environmental systems. To assist in analyses about sustainable development, the indicators of sustainability appear to gather and quantify social, environmental and economic information in a way that complex phenomena can be simplified and communication process between agents can improve. It is under a data set obtained from indicators that environmental management policies will be targeted for most rational use of natural resources (Kemerich, Ritter e Borba, 2014).

Historically, it is possible interpret the increasing doubts about the future of the environment as one of the consequences of a succession of crises in the second half of the 20thcentury. Between 1960s and 1980s, many environmental disasters, as those taking place in the Gulf of Minamata in Japan, and in nuclear plant of Chernobyl in the former Soviet Union, brought a breakthrough in the awareness of environmental problems (Van Bellen, 2014). Consequently, the sustainable indicators began to grow more strongly in this period through Index of Sustainable Economic Welfare (ISEW) and Measure of Economic Welfare (MEW), among others.

Despite the critics, sustainable indicators are being consolidated as important instruments in the last years, since they facilitate joint analyses of the social, economic and environmental dimensions. However, due to the considerable degree of subjectivity in measurement processes, no widely recognized indicator exists. This work will seek to propose a sustainable indicator constituted by objectives variables and a single methodology to measure theoretically and empirically the magnitude of welfare, called Green Economy Index. It was assembled from an analytical instrument, named Magic Triangle, which is based on the ideas of Kaldor (1971). A positive aspect of this indicator is the fact that it does not depend on the ordering of the variables, a problem present in other measures based on the Kaldorian approach, such as the Magic Square. In addition, due to its simplicity of measurement and graphical representation, this index appears as an analytical tool among various more complex indicators of sustainability. After this introduction, section 1 will review the literature on sustainable indicators; section 2 will introduce the theoretical formulation of the proposed indicator; section 3 will apply the indicator to a Brazilian context; and the conclusion will summarize the most important points explored in the article.

**1. Sustainable Indicators**

According to Castañeda (1999), discussions about economic growth goals in a social and environmental welfare context have occurred since 1960. Some important questions are dealt with, such as: whether economic growth could help in the increase of welfare, and whether it was limited by natural resources scarcity and high levels of pollution. Economists related to ecology proposed the “threshold hypothesis” (Max-Neef, 1995), suggesting that economic growth has contributed to human welfare to some degree, the threshold point. From this concept, many indicators were built tomeasure the relation between progress, welfare and sustainability.

The scientific debate about sustainability indicators was raised by the chapter “Is growth obsolete?”in the fifth volume of the series published in 1972 by William D. Nordhaus and James Tobin, Economic Research: Retrospect, the National Bureau of Economic Research (NBER). Although the focus of such work is not on indicators, but rather on the hypothetical obsolescence of economic growth, the authors did not fail to address the loss of natural resources inevitably caused by economic progress. Nordhaus and Tobin wanted to demonstrate that the progress indicated by measures resulting from the national accounting, such as GDP, could become non-existent when compared to measures more focused on the social well-being. In this way, they built the so-called MEW from a series of amendments to the calculation method of the national product, for example, to remove components that do not contribute to the well-being.

Unlike MEW, the Index of Sustainable Economic Welfare (ISEW) proposed by Daly and Cobb (1989) has had great practical effect, since it can be calculated for many countries, such as Canada, Germany, the United Kingdom and Scotland. Some problems found with this indicator are the pricing of environmental damage, gains in leisure, and domestic or volunteer work present in its formulation. According to Lawn (2003), the ISEW was developed to provide a more accurate way to measure the social well-being and the sustainability of the economic progress of a country. For this, they considered a significant number of benefits, social and environmental costs, beyond invariably of the valuation made by the markets.Parte superior do formulário

 Little effort was devoted to the realization of improvements in the methodology of this indicator. Thus, the consolidation of the index was compromised by its weak theoretical foundation. In 2004, the ISEW has been transformed into the Genuine Progress Indicator (GPI), by the NGO Redefining Progress.

Since1995 two new approaches have emerged: (i) composite indices, or synthetic ones, with various dimensions; and ii) indicators focused on the degree of over-consumption, underinvestment or excessive pressure on resources. In the first category, the most prominent initiative was the creation of the Environmental Sustainability Index (ESI) and Environmental Performance Index (EPI) by the researchers of Yale and Columbia (ESTES et al, 2005).The first contains 76 variables covering five dimensions while the second is constituted by the same variables, but separated into 21 intermediary indicators. Despite gathering a large number of information, the indicators are precarious statistically, blending objective with subjective aspects, for example, a grade given to the quality of the environmental agencies of a country.

In the second category, two indices have gained great visibility: Adjusted Net Savings (ANS) and Ecological Footprint. The ANS, also known as savings genuine, is focused on the evaluation of wealth rather than income streams (World Bank, 2006).It is based on the concept that sustainability requires the maintenance of a constant stock of wealth formed by natural resources, physical and human capital. However, the indicator has a methodological problem due to the difficulty of asset pricing, such as natural resources. Thus, their results are not considered very persuasive (Veiga, 2009).

On the other hand, the indicator Ecological Footprint seeks to show the pressure of consumption by human populations on the natural resources. Proposed initially by Wackernagel and Rees (1995), it allows to compare different consumption patterns and verify whether they are within the ecological capacity of the planet. However, this indicator also has inconsistencies in its methodology, for example, the weights of its components used in the measurement, which assign greater relevance to some areas at the detriment of others.

Rockstrom et al (2009) inaugurated a new way of approaching global environmental problems. This new effort, called planetary boundaries or area of safe operation for mankind, appears as an instrument to assess the trajectory of the global governance of the environment and, in a deeper sense, to reflect on the direction of the civilization. The central thesis is that humans became the main vector of systemic global change. So, the increasing anthropogenic pressure on the planet threatens to destabilize biophysical systems, with deleterious or even catastrophic consequences to our well-being (Viola & Franchini, 2012).

The measure of economic performance, which tends to replace the GDP, is the “actual net income available per household”, but it could not be properly calculated by the more sophisticated statistics agencies of countries. To proceed in such direction was one of the main recommendations of the report produced by the Stiglitz-Sen-Fitoussi Commission (2009), which was formed in 2008 by the then President of France, Nicolas Sarkozy, in response to the growing concerns about the effectiveness of current measures of economic performance, in particular those related to GDP. Thus, this international commission had as its objective to align the indicators of social well-being that really contribute to the quality of life (Stiglitz et al, 2010).

**2. Magic Triangle**

In the quest to contribute in this area of measurement by means of indicators that are multi-varied, the use of the Magic Square of Kaldorian inspiration appears as an appropriate analytical tool, since it allows for the comparison of results between countries of different levels of development. . It permits the study of several variables simultaneously and a more direct comparative performance, evolving socioeconomic and environmental issue of sustainable development.

The idea of evaluating and comparing the accomplishment of countries appeared in a seminal paper of Kaldor (1971), in which the author has studied the macroeconomic performance of the United Kingdom. The analysis was performed using four variables (inflation, balance of payments, unemployment, and income), but did not contain mathematics or diagrams. With this in mind, Karl Schiller introduced a graphical representation of the ideas of Kaldor during the decade of 1970, which has been applied by researchers of the OECD. This diagram was called “Magic Square”. This geometric vision was extended by Medrano-B and Teixeira (2013) and provides a numerical evaluation of the area of the figure, which before could not be done due properly to the different units of the variables’ dimension.

The index proposed by Medrano-B and Teixeira (2013) from the Magic Square is based on the country ideal (wonderland).This concept is constructed by means of intervals that establish values of maximum and minimum for each variable. In this sense, the larger the area of the country in the Magic Square, the better will be the results obtained and the closer the country will be in relation to the optimal performance. As mentioned by Alouini (2012), it is very difficult for a nation to achieve a good result in all the parameters present in the geometric figure. In this way, the definition of a country ideal, even being a great quantitative criterion of comparison, is difficult to be achieved.

However, the use of the “Magic Square” as the analytical instrument is not limited to the macroeconomic. The index may favor different interpretations, depending on the variables chosen to compose it. This theory was tested in the article of Teixeira, Pinheiro and Vilasboas (2015), where it was used to compare the performance of China and the USA in relation to a sustainable development. The variables chosen, by the above mentioned authors, were: CO2 emissions, access to basic sanitation, HDI and the percentage of renewable resources in energy matrix.

In a recent work of Saavedra-Rivano & Teixeira (2016), a problem in the ordering of the variables has been observed, which if changed, different results may generate for the index. This is not an inconsequential oversight and they proposed a solution called “Hypercube Magic”. In this approach, four variables are used. However, since the geometric figure chosen has more than three dimensions, its graphical representation becomes difficult.

Due to these limitations, in the present work, it was chosen an alternative way to calculate the index called the Magic Triangle. In this new geometric form, we chose only three variables, which makes the results of the index indifferent to the ordination of the variables, because it provides a single value for the indicator. The choice of a simple figure, the triangle, resulted also in a graph, which analysis is almost intuitive.

**2.1 The formalization of the Magic Triangle**

As it is well known, a economically sustainable system should be able to continue producing products and services at the same time maintaining a stable base of resources, avoiding environmental degradation, and taking care of socioeconomic relations. According to Marien (2015), this attends by Sachs’ definition of sustainable development as “both a way of looking at the world, with a focus on the interlink ages of economic, social, and environmental change, and a way of describing our shared aspirations for a decent life, combining economic development, social inclusion, and environmental sustainability”. Figure 1 is the result of this intellectual effort[[1]](#footnote-1). It shows how and whether the above mentioned variables are serving the needs of society.

Figure 1: The three pillars of sustainable development



Source: World Bank (2012).

The green economy appears as the basis for sustainable development, since it is able to align these three aspects in a same context and. It is characterized by being low carbon, efficient in the use of resources, both economic and environmental, and socially inclusive. Of course, the form of representation of these characteristics can vary. For example, a low-carbon economy can be measured by carbon dioxide emissions per capita, or, simply, by the innovations of technology. The emission of CO2 (τ) can show the aspect of low carbon, while the amount of renewable resources (φ) present in the energy matrix will be a proxy of the efficient use of resources. Finally, the evolution of the income per capita (γ) will represent the social part.

In seeking to establish the green economy index by means of the calculation of the area of the Triangle, and a correct graphical analysis, it was necessary to normalize the units of the chosen variables, because each of them has a different dimension.

The normalization consisted in standardizing all the variables (axes) to a unit and, from that, be able to calculate the area of the graph formed by the interaction between the chosen variables.

To normalize the variables, it is necessary to establish limits of variation for the parameters individually. The ranges are defined according to the analysis of the historical series and it was decided that the index would vary between -1 and 1. Their limits are given in the following expressions:

-1 ≤ γ ≤1; -1 ≤ τ ≤ 1; -1 ≤ ≤ 1. (4)

In search of simplification, the calculation of a numeric constant, β, normalizes the unit of the area, obtaining the values of γ´, τ´ and ´, which correspond to the normalized variables of each proxy. That is:

0 ≤ γ´≤ β; 0 ≤ τ´≤ β; 0 ≤ ´≤ β. (5)

The normalization process was based on the linear transformation proposed by Medrano-B and Teixeira (2013).In this way, it is possible to describe the performance of each variable by a linear function. According to Figure 2, it is concluded any point on the axis γ` corresponds to a point on the axis γ.

**Figure 2:** Normalization Process

 γ'

 β

 -1 1 γ

Source: elaborated by the authors.

Thus, the equation of the straight line to the income per capita is:

|  |  |  |
| --- | --- | --- |
|  | $$γ` =\frac{β(γ+1)}{2}$$ | (7) |

By the same process, the other variables are obtained:

|  |  |  |
| --- | --- | --- |
|  | $$τ`=\frac{β (1-τ)}{2}$$ | (8) |

|  |  |  |
| --- | --- | --- |
|  | $$φ` =\frac{β (φ+1)}{2}$$ | (9) |

Thus, it is possible to measure the area of the Magic Triangle, as can be seen in the Figure 3.

**Figure 3:** Magic Triangle’s Area

 γ'

 β

 β β

 τ’ ϕ’

Source: elaborated by the authors.

The area of the triangle, which will be called (Aw), in Figure 3, represents the index of an ideal country. Assuming that the relation of two variables, for example, γ' and τ’, formed equilateral triangles, the value Aw can be calculated in the following way:

|  |  |  |
| --- | --- | --- |
|  | $$Aw =3 x \frac{h β}{2}$$ | (10) |
|  |  |  |

where h is the height and β is the side of Figure 3. Thus, $β^{2}=\frac{4\sqrt{3}}{9}$.

Using the same approach for the area of a triangle formed by the actual values of an economy, called A’, the performance of a country can be calculated from the standard values of each variable found in (7) to (9) :

|  |  |  |
| --- | --- | --- |
|  | $$A’ =\frac{\sqrt{3}}{4} (γ´τ´+ τ´φ´+φ´γ´) $$ | (11) |

where that 0 ≤ A≤ 1. Thus, the proposed index would have the same interpretation of well- known indicator, such as the HDI (Human Development Index), in which the best performance is 1 and the worst 0.

**3. Application of the Green Economy Index for Brazil**

The aim of this section is to apply the method of the Magic Triangle to calculate the green economy index for Brazil. First, the chosen variables were normalized based on the values of Table 1 and in the expressions (7) to (9).Data from Brazil for the periods of 2000-2007 and 2008-2014 were used to establish the values of minimum and maximum per capita income (γ), CO2 emissions (τ) and the supply of renewable energy (φ).

The database used in the present work was obtained through the database of the IBGE, the National Energy Balance by the Company for Research in Energy and the Overall Emissions of the NGO Observatory of the Climate. The rate of growth of per capita income (γ) was considered on constant prices. Parte superior do formulário

For all variables, it was calculated the average growth rate based on absolute figures available in the databases. Table 1 presents those data.

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| --- |
| **Table 1-** The rage of change of green variables (%) |
|
| Period | Income *per capita*(γ) | CO2 emission (τ) | Supply of renewable energy (ϕ) |
| 2001-07 | 10.96 | -1.33 | 1.68 |
| 2008-14 | 9.64 | -2.31 | -2.01 |

 Source: IBGE, Company for Research in Energy, Observatory of Climate.

With the data contained in Table 2, it is possible calculate the area of the Magic Triangle, Table 3, which corresponds to the value of the green economy index in Brazil.

|  |
| --- |
| **Table 2- Normalized Variables** |
|
| Period | *Per capita* income(γ) | CO2 emissions (τ) | Sypply of renewable energy (ϕ) | Ideal |
| 2001-07 | 0.487 | 0.445 | 0.446 | 0.877 |
| 2008-14 | 0.481 | 0.449 | 0.430 | 0.877 |

 Source: elaborated by the authors.

|  |
| --- |
| **Table 3- Green Economy Index (Brazil)** |
| Period | Green Economy Index | Ideal |
| 2001-07 | 0.274 | 1.000 |
| 2008-14 | 0.267 | 1.000 |

 Source: elaborated by the authors.

Since the results of each year of the index depend on those previously attained, the geometric formula to the rate of variation is given by:

|  |  |  |
| --- | --- | --- |
|  | $variation=100∙(\sqrt[n]{\frac{green index\_{\frac{2008}{2014}}}{ green index\_{\frac{2001}{2007}}}}-1$) | (12) |

Therefore, the rate of annual change for the period studied is – 0.370%. In Figure 4, the Magic Triangle was used to visualize the results obtained. As the performances in the periods were very close, the triangles of the graphical representation are superimposed.

Source: elaborated by the authors.

In order to establish if the GDP per capita adversely affects the results the calculated indicator, the Gini Index, was chosen to represent a proxy of the social pillar. The average of the rate of change of the actual data for the period 2001-2007 and 2008-2014 to Brazil is presented in Table 4.

|  |
| --- |
| **Table 4** - Gini Index: Brazil (%) |
| Period | Gini Index (γ) |
| 2001-07 | -0.009 |
| 2008-14 | -0.010 |

 Source: the authors.

The rate of variation of the indicator of a green economy for Brazil, taking to account the Gini Index, is:

$variation=100∙(\sqrt[7]{\frac{0,252}{0,257}}-1)$ = - 0.252%

Notice that the difference between the two approaches is relatively insignificant. This shows that Brazil was in a period of stagnation, concerning the sustainability. Thus, the GDP *per capita* is a good proxy for the social pillar.

**3.1 Hypercube: an alternative approach**

Another way to analyze the results achieved in the version of the Green Economy Index, which uses the GDP per capita, would be the method adopted in Saavedra-Rivano &Teixeira (2016), named the Hypercube[[2]](#footnote-2). Unlike the proposal of this article, they chose to resolve the sorting problem of the Magic Square by calculating the volume of a hypercube.

Notice that, by stipulating three pillars, as is the case of the index calculated in the present work, the volume of a cube is obtained. As only the rate of change between the periods is analyzed, it is possible to compare the values found by the two methodologies. In this way, the following equation is used:

|  |  |  |
| --- | --- | --- |
|  | $$V= z^{3}$$ | (13) |

being z the edge of the cube, which corresponds to the value of each variable. In this method, it is also used the concept of “country ideal”, in that all the components would have the same value when normalized. In addition, it should be noted that V varies between 0 and 1, as in the Magic Triangle. Table 7 shows the results:

|  |
| --- |
| **Table 7- Green Economy Index(Hypercube)** |
| Period | Green Economy Index | Ideal |
| 2001-07 | 0.143 | 1.000 |
| 2008-14 | 0.137 | 1.000 |

 Source: the authors

From the values present in the Table 7, it is possible to calculate the rate of change between the periods by means of (12):

$variation=100∙(\sqrt[7]{\frac{0,137}{0,143}}-1)$ = -0.559 %

Comparing the results obtained between the Hypercube and the Magic Triangle, it is possible to see that both show a relative decline in the performance of Brazil towards a more sustainable economy, denoting a certain stagnation of the country in recent years.

**3.2 The analysis of the results**

According to Jackson (2009, p. 215), in a sustainable economy, “the stability is no longer based on growing consumption, but it emerges from strategic investments in jobs, social infrastructure, sustainable technologies, and the maintenance and protection of ecosystems ”.In recent years, the Brazil’s government has not adopted this strategy. Resources of low-carbon reduced its share in the energy matrix l. While the total energy produced and supplied grew by around 40% approximately between 2003 and 2012, the natural resources grew between 36% and 37% during the same period. Thus, the increase of the share of non-renewable resources in the energy matrix was significant. The others are related to energy efficiency. Due to the interval of time required for research and resources development of low-carbon, and the intrinsic necessity of reduction of energy consumption as a way to assimilate a more sustainable life, investing in energy efficiency is the most rational choice to achieve a green economy.

Another factor that has increased the participation of fossil energy in the matrix is related to the water crisis that started in mid-2012.The main reservoirs of the country have been below the dead volume[[3]](#footnote-3) in some periods, due to the lack of rain. Compounding the situation, this decrease in the supply of energy was accompanied, concurrently, by an increase of demand by part of the population (ANA, 2014).The water crisis led the government to resort to the use of thermoelectric plants based on gas and coal, which are more polluting than the plants.

Energy efficiency also had a growth consistent with the policies during that decade. Concerning CO2 emissions, Brazil is signatory of several multilateral agreements in the global effort of reducing greenhouse gas (GHG) emissions, while not having binding targets for mitigation of carbon dioxide. However, the environmental policies adopted so far do not include the formal control of emissions, such as taxes or trade quotas. Unlike other countries, whose burning of fossil fuels is the main source of GHG emissions, the Brazilian emissions originate, primarily, in changes in land use and forests, with the forest fires and deforestation leading this process. The policies adopted do not include emission restrictions, but alternative actions linked to the enlargement and efficiency of the supply of renewable energy sources, small hydro and bio fuels (LEAL et al, 2015).

**Conclusion**

According to the preface written by Nicholas Sarkozy in Stiglitz et al (2010), the statistics and methods of measurement reflect the aspirations and values of a society. Indeed, they are inseparable from the vision of the socioeconomic world, the concept of the human being and their inter-relationships. To treat these issues as being external to a particular population is very comfortable, and, at the same time, dangerous, since it can get to a certain point at which the authorities and researchers begin to lose the true focus of what they are doing, what they are truly measuring, and what lessons need to be learned.

In this context, the present work had the purpose of building a new indicator of sustainability: the Green Economy Index. It was assembled from an analytical instrument, called the Magic Triangle, which is based on the ideas of Kaldor (1971), and part of a reformulation of the proposed index in Medrano-D and Teixeira (2013). In addition, the methodology presented in this work was formulated according to the three pillars of the green economy.

A positive aspect of the Green Economy Index, with just three variables, is the fact that its outcome does not change according to the ordering of the vectors **-** a problem, which occurs in other measures based on the Kaldorian approach, as the Magic Square. In addition, due to its simplicity of measurement and graphical representation, this index appears as a fair analytical tool among the various indicators of sustainability. In seeking to apply the Green Economy Index, Brazilian data were used for the two periods 2001-2007 and 2008-2014.When analyzing the results, we found that Brazil was stagnant in the process of transition to a more sustainable economy.

We conclude that the implementation of a green economy is a profound challenge for governance at all levels. The present analyze indicates that society needs to be cautions and use rash measures in which the thresholds of the planet become global commons. Consequently, without high levels of domestic and international cooperation, it is impossible to define and protect a coming spaceship earth. On the face of it, with the election of Donald Trump to the presidency of the United States, there arises a new moment of uncertainty and insecurity with respect to a global agreement, since, during his campaign, he showed himself a strong opponent of the policies of combating climate change. In addition, shortly after his inauguration, the link, from the site of the White House, relating to climate change has been removed. It is a fact that reaffirms the contrary position of the new government to any possible agreement. Thus, the discussion of global environmental policy takes on a new train of thought, where, “in a different way than in the past, man will have to return to the idea that his existence is a free gift of the sun” (Georgescu-Roegen, 1971).

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1. The green economy has the primary goal of ensuring that the economy and environmental sustainability are compatible, so the use of the dashed line in Figure 1. [↑](#footnote-ref-1)
2. It consists of the n-dimensional paralloltope with edges along the axes going from the origin to the value of the corresponding variable. [↑](#footnote-ref-2)
3. The dead volume is a reservoir with 400 million cubic meters of water situated below the floodgates of the dams of the Cantareira System, for example. Also known as the reservation technique, this water tends not to be used to assist the population. [↑](#footnote-ref-3)