DEPARTMENT OF INTERNATIONAL AND EUROPEAN ECONOMIC STUDIES

ATHENS UNIVERSITY OF ECONOMICS AND BUSINESS

The Economics of Sustainable Development

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Working Paper Series

20-05

March 2020

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Abstract

In this introductory chapter we aspire to offer a comprehensive yet complete roadmap of the concept and content of the much used but not quite appropriately perceived term of sustainability economics. Interestingly, there is not a formal and universally accepted definition as the field is considered as a relative science and thus requires an interdisciplinary approach to be studied. However, through indicative yet recent literature we offer an insight on the state of the art in order to relate with its core meaning. A historical background is also outlined as understanding the foundations is crucial. Elements of Economic Theory serve as means to bridge the past and current trends on how theories have evolved to understand what is necessary to achieve not only economic growth in numbers but also to ensure well-being and prosperity for the current and future generations.

1. Introduction

1.1 The Theory of Economic Growth through basic models

Within the Theory of Economic Growth different strands have been surfaced throughout the years aspiring the explain variation in income levels across countries, or in other words, how nations grow and prosper. The Solow-Swan model (1956) was a pioneering approach using aggregate production functions to study the accumulation of capital in order to improve nations' income. Although influential, Solow's model assumes that technical progress is exogenous. Put in another way, the model assumes that technological progress captured by the (unexplained by the model) Solow residual, just happens. The latter is the main shortcoming of the model as in the absence of technological progress, sustained growth is questionable. Moreover, the rate of capital accumulation (i.e. change) is determined by the savings rate, the depreciation, and the rate of population growth respectively, which are also assumed to be exogenous. In other words, in this exogenous growth model, the interest is placed on capital accumulation as this was believed to be the means for welfare and prosperity at that time, neglecting however the role of technology in sustained growth. Nevertheless, the Mankiw et al. model (1992) provides an estimate of the rate of total factor productivity i.e. the Solow residual.

Another strand is the neoclassical growth models which explicitly model consumer's side by taking into consideration (or in economic terms, endogenizing) savings. The Ramsey (1928) or Cass – Koopmans model (1965) introduces household optimization assuming an infinitely living representative household. Household preferences are specified; therefore, savings can now be linked to them, along with technology and prices in the economy. The most important contribution attached to this line of models is that it paves the way for a more systematic analysis of capital accumulation, investment in human capital and endogenous technological progress.

Although it does not shed light to the causes of cross country income differences and economic growth, it clarifies the nature of economic decisions. However, the main assumption of the model is its major shortcoming as well.

In the overlapping generation models (OLG), such as Diamond's model (1965), households do not live eternally but also allow for new households in the economy over time however, their usefulness is not limited to that. Totally different implications are derived compared to the aforementioned neoclassical model, while the dynamics of capital accumulation and consumption are closer to Solow's rather than the neoclassical model.

The common feature of the models described so far is the focus on capital accumulation and that growth is generated via exogenous technological progress. However, the later was challenged by the Endogenous Growth Theory stating that technical progress occurs within the system through Research and Development (R&D) activities and is therefore endogenous. The most important representatives of this class of models are David Romer and Robert Lucas.

From the one hand, Romer (1994) assumes that generated knowledge by a firm's research spill over to other ones creating new knowledge for them as well. In other words, technology has spillover effects across the entire economy and constitutes the ultimate determinant of long-run growth. On the other hand, Lucas (1988) puts human capital under the spotlight. Investment in education contributes to production of human capital boosting growth. He argues that through education, the individual worker undergoing training becomes more productive (internal effect), and that spillovers increase both the productivity of capital and that of other workers in the economy (external). It is investment in human rather than physical capital that has spillover effects increasing the level of technology.

Overall, the focus is on technological progress, without explicit explanation on the details of the investment *per ce*. However, income differences across countries could be attributed to differences in technology levels. Thus understanding the sources of such differences is a necessary condition to achieve economic growth.

Grossman and Helpman (1994) brought to the discussion the role of innovation process to explain growth arguing that research leads to a greater variety of final goods, and income improves because households gain more utility through product proliferation. However, a country's technological progress is solely determined by its own investment in R&D, which is questionable. Technological advancements diffuse across countries and each country has the potential to absorb knowledge generated through the world technology frontier making diffusion equally important to the creation of new technologies. Another limitation of these models is that they do not capture the notion of the creative destruction process that is although innovation creates new technologies, it also "destroys" others, by making them obsolete.

Last but not least, the Schumpeterian models of economic growth capture that process, however those have their own limitations that go beyond the scope of this chapter.

1.2 The role of technology in production

A well-known fact in economic theory is that the production functions i.e. production frontiers of two different country economies are not directly comparable due to differences in the level of technology they have access to. Empirically speaking, this is one of the main issues that cause inconvenience to researchers in cross-country comparisons using most of the times the Gross Domestic Product. A production function combines inputs such as labor, capital, energy in order to produce

outputs such as Gross Domestic Product employing a given technology level. The latter is not directly observable and it is considered as a black box.

Recent methodological advancements acknowledging that technology is a source of productivity and prosperity differences revolutionized the way cross-nation comparisons and benchmarking is done. The pioneering work of Haymi (1969) and Hayami and Ruttan (1970) introduced the concept of the metaproduction function as a function that envelops all the individual frontiers. Moreover the influential contribution of O'Donnell et al. (2008) developed further the concept and notions that could be used for benchmarking purposes and performance evaluation of the Decision Making Units under examination.

The latter paves the way for the calculation of the technology gap which is the distance of the individual frontier to the metafrontier. The use of the metafrontier as an empirical tool to account for all the possible heterogeneity among the units under consideration has become a growing wave and has triggered many studies in the field of Economics of efficiency and productivity.

It has become apparent that growth and prosperity can be sustained through technology diffusion. Recent contributions (Tsekouras et al., 2016; Chatzistamoulou et al., 2019) have used the metafrontier to capture knowledge flows i.e. spillover effects that improve the performance of the units bringing to the forefront that productivity differences are attributed to technology heterogeneity.

2. Conceptual Framework

2.1 Tracing the events; a historical background

In 1982 the term sustainability enters the scene in the World Charter for Nature (United Nations-UN, 1982) but the concept was officially introduced in the Brundtland Report (WCED, 1987) which was the launch pad of the emergence of the

sustainability literature (Pezzey & Toman, 2002), although there was an earlier contribution by Barbier (1987). It was elaborated in the Agenda 21 during the Earth Summit in 1992 (UN, 1992).

The social dimension of sustainability was first introduced at the World Summit on Social Development in Copenhagen in 1995 (UN, 1995) and later endorsed by the World Summit in Johannesburg in 2002 (UN, 2002). Prior to that, during the Millennium Summit (UN, 2000), the Millennium Development Goals (MDGs) surfaced from the Millennium Declaration as a set of eight goals for the period 2000 through 2015 while the Conference in Rio De Janeiro in 2012 embraced the outcome of 2002 Summit (UN, 2012) namely the social pillar of sustainability, receiving significant attention.

The Sustainable Development Goals (SDGs) initially proposed in 2014 by the Open Working Group of the UN General Assembly (UN, 2014) only to be adopted in 2015 (UN, 2015), as a network of goals (Le Blanc, 2015) which is important to understand (Singh et al., 2018) in order to be achieved by 2030 to inherit the MDGs. The initiative comprises of 17 goals, 169 targets and a few hundreds of indicators.

2.2 Literature review

Although sustainability has become a modern buzzword, any attempt of providing a formal definition is not an easy task, mostly due to the fact that it encapsulates many concepts, meanings and perspectives. It has become apparent already that early studies have placed, the interest on how economic growth occurs, on the capital accumulation, and then, on the role of technology, human capital deepening and innovation. However, in achieving sustainable development all of the aforementioned are necessary but not sufficient.

In the beginning "sustainability" has had an environmental-ecological flavor mainly. The term "sustainability" is considered as a normative notion that is related to human-nature and current-next generation relationship. Although, a coherent consensus about the precise content of "sustainability economics" is not readily available, a growing body of literature suggests that it aims at efficient management considering uncertainty entailing a cognitive interest as well. This is what makes "sustainability economics" a relevant science (Baumgärtner & Quaas, 2010 –BQ) and it has also been linked to a final product (Victor, 1991).

In developing the term, Van den Bergh (2010) through a critique on the work of BQ, suggests that environmental externalities and sustainability should be conceptually associated, highlights other facets of sustainability (e.g. weak, strong, spatial) and argues that offering policy insights is at the core of the field. Those two papers have triggered an active discussion bringing to the forefront the origins of sustainability concept-content derived through the Summits whereas Bartelmus (2010) argues about the usefulness of the field. Other important contributions on the concept of sustainable development/sustainability are those by Daly (1990), Pezzey (1992), Toman (1994) and Beckerman (1994) just to mention a few. Although it has been argued that the two terms differ, in fact those embrace the identical facets and lead to similar policy suggestions. It should be noted that Pezzey & Toman (2002) enlighten our understanding through a systematic literature review about sustainability economics.

Therefore, the terms are used interchangeably highlighting the long run orientation. Nowadays, due to the intrinsic complexity and multi-disciplinary content of sustainability, no clear definition exists to serve as a guideline for policy making

(Holden et al., 2014). Research has increased awareness around the concept indicating that it is a rather multi-dimensional and by all means not a straightforward notion.

Ecosystem services are also related to sustainability and have also gained merit in the body of literature. In particular, efficient resource management and more precisely, the water management of all kinds, has been studied extensively as its scarcity hinders sustainable development across the globe. The Water Framework Directive (WFD) sets the guidelines for efficient management and in this line Koundouri et al. (2016) introduce a methodology that evaluates the total economic value of water services aligned with the WFD. Navarro-Ortega et al., (2015) and Akinsete et al. (2019) under the GLOBAQUA project explore the linkages between the factors affecting water quality and human wellbeing by focusing on several river basins respectively. Sustainable river management (Dávila et al., 2017; Pistocchi et al., 2017), the value of biodiversity (Birol et al., 2009), the marine and coastal ecosystems mitigation measures against climate change (Remoundou et al., 2009; Remoundou et al., 2015), the oceans (Koundouri, & Giannouli, 2015; Koundouri, 2017) as well as the seas (Remoundou et al., 2014; Stuiver et al., 2016; Van den Burg et al., 2016; Zagonari et al., 2018) have also been subject to research.

2.3 Measurement efforts

The interest in monitoring sustainability over time generates the urge for proper measurement. A growing body of literature underlines the need for appropriate indicators, comparable across nations and universally accepted (e.g. Dahl, 2012; Hák et al., 2016). The SDGs could put the world in a *sustainable trajectory* (Sachs, 2012) as the former introduced as an opportunity to rationalize the expectations of their predecessors, i.e. the MDGs (Joshi et al., 2015). Soon after the introduction of the

former which made possible the measurement of sustainability, many studies focusing on specific goals have surfaced.

For instance, Le Blanc (2015) employs network analysis to study the interlinkages between the SDGs focusing on the SDGs 10 and 12. The network analysis supports that links come from targets that are listed under SDGs other than the selected ones, underlining the fact that those constitute indeed a network. Singh et al. (2018) also study the interconnections of SDGs as they argue this could drive sophisticated policy making, they focus on SDG 14 (oceans) to highlight its importance in achieving sustainable development. Although the interest is placed on specific SDGs, studies analyzing the SDG index (Sachs et al., 2016-2019) have yet to be surfaced.

Before the SDGs and the development of the SDG index (Sachs et al., 2015-2019) and since sustainability was perceived to encapsulate environmental as well as human well-being concerns, corresponding indices, although partial, have been employed in empirical research. Just to mention a few of the most recent ones, Moran et al. (2008) use the UN Human Development Index (HDI) and the Ecological Footprint to measure SD within ecological limits, by setting thresholds, to find that low income countries managed to reduce the latter and increase the former while the opposite holds true for the high-income countries.

Among the indices that have been employed, one finds the Environmental Vulnerability Index, the Environmental Sustainability Index and the Environmental Performance Index although it has been argued that it is not straightforward to assess sustainability adequately (Dahl, 2012). Moreover, Holden et al., (2014) employ the HDI to measure equity representing quality as well as the Gini index measuring equality (representing quantity) by assigning thresholds as well.

This somehow foreshadows the SDG index as by Sachs et al. (2015; 2016; 2017; 2018; 2019) offering a unified framework for measuring sustainability achievement through the common set of goals, targets, indicators facilitating cross nation SD comparisons, by passing the need to set thresholds to determine improvement. The latter however is one of the main points of criticism as different nations have different initial conditions affecting their progress.

All in all, the SDGs have revolutionized the way of integrating the same policy targets into national level discussion. Such undertaking is most certainly multifaceted and the use of the SDG index facilitates such comparisons. However national-level political decisions prove to be hard to quantify and will remain unobserved. The main challenge is to promote the adoption and find a monitoring mechanism in an attempt to guide universal implementation.

2.4 An introduction to the circular economy

We now shift the attention to the concept and meaning of the circular economy as it is a trending topic of the public dialogue. From the United Nations to the European Commission, both sides of the ocean have dedicated a significant amount of resources to communicate the importance of building a circular economy rather than wasting irrationally scarce resources to deliver a sustainable future to the generations to come. Thus, the aim is to put things in perspective rather that offer an in-depth analytical framework.

The (First) Industrial Revolution that occurred in the 18th century set the foundation on which the modern (manufacturing mostly) processes are established. Ever since, the list with the events that occurred i.e. the technological progress and changed the way production takes place is quite long. However, at that time the philosophy of production was of a *linear form*, in the sense that raw materials i.e. inputs where transformed with some sort of technology into outputs whereas non-

recyclable waste was occurring as a natural consequence. Time passed by and societies come to realize that this "take-make-waste" model is not a sustainable forward-looking strategy as it was exponentially draining the Earth's scare resources to cover the needs of the modern societies.

Another related notion to that of the circular economy is the *recycle-reuse economy*. This is mainly based on the act of re-using or taking materials that have been already processed and adding value to them by generating new ones without involving additional raw materials. From the viewpoint of the economist, this is translated into generating value through products that have been produced and used previously so as to enter the system again, improving the prosperity and welfare of societies with restricted access to production means while it is also linked to higher quality of life since it comes with jobs creation and business opportunities. Nevertheless, the common feature of a linear and a reuse economy is that both are associated with non-recyclable waste.

Undeniably, the term *circular economy* has been the buzzword that has dominated the public interest reaching a diversified audience, from academics and scholars to practitioners, stakeholders and policy makers. This is mainly the reason it has received multiple meanings and content.

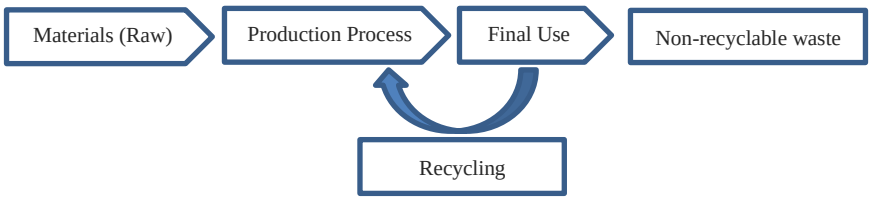
Although it is a very complex and tangled notion as it is affected by many streams of thought and disciplines (Ellen MacArthur Foundation, 2012; 2013), a rather general definition could be that *a circular economy is an economy that aims to extract fewer scarce resources as time goes by in order to minimize the waste produced by maintain the value of the items for longer and putting them into the production cycle generating a feedback process to avoid using raw materials* (Eurostat, 2019).

Efficient use of resources and keeping waste to the bare minimum is central to the concept of the circular economy as a sophisticated product design and material use leads to a higher quality product that is associated with less efforts to manage waste, preserves and respects the relative scarcity of resources and generates value through the associated business opportunities that arise in the process. In short, *circular economy is a redesigning, regenerative and restorative system towards the use of renewable energy* (Word Economic Forum, 2019).

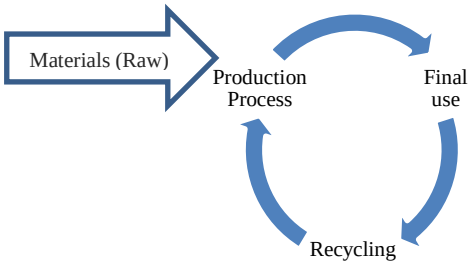
However, the above is only a broad term regarding the circular economy. Recently Kirchherr et al., (2017) conducted a systematic analysis regarding the definitions of the circular economy used in the current discourse. Findings indicate that there are more than one hundred definitions which may be a source of misunderstanding among the stakeholders and agents. The authors argue that some of the definitions adopted mix circular economy to recycling and that the links with sustainable development appears to be weak as the associations with prosperity of the future generations is hardly part of the picture. The latter highlights the need for a clear understanding of the notion to boosting its importance for the quality of life. The graph below (Graph 2) illustrates the flow of process and main differences between the concepts described above.

Linear Economy

Reuse Economy



Circular Economy



Graph 2. The linear, reuse and circular economy.
Source: Own construction.

The implementation of the concept of the circular economy has led to the creation of the circular economy business models (CBM). In particular, the CBM is a model that implements the principles underpinned by the circular economy philosophy. The latter may take the form of industrial symbiosis, the sharing economy, which is becoming especially popular in Europe, the circular-sustainable design gaining ground on a worldwide scale, the reverse logistics and remanufacturing.

Irrespective of the CBM adopted and implemented, the benefits take a similar form. Above all is the effort to reduce the environmental footprint and reduce overloading the ecosystems from the effects of the production process while preserving the scarce resources such as energy and raw materials, boosting economic growth and competitiveness at a global scale, triggering innovation activity and generating jobs have proven to be among the main benefits.

It goes without saying that the research around circular economy proliferates in an exponential manner during the last decade. For instance, Ritzén and Sandström (2017) argue that the concept of the circular economy is not far from its complete implementation in practice as there are financial, structural, operational, attitudinal and technological obstacles making the transition hard to be achieved. In a similar vein, Korhonen et al., (2018) report six potential challenges of the circular economy

with respect to the sustainability of the environment that being *the thermodynamic limits, the limits posed by physical scale of the economy, the limits posed by path-dependency and lock-in, the limits of governance and management, the limits of social and cultural definitions and the definition of physical flows*.

In addition to those challenges, the Institute for European Environmental Policy (2016) mentions that the concept of circular economy does not encapsulate concepts of social and environmental justice to be part of the future agenda, and they also highlight the fact that the CBM are not in position to offer optimal solutions. However, the systematic review of the literature conducted by Kalmykova et al. (2018) identified that market-ready solutions to be applied already exist for the implementation levels of the adopted strategies.

The circular economy concept has evolved throughout the years to include more aspects that promote a more resilient and resource efficiency society (Graph 4 below). Currently, there are 10 principles or R's that describe the concept of circular as a system and therefore are linked to each other in a feedback loop (Reike et al., 2018). In particular, Refuse (R0), Reduce (R1), Resell/Reuse (R2), Repair (R3), Refurbish (R4), Remanufacture (R5), Repurpose (R6), Recycle (R7), Recover (R8), Re-mine (R9). The authors offer a graphical representation of the system as well.

Despite a rapidly growing wave of research related to the concept of circular economy and sustainability, the exact content of the two notions is not easy to be defined. Prieto-Sandoval et al., (2018) provide a systematic literature review using content analysis to clarify the concept of circular economy. An interesting finding is that they mention that the multiplicity of the definitions stem from the interdisciplinary nature of the term as many scientific fields such as Ecology, Economics, Engineering, Design and Business have incorporated the notion among

their analytic tools. The authors provide a timeline from the first industrial revolution to the commonly accepted viewpoint that circular economy is a bring on the wall to achieve sustainable development (Xue et al., 2010; Ma et al., 2014; Geissdoerfer et al., 2017; Kirchherr et al., 2017). Sustainability itself is not a straightforward term to define though as it has a few hundred definitions (Johnston et al., 2007), as already mentioned.

It should also be mentioned that circular economy and sustainability are linked through the inclusion of the former within the SDGs initiative. More precisely, the circular economy is found in the SDG 8 which promotes inclusive and sustainable economic growth, employment and decent work (Decent Work and Economic growth; indicator 8.4 Sustainable Consumption and Production), 9 building resilient infrastructure, promotes sustainable industrialization and foster innovation (Industry, Innovation and Infrastructure; indicator 9.4 Green Industry) and 12 which addresses resource and energy efficiency (Responsible Consumption and Production; indicators 12.2 Natural Resource Management and 12.5 Waste Management) (United Nations, 2019).

Geissdoerfer et al. (2017) offer a systematic, comprehensive and illuminating presentation of, the differences as well as similarities between the two notions. Regarding the similarities they identify twelve of them related to a wide range of interactions and interdependencies between the agents and the environment such as the role of business innovation and technology , the interdisciplinary nature of the fields, the necessity that many stakeholders need to co-operate among others whereas as far as the differences are concerned, the authors compare the two notions based on the origins of the term, the goals and motivation, potential benefits, responsibilities could be found among those.

3. Methodology

3.1 Introducing the Sustainable Development Goals

The Sustainable Development Goals have been introduced by the United Nations (UN) in 2015 aiming to develop a framework of seventeen interconnected Goals, each proxied by additional targets, for monitoring the growth, economic prosperity, challenges, inequality, poverty, peace, climate change, responsible consumption and production and raise environmental awareness among others, so as each goal and every target to be achieved on a global scale by 2030 not only for industrialized but also for developing and emerging nations.

Each goal has several targets that capture aspects of its content. Those targets are subject to change to achieve a better grasp of each SDG as time goes by. It is not worthless to mention that although the SDGs have been agreed by all countries, implementation is not obligatory. The interested reader may find useful information about the SDGs initiative at the official site of UN Sustainable Development Goals[1]. As there is diversity in the aspects that need to be monitored, the latter have been categorized in seventeen SDGs, such as No Poverty (Goal 1), Zero Hunger (Goal 2), Good Health and Well-Being (Goal 3), Quality Education (Goal 4), Gender Equality (Goal 5), Clean Water and Sanitation (Goal 6), Affordable and Clean Energy (Goal 7), Decent Work and Economic Growth (Goal 8), Industry, Innovation and Infrastructure (Goal 9), Reduced Inequalities (Goal 10), Sustainable Cities and Communities (Goal 11), Responsible Consumption and Production (Goal 12), Climate Action (13), Life Below Water (14), Life on Land (Goal 15), Peace, Justice and strong Institutions (Goal 16) and Partnerships (Goal 17).

3.2 The SDG index

[1] Please follow https://www.un.org/sustainabledevelopment/.

The SDG Index Report provides insight regarding the performance of nations with respect to the SDGs. It is produced by Bertelsmann Stiftung with the support of the Sustainable Development Solutions Network (SDSN) Secretariat and member institutions (UN, 2019) by bringing together information from official sources such as the World Bank, the Organization for Economic Co-operation and Development, national authorities as well as research centers. It captures the average performance of the nations on all of the SDGs.

Aspiring to get the big picture as regards the SDG performance of nations, we devise a dataset by collecting combing and matching the most recent information on the SDG index from 2016 through 2019 (Sachs et al., 2016; 2017; 2018; 2019) including 148 countries worldwide. Due to missing data, 45 countries have been excluded from the sample. Thus, the dataset consists of 592 observations.

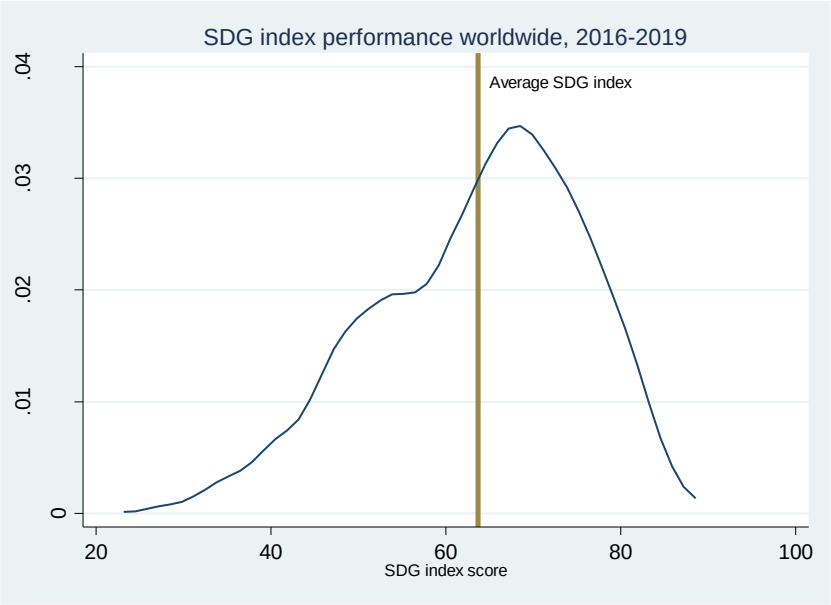
4. Results and Discussion

Table 1 below presents the basic descriptive statistics for the SDG index for the period of study. The index is increasing (on average) within the period which is an encouraging fact as countries improve their performance in the targets and consequently at the SDGs. The minimum score is also being improved as time goes by and this promising as well.

Year	Mean SDG index	St. Dev	Min SDG index	Max SDG index
2016	58.43	13.84	26.10	84.53
2017	64.94	10.97	36.70	85.60
2018	65.04	10.32	37.70	85.00
2019	66.26	10.22	39.08	85.22
Sample period	63.67	11.81	26.10	85.60

Table 1. Basic descriptive statistics for the Sustainable Development index, 2016-2019.
Source: Own construction.

Graph 1 below illustrates how the SDG index is distributed on a global scale for the period of study. The vertical line corresponds to the global average, for the period of study, indicating how well countries perform. The 56.08% of the sample perform better than the average. Therefore, the fact that more than half of the sample exhibits an encouraging performance indicating that most countries embrace and implement the SDGs to a satisfying extent.



Graph 1. The distribution of SDG index globally, 2016-2019.
Source: Own construction.

On a final remark and as the scope of the chapter is to introduce the concepts, the interested reader may seek additional information through the United Nations SDG Index and Dashboards official site which provides amazing interactive tools and graphs about the country profiles.

5. Concluding Remarks

In its infancy, the concept of sustainable development was almost exclusively about the environmental-ecological footprint of societies related to the quality of the environment the current generation bequeaths to the next one but progressively, governments, agencies and authorities realized that there are most aspects included in the term. Nowadays the term embraces a spherical appreciation of the human-environment relationship requiring an interdisciplinary approach in order to be studies.

Recent endeavors focus on the importance of the SDGs mostly by selecting a particular goal to study. The SDG index is gaining ground in the empirical analysis but research has not explored its potential yet. Combining it with other performance measures could offer useful insight in policy making. In the light on the severe climate change, nations are becoming increasingly aware of the potential of the circular economy principles. The responsible authorities however should dedicate resources to increase awareness to the level of stakeholders and households to achieve the desired outcome.

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