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Executive Summary

- As part of the transition to the CE (circular economy), there is a need to rethink how the purpose of the economic system is framed. This includes questioning how economic performance is measured.
- Economic performance has traditionally been associated with monetary measures like GDP. As a result, the measurement of CE performance has often been shaped by indicators borrowed from conventional mainstream economics.
- Reviewing a set of relevant indicators designed as alternative ways to measure the performance of an economy from different perspectives suggests that a framework focusing on environmental and societal priorities could provide a more comprehensive picture.
- Most of the analysed indicators and frameworks face similar challenges including the difficulty of obtaining data, the lack of consistency regarding cross-country data collection, and the diversity of social values and public priorities, challenging the idea to create a unified indicator.
- The alternative indicators to measure economic performance have the ability to provide a better picture that is more in-keeping with the new understanding of the economy involved in the adoption of the CE. However, despite the adoption of the CE, the use of GDP has not been reconsidered yet, and the main policies that promote the CE still use GDP as a benchmark.

List of Abbreviations/Acronyms Used

3R - reduce, reuse, recycle

ACF - Atkinson Charitable Foundation

CE - Circular Economy

CGI - circularity gap index

CIW - Canadian Index of Wellbeing

EEA - European Environment Agency

EPI - Environmental Performance Index

ESPI - European Social Progress Indicator

FTIR - Fourier-transform infrared

GDP - Gross Domestic Product

GNH - Gross National Happiness

GPI - Genuine Progress Indicator

HPI - Happy Planet Index

IAEG - Inter-agency and Expert Group

ICLS - International Conference of Labour Statisticians

MIMIC - Multiple Indicator - Multiple Cause

NCI - Natural Capital Index

NDIR - non-dispersive infrared

ODS - ozone depleting substances

OECD - Organisation for Economic Co-operation and Development

SDG - Sustainable Development Goal

UNCED - United Nations Conference on Environment and Development

UV - ultraviolet-fluorescence

WBCSD - World Business Council for Sustainable Development

1. Introduction

The Circular Economy (CE) lacks a solid theoretical foundation and is therefore a contested concept without a unique definition (Korhonen *et al.*, 2018; Merli, *et al.*, 2018; Genovese and Pansera, 2021). Nonetheless, a prevalent line of thought in the CE discourse claims that the CE holds the potential to successfully decouple economic growth from environmental degradation. As a result, the CE has inevitably been associated with improvements to economic performance, and this is also reflected in the existing literature (Figge *et al.*, 2018).

As part of the transition towards the CE, and as discussed in Deliverable 3.3, there is a need to rethink how the economy is framed and how its performance is measured. Traditionally, most economic policies have focused on improving Gross Domestic Product (GDP) and further increasing it as a central measure of economic effectiveness. However, there have been some intellectual, political, and economic criticisms associated with the centrality of productivity and with the use of GDP to assess economic performance. This productivity-centric vision of the economy has been further challenged over time, and there is a vibrant discussion within academic and social spheres on how the economy and its performance can be re-understood. This concern has also been reflected in the political sphere. Recently, the leaders of the EU member states challenged the adequacy of traditional economic indicators such as GDP. They stressed the need to rethink how progress is measured, including from economic, social, and environmental perspectives.

> *"We welcome, as another success of European social dialogue, that the European Social Partners have made a joint proposal for an alternative set of indicators to measure economic, social and environmental progress, supplementing GDP as welfare measure for inclusive and sustainable growth."*
>
> *The Porto Declaration (European Council, 2021)*

The previous deliverable in this series (Deliverable 3.3) focused on reviewing 'conventional' conceptions of efficiency stemming from neoclassical economics, as well as the more recent notion of 'eco-efficiency,' in the context of the CE. Deliverable 3.3 concluded by suggesting that the multi-dimensional nature of the CE concept clearly dictates that 'efficiency' is redefined beyond narrow financial terms and the simple maximising of production and/or minimising of costs.

The aim of this report is to build on and expand this line of argument by reviewing the principal approaches that might be utilised to understand ***economic performance*** more broadly, and in ways that are consistent with the economic, environmental, and social goals described by the CE's proponents. It is envisaged that the approaches explored in this report might be used in combination with other approaches to form a more accurate and balanced view of economic performance in the context of the Circular Economy. This report will examine approaches that have already been applied in real-world case studies to date, as well as the lessons that can be drawn from this. The scope has deliberately been confined to macro-level approaches (i.e., focusing on the economy as a whole) given the content of deliverables in adjacent work packages of the ReTraCE project.

Table 1 below provides an overview of the approaches that will be covered in the report. These have been classified into three pillars reflecting the multi-faceted nature of the CE: resource efficiency, environmental sustainability, and well-being/social welfare. As will be detailed more in what follows, we have focused on approaches that have been developed by governments and high-profile international organisations and where, as a result, there is a relevant track-record to examine. As Table 1 suggests, many of these indicators are applicable to more than one pillar. However, we have classified them to one of the three pillars based on the main issues that they address.

Table 1- Approaches covered in the report (by pillar)

	Resource efficiency	**Environmental sustainability**	**Wellbeing**
Eurostat Resource Efficiency Scorecard (Section 3)	✓✓	✓	
National Circularity Gap (Section 3)	✓✓		
OECD Green Growth Indicators (Section 3)	✓✓	✓✓	
Sulphur Dioxide emissions (Section 4)		✓✓	
Sustainable development indicators (Section 4)	✓	✓✓	✓
Environmental Performance Index (Section 4)		✓✓	✓
Beyond GDP indicators (Section 4)		✓✓	✓
Gross National Happiness Index (Section 5)		✓	✓✓
Canadian Index of Wellbeing (Section 5)		✓	✓✓
Genuine Progress Indicator (Section 5)		✓	✓✓
European Social Progress Index (Section 5)		✓	✓✓
Size of the Informal Economy as a percentage of GDP (Section 5)			✓✓

✓✓: highly relevant, ✓: relevant

In terms of structure, Section 2 begins with a short discussion of 'conventional' or 'linear' conceptions of economic performance – centred on GDP and 'eco-efficiency' – and the limitations of these approaches. Sections 3, 4 and 5 then introduce approaches that focus on resource efficiency, environmental sustainability, and well-being respectively, as well as the case studies where these approaches have been applied. Finally, Section 6 discusses the suitability of the various approaches vis-à-vis assessing the economic performance of the CE and suggests avenues for future research.

2. Approaches relevant to a linear economy

2.1. Efficiency and Gross Domestic Product

Economic efficiency constitutes one of the two defining elements of an economy's performance – along with economic growth – and its measurement has strong political implications (Bimpizas-Pinis *et al.*, 2021). The notion of economic efficiency serves as a driving force, particularly in capitalist societies, as it provides guidance to allocate resources both in the private and in the public sphere (Zerbe, 2002). The idea behind efficiency is to allocate resources in a way that achieves a state of market equilibrium following the Pareto optimality principle (Zerbe, 2002; Krugman and Wells, 2015).

The pressure to operationalise efficiency and to improve the general performance of the economy, created a need for an indicator that could measure the progress of the economic system. This need has been satisfied by the use of GDP (Coyle, 2015; Stiglitz *et al.*, 2020). GDP is a measure often deployed to evaluate economic performance at the national level. The aim of GDP is to calculate the monetary value of the total goods and services produced, stored, and exchanged in a certain country over a year. The Organisation for Economic Co-operation and Development (OECD) defines GDP as "an aggregate measure of production equal to the sum of the gross values added of all resident and institutional units engaged in production and services, plus any taxes, and minus any subsidies, on products not included in the value of their outputs" (OECD, 2021). The notion of GDP was developed in the decade of the 1940's due to the need to better monitor the state of the economy and to design policies for the economic recovery after the crisis of 1929, and to assess the capacity of governments to raise taxes to fund the cost of World War 2 (Coyle, 2015). The first precedents to measure national spending were developed between the 1930s and 1940s in the United States by Simon Kuznets, in the United Kingdom by Colin Clark, and in the Netherlands by Jan Tinbergen, and the first calculation of GDP was developed by Richard Stone and James Meade in 1941 in the UK (Coyle, 2015). The need to recover European economies after World War 2 motivated policymakers to keep developing GDP statistics. These statistics were key to properly plan taxation systems, and to develop Keynesian policies to boost economic growth (Coyle, 2015). After the war, the use of GDP as a measure of progress was promoted, and its growth became linked with the creation of employment, rising incomes, and other amenities to promote social stability (Costanza *et al.*, 2014; Schmelzer, 2015; Fioramonti, 2017). Nowadays, GDP is used as a key indicator to measure economic performance, guiding macro-economic governmental policies, and its growth has become a policy objective itself within capitalist societies (Landefeld *et al.*, 2008; Fioramonti, 2017).

There is an ongoing debate around the adequacy of GDP and to measure economic performance. GDP has been criticised because it disregards several important elements such as environmental externalities and social equity (Bimpizas-Pinis *et al.*, 2021), and it simplifies output in merely monetary terms (Coyle, 2015). Furthermore, it ignores the contribution of the informal economy and non-monetised activities(van den Bergh, 2009; Stiglitz *et al.*, 2020). As a result, the welfare of people and nature is ignored, which can result in significant bias in associated economic analyses. As an example, the exclusion of the informal economy in the context of the household services sector introduces a gender bias, since these services are disproportionately performed by women (Waring, 1988, 2003; Benería, 1992). Despite these critiques, the correlation between economic growth and rising living conditions of the general public after WW2 consolidated the centrality of GDP, and it remains as the most relevant indicator to influence economic policies (Costanza *et al.*, 2014; Schmelzer, 2015; Fioramonti, 2017).

The CE, as it is conceived by the EU, still relies on GDP as the basic indicator for economic performance. One of the main expectations of the CE is the reconciliation of economic growth and environmental sustainability by decoupling growth from environmental impact. In this view, it is assumed that economic growth (GDP growth) is a societal need (Institut Montaigne, 2016). As a result, the implementation of the CE is seen as a way to not only preserve, but even further increase GDP (McCarthy *et al.*, 2018). The growth of GDP is acknowledged in most of the national CE strategies. For example, the first page of the CE Action Plan of the EU acknowledges that the implementation of the CE has the potential to increase the EU GDP by 0.5% by 2030 (European Commission, 2020a). Therefore, GDP has such centrality that it is a policy objective itself within the CE ambitions of the EU. There have been attempts, besides GDP, to measure the performance of the economy. Most of those attempts emerge from explicit political attempts to either replace or complement GDP, or from the need to measure new economic and social goals beyond productivity. This report analyses and compares alternative indicators that aim to supplement GDP, to assess economic performance.

2.2. Eco-efficiency

Eco-efficiency was coined and popularised in the early 1990s by Stephan Schmidheiny (1992) following the proceedings of the United Nations Conference on Environment and Development (UNCED). The term has been developing as a concept of divergent yet overlapping discourses (Huppes and Ishikawa, 2005). Though the academic proponents of an early version of the concept can be traced back to the 1970s (Freeman *et al.*, 1973; McIntyre and Thornton, 1978), the starting point is considered to be the formal definition provided by the World Business Council for Sustainable Development (WBCSD, 2006):

> *"Eco-efficiency is achieved by the delivery of competitively-priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life-cycle to a level at least in line with the earth's estimated carrying capacity."*

Moving away from the normative overtones of Schmidheiny's (1992) entrepreneurial conceptualisation lens that combined the ideas of economic growth with environmental protection, Huppes and Ishikawa (2005) focused on the measuring frameworks related to the concept of eco-efficiency. Identifying the common ground of extant definitions around the ratio of environmental impact and value of production, the authors re-defined eco-efficiency as an overarching concept that comprises four different basic variants (Table 2). Looking at the table, the key distinction between these variants lies in the shift of focus from the creation of value (in terms of production) to the reduction of environmental impact (in terms of environmental improvement).

Table 2 - Four basic types of eco-efficiency (Adopted by Huppes and Ishikawa, 2005)

	Product or production primary	**Environmental improvement primary**
Economy divided by environment	Production value per unit of environmental impact, or *environmental productivity*	Cost per unit of environmental improvement or *environmental improvement cost*
Environment divided by economy	Environmental impact per unit of production value, or *environmental intensity*	Environmental improvement per unit of cost, or *environmental cost-effectiveness*

However, as Korhonen et al. (2018) aptly point out, due to the occurrence of rebound effects, the overall idea of economic growth inherent in eco-efficiency offsets the environmental gains associated with extending product life or closing material loops. According to Zink and Geyer (2017), CE rebounds can be mainly attributed to two factors, namely insufficient substitutability and price effects. Insufficient substitutability relates to the lower demand for CE (secondary) goods (i.e., recycled, or refurbished products) due to perceived inferior quality compared to their primary production counterparts, or otherwise lower consumer desirability. On the other hand, price effects pertain to the potential impact of the increased number of secondary goods on prices. The lower costs associated with secondary production will potentially result in an increased income for secondary producers. However, the uncertainty surrounding the choice of how and where this excess income will be spent, can have unpredictable results. In both instances, the lower-per-unit production impact of CE activities result in increased levels of primary production goods, thus offsetting the environmental appeal of the CE concept. In detail, the substitutability effect leads to increased primary production not only due to lower perceived quality but also the inability to support a second-hand market in view of the rapid rate of technological evolution. On the other hand, the price/income effect will generate an increased demand for both the product and its substitutes as the (lower) purchasing cost of a secondary good will result in a new state of market equilibrium of a higher quantity and a lower price.

Differentiating from and extending the traditional producer-consumer perspective of resource use (Zink and Geyer, 2017), Figge et al. (2021) identified the occurrence of "symbiotic rebound". The latter rebound framing moves away from the mechanism of consumer demand as a driver of the rebound effect and focus on the issue of opportunity costs among firms in the form of "either-or" choice which, depending on time, may or may not lead to a higher rate of circularity (Figge and Thorpe, 2019). Referring to the business choice between recycle and reuse, this symbiotic rebound effect pertains to the foregone benefit to the expected benefit due to changes in respective circular flows.

While the traction that the concept of the CE has gained has driven the development of eco-efficiency related indicators aimed at taking into consideration environmental externalities, they fail to capture the aforementioned undesirable rebound effects (Lonca *et al.*, 2018). The occurrence of these rebounds not only showcases the timeliness of the Jevons Paradox - higher rate of resource efficiency leading to higher resource consumption - but also reveals its entanglement with the dominant free-market economic system. The problematic nature of neoclassical economics which has methodically led to the "commodification and monetisation of ecosystem services" (Martins, 2016), the prevalence of consistently rational and narrowly self-interested *homo economicus* (Dixon, 2010), and the unconditional pursuit of economic growth (Schmelzer, 2015) expose the problematic nature of eco-efficiency. The only sufficient and necessary condition towards a non-superficial version of the CE is the displacement of primary production; moving away from the idea of profit-driven economy and going towards planning according to societal needs (Zink and Geyer, 2017).

2.3. The indicators analysed

In seeking to move beyond the traditional conceptions of performance such as GDP and eco-efficiency a range of indicators have been classified according to three pillars (resource efficiency, environmental sustainability, and well-being) that in concert reflect the multifaceted nature of the CE. The use of different indicators to assess economic performance could impact how the economy is understood and have implications for major public decisions and policies. In the following sections, a range of alternative approaches to understanding economic performance are reviewed, along with an exploration of why these approaches were created, how they are calculated, and the implications of their use.

Although there is vast literature on possible indicators and attempts to measure economic performance, this report focuses on indicators that are being developed or implemented by governments or other kinds of international organisations. Different examples of indicators or models that assess economic performance are reviewed from the perspective of the three pillars used to classify the approaches. In total, 12 indicators are selected that provide different visions of how to assess economic performance.

It is important to note that although these indicators have been assigned to one of the three pillars, in reality, most of these indicators are relevant to multiple pillars. For example, among the wellbeing-centred approaches, the calculation of both the Gross National Happiness Index and the Canadian Index of Wellbeing, require the use of data and statistics related to the protection of ecosystems. Therefore, although most of the elements that compose the approaches measure wellbeing, in reality, these approaches are complex and are relevant to more than one pillar.

3. Macro-Level Approaches to Resource Efficiency

In the CE literature, different methods and indicators are used to capture the notion of economic performance. Resource efficiency in particular has been given much attention for increasing circularity. In this section, we have put together the indicators and platforms that have been used to evaluate resource efficiency at the macroeconomic level in the context of the CE. We have focused on newly developed frameworks such as EU Resource Efficiency Scoreboard, OECD Green Growth Indicators, and indicators specified for CE studies (National Circularity Gap).

3.1. National Circularity Gap

3.1.1. Why was the National Circularity Gap created?

Aguilar-Hernandez et al. (Aguilar-Hernandez *et al.*, 2019) conduct a study focusing on waste recovery and environmental stock depletion. The aim is to quantify the unrecovered waste that can be potentially circulated back into the economy as either materials or products. By calculating circularity gap per capita, the trends of unrecovered waste in each country and region could be identified. Using that and absolute values of circularity gap, such analysis can help to understand which actions can be applied to contribute to CE policies in each region to reduce circularity gap by increasing waste recovery, decreasing waste generation, or reducing stock depletion.

3.1.2. How is the National Circularity Gap measured?

National circularity gap is defined as the combination of generated waste, old materials removed from stocks and durable products disposed (i.e., stock depletion), minus recovered waste across the country. Therefore, the formula for circularity gap index (CGI) is:

$$CGI = \frac{W_{sup} + S_{dep} - W_{rec}}{W_{sup} + S_{dep}}$$

where W_{sup} represents the waste generated that requires further treatment to be disposed, S_{dep} represents stock depletion or amount of materials and durable products that were previously disposed, and W_{rec} represents the amount of waste recovered or recycled back into the economy. *CGI* ranges between 0 to 1 where, with 0 means the best performance and 1 the worst performance in recovering waste.

3.1.3. Where has the National Circularity Gap been applied?

With the help of the EXIOBASE v3.3 database, the circularity gap of 43 nations is estimated with the data available in 2011. Using the results, the researchers present ways to reduce the circularity gap of a country via strategies such as product lifetime extension, closing supply chain loops, increasing resource efficiency, and residual waste management. Moreover, using data available for GDP and purchasing power parity of countries, they perform a regression analysis to analyse the relation between circularity gap index and income groups of each country.

There are a few points that are worth mentioning about this approach. First, *CGI* is developed by Aguilar-Hernandez et al. (2019) to specifically analyse waste recovery at the national level. If it expands into measuring and managing the recovery of other materials such as rare earths, industrial and construction minerals, iron and ferroalloy metals, precious metals and biomaterials (or at least the materials that have considerable environmental or economic impacts), it will certainly contribute to a higher degree of circularity. Second, in calculation of *CGI*, nothing is mentioned about material losses, quality, or recycling efficiency rates. We believe that these factors play an important role in recovery and recycling activities of any kind. It will be an improvement for this indicator if these factors could be added to the data collection and calculation process. Third, the focus on *CGI* and similar indicators is merely on improving material circularity and resource productivity. The main drawback of such approaches is their failure to address environmental and social impacts that are associated with decreasing *CGI*. As we discussed at length in D3.3, improvements in circularity indicators in developed and industrialised countries might offset serious environmental and social degradation in developing and non-industrialised countries around the world. Comprehensive analysis, especially at the national and regional level, is required to verify the positive impacts of improving indicators such as *CGI*.

3.2. EU Resource Efficiency Scoreboard

3.2.1. Why was the EU Resource Efficiency Scorecard created?

The Resource Efficiency Scoreboard is a composite indicator designed by the European Commission to map the progress mainly to improve the use of natural resources amongst the EU members individually and the EU as a whole. This tool comprises a set of indicators that are commonly used by the members of the EU to support the political actions and goals set by the Roadmap to a Resource Efficient Europe to transform the Europe's economy into a sustainable one by 2050 (European Commission, 2011). The main purpose behind developing such a framework is to monitor the trend for increasing resource productivity and decoupling economic growth from resource use and the related environmental impacts.

3.2.2. How is the EU Resource Efficiency Scorecard measured?

This framework follows a three-tier system in which indicators fall into three categories:

1. a lead indicator which focuses on resource productivity.
2. a dashboard of indicators which focus on carbon, water, and land.
3. a set of theme-specific indicators which focus on different subjects such as economy, air, waste management, etc.

Resource productivity measures how efficiently materials are used to produce products and services. If the growth rate of resource productivity is higher than the growth rate of GDP during the same period, then it can be deduced that decoupling of resource use from economic output has happened during the reporting period.

As mentioned before, the Resource Efficiency Scoreboard is a composite indicator which combines 32 different indicators. The Table 3 shows the main indicators that are focused on the macroeconomic aspect of resource efficiency and the way they are measured.

Table 3 - Main indicators of EU Resource Efficiency Scoreboard

Indicator	Definition	Interpretation
Resource productivity	GDP/DMC	economic value generated per kg of raw material consumption
DMC per capita	DMC/pop	raw material consumption per capita
Artificial areas productivity	GDP/TAA	economic value generated per unit of built up and non-built up land
Build up areas	TBA/TNA	percentage of artificial land development over total national area
Water exploitation index	TFWA/LAAW	evaluates the sustainability of water abstraction compared to water availability
Water productivity	GDP/TFWA	economic value generated per cubic metre of fresh water abstracted
GHG emissions per capita	GHGE/pop	volume of GHG emissions per capita
Energy productivity	GDP/EC	economic value generated per unit of energy consumed
Energy dependence	EI/GIEC	reliance on energy imports to satisfy domestic energy consumption
Share of renewable energy in gross final energy consumption	REG/GIEC	proportion of energy consumption that is met from renewable energy sources

GDP: Gross Domestic Product, DMC: Domestic Material Consumption, pop: population, TAA: Total Artificial Area, TBA: Total Built up Area (roofed constructions), TNA: Total National Area, TFW: Total Fresh Water Abstracted, LAW: Long-term Average Available Water, GHGE: Greenhouse Gas Emission, EC: Energy Consumption, EI: Energy Imports, GIEC: Gross Inland Energy Consumption, REG: Renewable Energy Generation

3.2.3. Where has the EU Resource Efficiency Scorecard been applied?

Resource Efficiency Scoreboard is the main tool to track the progress for implementation of Roadmap to a Resource Efficient Europe initiative (European Commission, 2011). Resource productivity, which is the main indicator used by the Resource Efficiency Scoreboard, has been recognised as the best available indicator for transition toward a more circular Europe by the European Commission's new CE action plan published in March 2020 (European Commission, 2020a).

3.3. OECD Green Growth Indicators

3.3.1. Why were the OECD Green Growth Indicators created?

Green Growth Indicators is a framework developed by OECD to help founding and supporting green growth policies by constantly monitoring the progress of each and all of its indicators. This framework comprises 26 different indicators to capture the main features of green growth.

This framework helps to track the progress of OECD and G20 countries towards achieving four main objectives:

- establishing a low-carbon and resource-efficient economy
- maintaining the natural asset base
- improving people's quality of life
- implementing appropriate policy to realise the economic opportunities of green growth

3.3.2. How are the OECD Green Growth Indicators measured?

OECD Green Growth Indicators is a theme-based framework. There are four themes embodied in this framework, however, only environmental and resource productivity of the economy is relevant to this section. Considering the indicators available in this theme, Table 4 contains the relevant information about each indicator and the way it is defined.

Table 4 - Selected relevant indicators of OECD Green Growth Indicators

Indicator	Definition	Interpretation
Production-based CO2 productivity	GDP/unit of energy-related CO2 emitted	economic value generated per unit of CO2 emitted
Demand-based CO2 productivity	RI/unit of energy-related CO2 in final demand	economic value generated per unit of CO2 emitted to satisfy domestic final demand
Energy productivity	GDP/TPES	economic value generated per unit of TPES
Material productivity	GDP/DMC	economic value generated per unit material consumed
Waste generation intensity and recovery ratios	Waste generated/GDP per capita	indicating the decoupling of waste generation from economic growth
Water productivity	Value added/unit of water consumed	economic value generated per unit of water consumed

GDP: Gross Domestic Product, RI: Real Income, TPES: Total Primary Energy Supply, DMC: Domestic Material Consumption

3.3.3. Where have the OECD Green Growth Indicators been applied?

OECD Green Growth Indicators serve as a tool to monitor the implementation of the Green Growth Strategy outlined a decade ago (OECD, 2011). This framework has been applied in several cities across the world, including Cebu, Philippines (OECD, 2017), Bandung, Indonesia (OECD, 2016), Stockholm, Sweden (OECD, 2013), to assess their situation based on green growth goals and agenda.

4. Macro-Level Approaches to Environmental Sustainability

Several attempts have been made to measure the environmental performance of the economy through the quantification of environmental elements based on the quality of natural resources such as water, air, and forests (Haab and McConnell, 2002; Lawn, 2003; Fairbrass *et al.*, 2020). While most of the approaches in this section focus on the environment, many are also used to represent other areas such as social and welfare aspects. For instance, the Beyond GDP and Sustainable Development Goal (SDG) approaches cover a wide spectrum and target areas such as gender equality and education. However, only the parts of the approaches that focus on environmental aspects are explored in this section. In addition, the Environmental Performance Index (EPI) approach and the volume of sulphur dioxide (SO_2) emissions are reviewed. It can be argued that these environmental approaches are multi-dimensional since the status of the environment has implications on the welfare of society.

Several other approaches exist to quantify the environmental aspects of the environment, such as the climate change performance index, greenhouse gas emissions, consumption of ozone depleting substances (ODS), Nitrous Oxide emissions, intensity of municipal waste generation, intensity of waste disposal, intensity of water usage, intensity of forest usage, intensity of fish stock depletion, intensity of energy usage and the number of threatened species. However, they were not reviewed in further detail, as they overlap with the approaches explored in this section. While there is also some overlap among the combination of approaches presented in this section, they also emphasise unique, non-overlapping, elements of the environment.

4.1. Total Amount of Sulphur Dioxide Emissions

4.1.1. Why was this indicator created?

SO_2 can have adverse effects on soil, water, and air quality, by depositing acids. This can be detrimental to human health as it can lead to breathing difficulties by worsening asthma conditions and provoking respiratory tracts (European Environment Agency, 2010). The acid also damages aquatic ecosystems and vegetation, crops, and forests. As such, monitoring this indicator is important to ensure any interventions intended to reduce SO_2 emissions are having the desired effect. Several other emissions can be harmful to the environment too and are useful to monitor. However, most of them are included within greenhouse gases, such as Carbon Dioxide, Methane, and Nitrous Oxide, which are monitored by other approaches presented later in this study. Since SO_2 emissions are not considered as one of the main greenhouse gases, and since case study applications of this indicator were found, it is explored here separately.

4.1.2. How is this indicator measured?

In Europe, the standard reference method EN 14791 is used to calculate this by adopting a wet-chemical method (Pellikka *et al.*, 2019). This is where a solution that contains hydrogen peroxide absorbs flue gases containing SO_2. The solution is subsequently sampled and analysed as Sulphates. Alternative techniques are also being explored, such as Fourier-transform infrared (FTIR) spectroscopy, non-dispersive infrared (NDIR) and ultraviolet-fluorescence (UV) techniques, which may replace the current standard reference method.

4.1.3. Where has this indicator been applied?

Although now discontinued, this indicator had been adopted by the European Environment Agency (EEA) to monitor the progress of national interventions to directly, or indirectly, reduce SO_2 emissions among several European countries (European Environment Agency, 2010). The implementation of SO_2 related interventions led to an 82% decrease in Sulphur Oxide emissions in European Economic Area (EEA) countries between 1990 and 2017 (European Environment Agency, 2019).

This indicator is also part of the framework of national level indicators adopted by China to measure and benchmark the implementation of the CE (Geng *et al.*, 2012). However, the implementation of the CE monitoring framework in China is criticised for not establishing a standardised process or detailed information of its calculation, with concerns it could lead to inconsistencies in the way it is evaluated in different regions of China.

4.2. Sustainable Development Indicators

4.2.1. Why were the Sustainable Development Indicators created?

The UN 2030 agenda for Sustainable Development aims to eliminate inequalities, end poverty, and improve welfare through the adoption of 17 Sustainable Development Goals (SDGs) and 169 targets.

From an environmental perspective, SDG 13 concerning climate change may be relevant since the impacts of climate change are often excluded in conventional estimations of economic performance, when producing and consuming products and services; yet, in the context of the CE, where environmental and social elements are important, the impacts to climate change could be pertinent. Other relevant SDGs are clean water and sanitation (SDG 6), affordable and clean energy (SDG 7), sustainable cities and communities (SDG 11), life below water (SDG 14) and life on land (SDG 15).

4.2.2. How are the Sustainable Development Indicators measured?

In order to track the progress of the EU against the SDGs, a set of 100 indicators were proposed, representing the Sustainable Development Indicators (SDIs), where each SDGs consists of several indicators. Appendix 1 outlines the indicators used by the EU for the SDGs relevant to the environment.

4.2.3. Where have the Sustainable Development Indicators been applied?

Although the SDGs have been adopted by 193 countries around the world, the indicators presented in Appendix 1 represent the indicators adopted by the EU to measure its progress against the SDGs. The indicators are evaluated annually and are supplemented by regular publications of the SDG Monitoring Report by the EU, which evaluate trends based on the average annual growth over the prior five years, and where data is available, longer term trends over 15 years (Eurostat, 2020). Although this list of indicators is correct at the time of writing, the EU recently conducted a review of the SDG indicators and outlined their intention to publish an updated list of indicators in 2021, in order to incorporate indicators from new sources and consider the direction of new EU priorities (European Commission, 2021b).

The SDGs are monitored by several nations outside of the EU through the global indicator framework, adopted in 2017, and proposed by the UN Inter-agency and Expert Group on SDG Indicators (IAEG-SDGs). The EU's SDG indicator framework is derived from the global indicator framework and they are largely identical, with some modifications to reflect the priorities of the EU. Other nations and regions also have the flexibility to complement the global indicator framework with other indicators. However, while it is a benefit to allow nations and regions to have the flexibility to modify parts of the framework, it limits the ability to make a full comparison among all countries for all indicators.

4.3. Environmental Performance Index (EPI)

4.3.1. Why was the EPI created?

EPI measures the health of a country's environment and the vitality of a country's ecosystem through 32 measures in 11 categories, related to environmental health or ecosystem vitality (EPI, 2020). It aims to monitor trends, identify problems, and highlight best policy practices, while supporting the UN SDGs. The EPI represents a collaboration between Yale University, Columbia

University, and the World Economic Forum, and has been in operation since 2006, when it replaced the Environmental Sustainability Index. Given that conventional conceptions of economic performance overlook environmental and social aspects, the EPI could represent a useful addition, especially in the context of the CE.

4.3.2. How is the EPI measured?

EPI is calculated using a score between 0 and 100 and is assessed every two years. It represents a composite index based on the scores of the 32 variables within the EPI framework. The 32 variables that produce the EPI represent several aspects including greenhouse gases, other types of air pollution such as particulate matter, water and sanitation, waste management, deforestation, and animal welfare (EPI, 2020).

Each variable is scored using the below formula, where X represents a country's value, B is the target for best performance, and W is the target for worst performance.

$$(X - W) / (B - W) \times 100$$

The scores are capped at 0 and 100 and prevent outliers from significantly influencing the values. The scores are then weighed and aggregated into an overall EPI score for each country. The weights used are based on a mix of subjective judgement, global trends and data quality.

4.3.3. Where has the EPI been applied?

In 2020, the EPI framework was applied to 180 countries. Table 5 displays the top 10 countries. Denmark took the top position with a score of 82.5, narrowly beating Luxembourg's score of 82.3. Switzerland took the third position with 81.5. All countries in the top 10 are from Europe, with Luxembourg increasing its score more than any other country in the top 10 over the last 10 years. Japan was the highest-ranking country outside of Europe in 12th position with a score of 75.1.

The biggest increase in EPI score in the past 10 years was achieved by Bahrain, increasing its score by 17.3 to reach a score of 51 in 2020. While the biggest decrease was achieved by Vanuatu, which dropped by 11.9 over the past 10 years to a score of 28.9 and a rank of 163.

The EPI has been beneficial in terms of the large number of countries where it has been applied. However, some countries are missing from the evaluation due to a lack of quality data, which represents a minor drawback. Furthermore, the methodology to calculate the EPI has evolved multiple times since its inception. Finally, the weights used to calculate the EPI score are partially based on subjective judgements, which may not be entirely reliable.

Table 5 - Top 10 countries by EPI score (EPI, 2020)

Rank	Nation	Score	10 year change

1	Denmark	82.5	7.3
2	Luxembourg	82.3	11.6
3	Switzerland	81.5	8.6
4	United Kingdom	81.3	9
5	France	80	5.8
6	Austria	79.6	5.4
7	Finland	78.9	6
8	Sweden	78.7	5.3
9	Norway	77.7	7.6
10	Germany	77.2	1.2

4.4. Beyond GDP indicators

4.4.1. Why were the Beyond GDP indicators created?

The set of Beyond GDP indicators is inclusive of environmental related issues and human health, as well as social issues (European Commission, 2021c). They were initially proposed at a conference in 2007 following a collaboration between the European Commission, European Parliament, Club of Rome, OECD and WWF (European Commission, 2021a). The indicators in the Beyond GDP framework are categorised into four groups: enlarged GDP, social, environmental and welfare aspects. Many of the indicators overlap multiple groups. Two of the indicators from the Beyond GDP framework are explored on the basis that they belong exclusively to the environmental group and have sufficient information to be reviewed.

4.4.2. How are the Beyond GDP indicators measured?

The first indicator from the Beyond GDP framework to be explored is Ecological Reserve, which measures the amount of nature used (i.e. ecological footprint), in comparison to the amount of nature available (i.e. biocapacity) (Global Footprint Network, 2021). Ecological Footprint is calculated by adding up all the demands for biologically productive space measured in global hectares and is contrasted with biocapacity (European Commission, 2018). Some examples of biologically productive spaces include forests, fisheries, and grazing land. In this context, the application of the Ecological Reserve indicator is considered at a country level, but it can also be applied at a regional, city, individual or product level too.

The second indicator from the Beyond GDP framework is Natural Capital Index (NCI), which measures the impact of humans on biodiversity and calculates the amount of remaining biodiversity (European Commission, 2007). It is defined as the product of two percentages, ecosystem quantity (%) and ecosystem quality (%).

4.4.3. Where have the Beyond GDP indicators been applied?

Ecological Reserve is calculated for 188 countries and published by the Global Footprint Network. Table 6 displays the 10 countries with the highest ecological reserve (i.e., the percentage that biocapacity exceeds ecological footprint), according to the most recent snapshot in 2017, with countries from Africa and South America taking all 10 positions.

Table 6 - 10 countries with highest ecological reserve (Global Footprint Network, 2021)

Rank	Country	Ecological Reserve
1	French Guiana	3,950%
2	Suriname	2,930%
3	Guyana	2,090%
4	Gabon	888%
5	Congo	738%
6	Central African Republic	540%
7	Bolivia	402%
8	Congo, Democratic Republic of	234%
9	Paraguay	218%
10	Eritrea	212%

In contrast, the countries with the highest ecological deficit (i.e., the percentage that ecological footprint exceeds biocapacity) were Singapore, Bermuda and Réunion, with 10,300%, 5,610% and 2,580% respectively.

A great advantage of the ecological reserve/deficit indicator is that a rich dataset allows a large number of countries to be measured and compared, and the data are validated to ensure they are of sufficient quality. However, due to the quality assurance, data for some countries are excluded. As such, not all countries are accommodated in the dataset. Furthermore, at the time of writing, the latest available data is for 2017, which is a few years old.

The NCI framework, on the other hand, has been applied to the Netherlands, where it was calculated for the country's natural aquatic and terrestrial ecosystems (European Commission, 2007). In terms of quantity, these ecosystems had declined to 40%, with a quality of 44%, producing an NCI value of 18%.

A disadvantage of the NCI framework is that it can be confused with competing indicators that share the same name, such as the new indicator recently announced by the World Bank (Natural Capital Project, 2020) , the index applied to Hungary by Czúcz et al (2008), or the framework presented by Fairbrass et al (2020), each with their own methodologies to measure natural capital. Furthermore, there appear to be very limited applications of the methodology from the Beyond GDP framework, yet the World Bank is attempting to be ambitious with its index and intends to measure many countries on a regular basis (Natural Capital Project, 2020).

However, the wider Beyond GDP framework could see more applications in the future, as EU leaders recently announced plans to only consider Beyond GDP as the measure of economic success to ensure that the welfare of citizens is prioritised (European Trade Union Confederation, 2021).

5. Macro-Level Approaches to Wellbeing

Several attempts have been made to create indicators to measure the performance of the economy from a wellbeing perspective. The general aim of these indicators is to quantify the economic performance of a country based on the social satisfaction, operationalising elements as wellbeing, equity, or happiness, among others. The fact that the presented indicators are mostly focused on wellbeing does not mean that they exclusively focus on wellbeing. In fact, most indicators are composite indexes that are composed of several indicators, offering a holistic picture of the performance of the economy, including environmental impact, income distribution, or living conditions. The criteria to decide whether indicators should be included or discarded is by looking at what indicators had been adopted by a governmental agency, and therefore, its implementation can be either reviewed or not. Consequently, many indicators that also calculate performance from a wellbeing perspective were not included in this section, for example, the Happy Planet Index (HPI) (Happy Planet Index, 2012), World Happiness Index (WHI) (Carlsen, 2018), National Wellbeing Index (NWI) (Kahneman *et al.*, 2004; Diener and Seligman, 2006), or the Index of Individual Living Conditions (Noll, 2002; Krishnan, 2015).

Finally, for this section, we included Gross National Happiness (GNH), the Canadian Index of Wellbeing (CIW), the Genuine Progress Indicator (GPI), the European Social Progress Indicator (ESPI) and the size of the informal economy. The main reason to include these indicators is because all these indicators had been developed and implemented to a certain territory, including international organizations (as the ESPI at all the EU countries), individual nations (as the CIW in Canada, or the GNH in Bhutan), sub-national divisions (as the GPI at several states of the USA). Meanwhile, the size of the informal economy was included because it can be used to represent important social elements such as gender equality and the extent of child exploitation.

5.1. Gross National Happiness (GNH) Index

5.1.1. Why was the GNH created?

The GNH index was created under the assumption that sustainable development should take a holistic approach towards notions of progress and give equal importance to non-economic aspects of wellbeing (Thinley, 2012; Ura *et al.*, 2012). The GNH served as a guiding philosophy for Bhutan's governance based on nine domains (Ura *et al.*, 2012):

- Psychological wellbeing
- Health
- Education
- Time use
- Cultural diversity and resilience
- Good governance
- Community vitality
- Ecological diversity and resilience
- Living standards

By using these nine domains, the GNH aims to orient the country towards happiness by assessing the presence of the conditions that generate unhappiness. The novelty of GNH is that instead of measuring aggregate happiness or average happiness, it aims to measure how members of the population, in this case Bhutan, reach a 'sufficient level' in a set of dimensions. The underlying assumption of GNH is that the ability of people to be happy depends on meeting a range of minimum conditions (Bates, 2009).

5.1.2. How is the GNH measured?

The aggregation method is a version of the Alkire-Foster method (Alkire and Foster, 2011). The index is aggregated out of 33 clustered (grouped) indicators. Each clustered indicator is further composed of several variables. When unpacked, the 33 clustered indicators have 124 variables, the basic building blocks of GNH Index. Weights attached to variables differ, with lighter weights attached to highly subjective variables. A threshold or sufficiency level is applied to each variable. At the level of domains, all the 9 domains are equally weighted as they are all considered to be equally valid for happiness (Adler, 2009; Braun, 2009).

5.1.3. Where has the GNH been applied?

The GNH Index is an indicator that has been implemented in Bhutan, as a personal decision of the 4th King of Bhutan, King Jigme Singye Wangchuck, in 1972. The GNH index is used as an indicator to assess Bhutan's policy performance and it has been even acknowledged in the national Constitution. The GNH was promoted as an alternative to GDP to promote an alternative political philosophy to GDP, and Bhutan's government is guided by this index to assess its performance. This approach allowed for a stronger focus on wellbeing and a more careful attention to its development that allowed for a stronger environmental preservation (Bates, 2009). Since 2011, the UN General

Assembly has been calling to other world nations to follow Bhutan's example and to measure happiness and well-being, although no other nation has followed this call so far.

GNH is an indicator that measures economic performance on elements alternative to production, overcoming the disadvantages of GDP on the economic policy debate and providing a more human measurement to economic performance than GDP (Thinley, 2012; Brooks, 2013; Tideman, 2016; Laczniak and Santos, 2018). However, the main weakness of using a happiness-based indicator is that happiness is a contextual, and culturally shaped notion that is understood differently across different contexts (Alesina *et al.*, 2001). Another of the criticisms of GNH is that it is only used in Bhutan, and there is a lack of available data across the world to perform cross-country comparisons (Veenhoven, 2007; Laczniak and Santos, 2018).

Although Bhutan does not have an explicit CE policy, and there are no cases where the GNH has been applied as an indicator to measure performance of CE practices, the political impact of GNH index had important implications for the sustainability performance of Bhutan, as it enhanced a more convivial perspective to develop the economy and to interact with the environment (Thinley, 2012; Tideman, 2016). We can easily hypothesise that the adoption of an indicator as the Bhutanese GNH could support the adoption of a CE model with a stronger focus on wellbeing and a development model more equilibrated with other needs than just production (Brooks, 2013; Tideman, 2016).

5.2. Canadian Index of Wellbeing (CIW)

5.2.1. Why was the CIW created?

The CIW aims to create a holistic measurement and track of Canadians' overall "wellbeing". This indicator was created within the Faculty of Applied Health Sciences at the University of Waterloo with the aim to generate a national, broad-based, and balanced instrument to show the public the evolution of wellbeing, in all of its possible dimensions. The second reason to generate this indicator was the misuse of GDP as a portrait of the economic performance of Canada (Graham, 2015; Canadian Index of Wellbeing, 2021b).

The CIW was designed as a tool to provide information, to allow key societal figures, as policymakers, media, NGO's, and citizens, to use to get the latest trend information on the wellbeing of Canadians in an easily understandable format (Canadian Index of Wellbeing, 2021b).

5.2.2. How is the CIW measured?

To calculate CIW, a set of 64 different indicators are extracted from data sources provided by Statistics Canada. These indicators are grouped in 8 different domains; Community Vitality, Democratic Engagement, Education, Environment, Healthy Populations, Leisure and Culture, Living Standards, and Time Use (Michalos *et al.*, 2011; Morgan, 2011). With many of the indicators measured in very different ways, a first step is to set each indicator to a value of 100 at the base year. Percentage changes are then calculated for each subsequent year with positive reflecting some improvement in wellbeing while negative percentage changes indicate a deterioration. This approach applies to all 64 indicators as well as the eight domains, and ultimately, the CIW composite index (Michalos *et al.*, 2011; Canadian Index of Wellbeing, 2021a).

5.2.3. Where has the CIW been applied?

The CIW is an indicator that is calculated only in Canada. Its creation is a citizen-led initiative that started at the Atkinson Charitable Foundation (ACF), in 1999, when a group of Canadian experts posed the question: "What would it take to create a tool that truly measured Canadian wellbeing?" In 2010, the ACF ceased calculating the CIW, which has been calculated and monitored by the Faculty of Applied Health Sciences at the University of Waterloo since 2011.

The CIW has been used in Canada, together with GDP, to provide a different perspective to decision-makers on the main problems and challenges that the Canadian society faces (Canadian Index of Wellbeing, 2021b). Although GDP has not been completely replaced, its use, accompanied by CIW provides a more nuanced vision on the performance of Canadian society other than how much the country produces. This led to a stronger political attention to the elements and issues identified with the CIW (Graham, 2015). However, the use of the CIW index presents a set of challenges, such as the difficulty to have complete stocks of data, the potential redundancy and interconnectedness of the different sets of data of the indicator, and the cost to calculate this complex indicator (McKessock, 2013).

Although Canada does not have explicit CE strategies, it cannot be empirically assessed how a CE guided by the CIW can be different. However, by looking at the calculation method of the CIW, it can be hypothesised that the implications of measuring the performance of the CE by using the CIW could provide a stronger focus on elements, such as living standards, leisure, culture, community vitality and so on. Also, the CIW measures the environment and healthy populations, which are ambitions of the CE, and moves the focus outside of mere productivity. A CE under these criteria would likely involve a set of different ambitions and goals.

5.3. Genuine Progress Indicator (GPI)

5.3.1. Why was the GPI created?

The GPI has been created motivated by the lack of comprehensiveness of GDP, and the need to create metrics broader than GNI and GDP to provide an indicator that includes economic, environmental and social elements into a common framework and observe progress in a more comprehensive way (Asheim, 2000; Hanley, 2000; Talberth *et al.*, 2007). Thus, the creation of the GPI was an attempt to provide a more accurate measure of welfare and to gauge whether or not an economy is on a sustainable time path (Cobb *et al.*, 1995; Hamilton, 1999; Costanza *et al.*, 2004). In this context, GPI was built to provide a better picture than GDP and to support more sustainable and socially inclusive economic policies (Cobb et al., 1995).

5.3.2. How is the GPI measured?

The GPI consists of more than twenty aspects of economic lives that are ignored by GDP. The list was based on the data available by Cobb et al., (1995) on their common sense. These aspects are grouped in the following five categories (Hamilton, 1999):

- Built capital.
- Financial assets.
- Natural capital.
- Human capital.
- Social capital.

GPI adjusts for income distribution effects, the value of household and volunteer work, costs of mobility and pollution, and the depletion of social and natural capital. The GPI considers households as the basic building block of a nation's welfare, and thus begins its accounting exercise with personal consumption expenditures. To this the GPI adds benefits associated with welfare enhancing activities such as parenting, housework, volunteering, and higher education as well as the services which flow from household capital and public infrastructure. The GPI then deducts costs associated with pollution, loss of leisure time, auto accidents, destruction or degradation of natural capital, international debt and resource depletion (Cobb et al., 1995; Hamilton, 1999). The end result is an index that attempts to measure our collective welfare in terms of principles of sustainable development drawn from the economic, social, and environmental domains.

One of the main characteristics of GPI is that it considers income distribution. GPI values the increase in income to the poorer sectors of society more than the increase of income for the wealthier sectors of society. This difference in income valuation is justified as income inequality correlates with several social problems, such as higher rates of drug abuse, incarceration and mistrust, and poorer physical and mental health (Costanza *et al.*, 2004). However, GPI is also criticised by lacking robust valuation techniques, the lack of appropriate data to value many of its components that are assumed, as GPI measures the cost of non-monetised elements as the cost of crime, the cost of noise pollution, the cost of family breakdown, or the cost of lost leisure time (Lawn, 2003).

5.3.3. Where has the GPI been applied?

GPI has been estimated for several countries around the world, a few Canadian provinces, the state of Vermont legislated to adopt it, and other USA states have replicated it as well (Cha, 2012). The GPI is an indicator that has been developed in the state of Vermont. This state has been traditionally ruled by a very progressive political elite and it is the only state that legislated to mandate the use of GPI, although this indicator is also being calculated in other states in the USA and Canada (Talberth *et al.*, 2007; Hayden and Wilson, 2018). Just as CIW, GPI is used in combination with GDP to provide a nuanced vision to economic performance but without completely abandoning productivity.

The main political implication for the state of Vermont is the development of its Comprehensive Economic Development Strategy (State of Vermont, 2021). The Comprehensive Development Strategies have been developed in Vermont since 2014, and they allow a more holistic development of policy measures that do not exclusively aim for increasing productivity and it promotes alternative goals, such as resilience, environmental protection, and social equity (Cobb et al., 1995; Costanza *et al.*, 2014). Although Vermont does not have an explicit CE strategy either, the adoption of the GPI has the expectations to promote changes in how economic performance is measured, encouraging more environmentally and socially minded policymaking.

5.4. European Social Progress Index (ESPI)

5.4.1. Why was the ESPI created?

This indicator was developed to measure social progress as a complement to traditional measures of economic progress, such as the Gross Domestic Product (GDP). It is important to highlight that the ESPI has been created explicitly with the aim to complement and not substitute GDP (European Commission, 2020c). It was developed within the framework of the "Beyond GDP" discussion, and there have been only two editions, in 2016 and in 2020 (European Commission, 2016, 2020c). The ESPI is developed by the EU-SPI Pilot project, and funded by the European Commission to improve policy-making, in particular for policies supported by cohesion policy (European Commission, 2019).

5.4.2. How is the ESPI measured?

The Index measures social progress in European regions at the NUTS2 level, using twelve components that are further aggregated into three broader dimensions describing respectively basic, intermediate and subtler aspects of social progress.

- Basic Human Needs: Nutrition and basic medical care, Water and sanitation, Shelter, Personal security.
- Foundations of wellbeing: Access to basic knowledge, Access to information and communication, Health and wellness, Environmental quality.
- Opportunity: Personal rights, Personal freedom of choice, Tolerance and inclusion, Access to advanced education.

All the EU-SPI scores are calculated based on a 0-100 scale, with 0 meaning the worst performance, 100 the best, ideal performance. This scale is determined by identifying the best and worst global (possible) performance on each indicator by any region in Europe. This type of normalisation allows the EU-SPI scores to benchmark against realistic rather than abstract measures and track absolute, not just relative, performance of the regions on each component of social progress as described by the index (European Commission, 2020b).

5.4.3. Where has the ESPI been applied?

This indicator has been developed only in two series at the European Union (European Commission, 2016, 2020c) and it is still under development, also, there is not yet a set of literature discussing the implications of this indicator. The ESPI is an indicator that has been developed experimentally by the EC, but it has not been used yet as a system to measure economic performance, therefore, we lack empirical data to see its political impact. However, by reviewing its calculation methods, we can speculate that its use may shift the political attention of economic policy from productivism towards a stronger focus on wellbeing, guaranteeing basic human needs, and opportunities. Within Foundations of well-being, the ESPI also measures the environmental quality and health as two basic elements to be calculated. With a stronger focus on equity, environmental performance, and well-being, the ESPI has the untapped potential to influence the implementation of the CE at the EU by shifting away from the productivism approach and incentivizing policymakers to ensure a more holistic development model.

5.5. Size of the Informal Economy (as a percentage of GDP)

5.5.1. Why was this indicator created?

The informal sector was defined using the attributes of the economic units where individuals work, for instance where individuals are not registered, or where fewer than five permanent paid employees exist (International Labour Organization, 1993). To supplement this, the International Conference of Labour Statisticians (ICLS) defined the informal economy as labour that is outside the scope of mechanisms such as social protection, benefits including sick leave or annual leave, income taxation or labour legislation (International Labour Organization, 2003). Some specific examples of the informal economy include child employment and household services, such as domestic labour and care work.

5.5.2. How is this indicator measured?

Several studies have attempted to measure the size of the informal economy. While it is usually expressed as a percentage of GDP, the precise methodology to calculate the size of the informal economy is not unanimous, with studies attempting to use a variety of techniques such as structural equation modelling (Vuletin, 2008), Multiple Indicator - Multiple Cause (MIMIC) modelling (Arby *et al.*, 2010), and the Gutmann approach (Davidescu *et al.*, 2015).

5.5.3. Where has this indicator been applied?

Studies have attempted to measure the size of the informal economy in several countries: Soviet countries (Kim, 2003); South Africa (Saunders and Loots, 2005); North Korea (Kim and Song, 2008); Latin America (Vuletin, 2008); Pakistan (Arby *et al.*, 2010); Romania (Davidescu *et al.*, 2015); the Caribbean (Vuletin, 2008; Peters, 2017); and Spain (Duarte, 2017). Furthermore, the studies are characterised by a variety of contexts. For instance, the study into South Africa found that policies aimed towards the formal economy had no impact on the informal economy (Saunders and Loots, 2005). However, the reverse appears to be valid, whereby policies aimed at the informal economy also impact the formal economy.

In contrast, the study into Spain concluded that both GDP and the informal economy appear to operate largely independently (Duarte, 2017). The study into Soviet countries investigates the informal economy and finds that it was not responsible for the collapse of the Soviet economy (Kim, 2003). And finally, the study into North Korea explores why the informal economy is as significant as 78% of the total income of North Korean households, and finds that high levels of poverty drive North Korean households to seek secondary jobs simply to survive, which in turn also reduces the proportion of the formal economy (Kim and Song, 2008).

GDP is not inclusive of the informal economy, and the preceding review of its applications suggest it can represent significant portions of a country's economy. The exclusion of the informal economy from GDP has led to several social problems such as labour without protection and benefits including insurance, sick leave, and annual leave. In the context of the CE, where social elements are relevant, the size of the informal economy should be monitored.

6. Discussion and Conclusion

The CE is closely associated with the notion of economic performance (Figge *et al.*, 2018). However, the conceptualisation and operationalisation of the notion of economic performance represents a significant challenge given the ambiguity of the notion of *performance* and the diverse ways that it can be operationalised (Bimpizas-Pinis *et al.*, 2021). Indeed, the definition and operationalisation of the notion of economic performance is essentially a political act as its definition involves the setting of a range of priorities, and because the measurement of performance influences political decisions and shapes policies (Zerbe, 2002; Krugman and Wells, 2015).

Until now, one of the most widely used indicators related to economic performance is GDP. However, there is a great discussion on the adequacy of GDP to evaluate economic performance, a discussion that is more relevant as new conceptions of the economy emerge (van den Bergh, 2009; Stiglitz *et al.*, 2020). This centrality has been recently contested at the policy level, as key governmental agencies, such as the European Commission and the European Council, expressed the need to develop new systems of indicators to either complement or substitute GDP (European Commission, 2020c; European Council, 2021). Despite the acknowledgement of the shortcomings of GDP, this indicator remains as the main referent to assess economic performance and GDP growth is even included in the CE strategies of the European Commission (European Commission, 2020a)

Many scholars, governmental organisations, and even civil society organisations have developed alternative indicators to evaluate economic performance. Some of these indicators have been developed as an alternative to GDP, others with the intention to complement GDP, and others, as an indicator to evaluate certain aspects of the economy without any explicit reflection on the debate on GDP. In this report, we systematically reviewed a selection of the most relevant of these alternatives and we compared these indicators/frameworks with each other to provide an overview of how economic performance can alternatively be assessed (see Table 7).

Table 7 – Comparison of alternative indicators/frameworks for measuring economic performance

Indicator/ framework	**Implementation context**	**Elements measured**	**Link to the economic performance of the CE**	**Shortcomings**
National Circularity Gap	43 countries in different regions.	Performance in recovering waste.	This indicator measures directly the gap in waste recovery.	Only focuses on waste management, although it can be extended for other applications.
EU Resource Efficiency Scoreboard	European Union.	Multi-factor indicator framework, focused on Resource Productivity.	All the factors in this framework focus on either economic or environmental aspects. Additionally, some indicators include the economic value	Interpretation for some indicators require extra accuracy since there are indicators that overshadow each other, no social factor has been taken into consideration.

			generated per unit of input used.	
OECD Green Growth Indicators	38 member states of the OECD.	Multi-factor indicator framework, focused on economic and environmental aspects.	All the factors in this framework focus on either economic or environmental aspects. Additionally, some indicators include the economic value generated per unit of input used.	Some of the indicators are still in the phase of development and it is not clear how they are measured; no social factor has been taken into consideration.
Amount of SO_2 emission	European Union, China.	Air emissions.	The CE is inclusive of social and environmental elements. This indicator attempts to measure how effectively a nation is minimising its environmental externalities.	The application in EU has been discontinued. Used in China, but no standardisation of measurement can lead to inconsistencies in its calculations among China's regions.
Sustainable Development Indicators	UN Inter-agency and Expert Group on SDG Indicators (IAEG-SDGs).	Climate change, energy, life under water, life on land, sustainable cities and communities.	The CE is inclusive of social and environmental elements. These indicators attempt to measure how effectively a nation is minimising its environmental externalities.	The flexibility in which precise indicators are chosen by a nation makes it difficult to make a full comparison across countries.
EPI	180 countries (including Denmark, Luxembourg and Switzerland).	Environmental health and ecosystem vitality.	The CE is inclusive of social and environmental elements. This indicator attempts to measure how successfully a nation is taking care of its environmental health and ecosystem vitality.	The methodology to calculate EPI scores has evolved multiple times since its inception. Furthermore, although the score was calculated in 2020 for 180 countries, a few nations are still missing.

Beyond GDP indicators	Ecological Reserve (applied to 188 countries, including French Guiana, Suriname, and Guyana, NCI applied to the Netherlands).	Expanded GDP, Environmental, Social and Welfare aspects.	The CE is inclusive of social and environmental elements. These indicators attempt to measure how effectively a nation is minimising its ecological footprint and maintaining its biodiversity.	Although the Ecological Footprint score was calculated for many countries, a few nations are still missing. Natural Capital Index from Beyond GDP framework not applied in many cases. Other Natural Capital indicators exist but adopt different methodologies.
GNH	Government of Bhutan.	Multi-factor indicator, focus on wellbeing and environmental performance.	This indicator focus on maximising the ability of a country to meet the conditions that allow happiness, therefore, decreasing the attention on productivity or resource demanding activities.	This indicator has been calculated only in Bhutan. It has been developed as an initiative of the monarchy without public involvement.
CIW	Canada.	Multi-factor indicator, focus on wellbeing and environmental performance.	This indicator focus on maximising the ability of a country to generate wellbeing among its citizens, while it includes elements as wellbeing and environmental performance, therefore, decreasing the attention on productivity or resource demanding activities.	This indicator has only been used by one country (Canada). The data necessary to calculate this indicator is often unavailable or challenging to calculate.
GPI	State of Vermont, State of Maryland, State of Washington, State of Hawaii (United States).	Multi-factor indicator, focus on wellbeing and environmental performance.	This indicator focus on maximising the ability of a country to generate wellbeing among its citizens, while it includes elements as wellbeing and	This indicator has only been used by few states within the USA. The data necessary to calculate this indicator is often unavailable or challenging to calculate.

			environmental performance, therefore, decreasing the attention on productivity or resource demanding activities.	
ESPI	European Union.	Multi-factor indicator, focus on wellbeing and environmental performance.	This indicator focus on maximising the ability of a country to generate wellbeing among its citizens, while it includes elements as wellbeing and environmental performance, therefore, decreasing the attention on productivity or resource demanding activities.	This indicator is still under development, and it has not been used yet by the EU.
Size of the Informal Economy	South Africa, North Korea, Latin America, Soviet countries, Pakistan, Romania, the Caribbean, and Spain.	Extent of labour that is outside the scope of mechanisms such as social protection, benefits such as sick leave or annual leave, income taxation or labour legislation.	The CE is inclusive of social and environmental elements. This indicator attempts to measure how significant a nation's informal economy is, since a large informal economy is indicative of social/welfare issues.	While the informal economy has been estimated for several nations, it has not been calculated for many nations. It also has not been calculated on a regular basis for most nations. Furthermore, there are several methodologies adopted for its calculation, including structural equation modelling, Multiple Indicator - Multiple Cause (MIMIC) modelling, and the Gutmann approach. This makes it hard to make reliable comparisons across nations.

The main observation after comparing all the 12 indicators and frameworks is that acknowledging the priorities and main needs of a society within an indicator, allows a more comprehensive picture of the performance of the economy than GDP.

The resource efficiency-based indicators and models offer a good overview for activities such as recycling and reusing. By adopting this focus, this group of indicators promotes a productivity-based vision of the economic performance. For example, the National Circularity Gap is an example of indicator that focuses on material circularity. However, the use of this indicator ignores the associated rebound effects and offsetting consequences, leading to a weak circularity approach. To prevent these shortcomings, the National Circularity Gap should be accompanied with other global indicators to shed light on possible rebound effects and offsetting ramifications. Other cases of resource efficiency-based indicators, as the EU Resource Efficiency Scoreboard and OECD Green Growth Indicators, represent frameworks that monitor the progress toward sustainable development from different perspectives. Both frameworks measure different things simultaneously which can be considered as an advantage since it is a break from focusing merely on GDP as an indicator to improve in order to achieve growth and prosperity. However, still GDP plays a major role in calculation of the embedded indicators, and it can play down the importance of focusing on environmental and social issues that the CE aims to take on. In addition, both frameworks lack accounting for any kind of social indicator. This is a concerning issue that can be frequently observed within frameworks and indicators that measure efficiency for sustainable development. Indeed, it is difficult to measure social variables, however, ignoring social aspects in methodological advancements would hinder the progress toward the CE. In summary, the use resource efficiency based indicators represent a good overview of how resources are used, but the efficiency-centred approach of all of the analysed indicators fail to capture, and even induce undesired consequences, as the Jevons paradox or the rebound effect (Lonca *et al.*, 2018). By not addressing these elements, the resource efficiency-based indicators lead to a productivity-based understanding of the economic performance that may be contradictory with some objectives of the CE, as the displacement of primary production, or the phase out of the idea of profit-driven economy.

The environmental sustainability-based indicators and models refer to a very specific aspect of a public priority, such as the sustainable development indicators, measure the level of compliance of the UN's Sustainable Development Goals, or the total amount of SO_2 emissions. Among the environmental sustainability related approaches, monitoring SO_2 emissions enable the inclusion of a substance that can have devastating implications for the environment in high volumes. Furthermore, as it is not one of the main greenhouse gases, it can be overlooked in other approaches. European countries have significantly reduced their SO_2 emissions over the past decades, so this indicator may not be relevant for Europe. However, high SO_2 emissions still remain a significant problem in many other countries, who may prioritise this indicator over some of the other environmental approaches explored in this study. Nevertheless, there is no standardised way to calculate SO_2 emissions, and there are differences in the methods used for data collection. Data concerns also extend to the other approaches related to environmental sustainability, with the EPI approach and Beyond GDP indicators also facing the same challenges, resulting in several countries being excluded from their application. The Ecological Reserve approaches within the Beyond GDP framework and EPI are still applied to a large number of countries on a regular basis.

There is a trade-off between specificity and breadth among the environmental approaches. The SDI and EPI approaches are broad and cover many aspects of the environment. Whereas SO_2 emissions and the Beyond GDP approaches are specific and measure only limited parts of the environment. These specific approaches may need to be supplemented with other approaches to obtain a representative perspective of the environment. Furthermore, the EPI relies on weights that are based on subjective judgements to create a single aggregated measure, which can be unreliable. Since SO_2 emissions and the indicators from the Beyond GDP framework are more specific, they do not require subjective weights for aggregation. In general, these indicators focus on the several environmental challenges that need to be addressed. With the exception of Sulphur Dioxide Emissions, they make an attempt to build an inclusive definition of sustainable development. Especially in the case of the Sustainable Development Indicators, that include elements as equality, poverty, or energy availability among many others. These indicators thus, provide an interesting example of how to acknowledge the environmental performance of a country, and to avoid the idea of a profit-driven economy. In conclusion, the approach of the environmental sustainability-based indicators is mainly based on environmental performance, and with the exception of the Sustainable Development Indicators, they largely ignore the societal dimension of the economic performance.

In the case of the wellbeing-based indicators and models, they can assess progress in a relatively holistic way, such as GPI, CIW, GNH or ESPI. Also, as the size of the informal economy, they can also present specific aspects of a public priority. The benefit of the holistic approach is that it provides a holistic picture to policymakers, although their complex definition makes them very dependent on how complex concepts as wellbeing or progress are defined differently across cultural contexts. However, this priority system is never neutral and reflects a set of political values, for instance, the GPI is closely aligned with the notion of eco-efficiency, while the GNH index can fit within a post-growth paradigm. Therefore, the appropriateness of each of these indicators for measuring the CE depends essentially on what kind of CE we aim to build and under what values we want to pursue public progress or wellbeing.

If we analyse the wellbeing indicators case by case, the GNH is an indicator that focuses on the ability of the citizens of Bhutan to meet the conditions to achieve happiness. The CIW and ESPI emulate the GNH in calculating wellbeing by incorporating a set of elements related to personal health, education, governance, ecological elements or living standards. Although the ESPI, CIW, and GNH are composed of different elements, and are calculated differently, these three indicators coincide in the main principles of how they are created. Although these indicators are not strongly tied to measurements related to resource consumption or efficiency, they decrease the attention to productivity or resource-related measurements. In this sense, the GNH, ESPI, and CIW provide three cases how to measure economic performance focusing on societal needs and avoiding the idea of a profit-driven economy. The GPI as an indicator essentially differs from the three indicators mentioned before, as it incorporates financial assets and built capital in its calculation. Although these elements are in combination with natural, human, and social capital, the presence of these elements may still induce a positive relation between production with economic performance, thus, being inconsistent with the notion of a non-superficial CE. Finally, the Size of the informal economy is an indicator that acknowledges a part of the economic reality by including it into the GDP calculations. This indicator thus, aims to assimilate the informal economy into the national accountings to further enlarge GDP. This indicator fails to inform how the society, or the economic system performs in terms of providing welfare to its citizens, or to preserve the environment, and only focuses on the productivity produced outside of the formal system. Therefore, it reproduces the exact same flaws than GDP in providing a calculation of economic performance.

In summary, the three groups of indicators focus on a set of priorities, either this being related to environmental sustainability, the use of resources, or wellbeing. Although these three dimensions are generally interrelated with each other, especially those indicators that refer to environmental sustainability and wellbeing, there is a lack of comprehensiveness in the analysed indicators. This lack of comprehensiveness can be explained because all indicators reflect a system of political and societal priorities. This is because the design of an indicator is expected to influence the political agenda and its improvement may become a political priority per se. Therefore, it is impossible to provide a neutral or generalist advice on how to select or improve an indicator without firstly defining a set of common goals or values as societal needs.

We can extract some lessons from the review of the 12 indicators of this report. For instance, as we established at the beginning of this report, there is a need to replace GDP for an improved indicator to measure economic performance. Among all the indicators reviewed, only the GNH has aimed to explicitly replace GDP. Another group of indicators, including CIW, GPI, and ESPI, are used not as a substitute, but as a complement to GDP to nuance its reading and to include more elements. Therefore, we do not only need to reflect on the design of an indicator but also to pay attention to its use. Although these indicators provide a good view on economic performance and welfare, they are not being used to replace GDP, thus, failing on this need to overcome the productivist-based vision of the economy. Other common challenges are the difficulty to generate or collect the data they need, the lack of comparable data across countries, and even the presence of different approaches and methods to collect data. This is a general weakness that affects most of alternative indicators, and it is necessary a global commitment towards one main indicator, and it is necessary to invest in the necessary resources to obtain the necessary data to generate an alternative that has the ability to be a feasible alternative to GDP.

The transition towards the CE needs a change in the logic of how the economy is framed and measured. This change should also be reflected in the main political strategies that promote the adoption of the CE. In this sense, the CE action plans promoted by the European Commission should be amended, avoiding any mention of GDP as a goal, and replacing it for an alternative or set of alternative calculations to assess economic performance. Although the European Commission has already developed a set of indicators, especially to focus on its performance on resource efficiency terms, there is still a need to further develop a vision that acknowledges the overall environmental performance and impact on public wellbeing of the EU economy. In this sense, the European Commission has already been working in the development of the Beyond GDP project, to elaborate a comprehensive indicator that measures progress in a holistic way. As a result of this project, the ESPI has been developed (European Commission, 2020c) as an example of an indicator that reflects what are the main societal needs and priorities to assess progress from an EU perspective. The ESPI is a case of an indicator that provides a picture of the economic performance combining elements related to human needs, wellbeing, and personal opportunities and freedoms. This indicator has been elaborated in the EU, and therefore it reflects societal values and public priorities that are important in the EU context, making it adequate for its implementation in the EU. The further development of ESPI and its adoption as the referent indicator to measure performance is an opportunity to replace GDP and the traditional productivity-centred understanding of the economy, also in the EU.

To overcome the productivity-centred vision of the economy from the GDP paradigm, we advise the European Commission to further develop the ESPI indicator, firstly, by integrating it to its practices and using it as a measure of its economic performance. Secondly, as we concluded, the design of an indicator is contingent of a set of societal values and public objectives. Therefore, we advise the European Commission to open up the design of this indicator to the general public and allow the civil society to directly participate in the value and priority setting from an EU perspective. The case of the CIW of Canada provides a good case how to develop an indicator engaging civil society organizations and scholars to provide a new view of the economic performance in Canada.

To conclude, with the adoption of the CE, we need to rethink how economic performance is measured, replacing the old productivist approach centred on the use of GDP. The alternative indicators to measure economic performance have the ability to provide a better picture that is more in-keeping with the new understanding of the economy involved in the adoption of the CE. However, despite the adoption of the CE, the use of GDP has not been reconsidered yet, and the main policies that promote the CE still use GDP as a benchmark. In our report, we show that there are several interesting alternatives that could be used to replace GDP. However, the different alternatives have big differences among them, and the selection of any indicator involves a set of political and social values, as there is no politically neutral indicator. In this sense, the debate on how to move forward should be opened up in order to collect a broader societal perspective of what should be the public priorities that a new indicator should include. We advise the European Commission to both, further develop the ESPI indicator as an alternative to GDP and to open up a public debate within the European civil society to define what are the set of values and priorities that this indicator should reflect.

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Appendix 1

Table 8 - Indicators measuring progress against relevant SDGs and their units of measurement. Adapted from EU SDF Indicator Set (European Commission, 2021b)

Indicator	How it is measured
SDG 6: clean water and sanitation	
Population having neither a bath, nor a shower, nor indoor flushing toilet in their household	% of population i. total ii. below 60% of median equivalised income iii. above 60% of median equivalised income
Population connected to at least secondary waste water treatment	% of population
Biochemical oxygen demand in rivers	mg O2 per litre
Nitrate in groundwater	mg NO3 per litre
Phosphate in rivers	mg PO4 per litre
Water exploitation index, plus (WEI+)	% of long term average available water (LTAA)
SDG 7: affordable and clean energy	
Primary & final energy consumption	million tonnes of oil equivalent, index 2005 = 100 and tonnes of oil equivalent per capita
Final energy consumption in households per capita	kg of oil equivalent
Energy productivity	Chain linked volumes (2010) in EUR and PPS per kg of oil equivalent
Share of renewable energy in gross final energy consumption	% i. all sectors ii. transport iii. electricity iv. heating and cooling
Energy import dependency	% of imports in total gross available energy i. all products ii. solid fossil fuels iii. total petroleum products iv. natural gas
Population unable to keep home adequately warm	% of population i. total ii. below 60% of median equivalised income iii. above 60% of median equivalised income
SDG 11: sustainable cities and communities	

Overcrowding rate	% of population i. total ii. below 60% of median equivalised income iii. above 60% of median equivalised income
Population living in households considering that they suffer from noise	% of population i. total ii. below 60% of median equivalised income iii. above 60% of median equivalised income
Settlement area per capita	square meters per capita
People killed in road accidents	persons and number per 100 000 persons
Exposure to air pollution by particulate matter	µg/m3 i. particulates <2.5µm ii. particulates <10µm
Recycling rate of municipal waste	% of total waste generated
SDG 13: climate change	
Greenhouse gas emissions	index 1990 = 100 and tonnes of CO2 equivalent per capita
Greenhouse gas emissions intensity of energy consumption	index 2000 = 100
Mean near-surface temperature deviation	Degree Celsius (annual/decadal) of global and European temperature deviation i. HadCRUT4 ii. GISSTEMP iii. NOAA Global Temp
Climate-related economic losses	million EUR and EUR per capita (current prices) i. Losses - all events ii. Losses - meteorological events iii. Losses - hydrological events iv. Losses - climatological events v. Losses - 30-year average
Contribution to the international 100bn USD commitment on climate related expending	million EUR (current prices) and EUR per capita
Population covered by the Covenant of Mayors for Climate and Energy signatories	million persons and % of population
SDG 14: life below water	
Surface of marine sites designated under Natura 2000	km2
Estimated trends in fish stock biomass	i. Number of fish stocks assessed ii. Biomass index 2003 = 100
Assessed fish stocks exceeding fishing mortality at maximum sustainable yield (Fmsy)	i. Number of assessed fish stocks ii. Number of overfished fish stocks iii. % of overfished fish stocks

	iv. Model based median value of all assessments
Bathing sites with excellent water quality	Number and % of bathing sites i. coastal water ii. inland water
Mean ocean acidity	pH value
SDG 15: life on land	
Share of forest area	% of total land area i. all forest area FAO ii. forest FAO iii. other wooded land FAO
Surface of terrestrial sites designated under Natura 2000	km2 and terrestrial protected area (%)
Soil sealing index	index 2006 = 100; % of total surface; km2 of sealed surface
Estimated soil erosion by water - area affected by severe erosion rate	km2 and % of potential erosive area
Common bird index	index 2000=100 and index 1990=100 i. all common species ii. common farmland species iii. common forest species
Grassland butterfly index	index 2000 = 100 and index 1990 = 100