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METHODOLOGY FOR INTEGRATED MEASUREMENT OF SUSTAINABILITY TRANSITION

Research Report
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METHODOLOGY FOR INTEGRATED MEASUREMENT OF SUSTAINABILITY TRANSITION

RESEARCH REPORT

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Abstract

BACKGROUND

Gross Domestic Product (GDP) has been the primary tool for measuring economic performance and development since its introduction in the 1930s. While GDP provides a quantitative measure of a nation's output, many argue that it fails to adequately capture broader aspects of wellbeing, sustainability, and human development. Critics contend that the limitations of GDP, particularly in the context of environmental degradation, social inequality, and quality of life, necessitate a rethinking of how progress is measured.

GDP was originally developed by Simon Kuznets in response to the Great Depression, offering a way to measure a nation's economic output. Kuznets himself acknowledged the limitations of GDP, cautioning that economic growth does not equate to societal welfare. Despite these early warnings, GDP became entrenched as the dominant metric of economic success throughout the 20th century, particularly in the aftermath of World War II and during the postwar economic boom (Stiglitz, Sen, & Fitoussi, 2010).

The most notable shortcomings of the GDP methodology are the following:

- Environmental Degradation: One of the major critiques of GDP is its inability to account for the environmental costs of economic activity. Economic growth often comes at the expense of natural resources, pollution, and ecological degradation, but GDP treats all production as positive.
- Social Inequality: GDP measures aggregate economic output but does not reveal how wealth is distributed within a society.
- Non-Market Contributions: GDP does not capture the value of unpaid work, such as household labor, caregiving, and volunteer work, which are essential to societal functioning.
- Subjective Wellbeing: Perhaps most importantly, GDP provides no insight into the subjective wellbeing or quality of life of individuals. A high GDP does not necessarily translate into high levels of happiness, health, or life satisfaction.

As we approach the mid-21st century, the impacts of climate change environmental degradation, depletion of some natural resources are becoming increasingly apparent. Consequently, nations around the world are striving to slow the progression of climate change and other negative trends in the state of natural capital and to minimize the economic and social negative externalities associated with them, directing efforts towards a more sustainable future. The green transition, often termed the ecological or environmental transition, denotes a structural shift from a carbon-intensive, resource-extractive economic model to one characterized by low carbon emissions, high sustainability, and minimized

environmental degradation. At its core, the green transition involves not only the adoption of renewable energy sources to supplant fossil fuels but also transformative changes across sectors — spanning energy, transportation, agriculture, and manufacturing — aimed at reducing negative environmental externalities and enhancing resource efficiency. The transition requires a holistic approach, encompassing technological, policy, and behavioral innovations to realign economic activities with environmental sustainability.

The global advancement of the green transition has been notably slow, raising concerns about the feasibility of meeting international sustainability targets within the desired timeframes. According to the 2024 United Nations progress report, of the 17 Sustainable Development Goals (SDGs) established in 2015, only two are projected to be achievable by the 2030 deadline, underscoring the magnitude of the challenges that remain. A fundamental issue in evaluating sustainability transition progress is the absence of a standardized, scientifically robust methodology for measurement. While the SDG framework provides a comprehensive structure through 169 targets and 248 distinct indicators, these indicators are not organized within an integrated system, which complicates systematic assessment and comparison across regions and sectors.

As will be clearly outlined in the literature review, the primary issue with GDP measurement methodology lies in its inability to accurately capture all production factors. Additionally, it fails to measure goods that are not valued in the market, and thus cannot effectively assess broader wellbeing. The sources of wellbeing or a sense of satisfaction are partly non-material in nature, although they are generally tied to material factors. The material wealth attained in the present depends on how much of our past income we invested and how effectively we used it to create goods that generate today's material wellbeing — these are the production factors, also known as capital goods.

The challenge in measuring and evaluating broader social wellbeing is that it is always easiest to measure the value of currently produced goods and services. Therefore, indicators presented to the public and indices that influence economic policy choices only reflect a portion of this broader concept of wellbeing. Another significant issue is the tradeoff: it is uncertain whether we can accurately gauge how maximizing our current wellbeing impacts the quantity and quality of our future capital goods.

OBJECTIVES

In the context of contemporary global challenges, where the impacts of climate change necessitate prioritization of sustainable transitions, it becomes evident that the traditional GDP framework is insufficient to comprehensively capture the multifaceted dimensions of both green transition processes and the enhancement of societal wellbeing. Recognizing this limitation, Hungary's foremost research institutions, in collaboration with the Hungarian Academy of Sciences and the Blue Planet Climate Protection Foundation, have initiated the development of a novel methodology that:

- is capable of longitudinally assessing the key dimensions of sustainable transitions;
- utilizes a sophisticated methodological framework and a comprehensive system of indicators to provide robust guidance for policymakers.

The scope of this research initiative addresses several critical gaps:

- the absence of an appropriate measurement framework for accurately evaluating sustainability transitions;
- the lack of an integrated system for transforming heterogeneous data sources into cohesive information, actionable knowledge, and evidence-based policy recommendations;
- the objective of furnishing United Nations member states with an adaptable toolkit that enables them to quantitatively assess their progress in green transitions and sustainability transformations, thus facilitating the formulation of tailored, data-driven policy interventions.

The developed methodology synthesizes the professional work of three prominent research centers in Hungary, involving the experts who designed the methodologies. The three significant professional studies, addressing the topic of 'beyond GDP,' are as follows.

- sGDP designed by MNB
- Sustainable Performance Framework Index (SPFI) by HÉTFA Research Institute
- Wellbeing Beyond GDP Index (WBGI) designed initially by Makronóm Institute as Harmonic Development Index

The methodology builds on the following pillars:

- Integration of four key dimensions — economic, social, human, and environmental — mirroring the classical macroeconomic production factors of labor, capital, natural resources, and human capital.
- A modular and flexible indicator system, enabling regional and developmental adaptation while maintaining a robust theoretical foundation.
- A novel three-tiered measurement approach, bridging sustainability-focused inputs and welfare-based outputs through a dynamic sustainable GDP (sGDP) metric.

The SPFI and the WBGI are composite indexes. SPFI is a flexible, composite macro indicator that can be adapted to various environments. It indicates the improvement or the deterioration of the state of production factors and resources. As with any other composite index, the SPFI uses elemental indicators which are able to measure the quantity and the quality of production factors (human, social, economic or natural) or the extent of the actions and impacts affecting these factors.

The original HDI is a composite indicator that captures broader aspects of economic development and allows cross-country and intertemporal comparisons between 87 countries. The HDI allows intercountry and intertemporal comparisons across six domains related to economic development, work and knowledge based society, and financial, environmental, social, and demographic sustainability. The composite indicator serves as a tool to rank countries and track changes in the rankings, providing useful information for policymakers and researchers. By revising the HDI, we created the WBGI composite index with the same methodology as the SPFI, which focuses primarily on the longitudinal study of countries, emphasizing the modularity of the elementary indicators.

The sGDP methodology on the other hand follows a different approach: it adjusts the level of GDP in economic (i.e. non-statistical) terms based on the five factors of sustainability. This approach aims to capture the relationship between sustainability and equilibrium. The sustainable growth path for an economy is on track when the various factors (economic, financial, social and ecological) are in balance simultaneously, while we claim that the deviation from the balances indicates the lack of sustainability. This is a useful abstraction, since the lack of balance can be captured easier than the sustainability in the economic, social and environmental subsystems of the economy.

METHODOLOGY FOR INTEGRATED MEASUREMENT OF SUSTAINABILITY TRANSITION

The methodology of our research primarily focused on developing a three-tire measurement system capable of assessing all dimensions of the sustainability transition. Consequently, two composite indices were created: a sustainability composite index and a wellbeing composite index. Both composite indices assess the sustainability transition across four dimensions:

- economic dimension
- social dimension
- human dimension
- environmental dimension

By the two composite indices we propose offer a methodological response to the criticisms leveled against GDP measurement. The sustainability composite index, the Sustainable Performance Framework Index (SPFI) facilitates the tracking of natural resource management, which GDP does not adequately capture. Meanwhile, the proposed wellbeing composite indicator, the Wellbeing Beyond GDP Index (WBGI) is designed to measure broader societal wellbeing, providing a more comprehensive assessment of overall social welfare.

The development of the sustainability and wellbeing composite indices relied on numerous metrics sourced from various international databases. These sources encompass reliable datasets from different specialized fields, providing a robust and credible foundation for the indicators.

The main advantage of this methodology is that both composite indicators are modular. This means that individual member states can select an indicator set they deem appropriate based on their level of development or geographical circumstances (e.g., sea-level rise, exposure to natural hazards). Modularity is further enhanced by the fact that all elementary indicators within each dimension are weighted equally, and the dimensions themselves are also weighted equally when constructing the composite index. In addition to this, less developed economies can focus on foundational issues such as infrastructure and education – due to the modularity of the composite indices -, while advanced economies can emphasize on innovation, mental wellbeing and cultural stability.

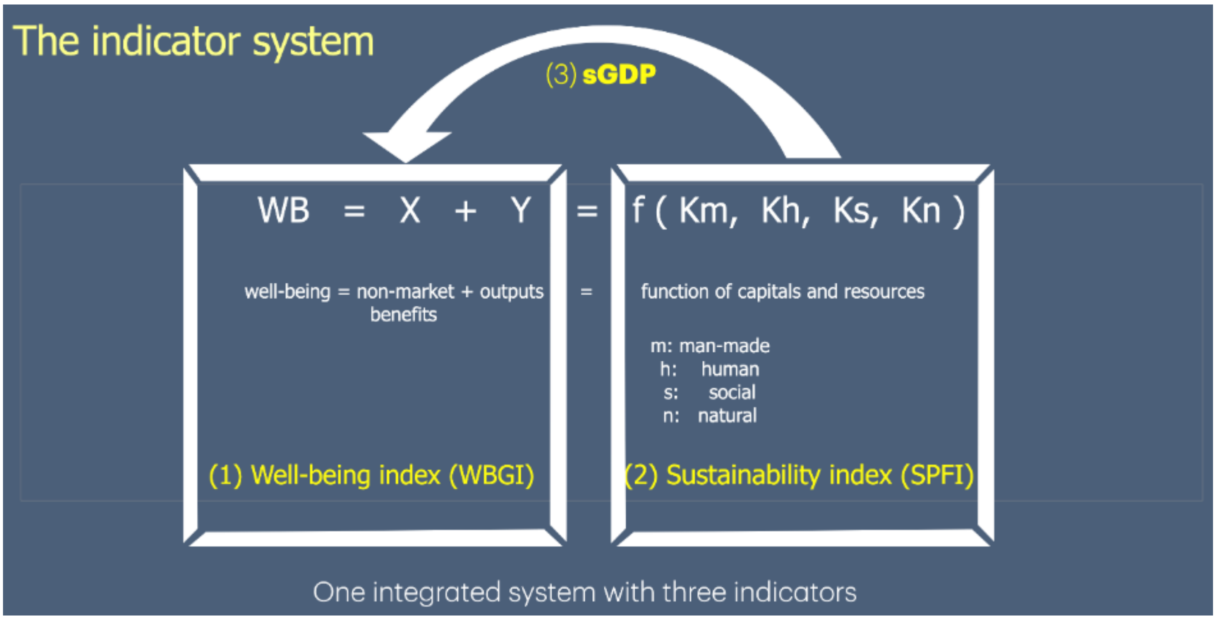
At the top of the two composite indices, we place the sGDP indicator within our triple system. Many methods used for measuring sustainability are based on alternative data sources, outside the standardized „hard" macroeconomic data. While these indicators may provide additional novel information which can help understand the economy better beyond the standard GDP, there are numerous caveats. The collection of data is less standardized, methodology can change often without proper readjustment of the past of the data series, data series are short, and it is only available in a smaller set of countries. The sGDP indicator was constructed considering these problems, and the main aim was to use the existing standard macroeconomic data, selecting a limited number of variables and utilizing longer time series with a wider set of countries.

The advantage of the methodology is that we obtained results that are comparable in time and space for all 27 countries of the European Union and most of the non-EU member states of the OECD (In case of availability of data, the sGDP methodology can be extended to non-OECD countries, as well). The results are presented in international comparison, in fixed price PPS in euro (comparative prices, 2023 base), in terms of GDP per capita between 2000 and 2023. The approach includes a small number of indicators, but in calculating cyclical movements and deviations from equilibrium, we considered a number of types of underlying data and information. The calculation draws on international practices (for example, in estimating the output gap and the credit gap) but combines them in a new way.

The core innovation of our methodology lies in its integration of factor-side and outcome-side indicators:

- Factor-side (sustainability): The SPFI measures the state of production factors, including their availability, quality, and utilization.
- Outcome-side (wellbeing): The WBGI quantifies societal welfare and quality of life.
- sGDP as a Connector: By dynamically adjusting GDP to reflect sustainability balances, the sGDP metric creates a feedback loop that links the two domains, enabling policymakers to evaluate how sustainability interventions influence welfare outcomes over time.

Figure 1. The indicator system of our methodology



With the integrated methodology we have developed, we aim to advance the international discourse on the 'beyond GDP' topic, offering an alternative methodology that, in our view, can measure progress in the sustainability transition of individual countries when longitudinal data becomes available.

The advantages of the integrated methodology based on the three indices we developed are as follows:

- Since the sGDP methodology is able to show the difference between actual and sustainable GDP — i.e., the deviation from the equilibrium state — it allows policymakers to identify intervention areas simply by examining sGDP, functioning as a quasi-early warning system.
- Our two composite indices — through their elementary indicators — can further specify the areas of necessary intervention, thereby enabling more effective policy-making.
- The two composite indices are entirely modular, meaning that individual member states can modify the relevant list of elementary indicators according to their specific needs.
- In our view, the most significant innovation of the methodology lies in its ability to measure all dimensions of the sustainability transition through a complex methodology based on elementary indicators.

CONCLUSION

- The biggest challenge in our research was the lack of accessible quality data. Nearly half of the indicators we considered ideal were not available in adequate time-series quality for the OECD countries we studied between 2005 and 2023. As a result, one of the key messages of our research is the need to develop an indicator set — with a well-defined methodology — that every country measures consistently over time. Once the data from elementary indicators are available in sufficient quality, we will be able to draw accurate conclusions regarding the sustainability transition of individual countries.

- Our methodology is currently designed to be a stepping stone on the long road toward beyond GDP approaches. The primary goal of our methodology is to invigorate the scientific discourse around beyond GDP methods and to highlight the importance of measuring sustainability transitions as a crucial element in policy-making.
- Our integrated methodology is capable of measuring both the quantity and quality of production factors, while also providing a realistic picture of wellbeing beyond GDP.
- By jointly evaluating composite indices and sGDP results, policymakers will be able to make decisions aimed at achieving the sustainability transition.
- The composite indices are capable of measuring progress across all 17 Sustainable Development Goals (SDGs) with a significantly reduced number of indicators.
- Our proposed three-tire and dual integrated indicator system enables the measurement of both sides of the fundamental economic identity equations presented below. By supplementing GDP, this system provides a comprehensive framework capable of capturing and quantifying each dimension of the sustainability transition, thus offering a more nuanced approach to evaluating economic, environmental, and social factors critical to sustainable development.
- The distinctive feature of the integrated methodology is that it enables temporal self-comparison within individual countries or regions but is not necessarily designed for cross-country comparisons.
- The precise measurement of the sustainability transition can only be reliably and accurately achieved by tracking changes in the national wealth inventories of individual countries.

This methodology marks a significant step forward in the quest for comprehensive sustainability metrics. By integrating factor-side and outcome-side measurements, leveraging modular design, and aligning with macroeconomic principles, it provides a robust foundation for tracking and fostering sustainable development. While challenges remain — particularly regarding data availability — the framework's adaptability and theoretical rigor make it a valuable tool for advancing global sustainability goals.

Literature review

GDP was originally developed by Simon Kuznets in response to the Great Depression, offering a way to measure a nation's economic output. Kuznets acknowledged the limitations of GDP, cautioning that economic growth does not equate to societal welfare. Despite these early warnings, GDP became entrenched as the dominant metric of economic success throughout the 20th century, particularly during the aftermath of World War II and the postwar economic boom (Stiglitz, Sen, & Fitoussi, 2010).

Over time, several scholars and policymakers have critiqued GDP for its narrow focus on economic output without considering other critical aspects of societal wellbeing. GDP, for example, does not account for income inequality, environmental degradation, or the value of non-market activities like unpaid household labor and volunteering. As Kuznets argued, "the welfare of a nation can scarcely be inferred from a measure of national income" (Kuznets, 1934).

- Environmental Degradation: One of the major critiques of GDP is its inability to account for the environmental costs of economic activity. Economic growth often comes at the expense of natural resources, pollution, and ecological degradation, but GDP treats all production as positive. For example, the GDP of a country may increase as a result of deforestation or pollution-intensive industries, but this growth may have detrimental long-term effects on the environment (Costanza et al., 2014).
- Social Inequality: GDP measures aggregate economic output but does not reveal how wealth is distributed within a society. A country may have a high GDP per capita, but if income is concentrated in the hands of a small elite, the majority of the population may experience poverty and a lack of access to essential services (Stiglitz et al., 2010). This has led to concerns that GDP-based policies can mask underlying inequalities and result in skewed policy priorities.
- Non-Market Contributions: GDP does not capture the value of unpaid work, such as household labor, caregiving, and volunteer work, which are essential to societal functioning. Feminist economists, in particular, have argued that GDP undervalues the contributions of women by excluding these forms of non-market labor from economic calculations (Waring, 1988).
- Subjective Wellbeing: Perhaps most importantly, GDP provides no insight into the subjective wellbeing or quality of life of individuals. A high GDP does not necessarily translate into high levels of happiness, health, or life satisfaction. This disconnect has prompted calls for a shift in focus toward indicators that capture broader dimensions of wellbeing, rather than relying solely on economic output (Diener & Seligman, 2004).

GDP, in its entirety, measures only the aggregated economic value of goods and services exchanged in the market. In some cases, we also have estimates for the economic value of factors that influence wellbeing but are not market-valued (e.g., externalities). Additionally, GDP includes the value of investments that increase production factors, as well as government spending on healthcare and education investments.

Indicators considered in decision-making generally reflect an attribute of current wellbeing. Gross Domestic Product (GDP) measures the economic activity level of the society under study, indicating the total economic value produced. Inflation shows how price levels have changed from one year to the next. The trade balance reflects the export-import balance for a given year.

However, we often do not measure changes in the factors that underlie economic activity and enable wealth accumulation and high export volumes. Output (as measured by GDP) depends on the quantity and quality of our production factors, also referred to as national resources or capital goods.

$$Y = f(K_m, K_h, K_s, K_n)$$

where Y represents output and K denotes production factors, which we currently categorize into four major groups: K_m for physical capital, K_h for human resources, K_s for social capital and K_n for natural resources (based on Acemoglu (2011).

The monetized economic value of resources, which collectively forms the total national wealth (TNW), is defined as the aggregate of the products of the fundamental quantities and unit values of these resources:

$$TNW=\Sigma EV(Ki) \text{ and } EV(Ki) = pi*Si$$

where EV represents the economic, monetized value of a single unit of resource, p is the unit value of the resource, and S denotes the stock or quantity of the given resource.

Critics such as Amartya Sen and Joseph Stiglitz have highlighted the inability of GDP to capture a broader range of indicators related to human wellbeing, such as health, education, and social equity. Their 2009 report, commissioned by the French government, emphasized that economic performance and societal progress should be assessed through a variety of measures that go beyond GDP. This has led to the rise of the Beyond GDP movement, which aims to develop alternative metrics that provide a more comprehensive understanding of societal wellbeing (Stiglitz, Sen, & Fitoussi, 2010).

In Annex 1, a more detailed summary of GDP alternatives can be found.

Challenges in Moving Beyond GDP

Despite the increasing recognition of the limitations of GDP, implementing alternative metrics faces significant challenges. One of the primary barriers is data availability and standardization. Many of the proposed alternatives, such as GNH and SPI, rely on subjective measures of wellbeing that are difficult to standardize and compare across countries. In addition, obtaining reliable data on environmental degradation, social inequality, and non-market activities can be challenging, particularly in developing countries with limited statistical capacity (Costanza et al., 2014).

While the methodologies behind Beyond GDP metrics offer valuable insights, several challenges remain in their development and application:

- Data Availability: Many alternative indicators rely on data that is either difficult to obtain or unavailable in certain countries. For example, subjective measures of wellbeing, such as those used in GNH or SPI, require extensive survey data, which may be challenging to collect in developing countries. Additionally, environmental data, such as the cost of pollution or resource depletion (used in GPI), can be complex to quantify and standardize across countries (Costanza et al., 2014).
- Subjectivity: Some Beyond GDP metrics rely on subjective measures, such as happiness, wellbeing, or perceptions of quality of life. While these indicators provide valuable insights, they are inherently subjective and can vary widely based on cultural, social, and individual factors. This subjectivity can introduce variability and reduce the comparability of the results across different regions.
- Integration into Policy: One of the key challenges of Beyond GDP metrics is translating the insights they offer into actionable policy. Governments may face political pressure to prioritize short-term economic growth, making it difficult to adopt policies based on more complex, multidimensional measures of progress. Additionally, GDP remains the dominant metric in global economic institutions like the International Monetary Fund (IMF) and World Bank, further entrenching its use in policymaking (Fioramonti, 2017).

There is also a cultural dimension to the challenge of moving beyond GDP. Many societies are deeply rooted in a growth-oriented economic paradigm that equates material wealth with progress and success. This consumerist mindset, particularly in developed countries, makes it difficult to shift toward alternative metrics emphasizing sustainability, wellbeing, and social equity over economic growth (Victor, 2010).

Finally, there is the issue of policy implementation. Even when governments express interest in adopting Beyond GDP metrics, translating these indicators into actionable policy decisions remains a significant hurdle. Governments may face competing priorities, limited resources, and institutional resistance when attempting to implement policies that prioritize environmental sustainability and social wellbeing over economic growth (Jackson, 2009). Additionally, alternative metrics can be more difficult to communicate to the public, making it harder to build political and societal consensus around them.

Methodology of Integrated Measurement of Sustainability Transition

INTRODUCTION

In the following chapter, we present the layered structure of the proposed tree-tire indicator system and provide an overview of the methodology used to develop each sub-indicator.

Our integrated methodology was designed to address fundamental critiques of GDP as an economic measure. Specifically, GDP fails to account for the sustainable management of natural resources and lacks scope for assessing wellbeing beyond economic production. While recent years have seen the development of numerous composite indicators aimed at measuring sustainability and social welfare, an integrated, unified system remains absent. The core innovation of our approach is a triad of interlinked indices that, when interpreted together, provide a comprehensive, data-driven assessment of social, economic, and environmental dimensions across the public policy spectrum.

The most notable scientific advancement is the sGDP methodology, which integrates a sustainability dimension to capture deviations from equilibrium states across countries. This enables sGDP to function as an alert mechanism, identifying critical policy or financial domains in need of intervention. However, precise targeting of policy adjustments is possible only through the combined analysis of the additional composite indicators we propose.

An essential feature of our framework is the use of a modular indicator pool, enabling countries to allocate elementary indicators within the triad system according to their specific needs, with only minimal constraints. We emphasize modularity for the following reasons:

- Developing a rigid methodology with the aim of being universally applicable to address all policy challenges is impractical.
- Sustainability transitions should be assessed based on longitudinal data within each country, rather than through mechanical cross-national comparisons.
- Nations exhibit diverse social, economic, and geographical characteristics that necessitate individualized approaches in achieving sustainability transformation.

In response to the pressing global challenges posed by climate change, environmental degradation, depletion of some natural resources, as well as growing social inequality, which demand urgent and comprehensive sustainable transitions, it has become increasingly clear that traditional metrics, such as Gross Domestic Product (GDP), are insufficient for fully capturing the complex and interwoven dimensions of sustainability and societal wellbeing. While widely utilized as a measure of economic activity, GDP lacks the scope and depth to accurately assess progress in environmental sustainability and social development. Recognizing this limitation, Hungary's leading research institutions have joined forces with the Hungarian Academy of Sciences and the Blue Planet Foundation to pioneer an advanced methodological approach that can address these gaps.

This new framework aims to longitudinally assess key dimensions of sustainable transitions through a comprehensive system of indicators, utilizing an advanced methodological foundation to provide reliable, evidence-based guidance for policymakers. Such an approach is critical, as the shift toward sustainable practices requires not only reforms of environmental policies but also a holistic assessment of social and economic impacts. The framework is thus designed to be multidimensional, capturing variables that span economic, social, and environmental domains, providing a more integrated approach to assessing progress.

This research initiative seeks to address several significant gaps in current methodologies. Firstly, there is an evident lack of an appropriate framework capable of accurately evaluating sustainability transitions on multiple fronts. Most existing metrics fail to capture the complexities of sustainability, as they are not designed to measure the interconnected facets of environmental, social, and economic wellbeing. Therefore, this initiative emphasizes creating a metric system that can account for these factors in a cohesive manner, reflecting both present conditions and future trajectories.

Secondly, the initiative offers an integrated system for processing heterogeneous data sources. Sustainability transitions involve data from diverse fields, including environmental science, economics, and social sciences. Without an efficient method to transform these disparate data into unified and actionable insights, decision-makers face challenges in making well-informed decisions. By transforming raw data into structured, actionable knowledge, the system supports evidence-based policymaking that aligns with both national and global sustainability goals.

Furthermore, the initiative seeks to provide United Nations member states with an adaptable toolkit for monitoring their progress in sustainability transitions. This toolkit is designed to be versatile, allowing countries to tailor the framework according to their specific contexts and priorities. A one-size-fits-all approach is impractical given the diversity of environmental, economic, and social conditions across countries. Instead, this toolkit is intended to be flexible, enabling countries to customize the indicators and data parameters to their unique circumstances. In doing so, it fosters a more accurate reflection of each country's progress toward sustainability transformation and supports the creation of targeted, data-driven policy interventions.

This research effort seeks to develop a longitudinal framework capable of evaluating the progress of sustainable transitions through a scientifically grounded system of indicators. This system would provide policymakers with reliable guidance to address not only immediate economic goals but also long-term social and environmental objectives. To ensure its relevance, the framework has been designed to align with global sustainability standards, including the United Nations' Sustainable Development Goals (SDGs). However, the realization of this project is contingent upon overcoming several methodological and data-related obstacles, as discussed in this paper.

In essence, this project advances a paradigm shift away from using only conventional economic indicators, advocating for a multidimensional framework that reflects the interconnected realities of sustainability and wellbeing. By providing a comprehensive and adaptable system of indicators, the methodology not only addresses the immediate need for sustainable practices but also offers a long-term pathway for nations to assess and enhance their progress in addressing climate challenges.

POOL OF ELEMENTARY INDICATORS[1]

Energy imports, net (% of energy use)

% of tertiary education completed

Access to electricity (% of population)

Age dependency ratio, young (% of working-age population)

Average Annual wage (*nominal_wage)*

Avoidable mortality, Deaths per 100,000 inhabitants

Central government debt, total (% of GDP)

Control of Corruption: Estimate

Credit gap - sGDP

Ecological footprint - sGDP

Educational attainment: % of secondary completed + % of tertiary completed

E-government index

Employment gap - sGDP

Employment in high- and medium-high technology manufacturing sectors and knowledge-intensive service sectors

Employment to population ratio, 15+, total (%) (national estimate)

Environmental and resource productivity - Contribution of natural capital

Exposure to air pollution

Exposure to extreme temperature

Extent of marine protected area

External gap - sGDP

Fast broadband (NGA) coverage, % of households

Fertility rate, total (births per woman)

Fossil Fuel Support - Detailed Indicators

GDP per unit of energy use (PPP $ per kg of oil equivalent)

Gender wage gap - Percentage of wages of men in the same decile

Gini Index

GNI per capita

Government Effectiveness

Green area (square meters) per capita

Greenhouse gas emissions Inventories

Gross capital formation (% of GDP)

Gross savings (% of GNI)

Groundwater supply

Gross value added at basic prices (GVA) (constant 2015 US$)

Individuals using the internet (% of population)

Individuals using the internet for internet banking

Inflows of foreign population (selected OECD countries)

Labor tax and contributions (% of commercial profits)

[1] Elements of the Wellbeing Beyond GDP (composite) Index

Elements of the Sustainable Performance Framework (composite) Index

Elements of sustainable GDP

Land cover and land cover change

Level of water stress: freshwater withdrawal as a proportion of available freshwater resources

Life expectancy at birth, total (years)

Logistics performance index: quality of trade and transport-related infrastructure (1=low to 5=high)

Material footprint (Units, Tonnes per person)

Agricultural expansion and contraction > Cropland

Natural and semi-natural land > Natural and semi-natural vegetated land

Mobile cellular subscriptions (mobile)

Mortality rate, infant (per 1,000 live births)

Net lending (+) / net borrowing (-) (% of GDP)

Number of foreign languages known (self-reported) by age, %

Number of people exposed to high noise levels inside urban areas

Old-age dependency ratio, %

Outflows of foreign population from selected OECD countries

Output gap - SGDP

P90/P10 disposable income decile ratio

People using at least BASIC drinking water services (% of population)

People using SAFELY managed drinking water services (% of population)

Persons at risk of poverty or social exclusion (% of pop)

Pisa math

Pisa read

Pisa science

Poverty headcount ratio at national poverty lines (% of population)

Prevalence of overweight among adults, BMI >= 25 (age-standardized estimate, %)

Prevalence of undernourishment (% of population)

Proportion of bodies of water with good ambient water quality (%)

Regulatory quality

Research and development expenditure (% of GDP)

Rule of Law

Share of organic farms

Starting a business: score

Suicide mortality rate (per 100,000 population)

Trust in government

Unemployment, total (% of total labor force) (national estimate)

Voice and accountability

Waste - Municipal waste: generation and treatment, Measure: Recycling

Wastewater - connection rates to treatment

Women mean age at first childbirth

Years of Schooling

SUSTAINABILITY AND WELLBEING COMPOSITE INDICES

In the following chapters, we detail the methodology and results associated with the construction of indices designed to capture national wellbeing and sustainability. The primary objective was to develop indices grounded in comparable dimensions — namely, economic, human, social, and environmental capital — that comprehensively reflect both wellbeing and sustainability across nations. A key focus of the indices is to ensure cross-country comparability and to enable temporal analysis.

The foundation of the composite indicator methodology is modularity. As previously outlined, our system, comprising approximately 80 selected elementary indicators, facilitates a nuanced measurement of the sustainability transition. This modular structure allows member states to select relevant indicators and seamlessly incorporate new metrics, ensuring adaptability. Within each of the four dimensions of the indices, indicators were weighted equally, adjusted based on the number of elementary indicators within each dimension. Each of the four dimensions was assigned an equal weight of 0.25 to maintain a balanced representation.

The dimensions of the composite indices align with the four primary capital types identified in Hungary's National Framework Strategy on Sustainable Development: economic capital, social capital, human capital, and natural capital. This framework aims to monitor Hungary's sustainability transition by assessing changes across these four resource categories, guided by the development of 16 key indicators.

METHODOLOGY

The theoretical and practical foundations for the construction of the composite indicator are drawn from the OECD [2008] framework, which comprises the following steps, with slight modifications tailored to our investigation:

- Development of the theoretical framework
- Selection of variables
- Management of missing data
- Data normalization
- Multivariate analysis
- Weighting and aggregation
- Decomposition of results
- Correlation with the MNB's sustainable GDP indicator
- Analysis of the temporal trends of the indices

Data Sources and Data Cleaning

To formulate composite indicators for sustainability and wellbeing, we employed a diverse set of metrics sourced from multiple authoritative international databases, thereby ensuring a rigorous and credible foundation for our analysis. The data utilized spans various domains, ensuring a comprehensive assessment of economic, social, environmental, and technological dimensions.

The World Bank's World Development Indicators (WDI) database served as a primary source for economic, social, and environmental indicators. Key metrics extracted include gross national income (GNI), employment rates, savings levels, and basic infrastructure indicators, such as access to electricity, potable water, and internet penetration. Additionally, the World Bank's Worldwide Governance Indicators (WGI) facilitated the evaluation of institutional performance, incorporating metrics such as government effectiveness, regulatory quality, and anti-corruption efforts.

The Organization for Economic Co-operation and Development (OECD) databases provided extensive data on economic and social dimensions, including real wages, income inequality, educational attainment, and health outcomes. Specifically, the Gini coefficient for income distribution, decile ratios (P90/P10), and indicators of welfare poverty were utilized to capture income disparities and social welfare. Environmental data from the OECD focused on energy efficiency, fossil fuel consumption subsidies, and recycling rates, thus adding an environmental dimension to the composite indicators.

Further enrichment of the analysis was obtained from Eurostat and the European Commission's Digital Economy and Society Index (DESI). These sources offered valuable data on technological progress, such as broadband internet coverage, the prevalence of online banking, and levels of digital literacy. These metrics were critical for incorporating digital transformation into our sustainability and wellbeing indicators.

Health-related indicators were sourced from the United Nations (UN) and the World Health Organization (WHO), including life expectancy, obesity rates, and suicide rates. Additionally, the UN's Sustainable Development Goals (SDG) platform provided ecological data on water quality and protected marine areas, reinforcing the environmental dimension of our analysis.

Collectively, these diverse datasets facilitate a robust, multidimensional approach to the measurement of sustainability and wellbeing, ensuring international comparability and enhancing the credibility of the analysis.

In an ideal scenario, the selected variables would be available for all countries and across all years. However, due to practical limitations, data availability was constrained, particularly for non-OECD countries and historical periods. The five EU countries excluded in this study — Romania, Croatia, Bulgaria, Cyprus, and Malta — are members of the European Union but not the OECD, which resulted in a reduced number of data points. Moreover, data availability diminishes significantly for years prior to 2005. Consequently, the focus of this study was narrowed to OECD countries for the period from 2005 to 2023, during which four types of systematic data deficiencies were encountered. These deficiencies are further detailed below:

1. Missing observations at the beginning or end of the period.
2. A significant portion of data is missing for the entire period; for instance, data may only be available for the 2013-2023 timeframe.
3. Data collection occurs intermittently, with gaps, such as data available only in alternate years.
4. Data such as the PISA results are available only at large intervals throughout the period.

There are various procedures for handling missing data, none inherently better or worse than others; rather, they are applicable in different contexts. The methods may include:

- Imputation of missing values using the mean or median.

- Imputation of missing values through linear interpolation.
- Imputation from alternative sources.
- Omission of the variable.
- Predictive model-based imputation using regression models.

We adopted the two latter methods to handle missing data. Specifically, in cases classified as 2 or 4, where data deficiencies were deemed excessive, we excluded the relevant variable from subsequent analyses. An illustrative example of this approach is the PISA results, which were recorded in the database only five times over the study period, thereby limiting their utility for robust longitudinal analysis.

For instances of minor data deficiencies, we employed fixed-effects panel regressions to impute missing values, using the year as the explanatory variable. The fixed-effects model is advantageous in that it controls for unobserved heterogeneity that is constant over time but varies across countries, thus accounting for time-invariant country-specific characteristics. This method ensures that such fixed effects are appropriately considered in the imputation process, thereby reducing potential biases that might arise from ignoring these factors.

This imputation strategy presents both strengths and limitations. The principal advantage lies in the ability to generate a complete and balanced panel dataset spanning the entire 2005-2023 period for all countries. This approach ensures that the resulting indices are available for every year and country in the sample, facilitating longitudinal and cross-sectional analyses. The primary limitation, however, is that the imputed values are estimates, rather than actual observed values. As such, these estimates may diverge from true observations, leading to potential inaccuracies or distortions in subsequent calculations. While these imputed values do not perfectly replicate actual data points, we argue that the benefits of a complete, balanced dataset outweigh the potential for estimation error, particularly given the necessity of maintaining temporal and cross-country consistency in the analysis.

Data Normalization

For conducting the analysis, standardizing variables to a common scale is essential to ensure comparability. This step is crucial to avoid incongruous comparisons, such as those between values expressed in dollars and percentages. Several normalization techniques are available, each offering different benefits and potential limitations. The selection of an appropriate method depends on the analytical requirements and the characteristics of the data.

In this study, we adopted the min-max normalization approach. This method rescales each variable to a range of [0, 1], preserving the relative distance between values while standardizing them to a common scale. The min-max normalization formula is as follows:

$$x'_{it} = \frac{x_{it} - \min(x_i)}{\max(x_i) - \min(x_i)}$$

To compute the normalized value of a variable i in year t we adjust the deviation of its observed value proportionally within the range defined by the minimum and maximum values for that specific year. By anchoring normalization to each year's minimum and maximum values rather than those across all countries, this method optimizes comparability between countries within the same year. However, it comes at the cost of reducing insight into each country's temporal trends. As a result, normalized data for each variable i in year t will fall within a fixed range of 0 to 1, enhancing comparability across variables with distinct units of measurement. This approach is advantageous for analyzing data in disparate units, but it has heightened sensitivity to outliers, as extreme values can disproportionately influence the normalized range.

It is also important to account for the directional intent of each variable. While some indicators inherently aim for high values (e.g., GDP), others are desirable at low levels (e.g., infant mortality). For variables where a lower value is preferred, we apply inverse normalization by subtracting the normalized values from 1, effectively reversing the scale. This approach, known as inverse normalization, ensures that higher normalized values consistently correspond to more favorable outcomes across all variables, thus maintaining interpretative consistency in composite indicators.

Multivariate analysis

Principal Component Analysis (PCA) is a widely applied technique for dimensionality reduction in datasets where variables may exhibit high intercorrelations, aiming to capture the maximum possible variance with fewer uncorrelated components. This is particularly valuable for our analysis, as it addresses the high number of variables presumed to convey overlapping information.

The key steps in PCA include:

- *Representing shared information:* The information contained in correlated variables is expressed through new, uncorrelated factors (principal components).
- *Quantifying explained variance:* The principal components are evaluated for their ability to explain the variance in the original data.
- *Identifying variable-factor relationships:* The relationships between variables and components are examined, with each component representing a distinct dimension of the data.
- *Grouping variables by factors:* Variables that align closely with particular components are grouped, indicating shared underlying characteristics.
- *Interpreting component meanings:* Each principal component is interpreted based on the variables it strongly influences, providing insight into the latent structure of the data (OECD, 2008).

PCA thus aids in revealing the data's internal structure, potentially informing new weighting schemes for indices based on identified principal components. Through PCA, we construct linear combinations of orthogonal original variables (principal components), ensuring no redundancy. The first principal component is configured to capture the highest proportion of the variance in the original dataset, making it the most informative single dimension. This approach allowed us to examine the internal structure of data associated with subcategories to verify that the variables in each subcategory truly capture a cohesive underlying dimension.

Our objective was to identify principal components where a single factor explains a substantial share of the variance, with similar magnitude and direction in the factor loadings of variables within each subcategory. In cases where this was achieved, the factors yielded a more concentrated and insightful summary of the data than the individual variables alone.

To optimize our results, we systematically excluded variables with the lowest factor loadings, iterating until a single component accounted for a significant proportion of the variance. The tables below summarize the variables retained within the dimensions of the two composite indicators. Variables subjected to inverse normalization are marked with a minus sign (-), indicating that a lower value is preferable from a social desirability perspective.

Weighting and Aggregation

In calculating the indices for each dimension, we applied the factor loadings derived from Principal Component Analysis weights. This approach enables us to leverage the variance explained by each principal component, thus ensuring that variables with stronger relationships to the underlying factor exert greater influence on the dimension's index. Following the calculation of weighted scores for each dimension, we applied min-max normalization, as previously outlined, to constrain each dimension's values within a standardized range of 0 to 1. This normalization step enhances comparability across dimensions by aligning them to a uniform scale.

The composite indicators and overall index values were then determined by averaging the normalized values at the dimension level. However, a limitation of this approach is that it allows compensatory effects across dimensions, meaning that positive developments in one dimension may offset or mask negative trends in another. This potential for counterbalancing effects could obscure dimension-specific variations and limit the sensitivity of the composite index to changes in individual areas. Despite this limitation, the method provides a coherent framework for synthesizing multidimensional data into interpretable indices, facilitating comparative analysis.

Decomposition of details

In this section, we analyze the internal structure and intercorrelation of the four dimensions (human, environmental, economic, and social) using Principal Component Analysis. The figure illustrates the eigenvalues of the principal components on the left, where two components have eigenvalues exceeding 1, indicating that they account for substantial variance in the data.

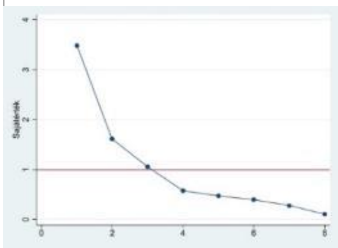
The first principal component (Factor 1) primarily captures the human and environmental dimensions, both of which are key contributors to the indices for wellbeing and sustainability. In the wellbeing index, the human dimension has the highest loading (0.49), while the natural dimension also contributes significantly (0.41). A similar pattern appears in the sustainability index, where the human (0.50) and natural dimensions (0.45) remain influential. This factor underscores the interdependence between human wellbeing and environmental quality, suggesting that these dimensions are fundamental in defining both indices. Thus, Factor 1 serves as a primary measure of the combined impact of human and environmental elements on overall wellbeing and sustainability.

The second principal component (Factor 2) encapsulates the economic and social dimensions, with strong loadings in both indices. Within the wellbeing index, the economic dimension has a high loading (0.53), and the social dimension is even higher (0.61), indicating that this factor reflects the material and social conditions associated with wellbeing. Similarly, in the sustainability index, the economic dimension holds a substantial loading (0.48). Factor 2 thus represents the economic and social determinants that are crucial for both wellbeing and sustainability, highlighting the influence of economic resources and social cohesion in these areas.

The third principal component (Factor 3) reveals a tension between the social and economic dimensions. In the wellbeing index, the economic dimension has a negative loading (-0.41), whereas the social dimension demonstrates a strong positive loading (0.82) in the sustainability index. This inverse relationship suggests that social advancements may sometimes come into conflict with economic growth, capturing a complex dynamic where social development may challenge economic constraints. Factor 3 thus emphasizes the interplay between social and economic factors, pointing to possible trade-offs or contradictions in advancing both simultaneously.

In summary, the three factors extracted from PCA reveal distinct contributions of the four dimensions to the wellbeing and sustainability indices. Factor 1 underscores the essential role of human and environmental wellbeing; Factor 2 highlights the importance of economic and social conditions; and Factor 3 reflects potential conflicts between social progress and economic growth. Together, these findings suggest a nuanced, multidimensional structure in how wellbeing and sustainability are influenced by interrelated but sometimes competing dimensions.

Table 1. Result of the factor analysis

	Composite index	Dimension	Factor 1	Factor 2	Factor 3
	Wellbeing Beyond GDP Index (Wellbeing index)	Economic	0.21	0.53	-0.41
		Human	0.49	-0.01	-0.01
		Social	0.08	0.61	0.17
		Environmental	0.41	0.10	0.15
	Sustainable Performance Framework Index (Sustainability index)	Economic	-0.28	0.48	-0.32
		Human	0.50	-0.04	0.03
		Social	-0.07	0.30	0.82
		Environmental	0.45	-0.06	-0.07

Correlation with the MNB's Sustainable GDP

The results of the fixed-effects panel regression analysis revealed significant associations between both the wellbeing and sustainability composite indicators and sustainable GDP (sGDP), as well as the logarithm of per capita sustainable GDP. However, the strength of these relationships varies between the two indicators.

For sGDP, the wellbeing composite indicator shows a relatively strong positive relationship, with a coefficient of 0.38, which is statistically significant at a high confidence level ($p < 0.001$, denoted by three stars). This indicates that the wellbeing indicator plays a meaningful role in explaining variations in sustainable GDP, suggesting that improvements in wellbeing factors correlate with sGDP growth.

The sustainability composite indicator also demonstrates a positive association with sGDP, though to a lesser extent. Its coefficient of 0.18 is statistically significant ($p<0.01$, denoted by two stars), though the impact is less pronounced compared to the wellbeing indicator. This result implies that sustainability factors also contribute positively to sGDP, albeit with a more moderate influence compared to wellbeing factors.

These findings suggest that while both wellbeing and sustainability dimensions contribute positively to sustainable economic growth, the wellbeing composite indicator has a stronger explanatory power for sGDP. This may reflect the immediate effects of factors such as human capital, health, and social cohesion on economic growth, whereas sustainability factors — while important — may have a more gradual impact on GDP growth due to their long-term nature.

Table 2. Coefficients

dependent variable	Wellbeing composite	Sustainability composite
sGDP	0.38***	0.18**
sGDP per capita	0.39***	0.14*

For per capita sustainable GDP (sGDP), both the wellbeing and sustainability composite index continue to exhibit a positive association. The wellbeing composite index shows a strong effect, with a coefficient of 0.39, which remains statistically significant, indicating a robust relationship between wellbeing factors and per capita sGDP.

In contrast, the sustainability composite index has a smaller coefficient of 0.14 and is less statistically significant, though it still represents a meaningful factor in explaining per capita sGDP. This suggests that, while sustainability dimensions contribute positively to per capita economic performance, their immediate impact is less pronounced than that of wellbeing dimensions.

Overall, both composite indices significantly impact both total sGDP and per capita sGDP, with the wellbeing composite indicator exerting a consistently greater influence in both contexts. This pattern indicates a stronger association between wellbeing factors — such as human capital, health, and social infrastructure — and economic performance, implying that improvements in wellbeing dimensions may be more directly linked to sustainable economic growth than sustainability factors. These findings highlight the crucial role of wellbeing in driving economic resilience and growth, while sustainability dimensions may provide long-term support to economic stability.

sGDP

In this chapter, we introduce and briefly summarize the sGDP methodology created by the Magyar Nemzeti Bank (MNB, the central bank of Hungary). Numerous methods worldwide aim to measure sustainability in the economy and other dimensions; many of these try to surpass the limitations of the GDP and standard macroeconomic data by utilizing alternative indicators and data sources (Matolcsy, 2024). The sGDP methodology on the other hand follows a different approach: it adjusts the level of GDP in economic (i.e. non-statistical) terms on the basis of five factors of sustainability. This approach aims to capture the relationship between sustainability and equilibrium. The sustainable growth path for an economy is on track when the various factors (economic, financial, social and ecological) are in balance at the same time, while we claim that the deviation from the balances indicates the lack of sustainability. This is a useful abstraction, since the lack of balance can be captured easier than the sustainability in the economic, social and environmental subsystems of the economy.

sGDP shows the economic output that would be generated if the product and labour market, the financial sector, the balance of financing capacity and the conservation of ecological resources were maintained, while ensuring a fair distribution of the goods and services produced. For each of these five factors of sustainability, a key indicator was chosen to capture the deviation of the given area from the equilibrium level, i.e., the shorter and longer-term cycles, and then adjusted GDP for these deviations. It is therefore possible to calculate what the value of GDP would have been at each point in time if the economy had been on a sustainable path along the five examined dimensions. The result can be higher or lower than the GDP shown in the statistics. It is lower if the economy expands faster than the sustainable path, which could lead to overheating and imbalances, and higher if the economy does bot exploit its equilibrium growth potential. Another important aspect of this indicator is that it is constructed in a way to provide cross-country comparisons over time, which means it can track the main trends over the last two decades between numerous countries.

METHODOLOGY

Many methods used for measuring sustainability are based on alternative data sources, outside the standardized „hard" macroeconomic data. While these indicators may provide additional novel information that can help understand the economy better beyond the standard GDP, there are numerous caveats. The collection of data is less standardized, the methodology can change often without proper readjustment of the past of the data series, data series are short, and it is only available in a smaller set of countries. The sGDP indicator was constructed considering these problems, the main aim was to use the existing standard macroeconomic data, selecting a limited number of variables and utilizing longer time-series with a wider set of countries.

The advantage of the methodology is that we obtained results that are comparable in time and space for all 27 countries of the European Union and most of the non-EU member states of the OECD[2]. The results are presented in international comparison, in fixed price PPS in euro (comparative prices, 2023 base), in terms of GDP per capita between 2000 and 2023. The approach includes a small number of indicators (Figure 1), but in calculating cyclical movements and deviations from equilibrium, we took into account a number of types of underlying data and information. The calculation draws on international practices (for example in estimating the output gap and the credit gap) but combines them in a new way.

[2] In the current version of the sGDP Iceland and Costa Rica is not included due to the unavailability of data

1. Figure: The sGDP indicator considers five sustainability aspects

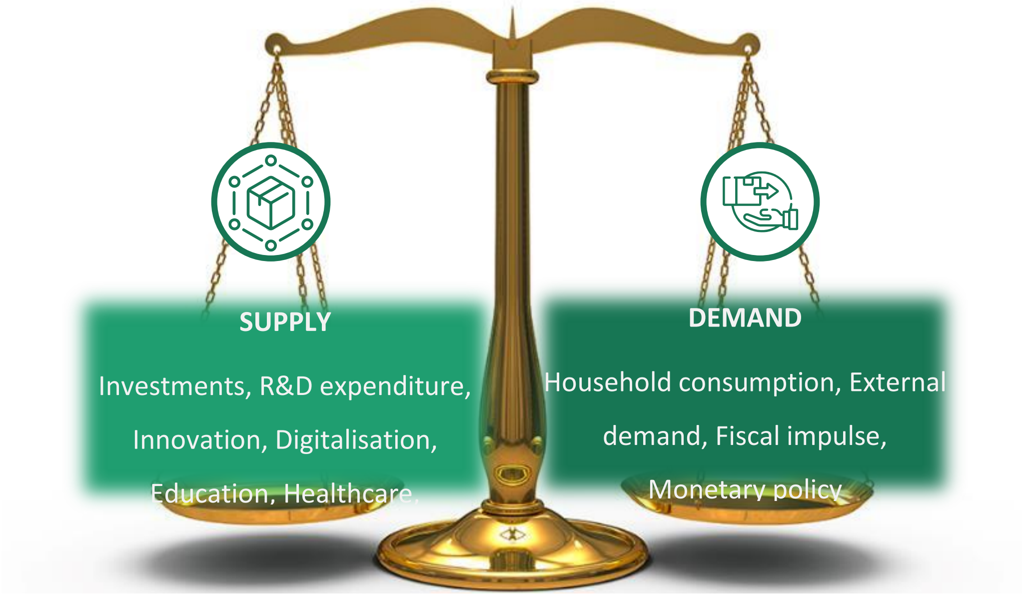
Source: MNB editing

The five dimensions of sustainability

1. Balance of supply and demand: the output gap

The balance between macroeconomic supply and demand is an important condition for sustainable economic growth. When calculating sustainable GDP, we take into account different macroeconomic variables, whose cyclical processes have different wavelengths. The shortest 5–10 years are called business cycles, which alternate between boom-and-bust periods and periodically divert the economy from its equilibrium – and therefore sustainable – growth path. During recessions and crises, real GDP levels are lower than the supply side of the economy would produce, but higher during booms. Several macro variables in the economy shape the short-term balance between supply and demand (Figure 2).

2. Figure: The output gap consists numerous macro variables



Cycles can be well described by the concept of the output gap, which is the difference between potential output and observed GDP. Potential output is determined by the supply capacity available in each period. If the output gap is positive, the measured GDP is higher than the potential GDP, and if it is negative, it is lower. The result of this cyclical movement can also be observed in the evolution of inflation rates. In a period of weak demand, inflation falls and remains low, while above-equilibrium GDP implies accelerating price increases. Thus, if the current performance of the economy is just about equal to its potential level, GDP growth is sustainable from an inflation perspective.

A negative output gap raises, and a positive gap lowers the level of sustainable GDP relative to actual GDP. When output is below potential, it would be possible to produce more output with the resources available. Conversely, when the economy overheats and the output gap is in positive territory, GDP sustainable in the long run is lower than real GDP.

We used the output gap series provided by AMECO (27 EU countries) and OECD (non-EU OECD members) databases as a percentage of the GDP. This way, the output gap can be directly added or subtracted from the GDP figures to adjust them to calculate the sGDP.

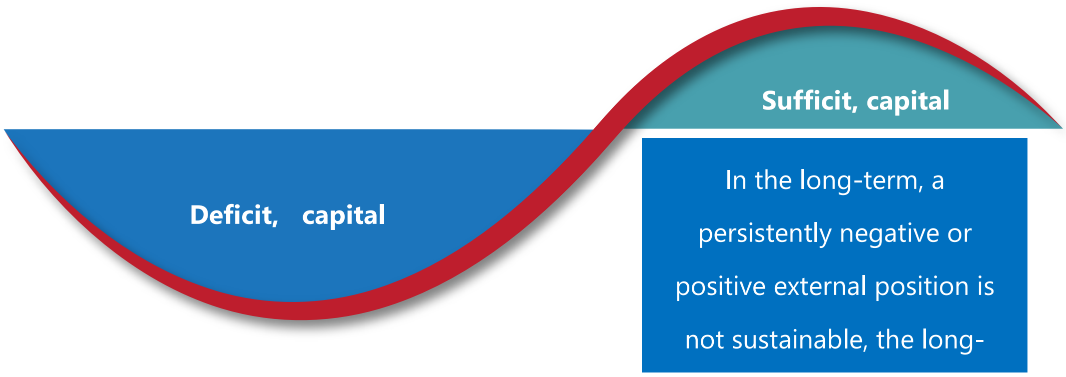
2. External sustainability of the economy: external gap

The long-term sustainability of the economy depends on the sustainability of the country's external financing. The main indicator of external financial balance is the current account, which includes both external trade and income transactions with the rest of the world and reflects the country's saving position vis-à-vis the rest of the world. Only the equilibrium position can be maintained in the long term. When estimating the equilibrium level of the current account balance, the cyclical position of the economy and country-specific characteristics should be considered. Some factors affect current account developments in the short term, while others have a long-term impact. Accordingly, current account imbalances may be the result of temporary shocks (such as higher imports due to soaring energy prices) or more permanent processes such as economic catching-up process.

International capital flows allow developing countries to catch up more quickly and can thus justify persistent external imbalances that may last for a decade or two. Developing countries benefit from this by seeing a surge in investment and productivity, accelerating economic catch-up. In principle, this process continues until the capital stock in the emerging country also reaches a level where the return on surplus investment no longer exceeds that of developed countries. Successful catching-up therefore results in the emerging country becoming one of the countries that invests more capital than it attracts. At the same time, the catching-up process turns from a negative current account balance into a current account surplus.

The current account may, therefore, durably deviate from the balance for structural reasons, but only a position around the balance can be sustained in the very long term (Figure 3). Considering the processes that cause persistent imbalances, it is not reasonable to assume that a country can maintain a unilateral relationship with the rest of the world over a very long period, even over many generations, in which its current account position remains negative or positive on an ongoing basis. Therefore, a current account balance around equilibrium appears to be desirable for sustainable growth in the long run, as it ensures that no large accumulation of international debt or claims occurs.

3. Figure: Only the equilibrium position can be maintained in the long-term



Emerging countries within the EU are in a special position thanks to the resources from the EU's Structural and Cohesion Funds. Some of these do not appear in the current account, but they still help the external financial balance. This means that, for the beneficiary countries, the sustainable level in the long term should not be the balanced current account, but the current account balance supplemented by EU-funded transfers (the so-called capital account), i.e., the balance of net lending. Data series for the current account and the net lending are acquired from the Eurostat and the IMF databases, these time series are expressed as a percentage of GDP, so they can be directly added or subtracted from the GDP figures to adjust them to calculate the sGDP.

3. Balanced lending developments: credit gap

The lending activity of the banking system is usually unsustainably strong in economic upturns and too weak in recessions. Lending flows are volatile by nature and the financial system tends to behave pro-cyclically: in good times, it overheats economic growth unsustainably by lending, and in recessions it restrains lending more than is justified, amplifying fluctuations in economic performance. Fluctuation in lending is not considered to be a state of equilibrium and is therefore excluded from sustainability-adjusted GDP.

We used major simplifications in order to have some kind of rough idea of the level of GDP "adjusted" for the financial cycle for all countries. Therefore, on the one hand, we restrict our approach to the cyclicality of lending, measured by the cyclical position of non-financial private sector (households and non-financial private corporations) credit-to-GDP. On the other hand, we make strong assumptions on the co-movement between credit and GDP based on the relevant empirical literature.

There are many ways of calculating credit gaps, and it is not clear which of these best measures the credit cycle, and furthermore, credit gaps are only moderately able to capture the evolution of the financial cycle (for a brief review of the relevant literature, see Hosszú and Lakos, 2021, whose main references are Detken et al., 2014; Tölö et al., 2018; and Lang et al., 2019). The European macro-prudential regulatory framework recommends that, for monitoring the booming phase of the financial cycle, the credit gap should be constructed with the widest possible loan portfolio and a one-sided HP filter that takes into account even the longest financial cycles (BCBS, 2010; ERSB, 2014). We also used this credit gap for our calculations with one modification. We used an HP filter with a maximum financial cycle length of 22 years (i.e., the lambda parameter was set to 125,000 instead of 400,000). The link between the credit gap and GDP was based on empirical results on the typical co-movement of loans and GDP. These imply that a 1 percent annual increase in the outstanding loans of the non-financial private sector loan portfolio is associated with an annual increase in nominal GDP of roughly 0.2–0.7 percent per year. To be conservative, we chose a value from the lower half of this range for our calculation: 0.3. The lower value chosen was also an attempt to dampen the multiple inclusion of the joint effects of the cycles in the adjustment of GDP for cyclical effects.

The data were obtained from four different data sources. Four-quarter rolling sum of current price GDP data in the denominator of the credit-to-GDP time series are from Eurostat. The bottleneck was the ECB credit data, which in many cases only available with short time series. The calculated credit-to-GDP time series were extended from the BIS credit database, and where this was not possible, from data of national macroprudential authorities. The credit gap time series for each country is traced back to at least 2000, and in the case of data gaps, we estimated values based on credit gaps for similar countries. The credit gap is expressed in the percentage of GDP, so it can be directly added or subtracted from the GDP figures to adjust them to calculate the sGDP.

4. Inclusive labor market: social gap

Economic growth can only be sustained if it benefits the widest possible section of society in a fair way. In contrast, excessive inequality leads to a weakening of social cohesion and wasting human capital capacity. While there is no optimal level of inequality, we assume that moderate levels of social inequality are an important criterion for sustainability. A wide variety of indicators are used in the literature to measure social inequality. The main reason is that inequality is multidimensional. This is reflected, for example, in differences in income and wealth of different groups, social mobility and employment opportunities. In addition to economic dimensions, differences between the relatively advantaged and the relatively disadvantaged people can be seen in differences in education, training opportunities, and opportunities for the preservation of health and recovery. The list of dimensions could go on almost endlessly.

To calculate sustainable GDP, we use an inequality index based on differences in employment opportunities. This indicator is the employment gap, defined as the difference between the employment rates of the highly educated (those with at least a college degree) and the low-educated (those without a high school diploma). Employment opportunities are closely related to other dimensions of inequality (e.g., income, health, life expectancy) and the strength of social cohesion. The data show that the employment gap has a similar pattern to indicators derived from other labour market data (e.g., wage distribution), thus confirming our view that the indicator chosen to calculate sustainable GDP captures social inequality in a sufficiently comprehensive way. We use a statistical approach and historical data to determine the extent of social inequality calculated in the employment gap, which is the basis for our calculation of sustainable GDP. The extent of the employment gap which is compatible with sustainable GDP was defined by examining the variation of the indicator across countries and looking for a value sufficiently far from extreme highs and lows. Since the low value is typically around zero, the mean value is defined as half of the maximum value recorded during the period under review.

The employment gap indicator has the advantage that, unlike other social inequality indicators, it is based on relatively easily available accessible data and can be produced for a wide range of countries and for a longer period relevant to the analysis. The employment data for the 27 EU Member States and the none-EU OECD member states were downloaded from the Eurostat and OECD websites, which are produced on the basis of the Labour Force Survey. Our approach is consistent with research that shows that excessive social inequality has negative effects on the economy. According to Ostry et al. (2014), rising social inequality also shortens the favorable period of the economic cycle when GDP is growing. Based on this experience, we calculated the contribution of sustainable levels of social inequality to sustainable GDP.

5. Ecological sustainability

The ecological aspect of sustainability is quantified by the extent to which available environmental capacities are used or overused. Since the first industrial revolution, the historically unprecedented growth in the world's economy and population resulted in increased utilisation of the available natural resources. As a result, the depletion of environmental resources has increased in past decades and has now become a tangible barrier to long-term sustainable growth. Natural resources are not merely input factors of production, but also serve as a framework for it. The volume of available resources is finite, and thus – with a view to ensuring sustainable growth – efforts should be made to use resources efficiently also in ecological terms.

Of the five key variables considered in the calculation of sustainable GDP, the ecological indicator has the longest cycle. There is a strong argument that we are in the first long, and deteriorating, global cycle in terms of ecological balance since the industrial revolution. Although it is difficult to quantify all environmental resources and their use in a single indicator, the data point in the direction of a global ecological footprint that significantly exceeds the Earth's carrying capacity. It is estimated that we currently use as much environmental resources each year as the Earth produces in 1.8 years (Global Footprint Network). The pursuit of ecological sustainability is therefore both a necessity and an opportunity for new technologies, investments and jobs. Ecological sustainability is not only a goal but also a major economic driver in all walks of life (Baksay et al., 2022).

The ecological balance is the difference between the natural resources (biocapacity) available in a given area and the resources used from it (ecological footprint) (GFN; MNB, 2022). Biocapacity is the sum of all biologically productive areas (both terrestrial and aquatic) that are needed to meet human needs and to reproduce. The ecological footprint is the amount of natural resources used to meet needs and the amount of waste generated. In order to quantify the impact of the ecological gap on sustainable GDP, we estimated country-specific parameters for our study due to the different geographic endowments. Several different methodologies were used to determine this in different estimations: time series, cross-sectional and panel examination. To estimate individual, country-specific variances, we fitted OLS (Ordinary least squares) models to time-series data for the countries and performed the process for period averages on the cross-sectional sample. Finally, we constructed a pooled OLS model on a panel database built from time series and cross-sectional data of the sample countries. With this econometric approach we determined one single parameter for each country which can transform the ecological balance into GDP effect, which can be used to calculate the sGDP.

Conclusion and recommendations

The methodology developed in this study offers an integrated framework for evaluating both the quantity and quality of production factors, providing a comprehensive perspective on national welfare that moves beyond the constraints of conventional GDP metrics. This approach acknowledges that national wellbeing is multidimensional, incorporating both tangible and intangible components of economic inputs. By including qualitative aspects — such as labor skill levels, environmental resources, and social cohesion — the methodology presents a more nuanced and realistic portrayal of a nation's economic health. In doing so, it captures aspects of welfare that traditional economic measures tend to overlook, reflecting a more robust and sustainable vision of economic development.

By juxtaposing composite indices with sustainable GDP (sGDP) results, this methodology provides policymakers with a sophisticated set of tools for strategic decision-making. The integrated analysis facilitates a comprehensive assessment of progress across multiple sustainability dimensions, allowing policymakers to design targeted strategies that support the sustainability transition. This approach is instrumental in aligning national policies with long-term environmental and social goals, helping governments balance economic growth with ecological integrity and social equity. Thus, this framework supports a proactive transition to sustainable development, tailored to meet the evolving demands of a complex global economy.

An innovative feature of our research lies in the joint evaluation of composite indices alongside sustainable GDP (sGDP) results, a dual-lens approach that strengthens the analytical framework for sustainability transitions. Composite indices, which combine multiple elementary indicators into aggregate scores, provide policymakers with a bird's-eye view of sustainability trends. When integrated with sGDP results, which adjust GDP to reflect sustainability factors, this dual-lens approach offers policymakers nuanced insights into both overall sustainability and specific areas of improvement. This capacity for targeted analysis is particularly valuable in policymaking, where decisions must often balance short-term economic considerations with long-term sustainability goals. Furthermore, the elementary indicators that compose these composite indices are designed to measure progress toward all 17 SDGs, ensuring alignment with internationally recognized sustainability benchmarks. This alignment not only enhances the validity of the framework but also promotes consistency with global sustainability efforts, thereby facilitating collaborative action across countries.

The construction of composite indices is guided by the need to measure progress toward all 17 Sustainable Development Goals (SDGs) using a refined, carefully selected set of indicators. By minimizing the number of indicators without sacrificing informational value, this streamlined framework supports efficient tracking of sustainable development across economic, social, and environmental dimensions.

This reduction mitigates the risk of data overload, enabling policymakers to integrate SDG targets effectively into national policy frameworks. As a result, this methodology strengthens institutional capacity to monitor, report, and advance sustainable development objectives with enhanced clarity and focus.

The proposed three-tier indicator system facilitates a thorough measurement of both sides of fundamental economic identity equations, as elaborated in subsequent sections. By supplementing traditional GDP with multidimensional indicators, this framework captures a wide range of factors essential to understanding the sustainability transition. This approach enriches the evaluation of economic, environmental, and social dimensions, allowing for a more holistic view of a nation's developmental progress. By quantifying each aspect of sustainable development, this methodology provides policymakers with a tool for assessing the trade-offs and synergies between economic expansion, environmental stewardship, and social cohesion — key components of sustainable economic growth.

One of the methodology's unique strengths lies in its emphasis on temporal self-comparison within individual countries. This approach enables nations to measure their own progress over time, which is particularly valuable for understanding unique, context-specific paths to sustainability. By focusing on internal trends rather than cross-country comparisons, this method allows for a more nuanced view of national advancements, underscoring the importance of internal improvements. Each country can therefore track its development trajectory in alignment with its own socioeconomic and environmental context, reinforcing a tailored approach to sustainable progress.

To precisely and reliably measure the sustainability transition, this methodology emphasizes the need for continuous monitoring of changes within national wealth inventories. By tracking shifts across all four types of capital — produced, natural, human, and social — the methodology enables an accurate assessment of long-term economic, environmental, and social sustainability. Restructuring the national accounting framework to monetize each type of capital allows for a comprehensive understanding of the trade-offs inherent in sustainable development. By assigning monetary values to produced, natural, human, and social capital, policymakers can evaluate the costs and benefits associated with different sustainability policies. This level of insight is essential for effective resource management and aligns policy decisions with long-term sustainable development goals. A national accounting system that recognizes these trade-offs empowers policymakers to make informed, balanced decisions, guiding nations toward a sustainable future where economic growth coexists with environmental resilience and social wellbeing. By creating a standardized methodology for the measurement and regular monitoring of these capital forms, countries can develop a fuller understanding of the factors that drive or inhibit sustainable development. National wealth assessments, unlike GDP, would enable countries to account for the depreciation of environmental resources (such as forests, water, and soil), the erosion of social capital (such as trust and social cohesion), and the degradation of human capital (such as health and educational outcomes). This form of assessment thus provides a more integrated and accurate perspective on progress, reflecting the capacity of nations to sustain wellbeing for future generations.

An international framework for capital stock assessment would foster data consistency, comparability, and transparency across countries, paving the way for a global standard in sustainability measurement. The development of such a framework would involve collaboration across research institutions, governments, and international organizations, drawing on diverse expertise to ensure that measurement techniques are scientifically robust and culturally adaptable. The alignment with internationally recognized goals, such as the Sustainable Development Goals (SDGs), would further enhance the relevance of these assessments, linking national wealth inventories directly to global sustainability objectives.

Moreover, by focusing on natural, social, and human capital, countries would gain the tools to adopt policies that account for resource limitations, promote social equity, and invest in human wellbeing. For instance, regular assessments of natural capital could help identify critical areas where ecosystems are at risk, guiding conservation efforts. Similarly, by measuring social capital, policymakers can address factors that contribute to community resilience, such as trust, social networks, and civic participation, which are essential for societal stability. Lastly, human capital assessments could drive investments in education, healthcare, and skills development, enabling societies to adapt to economic changes and technological advancements.

To sum up, our research presents an actionable framework for assessing sustainability transitions that emphasizes the importance of consistent, high-quality data collection and methodologically rigorous indicators turning the information into knowledge and policy shaping tool. By integrating composite indices, SDG-aligned elementary indicators, and sGDP adjustments, this approach provides a nuanced perspective on wellbeing that extends beyond GDP metrics. The development of such frameworks is essential for informing data-driven policy decisions that address the interconnected challenges of economic growth, environmental protection, and social wellbeing.

In closing, our findings underscore the critical role of interdisciplinary research in advancing beyond GDP approaches. Through collaborative efforts that draw on expertise from environmental science, economics, and social science, the development of innovative methodologies for sustainability assessment can pave the way for a more comprehensive and adaptive understanding of progress. By supporting the long-term goal of sustainability transitions, this research contributes to the foundation upon which nations can build resilient, equitable, and environmentally responsible societies that thrive beyond the limits of GDP-focused metrics.

The accurate measurement of sustainability transitions hinges upon tracking changes in the national wealth inventories of individual countries. These inventories represent a comprehensive measure that encompasses not only produced capital but also the natural, human, and social capital that are fundamental to long-term wellbeing. Traditional metrics, especially GDP, remain insufficient for capturing these dimensions due to their inability to account for the depreciation of vital assets, such as natural ecosystems, educational attainment, health, and community cohesion. GDP measures economic output but neglects the impact of economic activities on these foundational elements, meaning that unsustainable exploitation of resources, social inequities, and declines in public health often remain unaccounted for within economic performance assessments. This oversight can mask underlying issues, leading to policies that prioritize short-term gains at the expense of long-term sustainability.

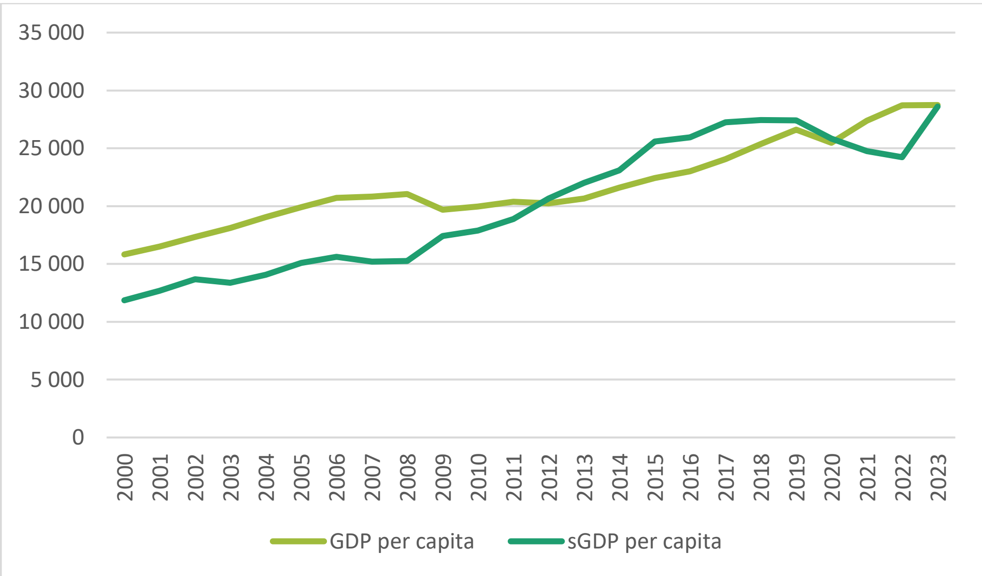
Results

As we said before, the development of the sustainability and wellbeing composite indices relied on numerous metrics sourced from various international databases. These sources encompass reliable datasets from different specialized fields, providing a robust and credible foundation for the indicators. In the following chapter, we will present our findings regarding some selected countries from the OECD.

HUNGARY

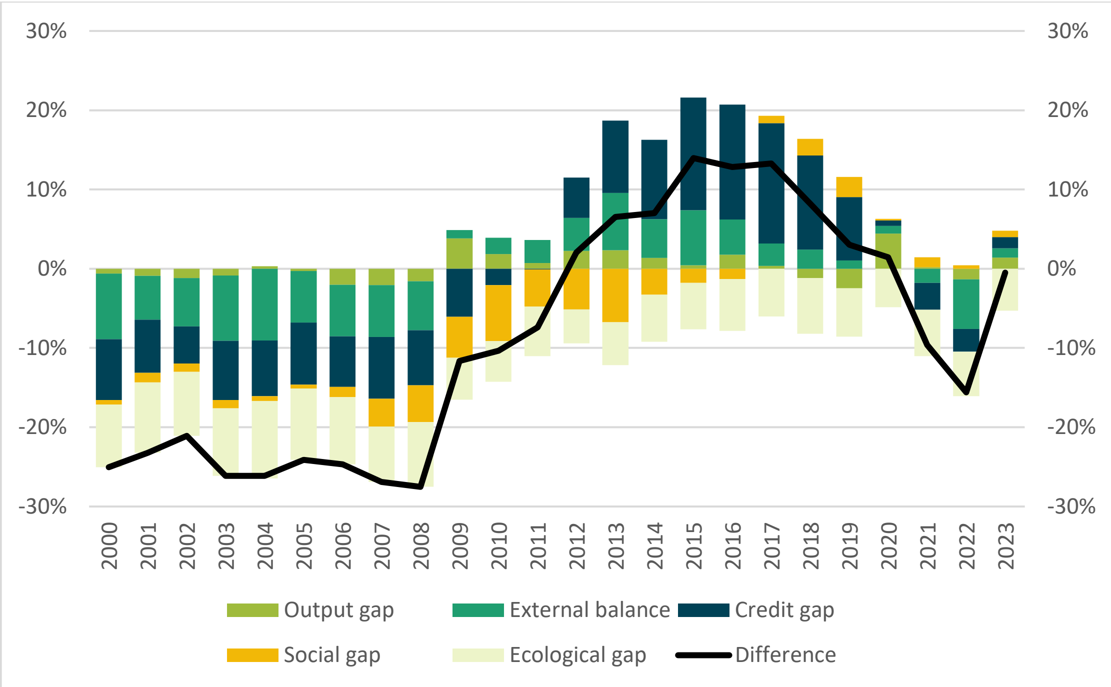
Based on our findings, the per capita sGDP (sustainable GDP) in Hungary surpassed the GDP level during the 2010s, but dropped below it in 2021. Economic growth prior to the 2008 financial crisis was only achievable at the cost of significant imbalances. In the mid-2000s, sGDP lagged behind actual GDP by an average of approximately 25%. This situation changed markedly due to the impact of the 2008 crisis and the financial reforms introduced in the 2010s. Between 2017 and 2019, the growth of sGDP slowed, and from 2020 onwards — partly due to crises affecting the economy — it began to decline. While statistical GDP rebounded quickly after the COVID-19 crisis, sGDP did not (4. Figure).

4. Figure: GDP and sGDP in Hungary



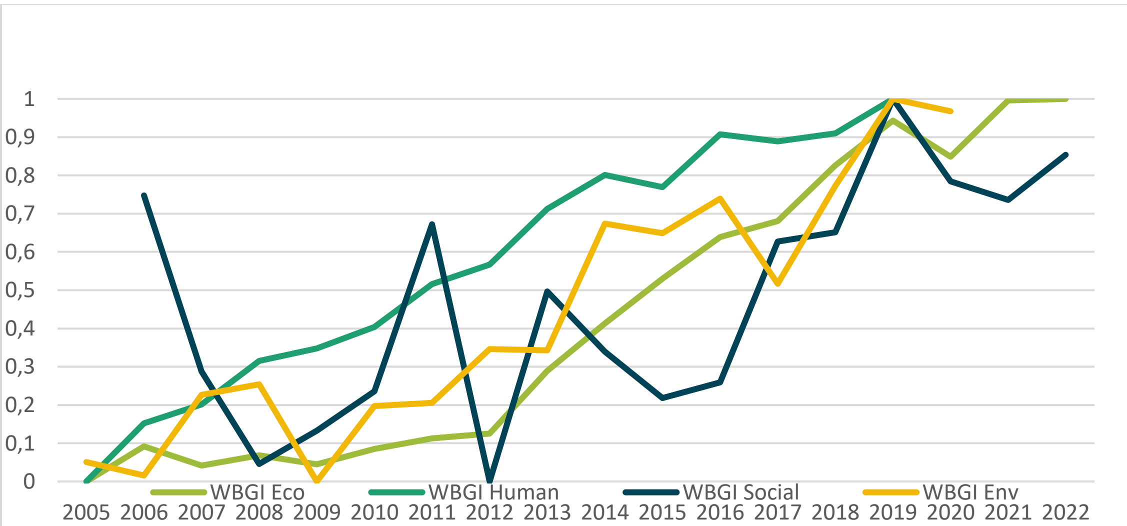
A breakdown of Hungary's sGDP adjustments reveals that, in the period preceding the financial crisis, the Hungarian economy was characterized by excessive indebtedness, reflected in credit imbalances. The domestic level of sustainable GDP peaked between 2015 and 2017, partly due to the gradually improving economic conditions. The growth in sGDP was primarily driven by improvements in financing capacity and lending processes. Since 2017, the level of Hungary’s sGDP declined, and since 2021, it has fallen below the statistical GDP. The surplus in financing capacity has disappeared, while the COVID-19 pandemic was followed by significant economic contraction. On the positive side, social inequality contributed favorably to sGDP, which can be attributed to near-full employment and a strong labor market.

5. Figure: Five dimensions of sGDP in Hungary



Overall, all dimensions of the Wellbeing Beyond GDP Index are on a growth trajectory; however, the impact of the COVID-19 pandemic serves as a clear example of how external shocks can disrupt this upward trend across multiple dimensions. In the economic dimension, most sub-indicators reflect a generally positive trend, yet the pandemic-induced spike in unemployment led to a downturn in 2020-2021.

6. Figure: Dimensions of the Wellbeing Beyond GDP Index in Hungary

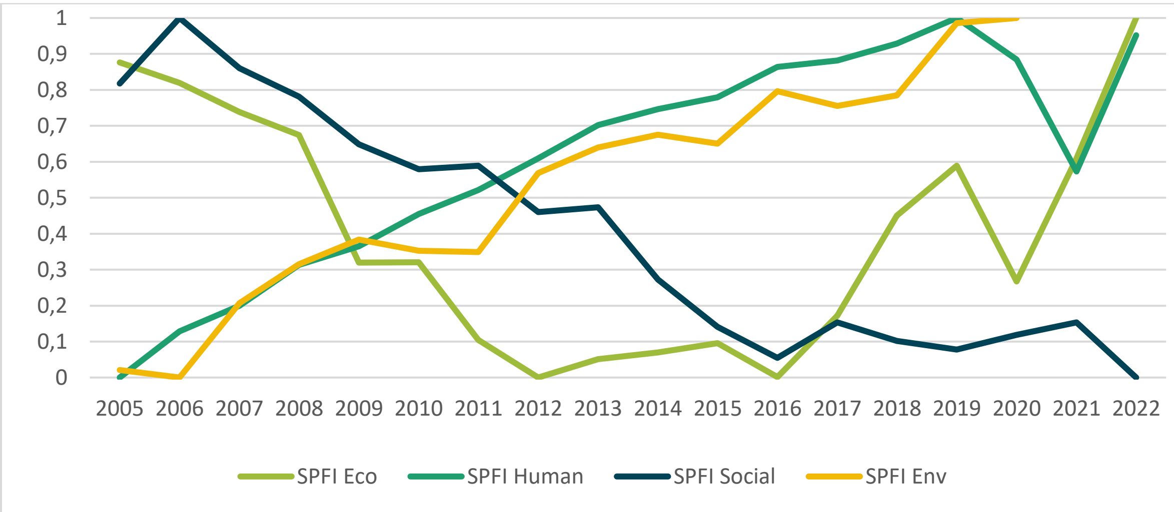


This setback highlights the vulnerability of economic welfare to sudden shifts in employment stability (7 Figure).

The social dimension, however, exhibits the greatest volatility, driven by substantial fluctuations in trust levels. These changes suggest that the pandemic's broader social impact may have weakened trust in institutions and created an environment of uncertainty, thus negatively influencing social welfare trends. This fluctuation within the social dimension underscores the importance of resilience in maintaining societal trust in times of crisis.

The observed U-shaped trajectory within the economic dimension is largely attributed to the cyclical nature of public debt and investment rates. This cyclicality was notably exacerbated by the fiscal responses during the COVID-19 pandemic, wherein central governments ramped up expenditures to mitigate immediate economic repercussions.

7. Figure: Dimensions of the Sustainable Performance Framework Index in Hungary

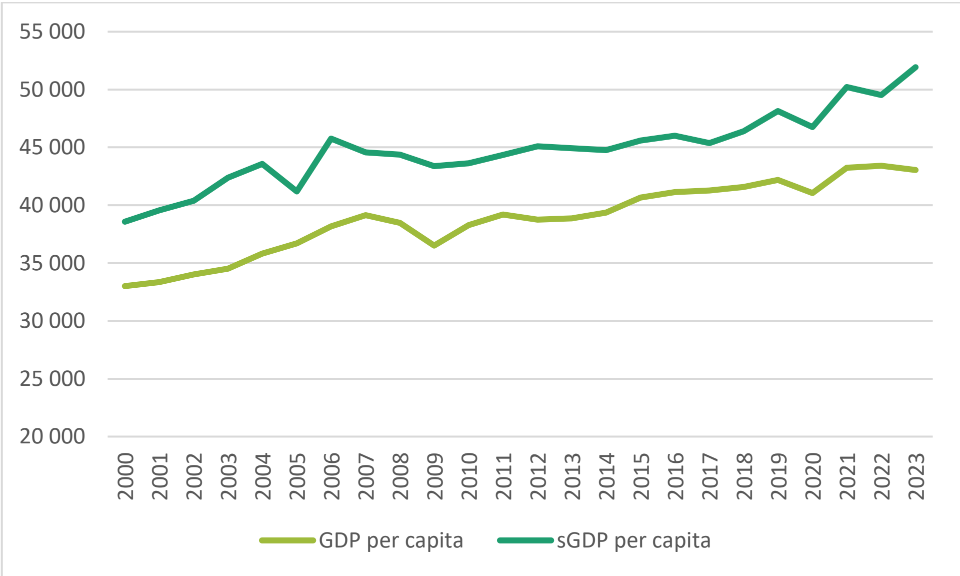


The pandemic instigated a decline in the relevant indicators within the human dimension. Notably, developed economies had previously demonstrated consistent improvements in life expectancy, supported by a sustained decrease in avoidable and preventable mortality rates, alongside reductions in infant mortality. These long-standing upward trends, however, faced significant disruption as excess mortality rates surged during the pandemic, which, in turn, reversed gains in life expectancy (8. Figure). This shock to the human dimension underscores the pandemic's profound impact on trajectories previously indicative of steady advancement within sustainability metrics.

SWEDEN

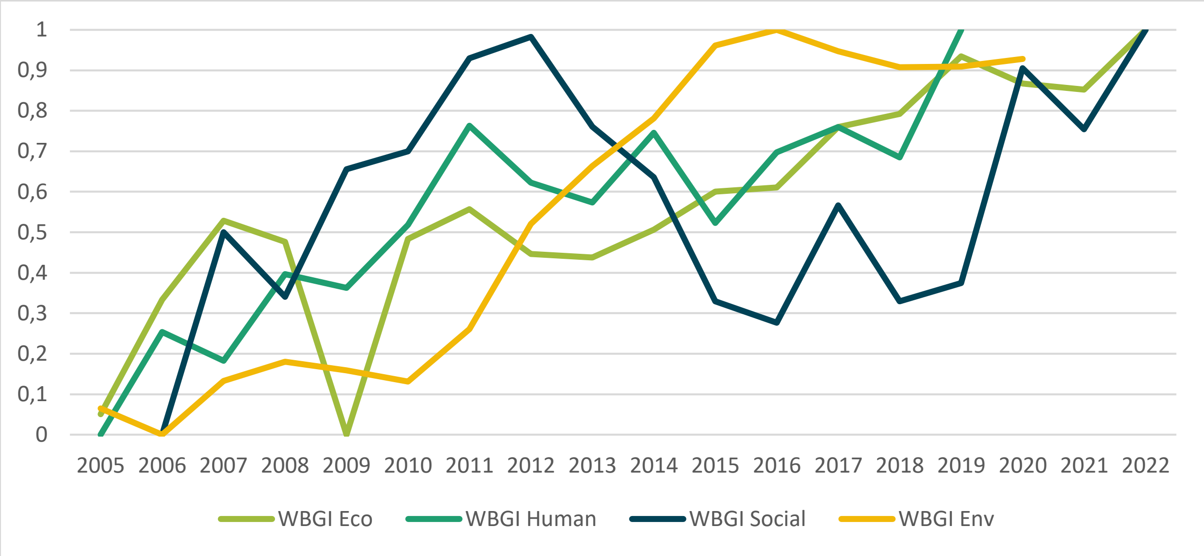
If we examine the pillars of sGDP it is interesting that social indicators show a slight negative effect post-crisis. Examining the social sub-pillar might reveal some unexpected patterns. Immigration could potentially impact labor market data, influencing these trends. On the ecological side, positive indicators are likely influenced by preserved natural landscapes (9. Figure). Additionally, foreign direct investment (FDI) flows are strong. Overall, the country displays stable, positive performance metrics, showing resilience even amid major shocks such as the GFC and COVID-19, thanks to ample resources that buffer these impacts.

8. Figure: GDP and sGDP per capita in Sweden



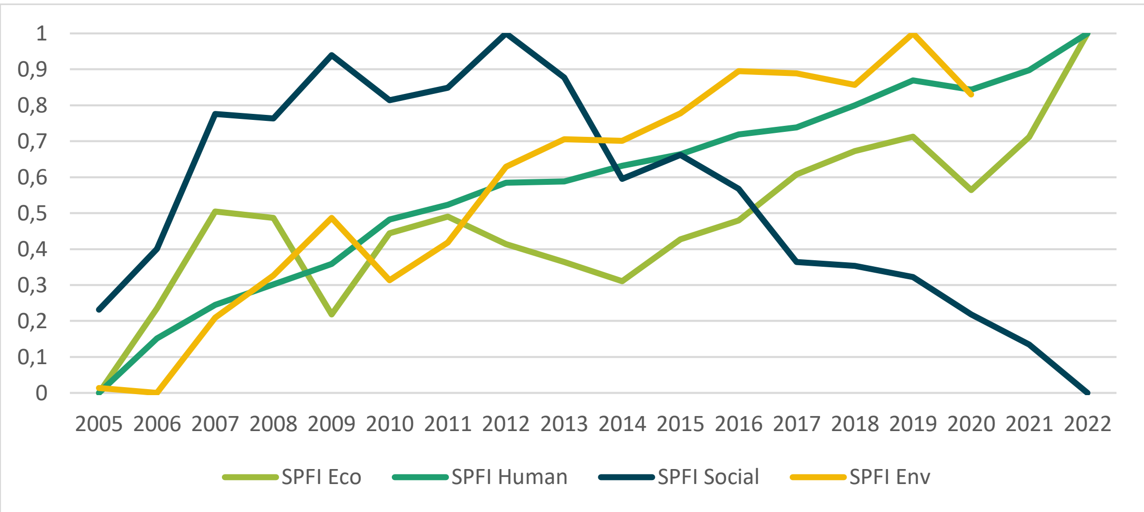
We can say about the economic dimension of the Wellbeing Beyond GDP Index, that the 2009 recession impacted employment, GNI, and savings, with notable repercussions across each area. Employment rates worsened significantly following COVID-19, although GNI and savings have partially offset this decline. In terms of the Human Dimension, the annual suicide rate shows considerable fluctuations, though there is an observable trend toward improvement. Life expectancy has steadily increased, maintaining this trajectory until the COVID-19 pandemic. Internet usage peaked in 2014, followed by a slight decline, but significant growth resumed from 2017 onward. Regarding the Social Dimension, trust levels paralleled transparency until 2019; however, transparency declined post-2020, while trust improved (9. Figure). Since trust carries more weight within the dimension, the overall social dimension reflects an improvement.

9. Figure: Dimensions of the Wellbeing Beyond GDP Index in Sweden



Examining the dimensions of the Sustainable Performance Framework Index, we observe that the economic dimension shows stable growth over the analyzed period, reaching its peak in 2022. This growth is primarily driven by improvements in the public debt ratio and the steady increase in investment volume. In the human dimension, health indicators show gradual improvement each year, which drives the observed trend; however, the impact of the COVID-19 pandemic remains unobservable due to data limitations. Regarding the social dimension, there is a gradual improvement observed up to 2012, followed by a continuous decline in all elementary indicators. This decline is reflected in decreased government efficiency, a weakened rule of law, and an increase in corruption levels (10. Figure). Finally, elementary indicators within the natural dimension demonstrate a gradual progression toward sustainability transitions, evidenced by reduced greenhouse gas emissions and an increase in the share of organic farms.

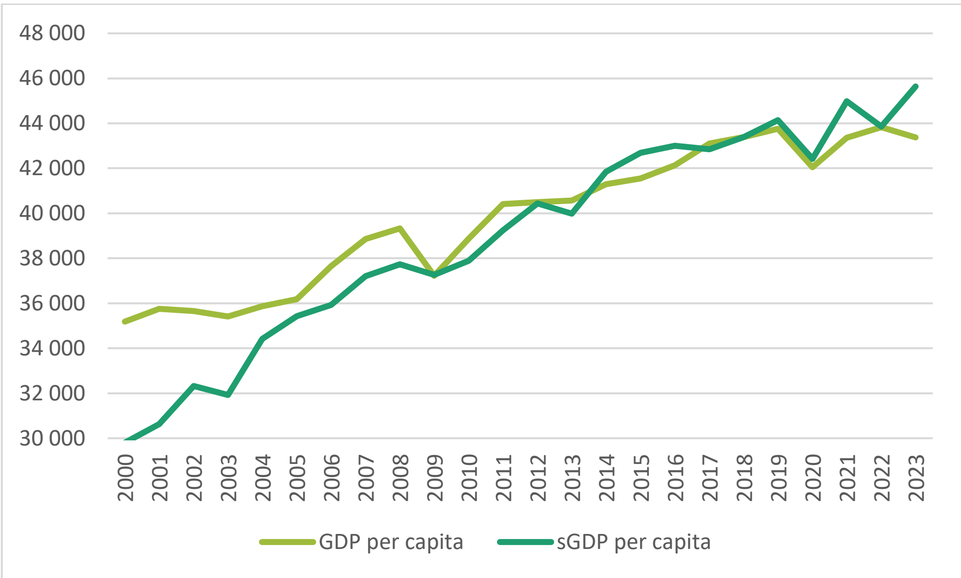
10. Figure: Dimensions of the Sustainable Performance Framework Index in Sweden



GERMANY

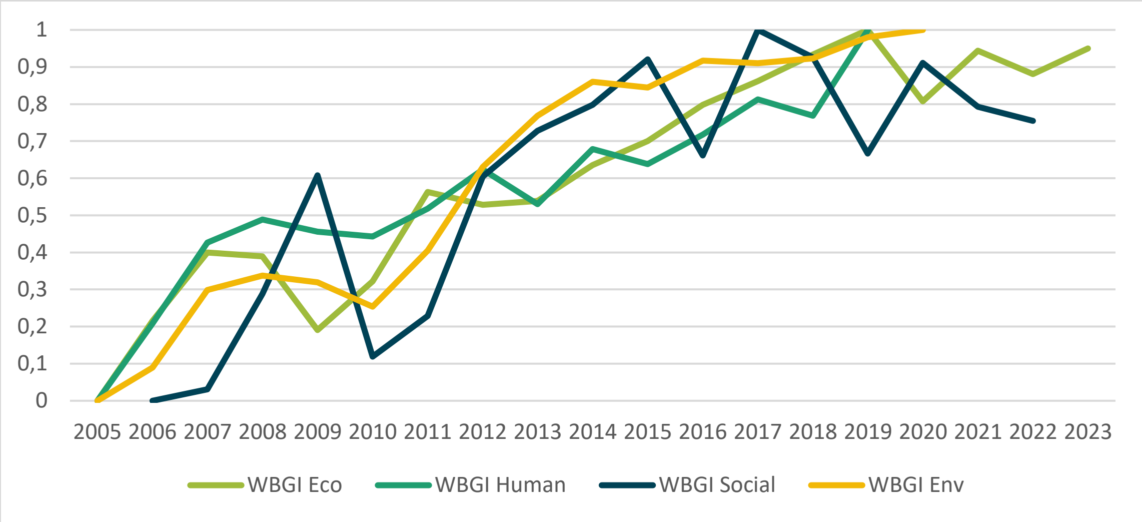
Interestingly, a more prominent gap appeared in the early 2000s, which closed even before the Great Financial Crisis (GFC). Moreover, it's also plausible that the economic boom and consumer-driven growth at the turn of the millennium skewed figures in numerous countries. Despite the crisis, Germany's metrics remained relatively stable, fluctuating only slightly around zero with minimal variance — small positives and small negatives without major disruptions. On the downside, Germany's ecological indicators, like those of France, improved over two decades, marking a positive trend. Social indicators also show substantial gains, reaching positive values by the end of the period, diverging from the French trajectory. Comparing social sub-pillar metrics between Germany and France could yield valuable insights into these differing dynamics (11. Figure). The financing pattern, largely explained by Germany's significant outward FDI, aligns well with the country's broader economic profile.

11. Figure: GDP per capita and sGDP per capita in Germany



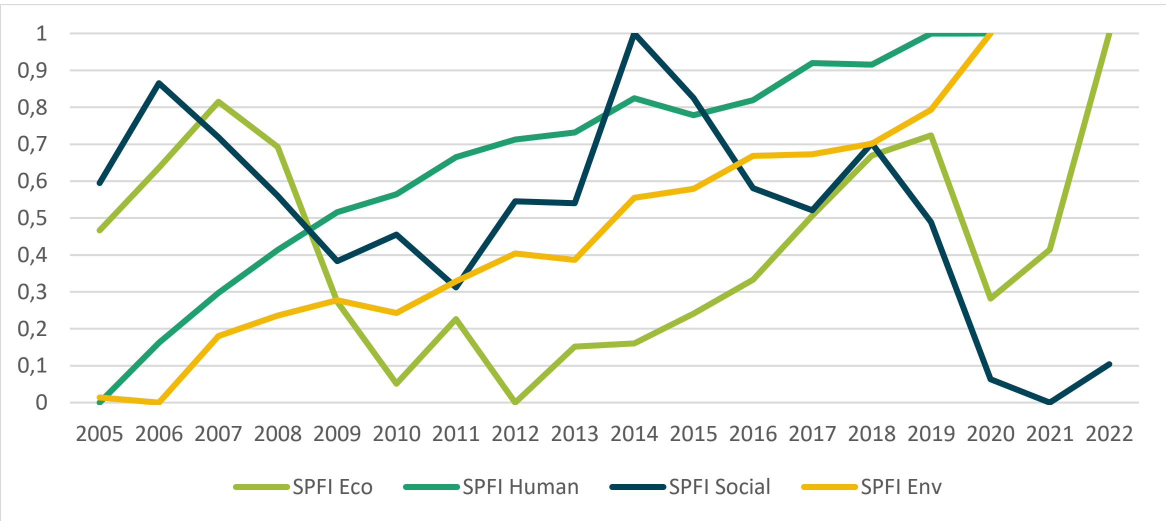
In examining the WBGI, the wellbeing composite indicator, it is evident that the 2008 global financial crisis led to a more pronounced downturn in the economic dimension than the COVID-19 pandemic. In 2009, there was a substantial decrease in the savings rate, and employment indicators fell more sharply than they did due to the pandemic. The trend in the human dimension of the welfare composite is driven by an increase in life expectancy at birth, a pattern observed in Germany as well. Annual declines in this trend are largely attributable to an increase in suicide rates. Regarding the social dimension, fiscal transparency measures at the start of the observation period display higher values over time compared to social trust levels (12. Figure). Social trust peaked in 2018, whereas fiscal transparency reached its lowest point. Within the environmental dimension, the elementary indicators show gradual improvement over the period analyzed, with a decrease in air pollution levels and an improvement in water quality.

12. Figure: Dimensions of the Wellbeing Beyond GDP Index in Germany



In the case of Germany, the trend in the economic dimension of the SPFI, the sustainability composite is primarily driven by the level of public debt; the situation was optimal before 2010 and showed improvement in fiscal sustainability even following the economic shock induced by the COVID-19 pandemic. Analyzing the human dimension, health indicators display growth up to the onset of the COVID-19 pandemic, at which point the data series is interrupted. A downturn in this dimension could also likely be observed here, following trends noted in other countries studied (13. Figure). The values of the elementary indicators within the social dimension vary considerably from year to year: public trust in the legal system and perceptions of corruption fluctuate significantly, with all indicators reaching their minimum in 2020-2021. In the natural dimension, the elementary indicators show substantial annual improvements, including an increase in waste processed within the circular economy and a reduction in greenhouse gas emissions.

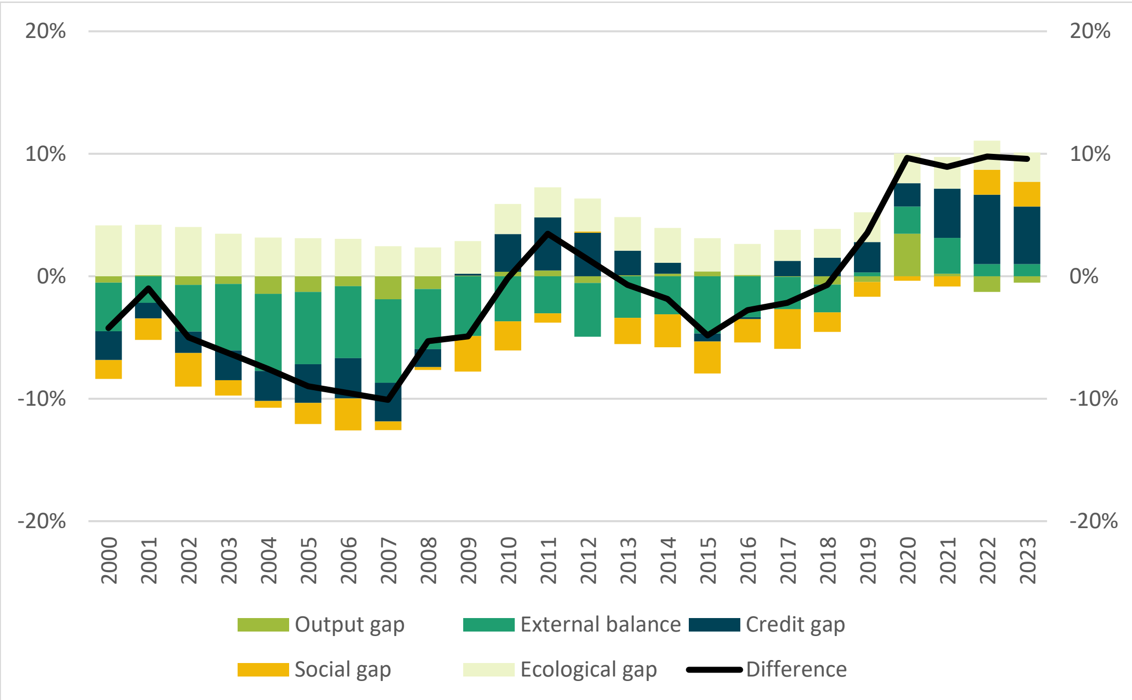
13. Figure: Dimensions of the Sustainable Performance Framework Index in Germany



AUSTRALIA

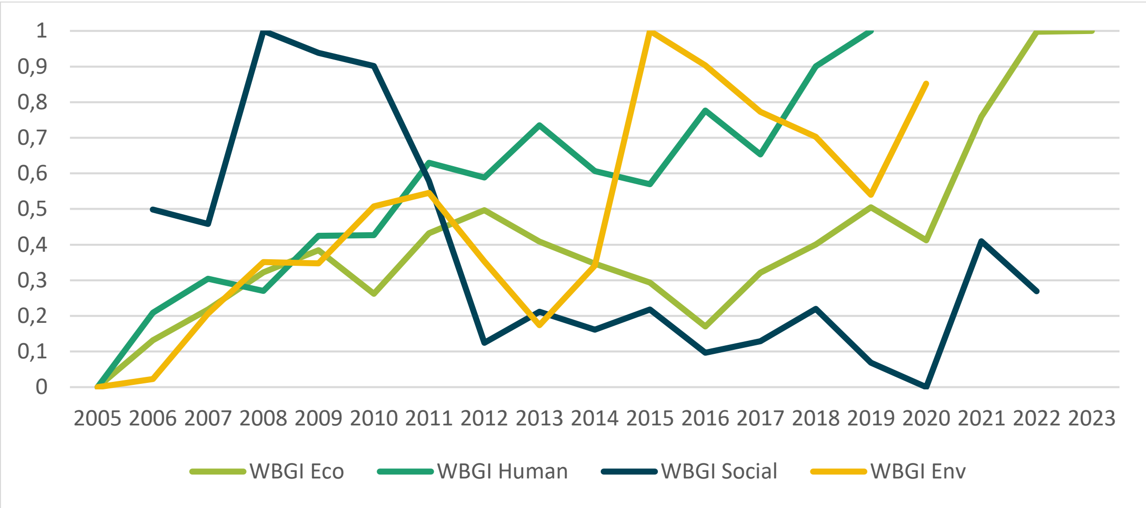
The findings indicate that, despite Australia's largely arid, uninhabited regions, its overall ecological gap remains positive, suggesting a net environmental advantage. Post-Great Financial Crisis (GFC), the pattern of sustainable GDP (sGDP) reveals an initial adjustment phase, followed by a swift return to negative growth, likely due to external financing pressures. While it's challenging to pinpoint a specific narrative without further context, an analysis of debt-related sub-indices could provide insights into this fluctuation. Interestingly, the consistently negative trend in social indicators saw a shift during the COVID-19 period (14. Figure). COVID-19 appears to have driven sGDP to a peak, and recent data show that credit reserves remain robust, which has contributed to sGDP's stability and relative strength in recent years. As anticipated, Australia presents a markedly different economic and sustainability profile compared to European countries.

14. Figure: 5 dimensions of sGDP in Australia



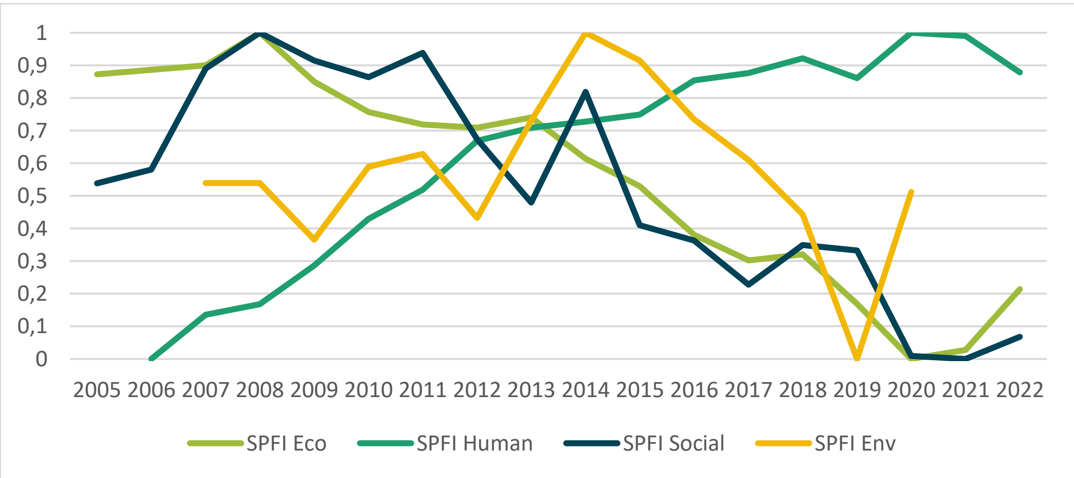
Concerning the economic dimension of the Wellbeing Beyond GDP Index, the trend is driven by GNI growth; however, post-2012 stagnation is attributed to a declining savings rate and sluggish employment expansion. In the human dimension, the gradual increase in suicide rates detracts from the trend, though it is somewhat offset by gains in life expectancy and a broader reach of internet usage. In Australia, social trust levels, as well as transparency, deteriorated significantly up until 2020. For the environmental dimension, the positive trend in welfare indicators is largely due to improvements in access to clean drinking water, which signifies progress in infrastructure and public health measures (15. Figure). However, this upward trend experienced a notable disruption in 2013 due to a recorded minimum in water stress levels, highlighting ongoing challenges related to water resource management and sustainability. This temporary setback underscores the sensitivity of environmental welfare indicators to shifts in resource availability and usage patterns, essential for sustaining long-term environmental welfare improvements.

15. Figure: Dimensions of the Wellbeing Beyond GDP Index in Australia



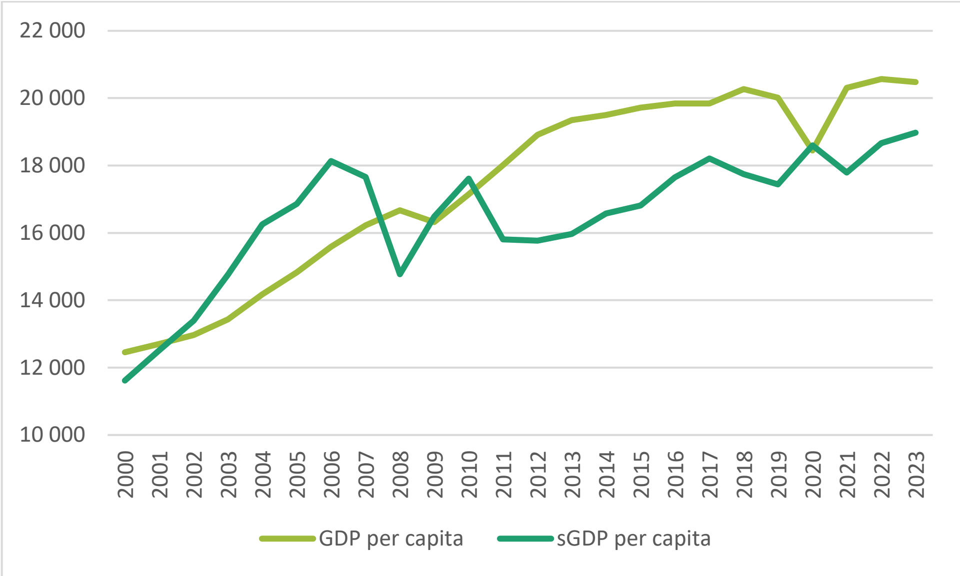
In analyzing the Sustainable Performance Framework Index's economic dimension, it is evident that the trend is primarily driven by a deterioration in public debt levels and investment rates. Within the human dimension, positive trends are observed, as indicated by a decline in both avoidable deaths and infant mortality, reflecting a gradual upward trend in wellbeing. The social dimension shows improvements in regulatory quality over time, yet perceptions of corruption and government efficiency have gradually declined, indicating challenges in institutional quality. Finally, in the natural dimension, the lowest point was reached in 2019, largely due to elevated greenhouse gas emissions and suboptimal waste management practices during that period (16. Figure).

16. Figure: Dimensions of the Sustainable Performance Framework Index in Australia



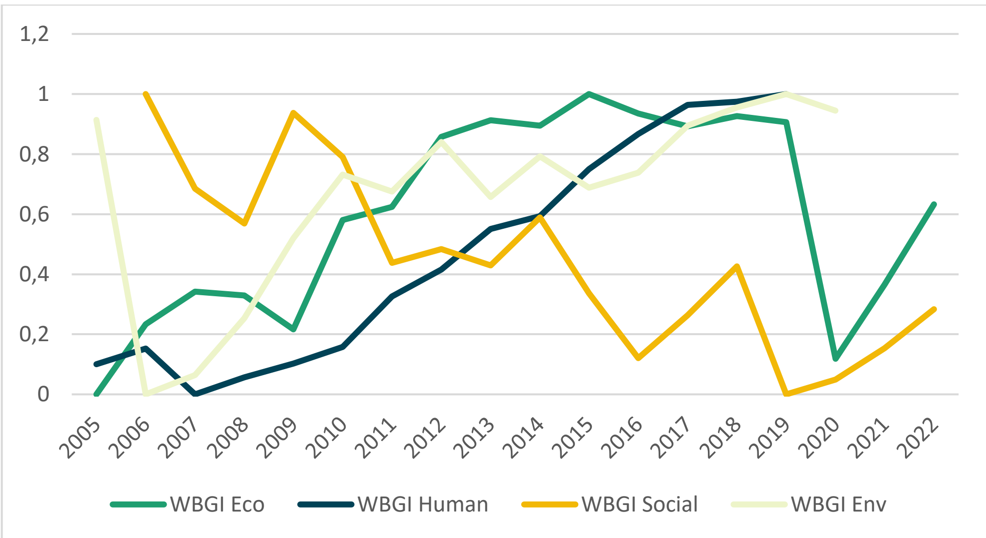
CHILE

17. Figure: GDP and sGDP per capita in Chile



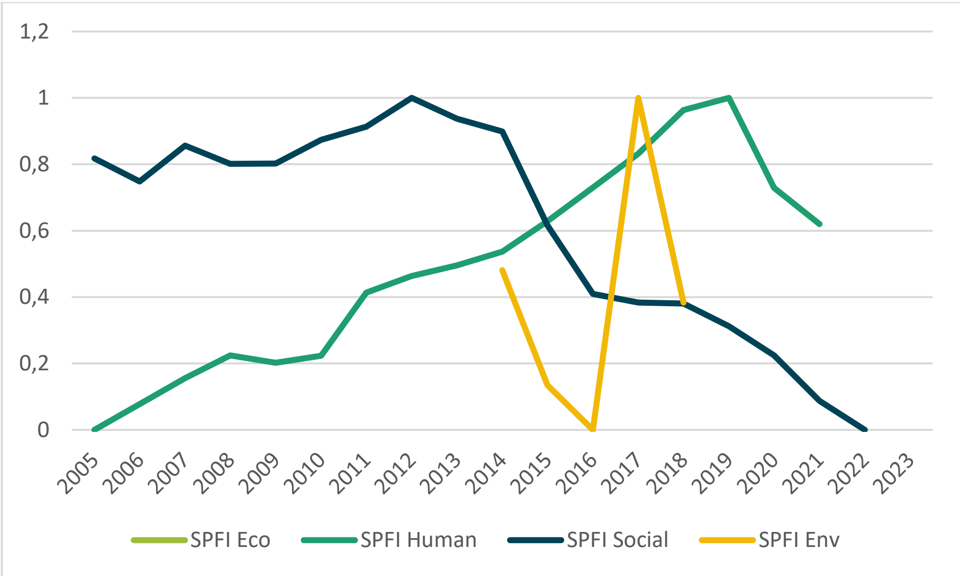
In discussing the economic dimension of the Wellbeing Composite Index, we observe that both GNI and employment expanded significantly up until the COVID-19 pandemic. However, employment levels in 2020 fell below those recorded in 2005. Regarding the human dimension, indicators for Chile, such as life expectancy and internet access, consistently improved until the pandemic, after which health indicators deteriorated due to its impact. In the social dimension, trust in the central government appears to follow the electoral cycle, as does the transparency of the national budget. The changes in the value of the natural dimension are primarily driven by variations in air pollution levels and consistently poor water stress values. The improvement in access to drinking water, however, positively influences the trend within the natural dimension (18. Figure).

18. Figure: Dimensions of the Wellbeing Beyond GDP Index in Chile



We were unable to calculate the economic dimension of the Sustainability Composite Index due to data limitations, though it is notable that the investment rate displays significant volatility among available economic indicators (19. Figure). Regarding the human dimension, the general trend of improvement in health indicators was interrupted by the onset of the COVID-19 pandemic. In the social dimension, trust indices stabilized at a high level until 2012, after which they declined steadily until the early 2020s, when all indices reached their lowest recorded levels. Due to data limitations, we were only able to calculate the natural dimension values for a brief period; however, an examination of the fundamental indicators reveals that, compared to 2005, greenhouse gas emissions have worsened in Chile, while material footprint indicators show an overall improvement.

19. Figure: Dimensions of the Sustainable Performance Framework Index in Chile



SUMMARY OF THE RESULTS

1. Economic Dimension and Susceptibility to External Shocks

The analysis of economic sustainability and wellbeing metrics across different nations indicates that economies worldwide are highly susceptible to external shocks, revealing structural vulnerabilities that can disrupt economic stability. The recent global crises — the 2008 financial crisis and the COVID-19 pandemic — served as stress tests, exposing weaknesses in many national economies, such as rising public debt, unemployment surges, and reduced investment rates.

However, responses to these economic pressures varied, underscoring the role of national policy in buffering against crises. Economies with robust fiscal frameworks showed more resilience, as balanced fiscal strategies allowed these countries to absorb immediate financial strain without compromising future stability. This variation suggests that well-designed policy mechanisms, such as fiscal sustainability measures, play a critical role in managing economic risks. By aligning short-term crisis response with long-term economic planning, countries can better withstand external shocks while protecting economic wellbeing.

Thus, the findings suggest that building resilience into economic policy — through measures that balance urgent needs with sustainable growth goals — can mitigate the effects of future crises and ensure more stable economic conditions over time.

2. Human Dimension Progress and Health Challenges

The analysis reveals that long-term improvements in human welfare, particularly in health metrics such as life expectancy and reduced mortality rates, were evident across the nations studied. However, these gains proved susceptible to disruption, as the COVID-19 pandemic exposed shared vulnerabilities within health systems. While progress had been steady in areas like healthcare access and preventable deaths, the pandemic underscored the need for resilience within public health infrastructure. Additionally, challenges such as rising suicide rates in certain regions indicate that mental health and preventive care policies are essential to sustain advancements in overall human wellbeing. These findings emphasize the importance of comprehensive and adaptable health policies that can maintain welfare improvements despite unexpected public health challenges.

3. Social Dimension Volatility: Trust, Transparency, and Institutional Quality

The social dimension highlights a consistent pattern of volatility tied to shifts in public trust and perceptions of institutional transparency, which play pivotal roles in social stability. Across nations, fluctuations in these indicators reveal that perceptions of government effectiveness can significantly influence public cooperation and broader social welfare. Periods of decreased transparency or trust, especially during crises like the pandemic, have shown that lapses in institutional credibility can weaken social cohesion and resilience. This underscores the essential role of transparent, accountable governance in maintaining public trust. Governance frameworks that proactively address public concerns, maintain transparency, and uphold institutional integrity are key to fostering social resilience and mitigating distrust during challenging times.

4. Environmental Dimension and Sustainability Transitions

The environmental dimension of sustainability demonstrates that while significant progress can be made, the outcomes vary widely depending on the strategies employed and the specific resources managed within each economic context. Indicators such as greenhouse gas emission reductions, enhanced waste management systems, and the availability of clean water are central to evaluating environmental welfare, as these directly influence the long-term sustainability of economic activities. The findings suggest that environmental welfare is particularly sensitive to policy decisions and infrastructure developments that govern resource use. For instance, water resources, which are vital for both consumption and industrial processes, are highly vulnerable to climate variability and usage intensity, thereby impacting economic resilience. Economic frameworks that integrate policies aimed at reducing emissions and improving waste management not only enhance environmental sustainability but also support sectors where resource efficiency is critical to competitive advantage.

Furthermore, this research underscores the necessity for cohesive policy interventions that align with broader sustainability objectives, including climate resilience, renewable energy adoption, and the promotion of sustainable agricultural practices. Long-term gains in environmental welfare are heavily dependent on regulatory frameworks that prioritize sustainable resource use and incentivize private sector investment in eco-friendly technologies. By incorporating mechanisms such as emissions caps, subsidies for renewable energy, and support for organic and sustainable farming practices, economies can strengthen their resilience against environmental disruptions. Ultimately, these policy measures foster a sustainable growth model where economic progress aligns with ecological balance, ensuring that environmental welfare is maintained across generations. Such an approach highlights the role of economic policy in safeguarding environmental assets that are foundational to future prosperity.

These findings indicate that sustainable development depends on integrated, multi-dimensional policy interventions tailored to economic, human, social, and environmental contexts. Effective policy responses should strengthen economic resilience to external shocks, enhance health system readiness, foster transparent governance, prioritize environmental management, and encourage balanced growth. This approach can support the stabilization of wellbeing and sustainability metrics, promoting more resilient and sustainable societies.

Annex I.

The Rise of Alternative Metrics

In response to the limitations of GDP, various alternative metrics have been proposed to provide a more holistic view of societal progress. These indicators seek to integrate economic, social, and environmental dimensions of development, moving beyond the narrow confines of economic output.

Human Development Index

Developed by the United Nations Development Programme (UNDP) in 1990, the HDI is one of the most widely used alternative indicators. It combines three core dimensions of human wellbeing: life expectancy, education (measured through mean years of schooling and expected years of schooling), and per capita income. The HDI emphasizes that economic growth is a means to an end, rather than an end in itself, and that human development involves improvements in health, education, and living standards (UNDP, 1990). While HDI broadens the scope beyond income, it still faces criticism for its limited focus on environmental sustainability and subjective wellbeing.

HDI Calculation Method:

- Life Expectancy: This dimension measures health and longevity, using life expectancy at birth as an indicator. It is based on the assumption that a longer life span is associated with better access to health services and higher overall wellbeing.
- Education: The education dimension is measured through two indicators: mean years of schooling (average years of education received by people aged 25 and older) and expected years of schooling (total years of schooling that a child of school-entry age can expect to receive). This captures both current educational attainment and future potential for human capital development.
- Income: The standard of living dimension is measured by GNI per capita. GNI is used instead of GDP because it includes income from abroad and reflects a more comprehensive view of income levels.

Each of the three dimensions is normalized on a scale from 0 to 1, with the HDI calculated as the geometric mean of these indices. The geometric mean reduces the impact of extreme values, ensuring that improvements in one dimension do not mask poor performance in others (UNDP, 1990).

While the HDI offers a significant improvement over GDP by focusing on human development, it is still subject to certain limitations. For example, it does not account for environmental sustainability or inequality within a country. To address some of these limitations, the UNDP has introduced complementary indices such as the Inequality-adjusted HDI (IHDI), which adjusts the HDI for inequality in each dimension.

Gross National Happiness

Originating in Bhutan, GNH is an alternative development model that prioritizes collective happiness over economic growth. Developed in the 1970s, GNH is based on four pillars: sustainable development, cultural values, environmental conservation, and good governance. GNH attempts to measure subjective wellbeing directly through surveys and assessments, offering a more human-centric approach to development (Ura et al., 2012). The concept of GNH has gained international recognition as a potential alternative to GDP, though its adoption outside Bhutan remains limited.

GNH Calculation Method:

- Survey Data: GNH relies on comprehensive national surveys to gather data on various aspects of wellbeing, including psychological wellbeing, health, education, time use, cultural diversity, good governance, and community vitality.
- Objective Indicators: In addition to subjective survey data, GNH includes objective indicators such as income, educational attainment, and access to health care. These are combined with subjective measures of happiness and satisfaction to create a holistic view of wellbeing.
- Weighting of Dimensions: Each dimension of GNH is weighted based on its importance to overall happiness. For example, psychological wellbeing and health may be given greater weight than other dimensions, reflecting their central role in determining happiness.

The GNH index aims to provide a more holistic view of progress, emphasizing wellbeing and happiness over economic output. It has inspired global interest, though its applicability outside Bhutan has been limited due to differences in cultural values and governance structures.

Genuine Progress Indicators

The GPI is a more comprehensive measure that adjusts GDP by accounting for both positive and negative externalities. Unlike GDP, which treats all economic activity as positive, the GPI deducts for social and environmental costs such as pollution, resource depletion, and income inequality, while adding in the value of non-market activities like volunteer work and household labor (Kubiszewski et al., 2013). GPI has been adopted in some local and regional contexts, though its broader adoption faces institutional and political challenges.

The GPI is calculated by adjusting GDP as follows:

- Positive Adjustments: The GPI adds the value of activities that contribute to societal wellbeing but are not included in GDP. This includes unpaid household work, volunteer work, and the value of leisure time. The GPI also adds the benefits of public infrastructure, education, and health care, which enhance the quality of life but are not always reflected in market transactions.

- Negative Adjustments: The GPI deducts the costs of environmental degradation, such as air and water pollution, resource depletion, and loss of biodiversity. It also accounts for social costs like income inequality, crime, and commuting time, which may increase GDP but negatively impact overall wellbeing.

The GPI offers a more comprehensive view of economic progress by distinguishing between activities that genuinely contribute to wellbeing and those that merely boost economic output. For example, natural resource extraction may increase GDP but can have long-term negative impacts on environmental sustainability. By accounting for these costs, the GPI provides a clearer picture of sustainable development (Kubiszewski et al., 2013).

However, one challenge with the GPI methodology is the difficulty of quantifying certain social and environmental costs, such as the value of leisure time or the impact of pollution. The subjective nature of these estimates can introduce variability into the calculation of GPI across different countries and contexts.

Social Progress Index

Developed by the Social Progress Imperative, the SPI measures non-economic aspects of societal progress, focusing on the provision of basic human needs, the foundations of wellbeing, and opportunities for individuals (Porter et al., 2013). The SPI offers a multidimensional view of social progress without relying on economic indicators, making it a more inclusive measure than GDP or HDI. By emphasizing social and environmental indicators, the SPI provides valuable insights into the wellbeing of societies, particularly in areas where economic growth does not directly translate into improvements in quality of life.

SPI Calculation Method:

- Basic Human Needs: This dimension includes indicators related to access to nutrition, basic medical care, water and sanitation, and shelter. It reflects the extent to which a society can provide for the basic needs of its citizens.
- Foundations of Wellbeing: This dimension includes indicators of access to education, information, health, and environmental quality. It reflects the factors that allow individuals to maintain a high quality of life.
- Opportunity: This dimension measures personal rights, freedom of choice, tolerance, and access to advanced education. It reflects the ability of individuals to pursue opportunities and improve their lives.

The SPI uses a variety of data sources, including official statistics and survey data, to compile these indicators. Each dimension is given equal weight in the final index calculation, and countries are ranked based on their overall performance (Porter et al., 2013). The SPI offers a comprehensive view of human development that goes beyond economic output, focusing instead on social and environmental outcomes.

One of the key strengths of the SPI is its focus on outcomes rather than inputs. By excluding economic indicators, the SPI avoids the assumption that economic growth necessarily leads to improvements in social and environmental wellbeing. However, the index still faces challenges in terms of data availability, particularly in developing countries where reliable statistics on social and environmental indicators may be lacking.

Integrated Assessment Models (IAMs)

Nordhaus's use of Integrated Assessment Models (IAMs) represents a pivotal methodological innovation in climate economics. IAMs are quantitative models that integrate climate science and economic theory to assess the interactions between the environment and the economy under various policy scenarios. The DICE (Dynamic Integrated Climate-Economy) model, developed by Nordhaus in the 1990s, was one of the first IAMs to gain widespread recognition and use.

Model Structure and Components

The DICE model comprises several interlinked modules that represent economic activity, carbon emissions, atmospheric processes, and temperature impacts. Here's a breakdown of the main components:

- Economic Module: The economic module of DICE represents GDP growth, consumption, capital investment, and population dynamics. It models how production and energy use lead to emissions, which, in turn, influence climate dynamics.
- Emissions and Carbon Cycle Module: This module estimates the relationship between economic activity and carbon emissions. It takes into account both industrial and non-industrial carbon sources, allowing the model to track the accumulation of greenhouse gases in the atmosphere. The carbon cycle is a key mechanism because it links economic activities directly to environmental changes.
- Climate Module: The climate module uses climate science inputs to model temperature changes resulting from emissions. It includes feedback loops that represent the persistence of carbon in the atmosphere and oceans, providing temperature projections based on emission trajectories.
- Damage and Mitigation Module: This final component translates climate impacts into economic damages, estimating how increases in temperature affect productivity, health, and infrastructure.

It also models mitigation costs, providing a framework for calculating the costs and benefits of various climate policies.

Nordhaus uses differential equations to model the temporal dynamics between these components, allowing DICE to run projections over long time horizons. This mathematical foundation enables the model to assess the cumulative impacts of emissions, helping researchers understand the long-term implications of different policy choices. By running the model with different policy variables, Nordhaus can simulate scenarios such as "business as usual," moderate mitigation efforts, or aggressive emissions reductions.

Assumptions and Calibration

To make DICE practical, Nordhaus employs a series of assumptions regarding parameters like economic growth rates, population growth, energy intensity, and the elasticity of substitution between capital and energy. He calibrates these parameters based on historical data and updates them periodically as new data become available. This calibration process is key to ensuring that DICE remains accurate and relevant, but it also opens the model up to critiques, particularly regarding assumptions like the discount rate (which determines the present value of future costs and benefits) and climate sensitivity (which dictates how temperature responds to greenhouse gas concentrations).

IAMs, particularly Nordhaus's DICE model, have also faced criticism. Scholars have questioned the model's assumptions regarding discount rates — the rate at which future costs and benefits are valued relative to the present. Nordhaus typically used a moderate discount rate, reflecting the view that future generations' wellbeing should be valued, but not as highly as the present generation's. Critics argue that a lower or zero discount rate would better capture the ethical obligations owed to future generations. Nevertheless, Nordhaus's model has laid the foundation for a broad field of IAM research, and subsequent scholars have built on his work to develop alternative models that adjust discount rates, include new environmental data, and extend analysis to consider broader societal impacts.

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