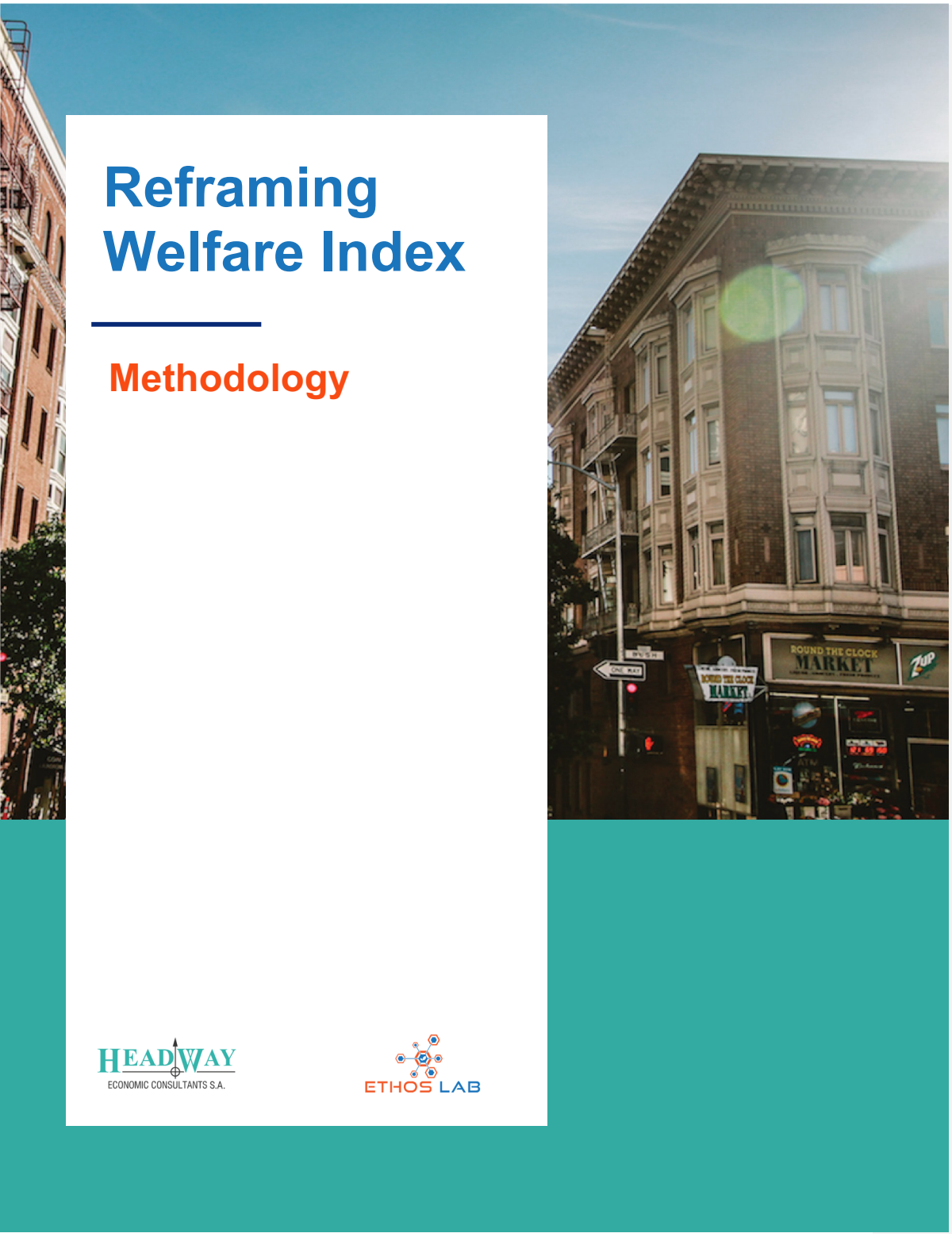
Reframing Welfare Index

Methodology



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About Reframing Welfare Index

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Social and individual welfare is more than just material wealth at the individual and social levels. It is a holistic aspiration of modern societies that reaches into the social, economic, political, financial, cultural, and environmental character of a society that allows all individuals to realise their full potential in a fair and just way.

Such a composite and complex notion is extremely hard to capture in a holistic way into a universal linear metric. Welfare is multifaceted, heterogeneous across time and space and non-linear. To capture this multidimensional concept, we propose a new composite index that seeks to explore, understand, measure, and reframe welfare; the Reframing Welfare Index (RWI). The proposed RWI addresses both normative and methodological issues that previous metrics lack, aiming at a holistic and robust measure of welfare.

"Advancing our understanding of how regions grow and citizens prosper"

1. INTRODUCTION

Conceptual Framework

GDP has long been regarded as the principal measure of economic development and national progress, offering a clear metric for assessing a nation's economic output. However, its limitations have become increasingly apparent, particularly in its ability to fully capture the complexity of societal welfare. While GDP effectively quantifies the total value of goods and services produced within an economy, it fails to account for many critical dimensions of human well-being. As a result, economists have sought to develop composite indicators that better reflect the multifaceted nature of welfare and provide a more accurate picture of societal progress.

Limitations of GDP:

- **Narrow Focus on Economic Output**: GDP is primarily concerned with economic production and market transactions, and as such, it offers a limited view of development. While economic growth remains important, it does not equate to societal welfare. GDP overlooks essential elements of well-being, such as health outcomes, educational attainment, and environmental quality, which contribute significantly to the quality of life.
- **Lack of Attention to Income Distribution**: GDP measures aggregate output but provides no insight into how income is distributed across a population. This limitation is significant, as high levels of income inequality can coexist with rising GDP, masking disparities in wealth and leaving large segments of the population disadvantaged. In this context, GDP fails to reflect the overall inclusiveness of economic growth.
- **Exclusion of Non-Market Activities:** Many forms of labor, such as household work, caregiving, and volunteer activities, contribute meaningfully to societal welfare but are not captured in GDP figures due to the absence of market transactions. This omission presents an incomplete picture of the contributions that sustain societies and improve well-being.
- **Failure to Account for Negative Externalities:** GDP growth can occur alongside environmental degradation, pollution, and resource depletion, without these negative externalities being reflected in the metric. Consequently, GDP can offer an overly optimistic view of economic progress by neglecting the long-term costs imposed on the environment and public health.

- **Disregard for Social and Environmental Sustainability:** GDP is often criticized for its inability to incorporate considerations of sustainability. It may register short-term gains in economic output, even if those gains are achieved at the expense of environmental resources or social stability. This myopic focus overlooks the long-term sustainability of growth and well-being, as well as the broader implications of economic activities on future generations.

The reliance on GDP as the sole or primary indicator of economic success has become increasingly insufficient in addressing the complexities of modern societies. The limitations of GDP, particularly its narrow focus on market transactions and economic output, have led to a growing recognition among economists, policymakers, and scholars of the need for composite indicators. These indicators provide a more nuanced and holistic approach to measuring welfare, capturing a broader spectrum of factors that contribute to human well-being and the sustainability of economic development.

The Need for Composite Indicators:

- **Holistic Measurement of Well-Being:** Composite indicators are designed to address the shortcomings of GDP by incorporating a wider range of factors that contribute to human well-being. These indicators aggregate data from multiple domains, such as health, education, environment, and social conditions, to provide a more comprehensive measure of welfare.
- **Recognition of Multidimensional Aspects of Welfare:** Human well-being is inherently multidimensional, encompassing material living standards, but also extending to non-economic factors like happiness, social equity, and political freedom. Composite indicators capture these diverse dimensions, providing a more nuanced and realistic assessment of societal progress.
- **Incorporation of Environmental and Social Considerations:** Many composite measures integrate environmental sustainability and social indicators into their calculations, offering a more balanced perspective on the long-term viability of economic growth. This is particularly important as the global economy grapples with challenges such as climate change, resource depletion, and social inequality.

The central aim of composite indicators is to provide policymakers and researchers with a more accurate and multidimensional assessment of national well-being, facilitating the development of policies that prioritize inclusive growth, social equity, and environmental sustainability. By moving beyond the narrow confines of GDP, these

indicators encourage a more balanced approach to economic and social development. They seek to:

- Promote Balanced and Inclusive Policy-Making: By integrating economic, social, and environmental factors, composite indicators support the design of policies that aim for sustainable and equitable growth, rather than merely maximizing economic output.
- Encourage Long-Term Thinking: By incorporating sustainability metrics, these indicators prompt policymakers to consider the long-term consequences of current policies, ensuring that future generations are not disadvantaged by short-term economic gains.
- Enhance Holistic Well-Being: The ultimate objective of composite indicators is to ensure that progress is measured in terms of comprehensive well-being, rather than simply in terms of economic success, thereby reflecting a more meaningful measure of societal development.

Need to move beyond national accounts towards regional welfare

Despite a significant growth in the production of welfare composite indicators at the global and national level (See meta-analysis + CITE), few attempts have tried to measure welfare subnationally. The creation of a new composite indicator at the subnational level, particularly at NUTS 2 (Nomenclature of Territorial Units for Statistics Level 2) in Europe, is necessary to address the significant variations in well-being, economic development, and sustainability that exist within and across European regions. While national-level indicators provide important insights, they often mask regional disparities that can affect policy effectiveness. A composite indicator at the NUTS 2 level would allow for a more granular understanding of these differences, thereby enhancing the precision and relevance of policy interventions. We aim to address this gap by proposing the Reframing Welfare Index (RWI) that goes beyond existing national accounts in 6 distinct ways:

1. Addressing Regional Disparities

Europe is characterized by substantial regional diversity in terms of economic development, social equity, and environmental sustainability. Even within the same country, regions can experience vastly different challenges and opportunities. For instance, metropolitan areas may benefit from higher income levels, better access to services, and more dynamic labor markets, while rural or peripheral regions may

struggle with lower growth, higher unemployment, and limited access to infrastructure or public services.

RWI will therefore capture these subnational variations, enabling policymakers to develop tailored strategies that address the specific needs of each region. By highlighting disparities in areas such as health, education, income distribution, and environmental quality, the indicator would provide a more accurate reflection of regional well-being. This is crucial for ensuring that policies aimed at fostering inclusive growth and social equity are targeted where they are most needed.

2. Promoting Regional Development and Cohesion

The European Union has long prioritized regional development and cohesion, seeking to reduce disparities between regions to foster balanced growth across the continent. However, current measures, largely centered around national GDP, are insufficient for assessing the true progress of regional development. GDP growth in a country's capital or urban centers may hide stagnation or decline in less developed regions, leading to policies that fail to promote cohesion at the subnational level.

RWI will therefore align with the EU's Cohesion Policy by providing a more comprehensive tool for assessing the multi-dimensional aspects of regional development. It would offer insights into whether economic gains are translating into improvements in other key areas, such as social equity, environmental sustainability, and quality of life. With this data, policymakers could better allocate EU structural and cohesion funds to regions most in need, thereby fostering balanced regional development and reducing inequalities.

3. Encouraging Policy Innovation and Targeted Interventions

Subnational regions often face distinct economic, social, and environmental challenges that require specialized policy interventions. For example, some regions may need policies aimed at improving education and skills, while others may require investments in infrastructure or green technologies. By developing a composite indicator at NUTS 2, policymakers would have access to a detailed dataset that reflects the unique conditions of each region. This would allow for more innovative and targeted policy solutions that address specific regional needs rather than relying on one-size-fits-all national approaches.

Moreover, by incorporating indicators related to sustainability and social equity, a subnational composite measure would encourage regions to pursue development models that prioritize long-term well-being. It would promote policies that not only boost economic growth but also ensure environmental resilience, social inclusion, and regional competitiveness in a sustainable manner.

4. Enhancing Accountability and Monitoring Progress

A subnational composite indicator at the NUTS 2 level would serve as a powerful tool for monitoring and evaluating regional policy outcomes. By tracking progress over time in multiple dimensions, such an indicator would enable regions to measure their advancement toward social, economic, and environmental goals more effectively. This could improve the accountability of regional governance by providing clear benchmarks for success and identifying areas that require further policy intervention.

RWI will therefore as a standardized composite measure facilitate comparisons between regions, allowing best practices to be shared across Europe. Regions that perform well on certain dimensions, such as environmental sustainability or social equity, could serve as models for others, helping to drive innovation in regional policy and development strategies.

5. Aligning with the European Green Deal and Sustainability Goals

The European Green Deal and the EU's commitment to achieving the Sustainable Development Goals (SDGs) underscore the importance of integrating environmental sustainability into economic and social policies. However, environmental challenges, like economic and social challenges, vary significantly across regions. Coastal regions may face issues related to rising sea levels, while mountainous regions may be more concerned with biodiversity loss and sustainable agriculture.

Building on the need for more localized and hollistic welfare measurement, the Regional Welfare Index (RWI), available on reframingwelfare.com, addresses the crucial gap in understanding well-being at the subnational level in Europe. The RWI is specifically designed to measure welfare at the NUTS 2 level, offering a detailed and multidimensional assessment of well-being across European regions. By incorporating economic, social, and environmental dimensions, the RWI provides policymakers with an essential tool for understanding regional disparities and guiding targeted interventions to improve quality of life across the continent.

One of the key strengths of the RWI is its comprehensive and integrative approach. While traditional metrics like GDP focus solely on economic output, the RWI considers a broader range of factors that influence welfare, such as education, health, income distribution, environmental sustainability, and access to public services. This allows for a more holistic view of regional welfare, highlighting areas of strength and identifying specific challenges that may not be visible through economic indicators alone. By focusing on these multiple dimensions, the RWI encourages more balanced, equitable, and sustainable policy-making at the regional level.

Another significant advantage of the RWI is its ability to track progress over time and facilitate meaningful comparisons between regions. The index is constructed in a way that allows regions to benchmark their performance against peers, enabling policymakers to identify best practices and areas for improvement. Moreover, the RWI's focus on sustainability aligns with broader European goals, such as the European Green Deal and the Sustainable Development Goals, ensuring that regions can pursue economic growth that is both inclusive and environmentally responsible. Through its precise, regionalized data, the RWI empowers regions to develop tailored strategies for enhancing welfare in ways that reflect their unique social, economic, and environmental contexts.

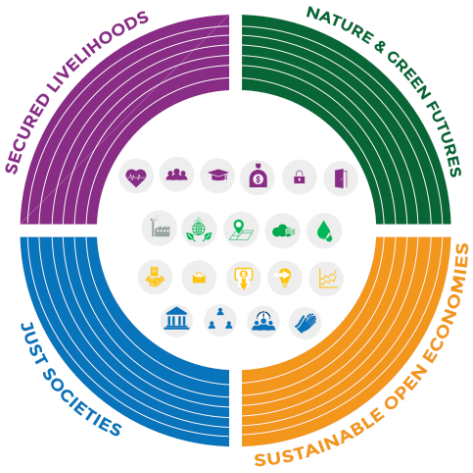
2. CATEGORY AND PILLAR PROFILES

The Reframing Welfare Index (RWI), a holistic measure of welfare designed to overcome the limitations of traditional metrics, seeks to capture the intricate tapestry of social and individual well-being across European regions. The RWI identifies ***21 distinct pillars of welfare***, each composed of multiple indicators, and categorizes them into ***four foundational domains***:

1. Just Societies: The Just Societies foundation captures the interrelational structures that exist between individuals in a society with formal and informal institutions in the quest of an inclusive, fair, just and collective social growth. This foundation consists of five pillars: 1) Formal Institutions, 2) Human Rights, 3) informal Institutions, 4) Religions and 5) Social Capital. Each pillar consists of multiple indicators.
2. Secured Livelihoods: The Secured Livelihoods foundation captures the levels, distribution and diffusion of the necessary means for human and societal flourishing. This foundation consists of six pillars: 1) Poverty, 2) Education, 3)

Health, 4) Access, 5) Wealth and 6) Security. Each pillar consists of multiple indicators (See Appendix for full list and description)

3. Sustainable Open Economies: The Sustainable Open Economies foundation captures the interrelational economic structures at the individual and aggregate level, looking both at the supply and demand perspectives. This foundation aims to understand and measure the extent to which an economy both at the micro and macro level is competitive, open to innovation, conducive to investments and trade and facilitates inclusive growth. It consists of five pillars: 1) Output, 2) Employment, 3) Business Environment, 4) Investment Environment and 5) Innovation. Each pillar consists of multiple indicators.
4. Nature & Green Future: The Nature and Green Future foundation captures the natural capital stock and green initiatives of each country. This foundation consists of five pillars: 1) Land, 2) Water, 3) Air, 4) Sustainable Productions and 5) Green Transformation. Each pillar consists of multiple indicators.



This section explores the four foundational domains of the RWI, providing detailed profiles of the constituent pillars. While the pillars are grouped for analytical purposes,

it is essential to remember that they are interconnected and contribute collectively to a comprehensive understanding of welfare. By examining these pillar profiles, we gain insights into the diverse dimensions of well-being encompassing the social, economic, political, financial, cultural, and environmental factors that enable individuals to realise their full potential in a fair and just society.

I. JUST SOCIETIES

The Just Societies foundation examines the intricate dynamics between individuals and the formal and informal structures that shape their collective well-being. This foundation rests upon five interconnected pillars—Formal Institutions, Human Rights, Informal Institutions, Freedom, and Social Capital—that together create the conditions for an inclusive, equitable, and just society.

Each pillar presents a distinct facet of social justice. Formal Institutions assess the effectiveness and fairness of governance, focusing on trust in government, perceived corruption, and political participation. Human Rights evaluates a society's commitment to protecting the rights and dignity of all, particularly marginalised groups. Informal Institutions explore the norms, values, and social networks that foster cooperation and cohesion, considering factors like prosocial behavior and the role of religion. Freedom examines the extent to which individuals feel empowered to express themselves and participate in civic life, while Social Capital gauges the strength of relationships, trust, and shared responsibility within a society.

By delving into these five pillars, we can gain a comprehensive understanding of the complex tapestry of a just society, identifying both strengths and areas for improvement.

Formal Institutions assesses the effectiveness and fairness of a society's governing structures, laws, and regulations. It measures the rule of law, the inclusiveness of political processes, and the accountability of government officials. In particular, this sub-pillar focuses on citizens' confidence in their national and regional governments, levels of perceived corruption, and their active participation in the democratic process. High levels of trust in institutions, low corruption, and active political engagement foster a stable and just society where all members feel their voices are heard and their rights are protected.

Human Rights examines the extent to which a society upholds the fundamental rights and freedoms of its people. It goes beyond a focus on civil and political rights to encompass a holistic assessment of how well a society supports the diverse needs and identities of its members. This sub-pillar focuses on whether the country provides an inclusive and welcoming environment for minorities, people of different religions, LGBTQ+ individuals, immigrants, and entrepreneurs. Respect for the rights and dignity of all individuals, regardless of their background, is fundamental to a just society where everyone can thrive.

Informal Institutions explores the norms, customs, traditions, and social networks that operate outside of formal legal frameworks. It investigates how these informal structures, rooted in shared values and beliefs, influence behavior, cooperation, and conflict resolution within a society. This sub-pillar focuses on the prevalence of prosocial behaviours such as helping strangers, the importance individuals place on religion in their lives, and their level of participation in religious activities. Strong informal institutions, characterised by widespread trust and reciprocity, can complement formal systems, contributing to social cohesion and a sense of shared identity.

Freedom explores the extent to which individuals within a society feel empowered to express their opinions and participate in civic life without fear of reprisal. It examines the presence of basic freedoms like freedom of speech and assembly, as well as the level of trust in law enforcement agencies. A high degree of freedom enables individuals to engage actively in shaping their communities and holding institutions accountable.

Social Capital focuses on the quality of relationships, networks, and shared values that facilitate cooperation and mutual support within a society. It explores the opportunities individuals have to form meaningful connections, their willingness to contribute to their communities through volunteering or helping others, and their perception of social mobility. Additionally, it examines societal attitudes and behaviours towards children, encompassing respect for their rights and creating an environment where they can learn and grow. Lastly, it considers the extent to which a society addresses the needs and vulnerabilities of its most disadvantaged members. High levels of social capital, characterised by strong bonds of trust, reciprocity, and shared responsibility, empower communities to thrive and overcome collective challenges.

II. SECURED LIVELIHOODS

The Secured Livelihoods foundation explores the intricate web of resources and conditions necessary for individuals and societies to not only survive, but to truly flourish. It recognises that well-being encompasses more than just meeting basic needs; it's about having the opportunity to access essential services, pursue personal aspirations, and live free from fear and deprivation.
This foundation is built on six interconnected pillars, each representing a critical dimension of a secure and fulfilling life.

Poverty delves into the harsh realities of deprivation, examining both the prevalence of those living below the poverty line and the daily struggles faced by individuals unable to afford basic necessities. Education emphasises the transformative power of knowledge and skills, evaluating the quality, accessibility, and inclusivity of education systems that equip individuals for a changing world. Health recognises the interconnectedness of physical and mental well-being, considering both access to healthcare and the broader factors influencing health outcomes. Access highlights the importance of equitable access to essential resources and services, ranging from basic necessities like clean water and sanitation to enabling resources like financial services and technology. Wealth examines the distribution of resources and opportunities within a society, focusing on both aggregate measures of economic prosperity and the lived experiences of individuals. Finally, Security underscores the fundamental need for a safe and stable environment, free from violence and fear, where individuals can pursue their livelihoods and participate fully in community life.

Together, these pillars offer a comprehensive understanding of the multifaceted nature of secured livelihoods, allowing us to identify areas for improvement and work towards a future where everyone has the opportunity to thrive.

Poverty assesses the extent and depth of poverty within a society, encompassing both income and multidimensional aspects. It examines not only the proportion of individuals living below the poverty line but also the lived experiences of deprivation that extend beyond income levels. This sub-pillar considers the prevalence of individuals unable to afford basic necessities such as food and heating, or experiencing periods without any income. Addressing poverty in its various forms and ensuring a

dignified standard of living are critical to securing livelihoods and fostering a just society.

Education examines the quality, accessibility, and inclusivity of education systems, recognizing its pivotal role in empowering individuals and fostering societal progress. It encompasses an assessment of educational attainment levels, the prevalence of secondary education dropouts, and the proportion of GDP invested in education. This sub-pillar highlights the importance of not only providing access to education but also ensuring its quality and relevance to equip individuals with the knowledge and skills needed to thrive in an ever-changing world. By prioritizing education, societies can cultivate a skilled workforce, promote social mobility, and create a more equitable future for all.

Health examines the physical and mental well-being of individuals, recognising its fundamental role in enabling people to lead fulfilling and productive lives. It encompasses both subjective assessments of health and mental health, as well as access to essential healthcare services such as general practitioners, dentists, hospitals, eye doctors, and mental health professionals. Additionally, this sub-pillar considers the prevalence of factors that can negatively impact health, such as worry, stress, and poor sleep. By prioritising both physical and mental health, and ensuring equitable access to quality healthcare, societies can enhance the overall well-being of their citizens and create a more resilient and thriving population.

Access assesses the availability of essential resources and services that enable individuals to meet their basic needs, participate fully in society, and pursue their aspirations. This sub-pillar encompasses access to both foundational necessities like clean water, sanitation, affordable housing, reliable energy, and transportation, as well as enabling resources such as financial services (bank accounts, loans, credit cards), communication technologies (fixed telephone lines, internet access), and household appliances (refrigerators, computers/tablets). Additionally, it considers the reliability of infrastructure and internet bandwidth, recognising their critical role in modern life. Ensuring equitable access to these resources is crucial for improving livelihoods, promoting social inclusion, and creating opportunities for all.

Wealth Wealth: Wealth examines the distribution of wealth and assets within a society, focusing not only on aggregate measures like GDP per capita but also on the lived experiences of individuals and the equity of resource distribution. This sub-pillar considers factors such as disposable income, savings and debt levels, income

satisfaction, and perceived place in the income distribution. It also acknowledges the impact of dependents and the cost of living on financial well-being. By striving for a more equitable distribution of wealth and promoting financial inclusion, societies can enhance economic security, expand opportunities for all, and foster a greater sense of shared prosperity.

Security assesses the physical safety, personal security, and stability of individuals and communities, recognising that a secure environment is foundational to well-being and societal flourishing. This sub-pillar focuses on the lived experiences of individuals, considering their sense of safety when walking alone, the prevalence of theft or property crime, and experiences of assault. By prioritising the reduction of violence and fostering a safe environment, societies empower individuals to pursue their livelihoods without fear, participate fully in community life, and enjoy a sense of peace and stability.

III. SUSTAINABLE OPEN ECONOMIES

The Sustainable Open Economies foundation captures the interconnected economic structures that drive prosperity and well-being. It evaluates an economy's ability to foster competitiveness, innovation, and inclusive growth through open markets and sustainable practices. This foundation rests on five interconnected pillars. Output examines the health and dynamism of an economy through indicators like regional GDP, income distribution, productivity, and export orientation. Employment assesses the quantity, quality, and inclusivity of employment opportunities, considering factors such as unemployment rates, gender pay gaps, and youth employment. The Business Environment evaluates the regulatory framework and ease of doing business. The Investment Environment gauges the attractiveness of an economy for domestic and foreign investment. Innovation examines the capacity for generating, adopting, and diffusing new ideas and technologies.

Together, these pillars reveal the complex factors shaping the economic landscape and sustainability. By examining these fundamental aspects, we gain deeper insights into the dynamics of sustainable open economies and the pathways to long-term success.

Output assesses the health and dynamism of an economy, examining both its current state and its potential for future growth. It encompasses a comprehensive set of indicators that capture various dimensions of economic output. Regional GDP

measures the total value of goods and services produced within a specific region, providing a fundamental gauge of overall economic activity and size. The regional Gini coefficient is used to track income inequality, revealing the distribution of wealth and economic opportunities. Regional productivity reflects the efficiency with which resources are utilised to generate output, offering insights into the economy's capacity for sustainable growth and improved living standards. Finally, the regional exports/GDP ratio quantifies the share of regional output that is exported, providing valuable information about the economy's integration into global markets. A healthy and diversified output structure, characterised by robust growth, equitable income distribution, and high productivity, is fundamental for sustainable economic development and the improvement of living standards.

Employment examines the quantity, quality, and inclusivity of employment opportunities within an economy. It goes beyond simple measures of job availability to consider the broader landscape of work, encompassing factors such as income levels, gender equality, and opportunities for young people. This sub-pillar utilises key indicators to paint a comprehensive picture of the employment situation. Regional unemployment and youth unemployment rates provide critical insight into the overall health of the labor market and the challenges faced by specific demographic groups. The gender pay gap serves as a measure of gender equality in the workplace, highlighting disparities in earnings between men and women. Additionally, the rate of women's unemployment offers further insight into the specific barriers faced by women in accessing and maintaining employment. Full and productive employment, characterised by high employment rates, low unemployment, equitable wages, and decent working conditions, is a key driver of economic growth, social well-being, and individual fulfilment.

Business Environment evaluates the overall climate for economic activity within a region, focusing on the ease of doing business and the effectiveness of the regulatory framework. It recognises that a supportive and efficient business environment is essential for fostering entrepreneurship, attracting investment, and promoting economic dynamism. This sub-pillar utilises a range of indicators to capture different aspects of the business climate. The regional ease of doing business index offers a comprehensive assessment of the regulatory and administrative barriers faced by businesses, from starting a new venture to navigating ongoing operations. Access to finance gauges the availability and affordability of credit and other financial resources for businesses of all sizes. The percentage of SMEs and micro enterprises per 100,000 people provides insight into the entrepreneurial landscape and the prevalence of

small-scale businesses. Finally, the number of days required to open a business serves as a concrete measure of administrative efficiency and the ease of entry for new entrepreneurs. A favourable business environment, characterised by streamlined regulations, efficient processes, strong property rights protection, and reliable contract enforcement, is crucial for unlocking the full economic potential of a region and fostering sustainable growth.

Investment Environment assesses the attractiveness of an economy for both domestic and foreign investment, recognising the critical role investment plays in mobilising capital, fostering innovation, and driving economic growth. It goes beyond simply measuring investment flows to consider a broader range of factors that contribute to a conducive investment climate. This sub-pillar utilises key indicators to gauge the overall investment landscape. The regional investment index provides a comprehensive assessment of the region's attractiveness to investors, considering factors such as economic stability, regulatory quality, and market access. Local corruption levels serve as an important barometer of transparency and governance, highlighting potential risks and deterrents for investors. Finally, investments per GDP per capita offer insight into the intensity of investment activity relative to the size of the economy and population, providing a measure of investment's contribution to overall economic development. A conducive investment environment, characterised by strong institutions, transparent governance, and investor-friendly policies, is essential for attracting and retaining investment, fostering innovation, and driving sustainable economic growth.

Innovation examines the capacity of an economy to generate, adopt, and diffuse new ideas, technologies, and processes. It recognises that innovation is a key driver of productivity growth, competitiveness, and long-term economic prosperity. This sub-pillar utilises a range of indicators to capture different facets of the innovation landscape. Per capita patents offer a measure of inventive activity and the generation of new knowledge within a region. The per capita population in informatics reflects the availability of skilled labor in technology-related fields, a crucial ingredient for innovation-driven growth. The number of new jobs in high-tech sectors provides insight into the dynamism and growth potential of knowledge-intensive industries. Additionally, regional productivity serves as an indicator of the economy's ability to translate innovation into tangible economic gains. A vibrant innovation ecosystem, characterised by strong research and development capabilities, a skilled workforce, and a supportive environment for entrepreneurship, is essential for driving long-term

economic prosperity and enhancing a region's competitiveness in the global marketplace.

IV. Nature & Green Future

The Nature and Green Future foundation encapsulates the critical interplay between the natural environment and human activities, assessing both the current state of our planet's health and the ongoing efforts to transition toward a more sustainable future. This foundation rests on five interconnected pillars, each representing a critical aspect of our relationship with the natural world.
The Land pillar evaluates the condition and management of land resources, encompassing the protection of natural habitats, responsible agricultural practices, and thoughtful urban planning to preserve biodiversity and ensure a healthy and resilient future. The Water pillar examines the quality, availability, and management of water resources, highlighting the importance of responsible water use, pollution control, and investment in water infrastructure for a secure and sustainable water future. The Air pillar focuses on air quality and pollution levels, encompassing various emissions and fine particle exposure, underscoring the urgent need to mitigate air pollution and transition towards cleaner energy sources to protect human and environmental health.

The Sustainable Productions pillar assesses the adoption of environmentally friendly practices across sectors, emphasising the need to minimize the environmental footprint of production processes through resource efficiency, waste reduction, and the promotion of circular economy principles. Finally, the Green Transformation pillar examines the progress towards a low-carbon and environmentally sustainable economy, encompassing the societal shifts necessary to mitigate climate change and create a more resilient future. It considers factors like health impacts of pollution, urban environmental conditions, wildfire occurrences, water quality, waste management, and progress towards net neutrality.

Together, these pillars offer a comprehensive understanding of the complex relationship between humanity and the natural world. They shed light on the current state of our environment, the challenges we face, and the proactive steps being taken towards a greener and more sustainable future. By examining these interconnected aspects, we gain deeper insights into the delicate balance between human activities

and the environment, enabling us to chart a course towards a more harmonious and sustainable coexistence.

Land assesses the condition and management of land resources, recognising the vital role they play in preserving biodiversity, mitigating climate change, and ensuring food security. It goes beyond simply measuring the quantity of land available to consider a broader range of factors that contribute to sustainable land management. This sub-pillar utilises key indicators to gauge the health and utilisation of land resources. The extent of park areas and natural reserves reflects a region's commitment to conservation and the protection of valuable ecosystems. The number of trees per 1,000 population offers a measure of urban green spaces and their contribution to human well-being. Green coverage per square kilometre, derived from satellite imagery, provides a comprehensive picture of vegetation density and land use patterns. Forest area and the extent of burned forest area offer insight into the state of forest resources and the impact of disturbances such as wildfires. Sustainable land management, characterised by the protection of natural habitats, responsible agricultural practices, and thoughtful urban planning, is essential for preserving the planet's natural capital and ensuring a healthy and resilient future for all.

Water examines the quality, availability, and management of water resources, recognising the vital role they play in human health, ecosystem function, and economic development. It encompasses a range of indicators that capture the complex relationship between water and human society. Flood occurrence serves as a reminder of the risks and challenges associated with water-related natural disasters, highlighting the importance of preparedness and resilience. Renewable water resources provide a gauge of the sustainable availability of water for human use and environmental needs. Access to freshwater underscores the fundamental human right to clean and safe drinking water, a critical determinant of health and well-being. Finally, clean ocean water reflects the interconnectedness of water systems and the impact of human activities on marine ecosystems. Sustainable water management, characterised by responsible water use, pollution control, and investment in water infrastructure, is essential for ensuring a secure and sustainable water future for all.

Air evaluates the quality of air and the levels of air pollution, recognising the crucial role clean air plays in human health, environmental protection, and mitigating climate change. It encompasses a range of indicators that capture the complex interactions

between human activities and the atmosphere. CO2, SO2, Nox, black carbon, and methane emissions provide a measure of the diverse pollutants released into the air, contributing to climate change and a host of health and environmental problems. Fine particle exposure highlights the direct impact of air pollution on human well-being, serving as a stark reminder of the consequences of unsustainable practices. Clean air, achieved through emissions reduction, sustainable energy transitions, and responsible industrial practices, is essential for protecting human health, preserving ecosystems, and ensuring a liveable planet for future generations.

Sustainable Productions assesses the adoption of environmentally friendly practices across various sectors, recognising the crucial role sustainable production plays in minimising environmental impact and ensuring the long-term viability of resources. It goes beyond simply measuring the output of goods and services to consider the environmental footprint of production processes. This sub-pillar utilises a range of indicators to gauge the progress toward sustainability. Soil quality provides a measure of the health and productivity of agricultural land, a critical resource for food production. The overexploitation of fish stocks highlights the impact of unsustainable fishing practices on marine ecosystems and the need for responsible resource management. The stability of marine biodiversity serves as a broader indicator of ocean health and the resilience of marine life in the face of human pressures. The percentage of energy used that is produced by renewables reflects the transition toward cleaner and more sustainable energy sources. Sustainable production and farming percentages offer insight into the adoption of environmentally friendly practices across various sectors, from manufacturing to agriculture. Embracing sustainable production methods, characterised by resource efficiency, waste reduction, and the promotion of circular economy principles, is essential for safeguarding the planet's natural resources and ensuring a thriving and sustainable future.

Green Transformation examines the progress towards a low-carbon and environmentally sustainable economy, recognising the urgent need to mitigate climate change, protect the environment, and create new economic opportunities. It goes beyond simply measuring environmental impact to consider the broader societal shifts required for a sustainable future. This sub-pillar utilises a range of indicators to gauge the extent of the green transformation. Health impact and satisfaction with air pollution capture the direct consequences of environmental degradation on human well-being and quality of life. The city pollution index provides a comprehensive

assessment of urban environmental conditions, reflecting the challenges and opportunities for sustainable urban development. The number of wildfires in the past 12 months serves as a stark reminder of the risks and consequences of climate change, underscoring the need for urgent action. Satisfaction with water quality highlights the importance of clean water for both human and environmental health. Recycling waste and waste management practices reflect the transition toward a circular economy and responsible resource use. Finally, progress towards net neutrality serves as a key indicator of a region's commitment to reducing greenhouse gas emissions and combating climate change. A successful green transformation, characterised by the adoption of clean technologies, sustainable infrastructure development, and a shift toward renewable energy sources, is essential for building a resilient and prosperous future for all.

3. Who can use the RWI

The Reframing Welfare Index has been developed as a practical tool to help identify what specific action needs to be taken to contribute to strengthening the pathways from poverty to prosperity and to provide a roadmap as nations chart their way through and out of the pandemic. The Index consists of 4 pillars of welfare, built upon 21 actionable policy areas (subpillars), and is underpinned by 184 indicators.

It is a powerful tool for policymakers, social service providers, researchers, and anyone interested in understanding and improving social welfare outcomes.

So, who can use the Reframing Welfare Index? The answer is simple: anyone. The Index is designed to be accessible and useful to a wide range of users, including:

- **Policymakers**: The Index can help policymakers better understand the social welfare needs of their communities and identify areas where resources are needed most. By tracking social welfare outcomes over time, policymakers can evaluate the impact of policy interventions and make data-driven decisions about resource allocation.

- **Social Service Providers:** The Index can help social service providers identify areas where their services are most needed and evaluate the effectiveness of their programs. By tracking social welfare outcomes, service providers can make data-driven decisions about program design and resource allocation.
- **Researchers**: The Index can be used by researchers to better understand social welfare outcomes and trends over time. By analyzing the Index data, researchers can identify areas where further research is needed and make data-driven recommendations for policy interventions.
- Advocates and Activists: The Index can be used by advocates and activists to raise awareness about social welfare issues and advocate for policy change. By highlighting areas of social welfare need, advocates and activists can build support for policy interventions and mobilize action.

The Reframing Welfare Index is a valuable resource for anyone interested in improving social welfare outcomes. It is designed to be user-friendly and accessible, with interactive dashboards and clear visualizations of data. Users can explore the data at a national, state, and county level and compare outcomes across different demographic groups.

To use the Index, simply visit the Reframing Welfare Index website and explore the dashboards and visualizations. The website provides clear explanations of the data and how to interpret it, as well as guidance on how to use the data for policy and advocacy purposes.

In conclusion, the Reframing Welfare Index is a powerful tool for understanding and improving social welfare outcomes. Anyone can use the Index, regardless of their background or expertise. By making the Index accessible and user-friendly, the creators of the Index hope to empower individuals and organizations to make data-driven decisions and advocate for positive change.

4. METHODOLOGY

The ongoing debate in the literature regarding the creation of a single, comprehensive metric for well-being, similar to GDP for economic output, highlights the challenges in developing such a metric due to the multifaceted and context-dependent nature of well-being. Despite the absence of a universal standard, various composite indices have been introduced by international organisations and national statistical institutes

to measure well-being. These indices share commonalities in defining domains and individual indicators, but they differ in their methodologies for normalisation, aggregation, and adjustment.

To address these challenges and limitations, we have created the Reframing Welfare Index (RWI), a holistic measure of welfare that goes beyond traditional economic indicators like GDP. The RWI recognises that welfare encompasses social, economic, political, financial, cultural, and environmental aspects, making it a complex and multi-dimensional concept.

The RWI is unique in two key ways:
1. It is designed to address the limitations of previous metrics by capturing the complexity of welfare and providing a more robust assessment.
2. It assesses well-being not only at the national level but also at the regional level, acknowledging the heterogeneity of welfare within countries.

To achieve this, we have defined four main foundations of welfare: individual well-being, institutional and social progress, economic welfare, and environment. We have carefully selected indicators and constructed pillars within each foundation to reflect the diverse dimensions of welfare. These pillars are interconnected, both within and across foundations, highlighting the complex and interrelated nature of welfare determinants.

The RWI utilises 178 distinct policy-focused indices derived from these pillars. Each index is designed to reflect a specific policy area that can be influenced by policymakers, providing actionable insights to drive policy changes and initiatives. (For further information, please refer to the Category/Pillar Profiles Section.)

The construction of our composite index is based on data selection, normalisation, aggregation, and the application of structural equation modelling (SEM). The first step, data selection, is crucial as accurate measurement is fundamental to effective policymaking. We have been guided by data availability at both country and regional levels to ensure the index's accuracy and relevance for policymaking.

Constructing the Index: Step-by-Step Approach

1. Data Selection

Data selection is crucial as relevant and reliable data is crucial for the rest of the process as well as the reliability of the final scores. At this stage, the goal of selecting and organising indicators underneath the framework of the RWI has been to enable measurement of welfare in all four categories at both country and regional levels.

We aim to use a set of indicators that (a) collectively act as a good proxy for the elements, and (b) have good coverage across regions and through time. Each of the 21 pillars is determined by two to fifteen indicators, resulting in a total of 123 indicators (excluding composite indicators).

Indicator Relevance

The selection of indicators is guided by three main criteria:

1. Support from Academic Literature: Indicators are chosen based on a wide consensus in academic research that they effectively capture the intended aspect of welfare. This involves a systematic literature review and meta-analysis of existing relationships. Additionally, expert panels provide guidance on the most suitable indicators.
2. Connection to Productive Capacity and Cantril's Ladder: Indicators are selected if they are considered plausible causal factors of both wealth and well-being. This connection is assessed by examining the correlation of each indicator with proxies for economic and social well-being (productive capacity and Cantril's Ladder) and reviewing existing research on the causal relationships between indicators and welfare outcomes.
3. Strong Internal Consistency: The collective quality of indicators within each element is evaluated using Cronbach's alpha, a measure of internal consistency. A high Cronbach's alpha value (above 0.85) indicates that the indicators within an element act as a cohesive group, effectively representing the underlying concept. This criterion ensures that the selected indicators work together to provide a comprehensive measurement of the specific aspect of welfare they are intended to capture.

By employing these criteria, we have selected a set of indicators that are not only theoretically sound but also empirically robust, ensuring that the RWI accurately reflects the diverse dimensions of welfare across European regions.

Coverage of Indicators Spatially and Temporally

The Reframing Welfare Index (RWI) prioritises the selection of indicators that accurately represent the multifaceted nature of welfare at both the national and regional levels. Recognising that the concept of welfare can vary across regions and countries, we adopt a context-specific approach, collecting data at the most granular level available for European countries.

The first step in calculating the RWI involves matching indicators, pillars, and domains to the available NUTS 2 level data. The dataset is compiled from various sources, including Eurostat, national accounts, World Bank, and Eurobarometer.

The initial consideration of the RWI covers 29 European countries (EU27, UK, and Norway) mainly at the NUTS 2 level starting from 2020. While we primarily use NUTS 2 level data, we utilise NUTS 3 for smaller countries like Latvia and Lithuania and NUTS 1 for larger countries like Germany and France. Our aim is to eventually provide indices at even smaller units, such as the municipality level, to capture the nuanced variations in welfare across different localities.

To maintain consistency and relevance, the indicator selection prioritises:

1. Wide Country Coverage: The RWI is designed as a global index, so data should ideally cover a wide range of countries. However, indicators with less coverage are still included if they focus on lower and middle-income countries, ensuring representation of diverse economic contexts. Indicators primarily relevant to higher-income countries, such as those from OECD datasets, are excluded to avoid bias.
2. Coverage Through Time: The RWI aims to track changes in prosperity over time, not just a snapshot of the current state. Therefore, indicators that capture trends and changes are preferred. Additionally, indicators that are expected to continue being measured are favoured to enable future updates and comparisons.

Following these criteria, 178 indicators were selected to underpin the four foundations of welfare in the RWI. (For further information, see the Appendix.)

2. Creating a Complete Dataset

The Reframing Welfare Index, like most composite indices, faces the challenge of incomplete data. Some data points may be missing for certain years or countries, and some indicators may be released with a time lag. To address this, the authors prioritise real data in the following order:
Firstly, where missing data are detected for a country or region, we first use the latest known value for an indicator if data is missing for a specific year. For example, if the data of a region is missing for 2020, corresponding values for 2019 is assigned to the dataset of 2020.
Secondly, where data are missing and no prior data are available, which happens for the early years' of the RWI or in the case of re-structured NUTS 2 regions, the earliest available data are employed for the previous years. For example, for a region included in NUTS 2 statistical system in 2021, the data for 2020 may be missing. In such cases, the corresponding data for 2021 is used for 2020. If no prior or reliable real data is available, augmentation and imputation techniques on a case-by-case basis are employed.

One way we deal with data missing for a country for all years is by inserting values directly based on other sources for the data. In some cases data are not included in a dataset but are obtainable through different means. In these cases, we manually insert accurate data points in the most recent year available.

If we cannot supplement missing data from an appropriate alternative source, we use linear regressions to impute an indicator value based on other values. Here we mainly use interpolation and extrapolation techniques.

- Interpolation: This technique involves estimating missing values that fall within the range of existing data points. For example, if we have data for an indicator in 2018 and 2020, but it's missing for 2019, we can use interpolation to estimate the 2019 value based on the trend between 2018 and 2020. In most cases where there is a missing value in between two data points, we get the average of the known data points to accommodate the missing data point. For instance, if we know the values

of an indicator for 2018 and 2020 but 2019 data is missing, we get the average of 2018 and 2020 for 2019.

- Extrapolation: In contrast, extrapolation is used to estimate values that fall outside the range of available data. This might be necessary if an indicator's values are only available up to a certain year, and we need estimates for subsequent years. For instance, if we have data up to 2022 but need an estimate for 2023, we can extrapolate based on the trend in the existing data. Extrapolation technique is mainly used for predicting late outcomes.

By employing a combination of these strategies, the Reframing Welfare Index strives to address the issue of incomplete data while maintaining the highest possible level of accuracy and reliability in its calculations.

3. Standardisation and Normalisation

Following the selection and imputation of missing data points, indicators undergo a meticulous standardisation process to ensure comparability and facilitate aggregation into composite scores. This standardisation is integral to constructing the RWI's multi-layered structure, enabling meaningful aggregation at indicator, pillar, category, and ultimately, index levels.

Transformation

The indicators in the RWI are based on many different units of measurement, such as percentages and ordinal scales. Given the diverse measurement units of RWI indicators, normalisation is essential for meaningful cross-indicator and cross-country comparisons. A key consideration in this process is the potential log-normalisation of indicators. For indicators exhibiting skewed distributions or long tails, such as disposable income or GDP per capita, log-normalisation is employed. This transformation mitigates the impact of extreme values and ensures that variations across observations remain within a comparable range, preventing undue influence on a country's overall performance assessment.

Normalisation

The RWI incorporates diverse indicators measured in various units, necessitating normalisation for meaningful comparisons. We employ a distance-to-frontier (DTF) approach for this task. The distance-to-frontier approach compares a region's or a country's performance in an indicator with the values of the assumed best-case and the worst-case for the indicator, transforming raw indicator values into standardised scores between 0 (worst) and 1 (best). In this way, the region's or the country's performance relative to the best and worst-case scenarios for each indicator can be captured by the distance-to-frontier score generated.

Defining the frontiers

The first step of the DTF approach is to define the frontiers — the best and worst cases for each indicator.

For indicators with inherent upper and lower limits, the best and worst cases are set close to the highest and lowest possible values. This scenario mainly applies to indicators with ordinal scales as units of measurement.

While the distance-to-frontier (DTF) approach typically relies on the identified best and worst-case values, in cases where indicators have clearly defined logical bounds, these bounds may not always be utilised. This is due to the fact that, in many instances, particularly with survey variables, the upper or lower logical bound is never actually achieved. Instead, where feasible, the DTF approach is adjusted to ensure that the normalised values (ranging from 0 to 1) maintain a relatively consistent standard deviation across all indicators. This adjustment prioritises maintaining consistent variability among normalised scores, even if it means deviating from the strict application of logical bounds in some cases.

For indicators lacking clearly defined upper or lower limits, the best and worst-case scenarios are determined based on historical data collected since 2009. However, to account for potential future advancements in certain indicators, such as internet bandwidth, where the historical upper bound may be surpassed, adjustments are made to incrementally extend the upper bound, leaving room for improvement. This approach ensures that the normalisation process remains adaptable to ongoing progress and avoids imposing artificial constraints on indicators with unbounded potential.

Normalising the values via DTF

After we determine the frontiers, the next step is to calculate a region's or a country's distance-to-frontier score for each indicator.

The DTF score is calculated using the formula:

(x1j - Vmin) / (Vmin - Vmax)

where x1j is the raw value for country 1 on indicator j, and Vmin and Vmax are the worst and best-case values, respectively. Higher scores always indicate better performance, with the direction inverted for indicators where higher values are undesirable. This approach allows for direct comparison across indicators and countries, as well as tracking performance over time.

Indicators are then transformed into indices ranging from 0 to 10 using the DTF normalisation method.

We implement DTF normalisation at 4 levels:

- **DTF within region:** This entails comparing the performance of a region to the best and worst performing regions within its country, capturing regional disparities. The DTF score is calculated as:

  (x_ij - min(x_j)) / (max(x_j) - min(x_j))
  where x_ij is the raw value for region i on indicator j, and min(x_j) and max(x_j) are the minimum and maximum values for indicator j within the country.

- **DTF within country:** This evaluates a country's overall performance relative to its best and worst performing regions, providing an internal benchmark. The DTF score is calculated as:

  (x_j - min(x_i)) / (max(x_i) - min(x_i))
  where x_j is the raw value for country j on indicator j, and min(x_i) and max(x_i) are the minimum and maximum values across all regions i within the country.

- **DTF within sample:** This assesses a country's performance relative to all other countries in the sample, offering a broader international comparison. The DTF score is calculated as:

(x_ij - min(x_i)) / (max(x_i) - min(x_i))
where x_ij is the raw value for country i on indicator j, and min(x_i) and max(x_i) are the minimum and maximum values for indicator j across all countries i in the sample.

Additional step for years 2022 onwards

- **DTF over time:** For data from 2022 onwards, we introduce a temporal dimension. We compare the performance of each region or country against its own performance over time, considering the variance across multiple years. This requires at least three data points (the current year, the minimum and maximum values from previous years) to establish a meaningful trend. The DTF score is calculated as:

(x_ijt - min(x_it)) / (max(x_it) - min(x_it))
where x_ijt is the raw value for region or country i on indicator j at time t, and min(x_it) and max(x_it) are the minimum and maximum values for indicator j across all time periods t for region or country i.

4. Constructing the Index

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Can we re-arrange this similar to the same section of the Legatum Methodology Paper? I can do this but I need clarification s like in weighting etc.

At this stage, we have a set of 123 indicators, using a comparable scale, organised underneath the definitional framework of welfare. They are now in a position to be combined, and aggregated up to measure each pillar and domain of welfare, as well as the overall measurement of welfare, the RWI score, for 29 countries and 233 regions.

Proceeding with the Structural Equation modelling

Structural Equation Modelling (SEM) is a combination of factor and path analysis and is perfect for estimating the structural relationship between variables. SEM allows for both, latent variables (unobserved variables) as well as for observed variables (variables that can be measured). SEM is only suitable for linear models with

continuous variables, and it makes the assumption that the relationships between the variables are linear and assumes that the errors are normally distributed.

The Generalised Structural Equation Modelling (GSEM), however, has some important features that are not available in the simple SEM. While the outcome variable in GSEM can also be either observed or latent, GSEM is generally used for more complex data and distributions that involve non-normally and categorical data. It generalised the SEM and allows for examining a wider range of data and distributions. Particularly, the GSEM framework allows for the analysis of non linear relationships and for variables that are not normally distributed. While SEM only allows for continuous responses, GSEM allows for both, linear and generalised linear response functions. The outcome variable can therefore be either continuous as in SEM, or categorical (eg binary, ordinal, count or multinomial).

In contrast to SEM, GSEM does not assume that the errors are normally distributed and does not require linear relationships. Therefore, it is flexible to estimate non-linear relationships and relaxes the assumption of normal distribution, thus, allows for errors to be non-normally distributed.
GSEM is using maximum likelihood (ML) method and allows for multilevel models. Overall, it is more flexible in dealing with more complex, non-normal and categorical data, while it further allows us to use more observations in case of missing values.

In SEM, you need to specify how the observable indicators (variables) relate to the latent constructs (domains and pillars). This is done by:

- Assigning each observable indicator to a relevant pillar and domain.
- Creating latent variables for each domain and subdomain.
- Modeling the relationships between these latent variables and the indicators using a reflective or formative approach.

A reflective model assumes that the indicators reflect the underlying latent variable (e.g., income reflects economic well-being), while a formative model assumes the latent variable is formed by the indicators.
The measurement model is where you define the relationships between observable indicators (variables) and latent constructs (domains or pillars). In SEM, these relationships can be either reflective or formative.

- Reflective model: The latent construct (e.g., “Just Societies”) is thought to influence the indicators (e.g., indicators of formal institutions, human rights). In this model, the indicators are reflective of the latent construct.

Mathematically, this is modeled as:

x_i = \lambda_i \xi + \epsilon_i

Where:

- x_i = observed indicator i (e.g., an indicator for human rights),
- \xi = latent construct (e.g., Just Societies),
- \lambda_i = factor loading for indicator i ,
- \epsilon_i = error term for indicator i .
- Formative model: The indicators (e.g., poverty rates, access to healthcare) are assumed to form or define the latent construct (e.g., Secured Livelihoods).

Mathematically, this is modeled as:

\xi = \sum_{i=1}^{n} \gamma_i x_i + \zeta

Where:

- \xi = latent construct (e.g., Secured Livelihoods),
- x_i = observed indicator i ,
- \gamma_i = weight or regression coefficient of indicator i ,
- \zeta = disturbance term (unexplained variance in the latent construct).

Specifying the model:

For each domain of welfare, like “Just Societies,” define latent variables corresponding to the five pillars (Formal Institutions, Human Rights, etc.). Each pillar is then associated with several observable indicators.

For example, for the Just Societies domain:

- \xi_1 = \text{Formal Institutions},
- \xi_2 = \text{Human Rights},
- \xi_3 = \text{Informal Institutions},
- \xi_4 = \text{Religions},
- \xi_5 = \text{Social Capital}.

Each pillar (\xi_i) is related to several indicators (e.g., for Human Rights, you might have \(x_1 = \text{Civil liberties}, x_2 = \text{Freedom of expression}, \dots\)).

The relationships between the latent constructs and the observed indicators are represented by factor loadings (\lambda_i) in reflective models, or weights (\gamma_i) in formative models.

5) Estimate the Measurement Model

Once the measurement model is specified, we proceed with Confirmatory Factor Analysis (CFA) to estimate the factor loadings (\lambda_i) or weights (\gamma_i) that relate the indicators to the latent constructs.

- The likelihood function used in SEM aims to minimize the difference between the observed covariance matrix of the indicators S and the model-implied covariance matrix $\Sigma(\theta)$, where θ represents the parameters (factor loadings, variances, covariances).

The log-likelihood function is:

$$L(\theta) = -\frac{N}{2} \left[\log|\Sigma(\theta)| + \text{tr}\left(S \Sigma(\theta)^{-1}\right) - \log|S| - p \right]$$

Where:

- N = sample size,
- p = number of observed variables,
- $\Sigma(\theta)$ = model-implied covariance matrix,
- S = observed covariance matrix.

This estimation process gives us the factor loadings (\lambda_i) or weights (\gamma_i) for each indicator, which tell us how strongly each indicator is related to its respective latent construct.

Assessing model fit

After estimating the model, it's important to check how well each model fits the data. Several fit indices are used to assess the quality of the model:

1. Chi-Square Test of Model Fit:

- \chi^2 is used to test the difference between the observed covariance matrix and the model-implied covariance matrix. A small \chi^2 relative to degrees of freedom indicates a good fit.

2. Root Mean Square Error of Approximation (RMSEA):
   - RMSEA assesses how well the model would fit the population covariance matrix.
   - Values less than 0.05 indicate a good fit.

\text{RMSEA} = \sqrt{\frac{\chi^2 / \text{df} - 1}{N - 1}}

3. Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI):
   - Both indices compare the fit of the user-specified model to a baseline model (usually a null model).
   - Values above 0.90 are considered acceptable.

In cases where the model does not fit well, we proceed with modifications that free up parameters (e.g., allowing error terms to covary).

Once the measurement model is validated, the structural relationships between latent constructs (domains) can be specified and tested.

For example, we may want to test the hypothesis that "Secured Livelihoods" (\xi_2) has a direct effect on "Just Societies" (\xi_1). This would be expressed as:

\xi_1 = \beta_{12} \xi_2 + \zeta_1

Where:

- \beta_{12} is the path coefficient (regression weight) between \xi_2 and \xi_1,
- \zeta_1 is the disturbance term.

This allows us to test how much each domain contributes to another domain or to the overall welfare construct. SEM also allows for the inclusion of covariances between latent constructs.

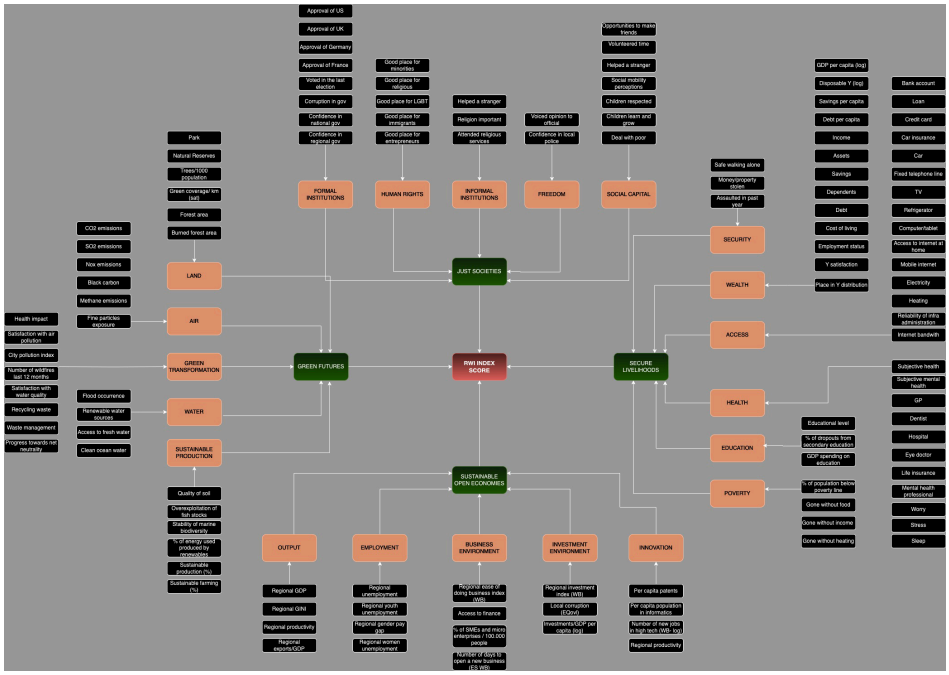
Once the structural and measurement models are finalized, the composite index can be calculated by aggregating the latent constructs. The weights (factor loadings) derived from SEM help in this aggregation process.

The final composite index, I, can be expressed as a weighted sum of the domains:

$$I = \sum_{j=1}^{4} w_j \xi_j$$

Where:

- **w_j = weight of the j-th domain (derived from factor loadings and standardized path coefficients),**
- **ξ_j = score for the j-th domain (latent variable),**
- **The summation includes the four domains: Just Societies, Secured Livelihoods, Sustainable Open Economies, and Nature & Green Future.**



These normalised indices are statistically tested using Structural Equation Modelling (SEM) to evaluate the current welfare calculation and assess additional indicators. The final indicators for each dimension are determined by evaluating loading factors from the SEM analysis for each region.

We, finally, employ a Partial Least Squares Structural Equation Modelling with K-Means clustering (PLS-SEM-KM) approach. This approach combines PLS-SEM, a method for modelling complex relationships between observed and latent variables, with K-Means clustering, a technique for grouping similar observations. By integrating these methods, the PLS-SEM-KM approach allows for simultaneous identification of clusters within the data and estimation of relationships between observed and latent variables. This is particularly useful for the RWI, as it aims to identify groups of regions with similar welfare profiles and understand the underlying factors contributing to these profiles.

K – Means clustering

When using the data on SEM to estimate each value, each regression is estimated by different regions and different countries, thus, modelling the relationship between X and Y variables and estimating their coefficients within each group of regions/countries. A simple estimator for examining this type of relationship would however lead to biased results. That is, because it would simply estimate the mean of the coefficients across all groups without weighting how the groups work. That is, all different regions would be estimated as if they are equal and work in the same way, which is not the case, especially since we don't use only nuts 2 regions. One way to solve this issue is to use the standard clustering method in econometrics which clusters the standard errors by a specific variable. However, since SEM is running all equations simultaneously (eg we run different estimations at the same time), the method of standard econometrics clustering is not possible.

Instead, we are using K-means clustering as this type of algorithm divides a dataset into k clusters. By this, it identifies patterns and groups data points into clusters of data that have similar features. By dividing a set of data points into groups, it enables us to compare the data points within each group. That is, since the data points within each group can be compared to one another, but, they are different from the data points within the other groups.
However, this algorithm only works if the number of groups are known. We partition our data into groups of regions and groups of countries which are all known in our dataset, hence, making the K-means clustering method suitable.

By dividing the dataset into k clusters, each data point belongs to the cluster with the nearest mean with the main aim to minimise the variance within each cluster.

Since this methods allows to run different estimates for each cluster, it runs different regressions for each group and at the end, it runs the regression for all data points. By that, it takes the differences of the mean of this group and the mean of all data points.

We are therefore running separate estimates for each region and each country in our data.

K-means clustering algorithm steps:

1. We specify the number of groups we have in our data, the so called k initial centroids. In our case we have 233 regions and 29 countries, a total of x clusters.

2. We assign each data point to the nearest centroid (group). That is, we run the estimation within those groups, we find one coefficient for each relationship of each group, and then we find the main coefficient for each data point. As a last step here, we use the Euclidean distance method to calibrate the difference of each individual data point and the mean (cluster centre).

   The regression for the K-means clustering looks as follows:

   ( ) | | ,

where represents each data point of each group of clusters (regions and countries), represents the centroid of cluster k and | | is the squared Euclidean distance between and

3. For each data point in each group, we compute the distance to each centroid and is assigned to the cluster whose centroid is closest. The centroids of the clusters are then recalculated so that for each cluster k, the centroid is updated to be the mean of all data points assigned to that cluster. By that, the new centroids are calculated by taking the average of the points in each cluster until they stabilize:

   — ∑

where represents the set of data points that are assigned to cluster k, and represents the number of points in cluster k. The steps are then repeated until there

is no significant change in the centroids, or, until they have reached a maximum number of iterations.

The main aim of K-means, the objective function of the k-means clustering method, is to minimise the total variance within all clusters which is done by minimising the within-cluster sum of squares as shown below:

$$\sum \sum |\quad|$$

where K is the number of clusters. By minimising the objective function, we calculate the most compact clusters with the smallest variance within each cluster.

Validation and overtime comparability

In the context of the Relative Welfare Index (RWI), out-of-sample validation can be particularly useful for testing the index's robustness across different regions or time periods. For example, if the RWI is constructed using data from Western Europe, you can split the data geographically by using Western Europe as the training set to build the model. Once the model is estimated, including the relationships between welfare domains like "Just Societies" and indicators such as human rights or social capital, you can then apply the model to data from Eastern Europe (the validation set). This allows you to test whether the factor loadings, path coefficients, and overall model structure hold up in a different regional context, which may have different socioeconomic conditions.

The same principle can be applied temporally. Suppose the RWI is initially developed using data from 2015 to 2020 as the training set. You can then validate the model by applying it to data from 2021 to 2023 (the validation set) to see if the relationships between welfare indicators and domains remain consistent over time. If the model performs well in these different regions or time periods, producing similar fit indices (like RMSEA, CFI, or TLI) and consistent index scores, it suggests that the welfare index is not just tailored to specific data but can reliably capture welfare dynamics across different settings. This ensures that the RWI is a robust and generalizable tool for comparing welfare across regions and time periods.

Out-of-sample validation in Structural Equation Modelling (SEM) is crucial to ensure that the model is generalizable and not overfitted to the original data. To perform this, you start by splitting your dataset into two parts: a training set and a validation set. The training set is used to estimate the SEM model, while the validation set is used to assess the model's performance. Once the model is developed on the training data, including estimating factor loadings and path coefficients, these parameters are applied to the validation set. The objective is to see if the relationships between the latent variables and the indicators hold consistently across both datasets. Model fit is assessed using indices such as RMSEA, CFI, TLI, and Chi-square, and these should remain similar between the training and validation sets for the model to be considered robust.

In addition to model fit, you also compare the estimated factor loadings and path coefficients across both datasets to ensure consistency. If the model performs well in the validation set, with similar parameter estimates and fit indices, it indicates that the model generalizes well to new data. On the other hand, if there is a significant drop in performance, this suggests the model may be overfitted to the training data, requiring further refinement. Sensitivity analysis, such as testing different weights or excluding certain indicators, can also help assess the stability of the model.

While the Regional Welfare Index (RWI) provides valuable insights into regional well-being across Europe, it is essential to approach comparisons over time with caution. Changes in the index scores may not always reflect real improvements or declines in welfare but could result from adjustments in data sources, methodology, or the inclusion of new indicators that better capture emerging dimensions of well-being, such as environmental sustainability or digital access. These changes can affect the consistency of the index over time, potentially complicating direct year-on-year comparisons. It is therefore important to account for any updates or revisions in the index's construction when assessing trends.

The need for careful interpretation of the Regional Welfare Index (RWI) across time is heightened by potential changes in the way the primary indicators that feed into the index are measured. For example, updates in the methodologies used to calculate indicators like employment rates, education levels, or environmental sustainability could affect the consistency of these measures across different periods. Statistical agencies may revise their data collection methods, apply new definitions, or improve measurement techniques over time. These updates are crucial for ensuring accuracy but can lead to shifts in the index that do not necessarily reflect real changes in

welfare. Therefore, when comparing RWI scores across years, it's essential to check whether adjustments in the underlying data or measurement processes have influenced the results.

Moreover, regions may experience external shocks differently, which can distort time-based comparisons in the RWI. Events such as economic recessions, natural disasters, or policy reforms may have a more severe impact on certain regions due to their specific economic structures, geographic vulnerabilities, or social dynamics. For instance, a region heavily reliant on tourism might experience a sharper decline during a global economic downturn compared to an industrialized region, leading to temporary dips in the RWI score. Similarly, climate-related shocks or health crises, like the COVID-19 pandemic, may affect regions unevenly, complicating the interpretation of changes over time. These differential effects mean that any apparent improvement or deterioration in regional welfare should be contextualized within the broader framework of external factors and regional sensitivities.