UNIVERSITY OF CAMBRIDGE
INSTITUTE FOR SUSTAINABILITY LEADERSHIP

The Competitive Sustainability Index

New metrics for EU competitiveness for an economy in transition

with the support of

Breakthrough Energy

Contents

Paolo Gentiloni

European Commissioner for Economy

At the very start of the von der Leyen Commission, we took a decision to place sustainability more explicitly than ever before at the heart of European economic policy. As such, we decided that Member States' progress towards the United Nations Sustainable Development Goals should be monitored through the European Semester, the EU's annual cycle of economic policy coordination. We launched the European Green Deal, with one of its central aims being to decouple economic growth from resource use. We renamed the Annual Growth Survey – the document setting out the general economic and social priorities for the EU for the following year – the Annual Sustainable Growth Survey. And we put forward the concept of competitive sustainability, with the aim of ensuring that measures to enhance fairness, boost productivity, ensure environmental sustainability and preserve macroeconomic stability would be pursued of a coherent and consistent policy mix.

The multiple crises impacting our economies and societies since 2020, from the COVID pandemic to Russia's brutal war of aggression against Ukraine, have in no way lessened the relevance or importance of this policy choice. On the contrary, they have only strengthened our resolve to shift the EU economy onto a more sustainable growth path. For evidence, one need only look at NextGenerationEU, designed not only to mitigate the economic and social impact of the coronavirus pandemic, but also to seize the opportunity to make European economies and societies more sustainable and resilient. Or at REPowerEU, our plan to transform Europe's energy system with the goal not only of ending our dependence on Russian fossil fuels, but also of tackling the climate crisis.

Delivering competitive sustainability in practice requires a paradigm shift in the way that our economies are run as well as how we understand their relationship to issues like climate change, biodiversity or inequality. Our strategy is to achieve that shift through the European Semester as well as a wide range of other policies that are directly referenced by it, from trade and competition to industrial, research and innovation, and of course environmental and social policies.

The transition to a sustainable economy will reshape global competitiveness and drive an economic strategy shift. Those who adapt faster to the new paradigm will become the next economic leaders, and the EU aims to be a forerunner in this for that reason. It is a highly challenging exercise, for which there may be no single answer, but the competitive sustainability framework is an effective starting point for it, and as it progresses, the EU remains at the leading edge of thinking and action globally on this.

It is very important to be able to track progress in the best way possible, especially given that other parts of the world are now rapidly adapting and catching up, challenging the competitive advantage that the EU has had in being a policy forerunner. I therefore welcome the launch of the Competitive Sustainability Index, which I believe can be a most useful complement to the Commission's own analysis in the framework of the European Semester. It strikes me as an excellent and helpful addition to the toolbox available to the EU and others for measuring performance in a way that is both innovative and integrates many of the elements of competitive sustainability in a coherent way. I encourage all stakeholders to use, test and develop it to our mutual benefit.

Clare Shine

CISL, CEO

Since 1988, the University of Cambridge Institute for Sustainability Leadership (CISL) has been at the vanguard of global efforts to catalyse change and accelerate the path to a sustainable economy,

CISL builds individual and organisational leadership capacity and capabilities and creates industry-leading collaborations. Our Rewiring the Economy framework provides a ten-point plan for collaboration between business, government and finance to drive positive outcomes aligned with the UN Sustainable Development Goals (SDGs), while our Rewiring Leadership framework proposes a model to achieve this. Our interdisciplinary research builds the evidence base for practical action through across multiple areas: sustainable finance, economic innovation, inclusive development, natural capital, future cities and leadership, to name but a few.

CISL's headquarters are in Cambridge but its reach and influence are truly global. Our office in Brussels, home to the EU institutions, is pivotal to our commitment to international policy leadership for sustainability. CISL's work with its European Corporate Leaders Group and EU Green Growth Partnership is rightly recognised by key decision-makers as instrumental to the EU's own activities on the European Green Deal and related activities.

Despite the progress made by CISL and like-minded organisations and individuals seeking to achieve a model of genuinely sustainable development, the urgency and complexity of the interconnected challenges involved is greater than ever. We are confronted almost daily with new and distressing evidence of converging crises and serial tipping points.

As the relatively new steward of a globally recognised and influential institute, I am determined that CISL address this outstanding responsibility and potential in its forward strategy. A sustainable and resilient future for people, nature and climate means thinking, acting and investing differently, embracing innovation and radical disruption, and creating new routes to engagement and impact across public policymakers, the private sector, academic and civil society.

The new Competitive Sustainability Index (CSI) aims to enable this by building on our track record of interdisciplinary research with a clear and practical aim in mind. It is a major contribution to CISL's thought leadership in the EU and beyond and I am delighted to see it come to fruition.

I am most grateful not only to colleagues at CISL for their dedication and excellent work but also to the partner organisations who supported it, notably Breakthrough Energy. Bold partnerships are essential to drive systemic change at scale and to catalyse new approaches and ambition. I am confident that together, we can and will build on this, as the CSI hopefully becomes an international reference point and useful tool for further work in the months and years to come.

Ann Mettler

Breakthrough Energy, Vice President Europe

New times call for new intellectual frameworks and policy paradigms. As *policrises* ripple through the world in general and Europe in particular, many concepts that have hitherto guided thinking and public debate seem oddly fatigued and out of touch with the realities of today. More than three decades ago, sustainable development was coined as a signpost towards a future where planetary boundaries would be experienced with full force. Anticipatory and ahead of its time, the concept became widely accepted and adopted to help steer policies in helpful directions.

As much of Europe's traditional economic model is reaching its palpable limits - both in terms of its resource-intensity in times of scarcity and some of the premises on which it measures success and growth – calls have grown louder for a novel frame of reference that will identify Europe's competitive advantage in a world that is facing a 'turning point in the history of energy'[1]. *Competitive sustainability* promises to answer the current policy void, providing a key barometer for how Europe can remain relevant, successful and prosperous in the years and decades to come.

By zeroing in on leading countries and best practices, we hope the Competitive Sustainability Index can instill a race to the top. But also not shy away from calling out the laggards. As management guru Peter Drucker aptly said: you can't manage what you can't measure. Pertinent data analytics are therefore key to charting a path towards a brighter, cleaner and more resilient future for all of us. For the fact is that right now across Europe, countless innovators, researchers and entrepreneurs are developing and scaling up the clean, low-carbon technologies the European Union needs to meet its legal and moral obligation to reach net-zero by 2050. At Breakthrough Energy, we are fortunate to support these visionaries. We invest our private capital in their startups, we leverage our policy expertise to advance their most impactful ideas, and we connect them with our vast and growing networks across business, government and civil society – including those at the University of Cambridge's Institute for Sustainability Leadership which authored this ground-breaking report.

Breakthrough Energy is proud to support cutting-edge thought leadership of this caliber. The Competitive Sustainability Index is designed as a living document and ongoing analytical tool. Read it, study it, help us improve the index. Like Breakthrough, the CSI has at its core a focus on dynamic and disruptive innovation ecosystems. When reaching the top of the index becomes an urgent goal for governments across the continent, we'll know we're on the right track. Until then, let's get to work. Because if not now, then when? And if not through innovation, then how?

[1] EU-27 average performance for this report has been calculated in all cases as the arithmetic average of the scores of the 27 countries.

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Expert contributors

The Index development benefited from the input of some leading experts through a series of interviews and two working groups. Experts having contributed to this work include:

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Executive summary

An innovative design

The Competitive Sustainability Index (CSI) provides a new means of assessing and tracking the competitive performance of EU countries as they progress in their transition to sustainability, with a climate neutral economy at its core. As the EU addresses this, it also faces greater competition for investment from partners and strategic rivals alike, along with a daunting combination of inter-connected social, economic and geo-political challenges. Therefore, **the success of its forerunner approach to the race to a sustainable model of development is more important than ever**.

The CSI's design complements the European Commission's own strategy for competitive sustainability, first articulated in the 2020 Annual Sustainable Growth Strategy. There are many studies and indices that track and assess countries' performance on the sustainability transition, competitiveness and innovation. However, **none has yet sought to address all of them in a way that reflects the paradigm shift implied by the competitive sustainability framework**. The CSI has been built with a deliberate focus on competitiveness and an integrated approach to addressing the four relevant dimensions of sustainable development: Economy, Society, Governance and Environment. Therefore, it not only builds on and refines the Commission's own framework, but also integrates the latest thinking on innovation to better capture the dynamics involved. The result of almost two years of preparation, and with an audit by the Joint Research Centre (JRC) to endorse it, the CSI offers a uniquely integrated picture of competitive performance in this context.

Its core focus is on how economies, their value chains and innovation ecosystems perform in the transition, where the role of innovation is considered the key prerequisite for success. **The CSI incorporates newly available sustainable finance data to better track economic activities that are aligned with the transition**. Using the very latest methods and data from the European Central Bank (ECB) and Eurostat, the CSI is ground-breaking in this respect. As well as giving a picture for the EU Member States overall, **there is also a detailed country profile for each**.

Overall impression of countries' performance across the Competitive Sustainability Index dimensions

	Economy / Productivity													Society / Fairness						Governance / Stability						Green / Environment					
AT	63	62	40	73	60	46	70	19	59	98	66	35	74	68	94	75	63	70	76	83	67	79	59	49	66	65	56	48	57	91	49
BE	65	49	47	26	63		64	24	39	96	54	23	63	73	84	57	44	78	70	67	65	52	36	47	60	40	53	17	22	86	52
BG	3	22	42	12	31	28	31	41	26	65	42	26	62	34	40	24	38	24	4	14	14	3	53	6	23	41	6	31	14	0	95
CY	33	52	16	33	43	16	98	13	10	86	56	7	70	61	91	48	67	57	98	39	39	38	35	3	28	4	55	13	45	74	12
CZ	44	34	65	30	37	33	42	28	57	69	58	73	71	46	91	89	78	74	55	65	52	38	59	28	46	45	18	26	25	51	91
DE	67	38	61	64	63	100	69	23	58	100	51	59	86	48	91	85	56	66	66	84	73	68	70	48	59	40	56	25	61	87	62
DK	93	69	61	45	13		52	34	40	68	61	44	70	93	93	84	90	80	70	99	90	84	84	59	58	45	63	12	100	80	91
EE	57	45	49	40	58	8	57	34	67	94	62	47	58	93	45	53	52	69	59	72	71	63	68	31	79	51	8	62	21	35	93
EL	37	32	29	26	23	46	66	14	32	83	19	5	0	42	32	21	3	44	74	27	34	41	17	21	35	51	29	34	41	69	73
ES	52	51	42	13	10	18	22	32	38	41	46	18	15	59	97	38	79	51	85	54	53	62	33	31	50	58	51	31	55	88	30
FI	75	56	67	83	93	77	81	26	69	97	74	40	73	92	79	63	86	85	79	99	100	87	72	72	56	51	53	100	8	83	66
FR	44	75	61	44	26	52	40	41	8	73	51	40	65	76	86	45	77	65	70	64	52	76	40	40	65	48	64	28	47	95	61
HR	34	31	23	38	13	26	56	37	23	69	44	62	29	34	78	36	2	65	45	27	35	25	39	16	49	44	45	46	47	68	71
HU	29	30	61	26	47	11	31	41	11	39	44	62	54	40	74	52	57	62	41	21	15	38	50	23	51	33	30	16	34	67	76
IE	38	89	76	33	59		51	14	51	49	51	54	65	47	87	68	100	61	85	82	71	69	71	41	35	51	68	33	100	87	66
IT	35	27	35	57	50	38	55	19	85	80	44	26	29	31	72	4	48	35	82	44	25	40	15	30	46	34	48	29	71	90	58
LT	31	51	38	22	30	16	41	82	35	54	41	60	54	62	67	50	11	56	23	47	55	58	61	13	45	46	43	37	46	54	91
LU	65	67	50	43	30		53	37	18	68	34	3	84	78	99	72	68	56	71	92	74	78	98	69	59	22	65	28	81	93	48
LV	25	35	33	9	23	9	27	53	48	43	66	25	49	66	47	32	39	57	22	38	45	45	48	20	54	46	32	59	40	53	97
MT	29	39	0	14	48	30	42	46	16	64	11	12	83	51	93	86	84	38	42	63	32	42	82	16	33	0	52	0	0	69	47
NL	70	69	73		85		67	43	42		55	45	88	79	99	100	79	70	78	90	78	87	76	87	72	45	70	8	35	86	49
PL	28	33	48	16	36	16	24	48	25	42	53	24	52	47	73	68	48	62	44	46	28	37	63	37	58	44	14	24	36	33	82
PT	39	56		44	37	45	45	46	28	58	39	16	46	46	87	63	46	62	54	66	59	46	41	18	58	67	60	33	61	81	50
RO	10	15	59	0	6	0	6	45	16	0	49	23	49	10	47	30	37	37	5	36	25	16	42	3	43	46	27	25	85	51	62
SE	82	61	68	33	54	37	65	22	38	78	62	78	76	100	91	83	81	78	88	95	91	75	72	94	57	77	67	90	32	100	47
SI	41	49	27	61	50	30	67	43	65	80	54	36	54	69	74	82	77	88	76	68	62	39	53	36	55	35	60	65	39	72	59
SK	21	28	34	21	19	11	22	75	40	45	46	33	40	28	63	39	54	81	41	40	37	30	45	22	57	13	39	32	21	66	81

For new insights…

The CSI findings indicate that:

- Overall, **EU countries are collectively performing competitively better on Society and Governance dimensions of the transition compared to Economy and Environment dimensions**. Among them, four countries are leaders in the overall index. All are leaders in the Governance dimension, but none of them (or any others) performs as a leader in the Environment dimension. Only one country is a leader in three dimensions, while eight countries perform strongly or as leaders overall. Conversely, there is only one country lagging in all dimensions, two that perform poorly overall and three that are only just ahead of them.
- In the dimension most usually associated with competitiveness, namely the economy, **three countries are clear leaders in both overall economy-wide transition performance as well as in the specific climate neutral innovation ecosystems at the core of a successful transition**. A further group of three countries are close behind, and three more just behind them. In most cases, these same countries perform well at both overall ecosystem and whole economy levels.
- For the four leaders, a relatively **strong performance in the Society and Governance dimensions does not seem to be the consequence of a greater emphasis on these aspects to the detriment of the Economy and Environment dimensions**. Rather, it suggests that they are approaching the transition in a manner integrated with their competitive advantage overall.
- It is noteworthy too that **smaller countries that have identified and pursued a sustainability agenda for a longer period appear to perform more competitively overall**, as well as in the Economy dimension. These are generally in Northern and Western Europe. However, there are signs that some newer Member States of the EU are performing more strongly. **Weaker performers tend to be found in southern and eastern areas of the EU**, suggesting that targeted policy interventions to support both economic and other transition dimensions remain very important for the EU overall for its performance to improve.
- When considering each of the indicators for the CSI, there are more negative than positive results. This indicates that there are more areas clustered towards poorer performance than best-in-class. **Of particular note for the economic competitiveness dimension are those for entrepreneurial culture, venture capital and gross value added of manufacturing**. The low average score for active citizenship also suggests a **worrying disconnect between civil society and policymaking** from a governance perspective. This is especially so when taken with poor performance regarding public perception of climate change as a priority. A number of areas in the Environment dimension give cause for concern.
- **Eight of the 31 components** (namely Innovation readiness, Human capital, Education, Social mobility, Fundamental rights, Transparency, Institutional efficacy, and Citizen engagement) are found to have a transversal impact across three dimensions of competitive sustainability, and are therefore the best predictors for a country's competitive sustainability in the European Union.

Performance of countries on the Competitive Sustainability Index and dimensions

Economy / Productivity		Society / Fairness		Governance / Stability		Green / Environment		Index	
FI	72	SE	87	NL	82	SE	69	SE	74
NL	67	DK	85	FI	81	IE	68	FI	73
DE	64	NL	84	SE	81	DK	65	DK	70
AT	60	FI	81	DK	79	AT	61	NL	70
SE	58	SI	78	LU	79	FI	60	AT	65
IE	53	IE	75	DE	67	PT	59	IE	64
DK	52	AT	74	AT	66	FR	57	LU	64
EE	52	LU	74	EE	64	LU	56	DE	63
BE	50	CZ	72	IE	62	DE	55	SI	59
SI	50	CY	70	FR	56	SI	55	FR	58
CZ	48	FR	70	BE	54	IT	55	EE	56
FR	47	DE	68	SI	52	LV	55	BE	54
LU	45	ES	68	EU-27	51	HR	53	CZ	52
EU-27	44	BE	68	PT	48	LT	53	EU-27	52
IT	44	MT	66	ES	47	ES	52	PT	52
PT	42	EU-27	62	CZ	47	EU-27	51	ES	49
LT	41	EE	62	LT	47	EL	50	LT	46
CY	40	PT	60	PL	45	RO	49	IT	44
HU	39	PL	57	MT	45	NL	49	CY	44
HR	35	HU	54	LV	42	EE	45	PL	44
PL	34	SK	51	SK	39	BE	45	LV	43
LV	33	IT	45	IT	33	HU	43	MT	43
MT	32	LT	45	HU	33	CZ	43	HU	42
SK	32	LV	44	HR	32	SK	42	HR	41
BG	31	HR	43	CY	30	PL	39	SK	41
ES	29	EL	36	EL	29	CY	34	EL	36
EL	28	RO	28	RO	27	BG	30	RO	31
RO	21	BG	27	BG	19	MT	28	BG	27

Source: Competitive Sustainability Index 2022

Score legend: ■ 'Leader' [70-100]; ■ 'Strong performer' [60-69]; ■ 'Good performer' [50-59]; ■ 'Moderate performer' [40-49]; ■ 'Weak performer' [0-39].

… and transition policy implications for competitiveness

There are obviously limitations and caveats to the interpretation from both a novel approach and new sources of data, as well as the complexity of the exercise. However, the resulting picture helps to confirm where synergies are being developed for best performance. It also highlights where negative trade-offs exist but can be avoided, and where poor performance can be improved, especially through targeted collaboration and learning from the most relevant peers.

- In terms of the EU's overall approach to the transition to sustainability through the European Semester, the CSI indicates that two factors are key to its competitive performance: the strength of its social market economy, and its ability to provide relatively stable, transparent and inclusive public policymaking along with relatively strong social outcomes. The institutional framework developed by the EU and **the European Semester process is one that provides a strong basis for doing this**, not least as it also seeks to integrate the two dimensions where the CSI indicates that performance is weaker.

- Governance performance seems to be the most relevant driver of competitive sustainability. Thus, having some dedicated funding – potentially from the Directorate-General for Structural Reform Support (DG REFORM) – to **ensure capacity building in critical areas of public administration could increase countries' performance on governance framework conditions potentially resulting on enhanced competitive sustainability results**.
- Although the average scores in the Economy and Environment dimensions are lower, the best performing EU country in each indicator is usually a best-in-class performer at a global level, as far as tentative comparisons with other indices available in these areas allow. This suggests that when the CSI is developed to be able to make wider international comparisons by including other countries, it will indicate that EU countries are likely to generally perform well against their competitors overall. Furthermore, it suggests that **where there are leaders in the EU, these are usually global best performers, so offer both insight and learning opportunities for other EU Member States**.
- However, the CSI results suggest that innovation performance in the economic ecosystems that are essential to effectively achieve a climate neutral economy is, with some notable exceptions, still lagging behind the economy overall. This shows there is still a long way to go to achieve high levels of performance in those critical areas. Consequently, **Europe should significantly improve its performance on these six key ecosystems if it is to retain its leadership in the global race to achieve a net zero emissions economy**.
- There are several areas of EU public policy where these insights are relevant and which are addressed in the European Semester process. **The CSI could be used as a monitoring tool for the European Green Deal overall.** Perhaps the most important possibility revealed from the CSI, however, is the potential of **collaborative learning on research and innovation (R&I) in these areas into groups of countries with similar structural conditions, and likewise to target the work and funds of the Directorate-General for Structural Reform Support (DG REFORM)**.
- While the EU should aim to lead on all six innovation ecosystems, Member States should prioritise their allocation of resources. EU countries (in particular smaller ones) should **leverage CSI data to pick a limited number of innovation ecosystems** where they have the highest potential to lead in the near future, and prioritise R&I investments on those ecosystems. **This approach should ideally be aligned with country's ongoing 'smart specialisation' process.**
- The improved and **more granular collection and analysis of taxonomy-related data by Eurostat and ECB will enable better performance assessment** by the CSI but also other indices and processes. Rapid progress on the valuation of natural capital is also important for improved measurement of environmental performance, which is crucial to determine the ultimate success of the transition.

In conclusion, **the CSI is a first attempt to offer an integrated approach to measuring competitiveness in the transition to sustainability**. It already demonstrates that it is both possible and offers a more holistic perspective than approaches that do not seek to do this and are therefore partial in their insights and conclusions. It will benefit from further scrutiny, use and application, as well as the development of metrics and data sources by others which will strengthen its approach and outputs. In the meantime, the richness of the picture presented and inspiration for new policy thinking or opportunities for collaboration, learning and investment in the EU are already an important step forward. Much like the sustainability transition itself, the CSI will succeed through innovation and experimentation, with a clear long-term goal to drive its thinking and activities.

Summary for policymakers

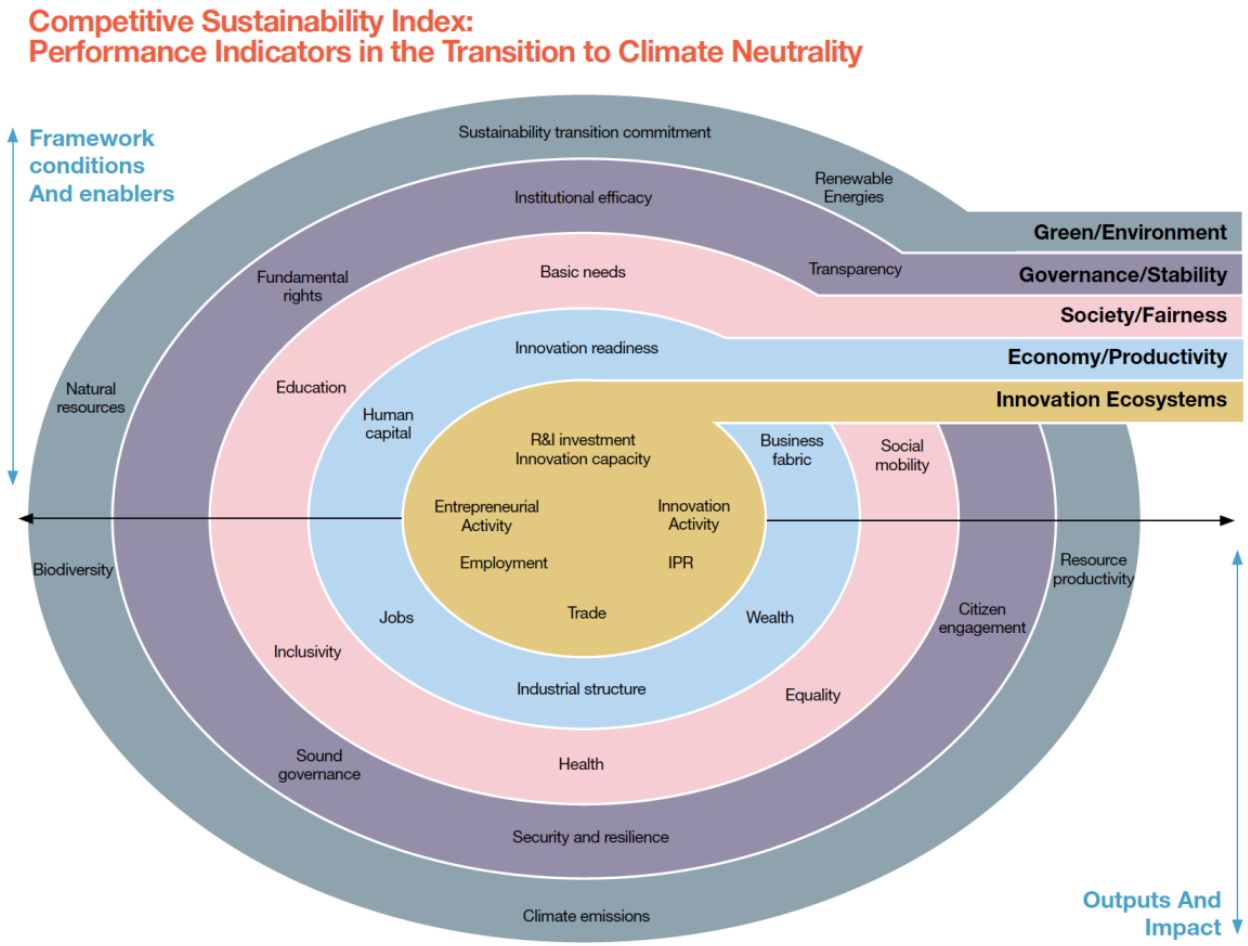
Aim, design and development methodology

The aim of the Competitive Sustainability Index is to **provide a new means of assessing and tracking the competitive performance of EU countries in relation to their transition to sustainability, with a climate neutral economy at its core.** The intent is to provide policymakers, corporate decision-makers, researchers and other interested civil society stakeholders with original insight and evidence that reflects the paradigm shift that this increasingly highly dynamic transition represents in economic thinking. This is especially the case when combined with other drivers of systemic innovation, notably digital. In doing so, it seeks to help ensure that efforts to enhance competitiveness better align with this paradigm shift, too, and strengthen both policy and performance as a result.

The CSI's design has been developed to complement the European Commission's own strategy for competitive sustainability, first articulated in the 2020 Annual Sustainable Growth Strategy and maintained since. The strategy is less well known than the European Green Deal that has been at the heart of the EU's political agenda since the same time. However, it provides a wider framework for how that relates to the European Semester and all the policies that it encompasses and seeks to co-ordinate and ensure are aligned.

Although there are many studies, scoreboards and indices at both European and international levels that track and assess country performance on the central issues involved – namely the sustainability transition, competitiveness and innovation – none has yet sought to address all of them in a way that reflects the paradigm shift implied by the competitive sustainability framework. This framework has been built with a deliberate focus on competitiveness and an integrated and comprehensive approach to addressing the four relevant dimensions of sustainable development: Economy, Society, Governance and Environment. Therefore, it not only builds on and refines the Commission's own framework, but also integrates the latest thinking on innovation.

Figure 1: Competitive Sustainability Index framework



Its core focus is on how economies, their value chains and innovation ecosystems perform in the transition. Here **the role of innovation** – both digital or technology enabled as well as socially driven, combining public direction and support with market-based competition – **is considered the key prerequisite for success**. In light of the wider context in which this economic transformation is taking place, the CSI embeds analysis and measurement in a framework that reflects and tracks performance on the other dimensions of sustainability, related to environmental and social goals and the governance process that manages them.

The result of almost two years of reflection, research, discussion and collaboration, the CSI therefore offers a more holistic view of how EU countries are performing competitively in relation to one another. The methodology has involved a combination of desk research and analysis, EU and international stakeholder engagement, and the development, testing and refinement of a scoreboard and ultimately an index to operationalise competitive sustainability assessment. As well as other quality checks and controls, it has also received a **positive assessment in a JRC audit** (see Annex X: JRC statistical audit of the Competitive Sustainability Index).

In addition to assessing competitiveness, the CSI offers one other key innovation – the **incorporation of newly available data filtered through the EU Taxonomy of sustainable finance**. This allows us to better track economic activities that are aligned with the transition, and which are also therefore expected to grow rapidly, while non-eligible activities conversely decline. Using the very latest methods and insights from key EU institutions, including the ECB and Eurostat, the CSI is also ground-breaking in this respect. In addition to the overall picture for all EU Member States, there is a specific profile for each one provided in Annex VIII.

Figure 2: Overall impression of countries' performance across the Competitive Sustainability Index dimensions

	Economy / Productivity													Society / Fairness						Governance / Stability						Green / Environment					
AT	63	62	40	73	60	46	70	19	59	98	66	35	74	68	94	75	63	70	76	83	67	79	59	49	60	65	56	48	57	91	49
BE	65	49	47	26	62		64	24	39	96	54	23	63	73	84	57	44	78	70	67	65	52	36	47	60	40	53	17	22	86	52
BG	3	22	42	12	31	28	31	41	26	65	42	26	62	34	40	24	38	24	4	14	14	2	53	6	23	41	0	31	14	0	95
CY	33	52	16	33	43	18	98	13	10	86	56	7	70	61	91	49	63	57	98	39	39	38	35	3	28	4	55	13	45	74	12
CZ	44	34	65	30	37	33	42	28	57	69	58	73	71	46	91	89	78	74	55	65	52	38	59	20	46	45	18	26	25	51	91
DE	67	38	61	64	63	100	69	23	58	100	51	59	86	48	91	85	56	66	66	84	73	68	70	48	59	40	56	25	61	87	62
DK	93	69	61	45	13		52	34	40	68	61	44	70	93	93	84	90	80	70	99	90	84	84	59	59	45	63	12	100	80	91
EE	57	45	49	40	58	8	57	34	67	94	62	47	58	93	45	53	52	69	59	72	71	63	68	31	79	51	8	62	21	35	93
EL	37	32	29	26	23	46	66	14	32	83	19	5	0	42	32	21	3	44	74	27	34	41	17	21	35	51	29	34	41	69	73
ES	52	51	42	13	10	18	22	32	38	41	46	18	15	59	97	38	79	51	85	54	53	62	33	31	50	59	51	31	55	88	30
FI	75	56	67	83	93	77	81	26	69	97	74	40	73	92	76	67	86	85	79	99	100	87	72	72	56	51	53	100	8	83	66
FR	44	75	61	44	26	52	40	41	8	73	51	40	65	76	86	45	77	65	70	64	52	76	40	40	65	48	64	28	47	95	61
HR	34	31	23	38	13	26	56	37	23	69	44	62	29	34	78	36	3	65	45	27	35	25	39	16	49	44	45	46	47	68	71
HU	29	30	61	26	47	11	31	41	11	39	44	62	54	40	74	52	57	62	41	21	15	38	50	23	51	33	30	16	34	67	76
IE	38	89	76	33	59		51	14	51	49	51	54	65	47	87	68	100	61	85	82	71	69	71	41	35	51	68	33	100	87	66
IT	35	27	35	57	50	38	55	19	85	80	44	26	29	31	72	4	48	35	82	44	25	40	15	30	46	34	48	29	71	90	58
LT	31	51	38	22	30	16	41	82	35	54	41	60	54	62	67	50	11	56	23	47	55	58	61	13	45	46	43	37	46	54	91
LU	65	67	50	43	30		53	37	18	68	34	3	84	78	98	72	68	56	71	92	74	78	98	69	59	22	65	28	81	93	48
LV	25	35	33	9	25	9	27	53	48	43	66	25	49	66	47	32	39	57	22	38	45	45	48	20	54	46	32	59	40	53	97
MT	29	39	0	14	48	30	42	46	10	64	11	12	83	51	93	86	84	38	42	63	32	42	82	16	33	0	52	0	0	69	47
NL	70	69	73		85		67	43	42		55	45	80	79	99	100	79	70	78	90	78	87	76	87	72	45	70	8	35	86	49
PL	28	33	48	16	36	16	24	48	25	42	53	24	52	47	73	68	48	62	44	46	28	37	63	37	58	44	14	24	36	33	82
PT	39	56		44	37	45	45	46	28	58	39	16	46	46	87	63	46	62	54	66	59	46	41	18	58	67	60	33	61	81	50
RO	10	15	59	0	6	0	6	45	16	0	49	23	49	10	47	30	37	37	5	36	25	16	42	3	43	46	27	25	85	51	62
SE	82	61	68	33	54	37	65	22	38	78	62	78	76	100	91	83	81	78	88	95	91	75	72	94	57	77	67	90	32	100	47
SI	41	49	27	61	50	30	67	43	65	80	54	36	54	69	74	82	77	88	76	68	62	39	53	36	55	35	60	65	39	72	59
SK	21	28	34	21	19	11	22	75	40	45	46	33	40	28	63	39	54	81	41	40	37	30	45	22	57	13	39	32	21	66	81

Source: Competitive Sustainability Index 2022

There are obviously limitations and caveats to the interpretation from both a novel approach and new sources of data, as well as the complexity of the exercise. However, the resulting picture should help to confirm where synergies are being developed for best performance. It should also reveal where negative trade-offs exist but can be avoided, and where poor performance can be improved, especially through targeted collaboration and learning from the most relevant peers.

By using a combination of established data sources as well as new ones that draw on the best available metrics and data from the sustainable finance arena, it offers an original insight on 'the big picture' as well as pointing to details that may deserve further specific attention. **Each individual country profile offers a wealth of information and insight that will be relevant to national policymakers**, especially when compared to other EU Member States – and no two are the same, so each is unique (see Annex VIII: Country profiles).

Key findings

Table 1: Performance of countries on the Competitive Sustainability Index and dimensions

Economy / Productivity		Society / Fairness		Governance / Stability		Green / Environment		Index	
FI	72	SE	87	NL	82	SE	69	SE	74
NL	67	DK	85	FI	81	IE	68	FI	73
DE	64	NL	84	SE	81	DK	65	DK	70
AT	60	FI	81	DK	79	AT	61	NL	70
SE	58	SI	78	LU	79	FI	60	AT	65
IE	53	IE	75	DE	67	PT	59	IE	64
DK	52	AT	74	AT	66	FR	57	LU	64
EE	52	LU	74	EE	64	LU	56	DE	63
BE	50	CZ	72	IE	62	DE	55	SI	59
SI	50	CY	70	FR	56	SI	55	FR	58
CZ	48	FR	70	BE	54	IT	55	EE	56
FR	47	DE	68	SI	52	LV	55	BE	54
LU	45	ES	68	EU-27	51	HR	53	CZ	52
EU-27	44	BE	68	PT	48	LT	53	EU-27	52
IT	44	MT	66	ES	47	ES	52	PT	52
PT	42	EU-27	62	CZ	47	EU-27	51	ES	49
LT	41	EE	62	LT	47	EL	50	LT	46
CY	40	PT	60	PL	45	RO	49	IT	44
HU	39	PL	57	MT	45	NL	49	CY	44
HR	35	HU	54	LV	42	EE	45	PL	44
PL	34	SK	51	SK	39	BE	45	LV	43
LV	33	IT	45	IT	33	HU	43	MT	43
MT	32	LT	45	HU	33	CZ	43	HU	42
SK	32	LV	44	HR	32	SK	42	HR	41
BG	31	HR	43	CY	30	PL	39	SK	41
ES	29	EL	36	EL	29	CY	34	EL	36
EL	28	RO	28	RO	27	BG	30	RO	31
RO	21	BG	27	BG	19	MT	28	BG	27

Source: Competitive Sustainability Index 2022
Score legend: ■ 'Leader' [70-100]; ■ 'Strong performer' [60-69]; ■ 'Good performer' [50-59]; ■ 'Moderate performer' [40-49]; ■ 'Weak performer' [0-39].

The CSI indicates that overall, **EU countries are collectively performing competitively better on Society and Governance dimensions of the transition compared to Economy and Environment dimensions**. Among them, four countries are leaders in the overall index (Sweden, Finland, Denmark and the Netherlands). All of them, and Luxembourg, are leaders in the Governance dimension, but none of them (or any others) performs as a leader in the Environment dimension. As shown in Table 1, only one country (Finland) is a leader in three dimensions, while eight countries perform strongly or as leaders overall: a group that includes Austria, Ireland and Germany, in addition to those already mentioned above. Conversely, there is only one country lagging in all dimensions (Bulgaria), two that perform poorly overall (Greece and Romania) and three that are only just ahead of them (Slovakia, Croatia and Hungary).

For the four leaders, a relatively strong performance in the Society and Governance dimensions does not seem to be the consequence of a greater emphasis on these aspects to the detriment of the Economy and Environment dimensions. Conversely, it suggests that they are approaching the transition in a manner integrated with their competitive advantage overall. It is noteworthy too that smaller countries that have identified and pursued a sustainability agenda for a longer period appear to perform more competitively overall, as well as in the Economy dimension. These are generally in Northern and Western Europe. However, there are signs that some newer Member States of the EU are performing more strongly – both Estonia and Slovenia do well in the Economy dimension in particular. However, **weaker performers tend to be found in Southern and Eastern areas of the EU**. This suggests that targeted policy interventions to support both economic and other transition dimensions remain very important for the EU overall for its performance to improve.

In the dimension most usually associated with competitiveness, namely the economy, **three countries (Finland, Germany and the Netherlands) are clear leaders in both overall economy-wide transition performance as well as the specific climate neutral innovation ecosystems** at the core of a successful transition. A further group of three countries (Austria, Belgium and Sweden) are close behind, and three more (Estonia, Slovenia and Luxembourg) just behind them. In most cases, these countries perform well at both the overall ecosystem and whole economy levels. However, Italy has a stronger performance in ecosystem innovation overall, which suggests it may improve in due course. The strength of Germany's performance in the Economy dimension is also significant, given its size and influence on overall EU performance.

Table 2: Performance on the country-level components of the Economy/Productivity sub-dimensions

	Framework conditions			Impacts		
	Innovation readiness	Human capital	Business fabric	Wealth	Industrial structure	Jobs
AT	63	62	40	66	35	74
BE	65	49	47	54	23	63
BG	3	22	42	42	26	62
CY	33	52	16	56	7	70
CZ	44	34	65	58	73	71
DE	67	38	61	51	59	86
DK	93	69	61	61	44	70
EE	57	45	49	62	47	58
EL	37	32	29	19	5	0
ES	52	51	42	46	18	15
FI	75	56	67	74	40	73
FR	44	75	61	51	40	65
HR	34	31	23	44	62	29
HU	29	30	61	44	62	54
IE	38	89	76	51	54	65
IT	35	27	35	44	26	29
LT	31	51	38	41	60	54
LU	65	67	50	34	3	84
LV	25	35	33	66	25	49
MT	29	39	0	11	12	83
NL	70	69	73	55	45	80
PL	28	33	48	53	24	52
PT	39	56		39	16	46
RO	10	15	59	49	23	49
SE	82	61	68	62	78	76
SI	41	49	27	54	36	54
SK	21	28	34	46	33	40
EU-27	45	47	46	49	36	57
Best	DK	IE	IE	FI	SE	DE

Economy / Productivity	
FI	72
NL	67
DE	64
AT	60
SE	58
IE	53
DK	52
EE	52
BE	50
SI	50
CZ	48
FR	47
LU	45
EU-27	44
IT	44
PT	42
LT	41
CY	40
HU	39
HR	35
PL	34
LV	33
MT	32
SK	32
BG	31
ES	29
EL	28
RO	21

Source: Competitive Sustainability Index 2022

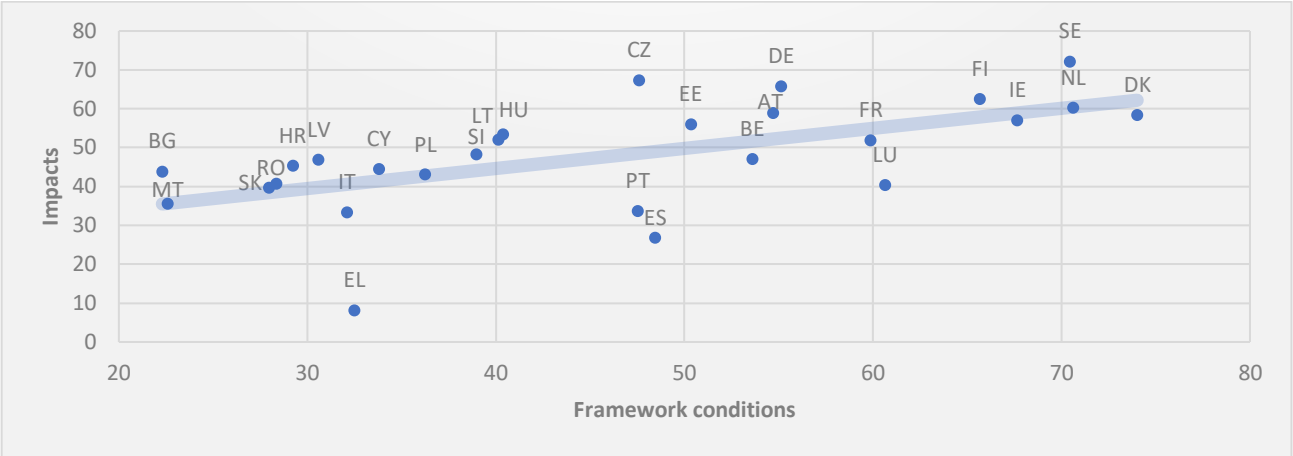
Score legend: ■ 'Leader' [70-100]; ■ 'Strong performer' [60-69]; ■ 'Good performer' [50-59]; ■ 'Moderate performer' [40-49]; ■ 'Weak performer' [0-39].

Within the economic inputs, EU Member States show a 'Moderate' performance across all three components. In terms of *innovation readiness*, Denmark is the top performer, but it is worth highlighting the overall low level of people with advanced ICT skills across European countries. Ireland leads in both *human capital* and *business fabric* components. **Overall low levels of entrepreneurial culture are worrying**, given the significant number of technologies that need to be developed and marketed for the net zero economy to be achieved. **Europe should reinforce its entrepreneurial culture if it is to lead the sustainability transition and prevent third countries from reaping the competitiveness benefits of EU R&I efforts.** Regarding economic outcomes, Finland has the highest *wealth* levels. This is a result of it having higher levels of Taxonomy eligibility and alignment[i] of its gross domestic product (GDP) output than countries that usually top classic wealth rankings focusing exclusively on GDP per capita. Overall the EU's labour market performance is good, although average earnings vary greatly across countries, with Germany particularly excelling regarding *jobs*.

Lastly, Sweden has the strongest *industrial structure* in the EU, leading on both early- and late-stage venture capital in clean technologies. **General low levels of cleantech's venture capital activity in most EU countries also send a clear signal about the need to double down efforts to underpin Europe's positioning as the global front-runner in the green transition**.

Overall, as Figure 3 indicates, there is **a clear correlation between higher performance in framework conditions and impacts in the Economy dimension**, which although further analysis would be required, seems to suggest that improving the former could lead to improved performance in the latter. In that regard, some countries prove to be more efficient translating economic inputs into outcomes. Sweden, the Czech Republic or Bulgaria are good examples of achieving higher level of economic outcomes than other member states with stronger framework conditions.

Figure 3: Correlation between 'Framework conditions' and 'Impacts' sub-dimensions in Economy/Productivity dimension

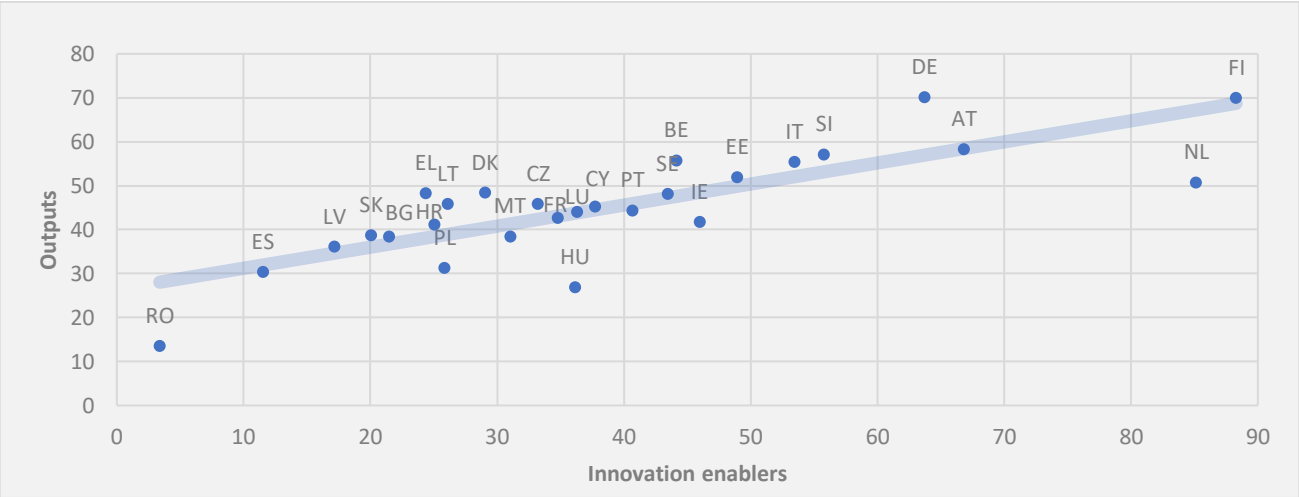


Source: Competitive Sustainability Index 2022

Furthermore, Figure 10 illustrates that Member States with **higher *Innovation enablers* inputs consistently get higher innovation *outputs*** (and ultimately *Impact* outcomes) as they probably manage to reap the benefits from the competitive advantages developed as a result of their R&I efforts. In general, some countries prove to be more efficient in transforming R&I inputs (*Innovation enablers*) into innovation outputs. In that sense, when analysing all six ecosystems together Belgium, Denmark, Greece and especially Germany show particular efficiency in terms of input-output conversion.

i Taxonomy-eligible activities are the economic activities that are described and have technical screening criteria set out in the EU Taxonomy. Taxonomy-aligned activities are the economic activities that make a substantial contribution to at least one of the climate and environmental objectives, while also doing no significant harm to the remaining objectives in the EU Taxonomy.

Figure 4: Correlation between 'Innovation enablers' and 'Outputs' sub-dimensions of all innovation ecosystems aggregated



Source: Competitive Sustainability Index 2022

The average performance of EU countries[ii] in the innovation ecosystems shows stronger results in the Digital and Energy ecosystems and lower scores in the Mobility and Land-use & Agri-food ecosystems. These results seem to be in line with the sustained efforts of the European Commission to foster the energy transition over many years now, and to integrate the digital transition throughout. However, they suggest that other ecosystems are lagging in their development and progress, a point further borne out by differences in performance between these ecosystems and the economies as a whole.

[ii] EU-27 average performance for this report has been calculated in all cases as the arithmetic average of the scores of the 27 countries.

No country manages to be a 'Leader' or 'Strong performer' in all six ecosystems, and there is a diversity of leading performers across the ecosystems. Germany and Finland are the best performers when analysing all ecosystems combined. However, no country qualifies as 'Leader' when considering the average performance in the six innovation ecosystems. Even the 'Strong performer' category is close to not having any representative. In fact, **22 out of the 27 countries are either 'Moderate' or 'Weak' performers**.

Although EU average performance is similar in both levels, there is a 12-point gap between the best performing country in the Economy/Productivity dimension (Finland) and that in the innovation ecosystems combined (Germany). In fact, overall scores at the ecosystem level are lower than those obtained for the whole economy in most countries. **All this suggests a general underperformance in R&I on sustainable economic activities compared to the other components of the countries' economies.** When considering each of the indicators for the CSI in order to have a picture of EU-wide average performance in them, **there are more negative than positive results.** This indicates that there are more areas clustered towards poorer performance than best-in-class**. Of particular note in this respect for the economic competitiveness dimension are performances for entrepreneurial culture, venture capital and gross value added of manufacturing**.

The low average score for active citizenship also suggests a **worrying disconnect between civil society and policymaking** from a governance perspective, despite the generally better performance in this and the Society dimension. This is especially so when taken together with **poor performance regarding public perception of climate change as a priority**. A number of areas in the Environment dimension give cause for concern, including circular material use, effective carbon rates and water productivity, and renewable freshwater availability and energy from renewable sources indicators have both particularly low average scores.

Moreover, **eight of the 31 components** (namely Innovation readiness, Human capital, Education, Social mobility, Fundamental rights, Transparency, Institutional efficacy, and Citizen engagement) are found to **have a transversal impact across three dimensions of competitive sustainability**, and are therefore the best predictors for a country's competitive sustainability in the European Union.

Conclusions

In terms of the EU's overall approach to the transition to sustainability through the European Semester, and the strategy and framework of the Commission for developing competitive sustainability, the CSI indicates that the following are key to the EU's competitive performance: the strength of its social market economy, and its ability to provide relatively stable, transparent and inclusive public policymaking along with relatively strong social outcomes. The institutional framework developed by the EU and the European Semester process is one that provides a strong basis for doing this, not least as it also seeks to integrate the two dimensions where the CSI indicates that performance is weaker.

Governance performance seems to be the most relevant driver of competitive sustainability. Thus, having some dedicated funding – potentially from the Directorate-General for Structural Reform Support (DG REFORM) – to ensure capacity building in critical areas of public administration could increase countries' performance on governance framework conditions potentially resulting on enhanced competitive sustainability results.

However, although the average scores in the Economy and Environment dimensions are lower, the best performing EU country in each indicator is usually a best-in-class performer at a global level, as far as tentative comparisons with other indices available in these areas allow. This suggests that when the CSI is developed to be able to make wider international comparisons by including other countries, it will indicate that EU countries are likely to generally perform well against their competitors overall. Furthermore, it suggests that where there are leaders in the EU, these are usually global best performers, and offer both insight and learning opportunities for other EU Member States.

However, the CSI results suggest that innovation performance in the economic ecosystems that are essential to effectively achieve a climate neutral economy is, with some notable exceptions, still lagging behind the economy overall. They also show that there is still a substantial way to go to achieve high levels of performance in those critical areas. Consequently, **Europe should significantly improve its R&I performance on these six key ecosystems if it is to retain its leadership in the global race to achieve a net zero emissions economy**.

There are several areas of EU public policy where these insights are relevant and which are addressed in the European Semester process. The **CSI could be used as a monitoring tool for the European Green Deal overall**. Perhaps the most important possibility revealed from the CSI is the **potential of collaborative learning on R&I in these areas** in groups of countries with similar structural conditions, and likewise to target the work and funds of DG REFORM.

While the EU should aim to lead on all six innovation ecosystems, Member States should prioritise their allocation of resources. EU countries (in particular smaller ones) should **leverage CSI data to pick a limited number of innovation ecosystems** where they have the highest potential to lead in the near future, and prioritise R&I investments on those ecosystems. **This approach should ideally be aligned with country's ongoing 'smart specialisation' process.**

In that sense, having a **public spending target for competitively sustainable R&I, enshrined in legally-binding EU law** -such as a reformed Stability and Growth Pact- could ensure that competitively sustainable R&I is deployed at the scale that is required. **The improved and more granular collection and analysis of Taxonomy-related data by Eurostat and ECB will enable better performance assessment** by the CSI but also other indices and processes. Rapid progress on the valuation of natural capital is also important for improved measurement of environmental performance, which is crucial to determine the transition's ultimate success.

Index development

There is always scope for indices to evolve and improve, and the CSI is no exception. There are a number of immediate possibilities for a second edition, namely:

- Several data sources were only available for the year prior to the Covid-19 pandemic, which prevented their collection, analysis and reporting. Key among these is data from the usually biennial Community Innovation Survey (CIS), a source used in many indicators in the Economy dimension. This is expected to be available again soon and would therefore update the information by four years, reflecting post-pandemic as well as pre-pandemic situations.
- The data for the innovation ecosystems is based on relatively small sample sizes, as they represent the early development stages of activities eligible for the EU Taxonomy. The amount of data is expected to grow as the economic activities themselves grow. Therefore, the sample size will become larger and provide a clearer picture of competitive performance in relation to the economic transition to climate neutrality. At the same time, there is much ongoing work by Eurostat, the ECB, JRC and others with respect to economic data in these areas, all of which may become available and relevant to the CSI.
- There is an ongoing challenge to value, measure and account for biodiversity and ecosystem services, as well as all types of material resources, and in relation to climate issues. As the metrics and associated data on these areas improve and become available, they can also be incorporated into the existing components or replace some current indicators. This work is complex but advancing at international as well as EU levels, and may soon become available.
- For some of the indicators, there is currently no immediately available international data source or obvious proxy available. However, in some cases this is expected to change – for example as more countries seek to use approaches similar to the EU Taxonomy, and the international equivalent of the Nomenclature of Economic Activities (NACE) codes can be applied to them. The extension of the CSI to a wider, international group of countries is therefore planned, and ultimately it may be possible for it to be truly global in scope, like some other indices.
- As the whole 'beyond GDP' research effort develops in the EU and internationally, there may be further agreement on metrics and data connected to them that can be useful to the CSI as well as others. In the same vein, innovation metrics and data are notoriously challenging, and the Community Innovation Survey is survey as well as EU-based. However, there is much international discussion about how to better measure and track innovation-related data, which the CSI would also be able to benefit and draw from. A key perspective here, as illustrated in the conclusions from the 2022 Global Innovation Index, is the need to better define and measure productivity itself – an endeavour that links both the 'beyond GDP' and innovation agendas, and which the CSI is actively seeking to contribute to.
- When the new CSI is implemented, time-series data will be available and comparisons will become possible. This means the CSI will also be able to track trends over time and to give indications of changes in competitive performance as well as annual snapshots.
- Possible development of the framework and index could be explored to encompass the micro level, such that it could be applied to and used by companies as well as countries.

In conclusion, **the CSI is a first attempt to offer an integrated approach to measuring competitiveness in the transition to sustainability**. It already demonstrates that it is both possible and offers a more holistic perspective than approaches that do not seek to do this and are therefore partial in their insights and conclusions. It will benefit from further scrutiny, use and application, as well as the development of metrics and data sources by others which will strengthen its approach and outputs. In the meantime, the richness of the picture presented and inspiration for new policy thinking or opportunities for collaboration, learning and investment in the EU are already an important step forward. Much like the sustainability transition itself, the CSI will succeed through innovation and experimentation, with a clear long-term goal to drive its thinking and activities.

1 Introduction: context, aims and objectives

This report and the Competitive Sustainability Index (CSI) itself build on previous work from CISL and in particular a working paper on the concept of 'competitive sustainability',[2] a term first used by the European Commission in its 2020 Annual Sustainable Growth Strategy.

As that work demonstrated, the concept was used by the European Commission in a narrative to describe the EU's overall strategy to link its approach to economic, social, environmental and governance challenges of sustainable development in the context of the European Green Deal. The intent was to lead a rapid change in approach at a global as well as a European level. Its ambition clearly spoke to specific European institutional needs at that moment. However, its implications of **a fundamental paradigm shift in thinking and policymaking are striking, and at the time may not have been fully appreciated** by many of those outside the institution, and perhaps even some within. Indeed, it still has not had the public attention that it probably deserves or that which has accompanied the European Green Deal, whose own scope and ambition remain an absolutely central part of its approach.

Among the profound implications of this new concept are those that relate to competitiveness, and how to assess and measure it in the context of the transition to a sustainable model of economic and social development. The initial working paper by CISL offered a brief review of key context and recent research and thought leadership by key EU and international organisations, as they were not always fully developed in the Commission's own explanation and use for the framework, namely:

- 'Competitiveness' lacks a single, agreed definition and remains fluid despite being widely used and referenced by the EU as well as many other organisations, private and public alike.
- The development of thinking on sustainable development has contributed to new approaches to competitiveness, broadening its scope. Planetary environmental limits, notably but not only climate neutrality, and social issues, 'well-being' or 'prosperity', are raised as goals of public policy, as well as gross domestic product (GDP) and productivity growth.
- There is a need to distinguish between the 'competitiveness' of the whole economy, sectors or companies – macro, meso or micro levels – and to understand comparative rather than absolute performance, within or between different geographies. This is within the context of a sustainability transition that is obviously highly dynamic and by definition moving away from 'business as usual'.
- Latest thinking on mission-oriented innovation and sustainability transitions, the importance of innovation as an enabler of competitive advantage, and the role of innovation ecosystems (value chains and geographical clusters) is not systematically integrated in the policy or associated data gathering for it.

As the CISL working paper observed, the **Commission's initial concept lacked sufficient definition for performance on it to be properly assessed in an integrated way**. Evidence to inform any such assessments is still partial and often inadequate, given that the underlying

data was organised and designed to inform economic and related policies rooted in a paradigm of what we now know is unsustainable development. This hinders clear-sighted understanding of the real current situation, as well as how best to direct policy to achieve better performance in due course. The result is that the potential for the concept to be put into practice with the most powerful effect remains unfulfilled.

To overcome these problems and demonstrate the utility of the concept, a clear need was identified for a more operational definition of competitive sustainability, and a linked set of performance indicators that can enable comparison over time and between different countries, parts of the economy and even individual companies. The preliminary definition provided in CISL's working paper was:

"**Competitive sustainability is the ability of an economy, its companies and industrial ecosystems to excel relative to international competitors in their transition to sustainable development (with climate neutrality at its core) through investment in the necessary innovation**."

The working paper suggested that success in this could be measured in relevant and fully aligned:

- enterprise-level technology and business model leadership in global growth markets
- infrastructure development enabling cross-sectoral productivity and economy-wide GDP growth
- strength of domestic industrial ecosystems in generating increased and high-quality employment and additional value-added as a proportion of their global value chains.

CISL's initial study called for further work to identify and develop the most relevant key indicators for competitive sustainability. These could be used to both assess current recovery plans and policy programmes, and to measure progress over time in each of these areas in order to maximise its chances of success. **The need for additional frameworks and models to help monitor progress towards sustainability and competitiveness in that has since also been identified by other work, such as the System Change Compass[3] and the European Commission's 2022 annual Foresight Report**.[4]

In addition to this, the EU has had to confront and manage the Covid-19 health pandemic and now the invasion of Ukraine by Russia, as well as their associated economic, social, health and geo-strategic impacts – all while the evidence and immediate impacts of the climate, biodiversity and natural resource crises, and social inequality worsened. The European Green Deal and the Competitive Sustainability framework for the EU have proven their resilience and continued to be relevant and important. However, the challenge to EU leadership in this area has also grown. More countries are setting Paris Agreement aligned climate neutrality targets and putting in place national economic strategies, policies and measures that will enable them to drive investment towards their own climate neutral, sustainable and smart industries. **The race to succeed in the transition has picked up in both pace and urgency, as has the importance of assessing and improving competitive performance in such a new world.**

Recognising the significant amount of other, related work that is ongoing within EU institutions, internationally and in other academic, private sector or not-for-profit organisations, this project aims to develop a conceptual framework and indicators to **help**

monitor the transition to a sustainable economy, contributing to the 'beyond GDP' discussion. With a unique ecosystem of actors and thought leaders in this area, and working closely with EU institutions throughout, the resulting Index and associated open-source tools, and this report itself, all reflect a mix of expertise and organisational capacity that links theory and practice. It also aims to offer practical solutions to policymakers and others interested in this important area of activity.

2 Structure and theoretical framework

Competitiveness is widely considered to be an indicator of economic welfare, and improved competitiveness can bring other advantages – material, social and political. However, **competitiveness is typically measured using productivity metrics that focus on economic growth and GDP, but which do not properly address the elements that enable us to have a better quality of life overall or avoid negative impacts on the environment.** War, pollution, crime and the destruction of nature can all have a positive economic impact in the short term. Pursuing them might also provide competitive advantages, but these activities clearly do not contribute to overall human well-being or respond to the increasingly urgent challenge of sustainability more broadly. Conversely, it is often the case that concerns about potential loss of competitiveness are expressed in the same relatively narrow terms. They often focus on short-term economic costs, without reference to longer-term and broader understandings including social, environmental and governance-related considerations that all clearly impact competitiveness in the context of a sustainable transition.

The debate about the need for a 'beyond GDP' approach to measure progress for a sustainable future is more current than ever. It dates back to *The Limits to Growth*[5] landmark publication in 1972, but was given voice as early as the 1960s by US President Kennedy, and even anticipated by its first proponents in the 1930s who recognised it as only one measure of progress. In the wake of the Covid-19 pandemic, it is now widely accepted that productivity and economic growth should not come with negative social or environmental impacts. Sustainable development, as stated by the Brundtland report,[6] must "meet the needs of the present without compromising the ability of future generations to meet their own needs." For competitive sustainability to be achieved, however, this must be turned into a positive affirmation. Any advantage or progress in the transition must ultimately be secured in a mutually beneficial way, across all countries and parts of society, and within planetary environmental boundaries.

No other work has yet tried to measure competitiveness performance under this new paradigm, reflecting this dynamic sustainability transition, and in particular the transformation to a climate neutral economy. This work sets out to fill this crucial gap with a specific focus on competitiveness in that context, contributing to the discussion about what meaningful and sustainable economic growth and progress involves. As argued in the Stiglitz report,[7] "**what we measure shapes what we collectively strive to pursue**." Indeed, this is at the heart of all management challenges, including managing the transition to sustainability.

2.1 Competitive Sustainability Index

The aim of the Competitive Sustainability Index (CSI) is to track the relative performance of countries, and their economies and companies, in relation to the transition to sustainable development and in particular the goal of achieving climate neutrality as set out in the Paris Agreement. The intention is that this Index is useful to public policymakers seeking to enhance the design and implementation of measures to support this transition, as well as to other stakeholders involved in the process, whether public or private sector or from civil society.

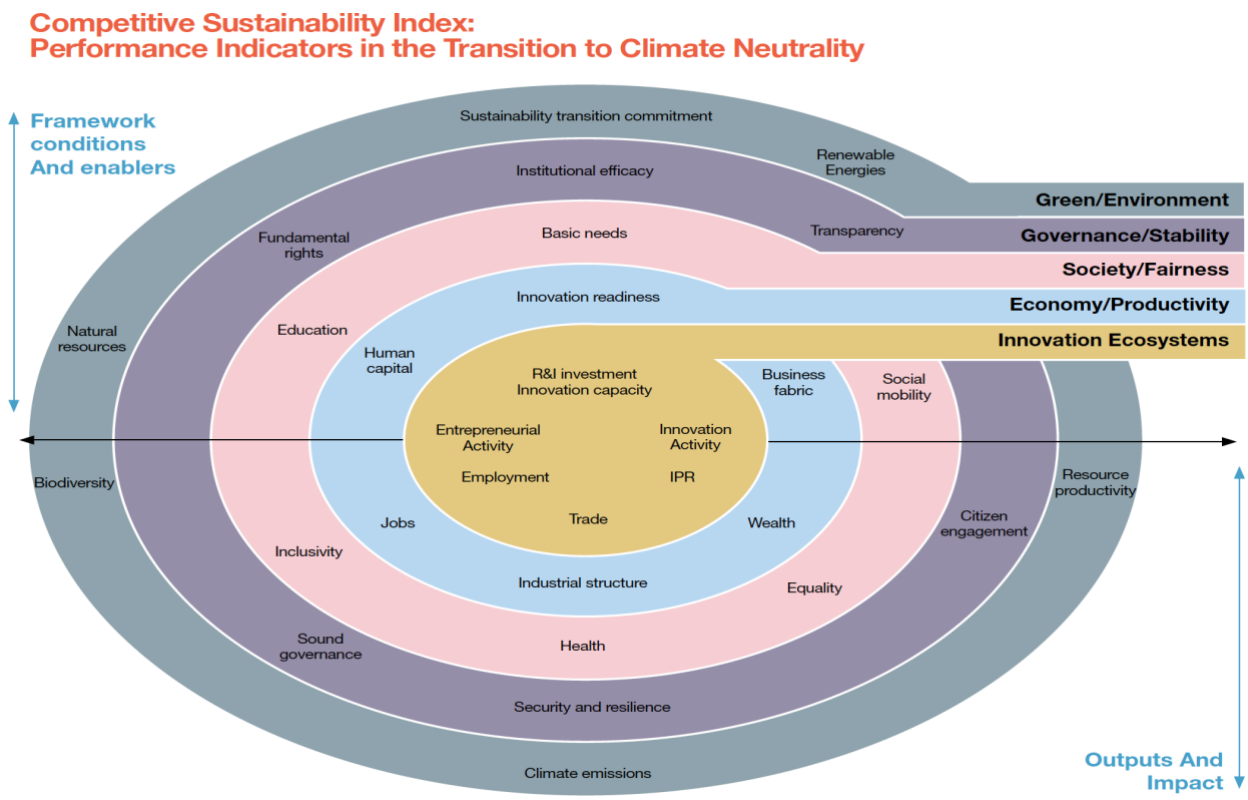
Its core focus is therefore on how economies, their value chains and innovation ecosystems perform in the transition, where the role of innovation is considered the key prerequisite for success. This applies to both digital and technology enabled innovation as well as socially driven, and combines public direction and support with market-based competition. In light of

the wider context in which this economic transformation is taking place, the Index embeds the analysis and measurement of this in a framework that reflects and tracks performance on the other dimensions of sustainability. These are related to environmental and social goals, and the governance process that manages it (see Annex V: Structure of the Index for the full list of indicators included in the Index).

In nesting consideration of the Economy dimension within this broader framework, the approach works within a paradigm of development. This assumes that **the purpose of the economy is to provide goods and services that meet societal needs, and that these must be delivered within planetary environmental boundaries**. It also assumes they are managed within a public governance approach that reflects agreed universal principles related to participation and accountability, human rights and security of both individuals and their societies.

In each of these four dimensions (Economy, Society, Governance and Environment), the Index identifies framework conditions for or enablers of performance, as well as outcomes or impacts that are indicative of success. A secondary descriptor for each (productivity, fairness, stability and environment) is also used to highlight the relationship to the most relevant EU policy goals cited in the European Commission's own approach to competitive sustainability. This combination of indicators of framework conditions or enablers on the one hand and indicators of outputs and impacts on the other creates a picture where the potential for future progress can be combined with an assessment of current performance. This approach seeks to inform decisions that lead to negative trade-offs between the four sustainability dimensions, and tracks the dynamic nature of the transition. This is up to the point where an overall harmony or equilibrium may be achieved and a model of genuinely sustainable development established

Figure 5: Competitive Sustainability Index framework



Source: Competitive Sustainability Index 2022

The components identified in each dimension may be considered to be:

- 'Framework conditions and Enablers': the necessary baseline or potential from which performance can be assessed
- 'Outputs and Impacts': the key real-world manifestations of success in achieving sustainable development.

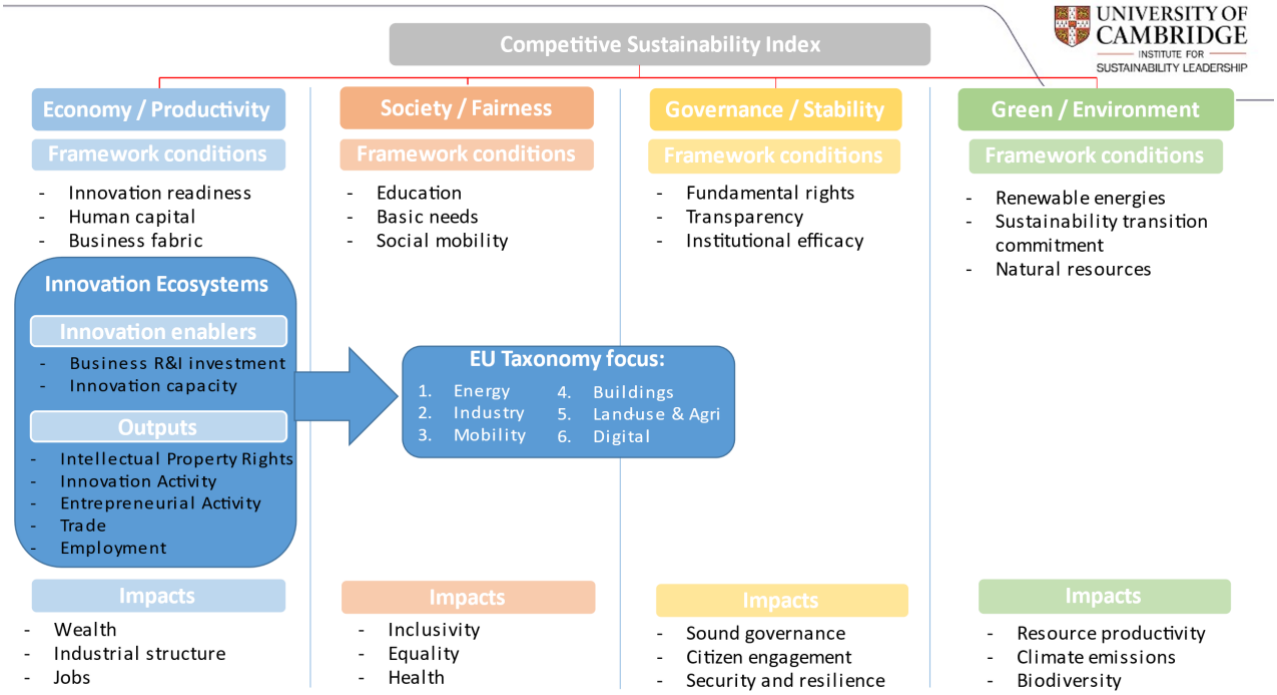
There is clearly a dynamic process and complex relationship between these two groups of sub-dimension and feedback loops, which cannot be fully captured in such an index. However, the structure does focus on the conditions that should be put in place and the outcomes that are most relevant to track success in achieving sustainable development as understood above.

The core economic innovation ecosystem indicators are tracked using the EU Taxonomy for sustainable finance. This is taken as a core proxy for economic activity that is sustainable and which will increase as the transition to climate neutrality and sustainability accelerates. This offers a greater degree of granularity and insight into performance in the Economy dimension in particular, which is where assessment of competitiveness is typically considered to be most important. The use of the EU Taxonomy also offers a focus on activities considered sustainable, and therefore avoids attributing positive performance to activities that are unsustainable, limiting contradictory results (see Annex IV: Integrating the EU Taxonomy into the Index for details).

In nesting the economic competitiveness dimension within the Society, Governance and Environment dimensions, and assessing it in relation to innovation metrics and a sustainability transition process with agreed goals and timeframes, **the Index offers a picture of competitiveness that integrates a new economic paradigm, not one that is at odds with it – competitive sustainability**.

This is all illustrated in the graphic below and set out in more detail in the Conceptual framework (see Annex III: Conceptual framework). The components and their indicators have been established and selected through a methodology combining analysis of other relevant scoreboards and indices, expert review and data quality from a range of the most highly regarded and well-established international organisations, institutes, think-tanks and private sector analysts (see section 3: Method summary).

Figure 6: Competitive Sustainability Index structure



Source: Competitive Sustainability Index 2022

2.2 Innovation ecosystems

Innovation ecosystems are a key element. They constitute one of the main added values of the CSI focusing on a limited number of indicators related to innovation within the Economy/Productivity dimension (Innovation enablers and Outputs sub-dimensions). No current framework has yet successfully addressed the assessment of competitiveness performance at ecosystem level, which is a key unit of analysis in the transition to a climate neutral and sustainable economy. Ecosystem level is considered particularly relevant for the assessment of competitive sustainability because that is the layer through which the new EU industrial strategy is to be implemented.

Innovation is considered essential for a successful transition to a sustainable and climate neutral economy as many unsolved challenges still remain in our path to net zero, particularly in the 'hard-to-abate' sectors. The International Energy Agency (IEA) estimates[8] that almost 50 per cent of the emissions reductions needed to get on a path to climate neutrality by 2050 may come from technologies that are not yet on the market. Thus, innovation plays a critical role for developing the solutions that are required to enable a net zero economy.

The transition to climate neutrality will reshape global competitiveness. It is a huge opportunity to build competitive advantages in the decarbonisation pathway and reinforce the positioning of the EU economy as the global leader in the sustainability transition. The magnitude of the changes that are ahead of us will provide significant benefits to those territories and businesses that are able to adapt faster to the new competitive sustainability paradigm and master the solutions that will enable the transition to climate neutrality.

The CSI develops in two levels:

- First, competitive sustainability performance is assessed at **country level**. At this level indicators assess performance at whole economy level, except for those sub-dimensions that are related to innovation (Innovation enablers and Outputs) where indicators reflect performance in the six economic ecosystems analysed (see below).
- Second, a state-of-the-art framework has been developed to assess performance in the transition to a climate neutral and sustainable economy. This focuses on the five key **economic ecosystems** to effectively achieve the net zero target (Energy, Industry, Buildings, Mobility, and Land-use & Agri-food) plus an ecosystem targeting the increasing range of material and energy-intensive digital economy activities (Digital and others).

The Index moves beyond the traditional logic of simply adding sustainability-related measures to economic measures. Instead, it adopts an integrated and systemic approach of developing indicators that are inherently related to sustainability.

That is done by adopting these ecosystems as the unit of measure to assess performance in the innovation-related components of the Economy/Productivity dimension. Thus, **the Index assesses performance in a series of economic elements** (namely Business R&I investment, Innovation capacity, Intellectual Property Rights, Innovation activity, Entrepreneurial activity, Trade, and Employment) **exclusively focusing on the activities that are considered sustainable under EU Taxonomy Regulation**[iii] (see Annex IV: Integrating the EU Taxonomy for more details on how the innovation ecosystems are built).

By restricting the analysis to those economic activities that are Taxonomy eligible, we aim to assess innovation performance that should drive the transition to a climate neutral and sustainable economy reshaping global competitiveness. These economic activities will be key for attaining a net zero economy, and the market demand for them will grow, implying that competitive advantage should be enhanced as these indicators improve.

The ecosystem level analysis aims at helping countries to assess the relative strengths and weaknesses of their economies. This will enable them to identify where they need to concentrate their efforts to improve their performance in the key economic ecosystems under the new competitive sustainability paradigm.

However, **to provide an enhanced assessment of a country's performance on the critical ecosystems for the net zero transition, more quality data is required**. That is, data availability from main data sources should be improved, as Nomenclature of Economic Activities (NACE)[iv] granularity is essential to building such ecosystems based on the EU Taxonomy and to compare performance across countries at international level.

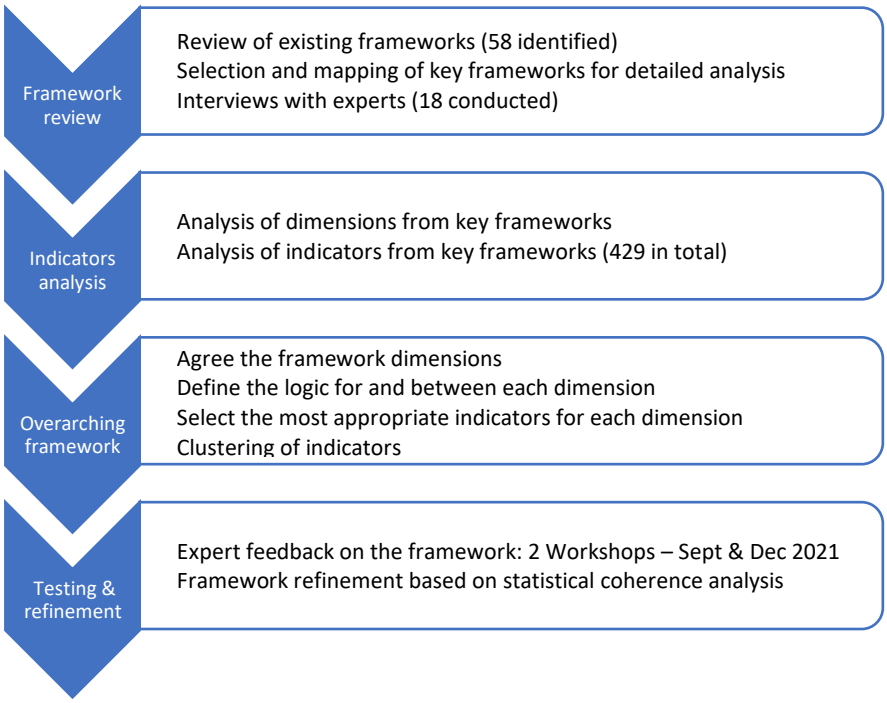
[iii] The EU Taxonomy is a classification system, establishing a list of environmentally sustainable economic activities. The Taxonomy Regulation sets out the conditions for an economic activity to be 'taxonomy-eligible', ensuring that the activity makes a substantial contribution to at least one of the environmental objectives and does not significantly harm any of the other environmental objectives. Economic activities included in the Complementary Climate Delegated Act of March 2022 (nuclear and gas) have not been considered as they were not included in the list of economic activities covered by the EU taxonomy at the time of this analysis. More details on the EU Taxonomy can be found at: https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/eu-taxonomy-sustainable-activities_en

[iv] Nomenclature of Economic Activities (NACE) is the statistical classification of economic activities in the European Community. More details on the NACE classification available at: https://nacev2.com/en

3 Method summary

The method used to conduct this project has involved a combination of desk research and analysis, EU and international stakeholder engagement, and the development and testing of a scoreboard for the operationalisation of 'competitive sustainability' assessment. Figure 7 below shows a summary of the methodological process followed and the derived activities conducted between May 2021 and July 2022. These are explained later in this report. **The resulting framework has been validated by the Joint Research Centre (JRC)** (see Annex X: JRC statistical audit of the Competitive Sustainability Index).

Figure 7: Overview of the *methodological process*



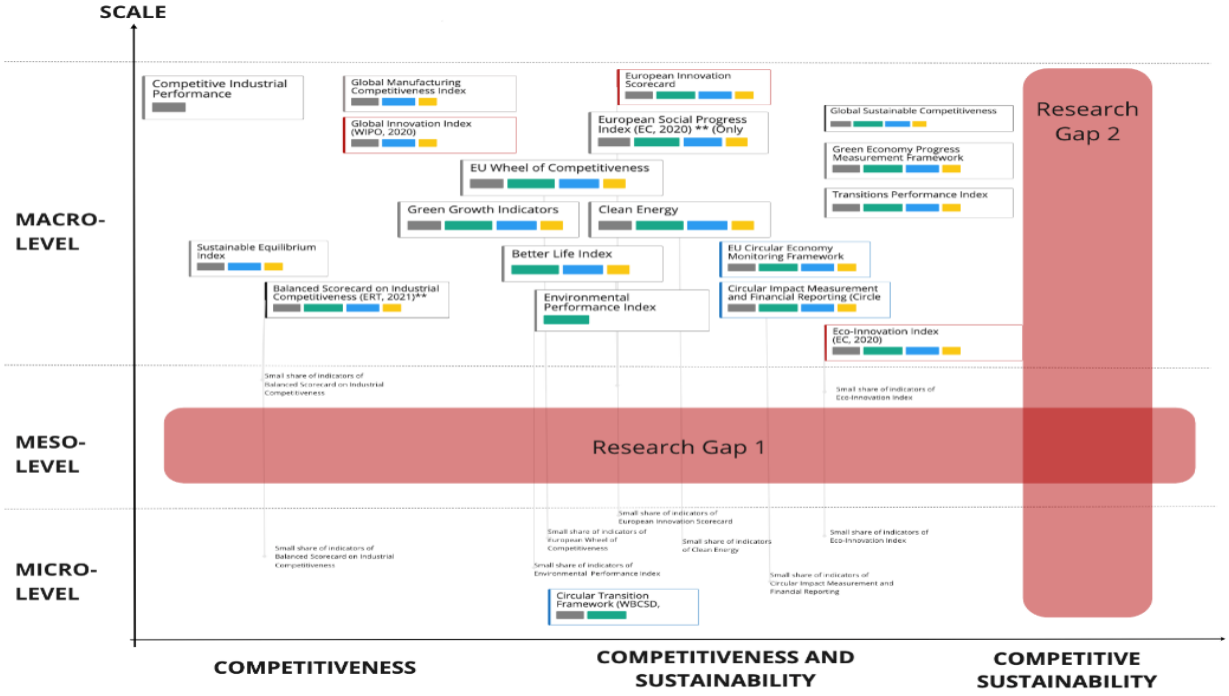
3.1 Review of existing frameworks

The review of already existing evidence potentially relevant for the work to be developed resulted in the identification of **58 frameworks** assessing competitiveness and/or sustainability performance from a variety of different angles (see Annex I: Review of existing frameworks).

This initial review revealed the **lack of any current framework assessing and measuring competitive sustainability performance that goes beyond simply adding sustainability-related dimensions** (environmental, social, governance) to the Economy dimension in a summative or complementary manner. No existing framework adopts an integrated and systemic approach to developing indicators that are inherently related to the transition to a sustainable and climate neutral economy.

As shown in Figure 8, most of the existing frameworks addressing competitiveness do so from a macro perspective, following the traditional logic of including mainly economic indicators. Several frameworks move beyond the classical understanding of competitiveness, environmental, social or governance dimensions. Yet, these frameworks include respective indicators in an 'additional' or 'complementary' manner next to economic indicators (thus categorised as 'competitiveness AND sustainability').

Figure 8: Overview of frameworks along scale (macro, meso, micro) and scope (from competitiveness to competitive sustainability)



Source: Cambridge Institute for Sustainability Leadership (CISL) - Thea Jung

However, the framework that comes closest to systemic logic when addressing the concept of 'competitive sustainability' is the Transitions Performance Index (TPI).[9] Although it does not have a specific focus on competitiveness, this framework measures countries' performance in their transitions towards a sustainable prosperity model. This progress is measured along four transitions (economic, social, environmental and governance), providing a comprehensive but summative approach to measuring performance in the transition to a sustainable economy and a strong narrative supporting it.

Along the same lines, **no existing framework has successfully addressed the assessment of competitiveness and sustainability performance at ecosystem level** (meso level), which is a key unit of analysis in the transition to a net zero and sustainable economy. Ecosystem level is considered particularly relevant for the assessment of competitive sustainability because that is the layer through which the new EU industrial strategy is to be implemented.

3.2 In-depth analysis of selected frameworks

The analysis conducted showed that **13 of the references reviewed were highly relevant** for the construction of the competitive sustainability framework (see Annex II: Frameworks selected for in-depth analysis). The content of these pieces of work was examined in more detail. The dimensions and indicators making up the frameworks were deconstructed and included in a database. Their nature was analysed and the individual relevance of the indicators was assessed.

In total, 429 indicators were analysed and classified. This exercise allowed an overview of the elements corresponding to each of the four dimensions of the competitive sustainability framework being developed (Economy/Productivity, Society/Fairness, Governance/Stability and Green/Environment) and provided a clear picture of the most relevant indicators per dimension.

Most of the frameworks analysed in detail have been developed by European Commission institutions, giving a high degree of confidence around the robustness and soundness of the approach and its alignment with the EU policy context. Among the work from private sources, the Global Sustainable Competitiveness Index[10] is noteworthy. This is a landmark framework in assessing competitiveness through sustainability metrics, although it still follows a standard approach in adding sustainability-related dimensions but without the methodological robustness and validation ensured by the JRC's auditing process.

This analysis informed an initial version of the CSI, based on previous relevant frameworks and the expert judgement of the project team.

3.3 Interviews with experts

In addition to the framework composition analysis, **18 interviews were conducted** with renowned experts on different elements of competitive sustainability, both at policy and corporate level, to test preliminary assumptions and contrast the initial framework logic.

Interviews were conducted in two separate rounds. The first round (14) was developed in parallel to the in-depth analysis. It aimed to learn from the experience of some of the most relevant frameworks under study and get valuable feedback on the work being undertaken. The second round of interviews (4)[v] occurred right after the first workshop, where participants flagged several initiatives being developed that would be of interest for the Index under construction. This set of interviews aimed to gain a deeper understanding of some relevant ongoing projects and to explore potential overlaps with initiatives facing similar challenges.

3.4 Workshops

Two expert workshops were held in order to test and strengthen the CSI's design. Experts participating in the workshops were a mix of stakeholders from research institutions (JRC, UNU-MERIT Maastricht University, Orkestra, etc), international organisations (International Energy Agency, European Patent Office, Eurostat, etc), corporates (ENEL, Solability, Cleantech Group, etc) and European Commission officials from various Directorates-General (DGs).

The first workshop was held on 17 September 2021. It sought to test some initial assumptions and introduce the CSI and underlying logic to some prominent experts in the field of competitiveness, sustainability and innovation performance measurement. The workshop contributed to building consensus on the relevance and added value of the Index to the thinking around competitive sustainability through the focus on performance measurement.

The second workshop (on 15 December 2021) was preceded by a series of bilateral meetings (second round of interviews) and aimed at validating the latest updates to the CSI. This event also served as a discussion forum, with experts from a series of initiatives sharing similar challenges as the Index.

3.5 Framework limitations

The CSI operationalises the concept of competitive sustainability and provides an assessment of the relative performance of economies in relation to the transition to a sustainable and climate neutral economy. Moreover, it allows for a deeper analysis within the Economy/Productivity dimension on the countries' performance in the key economic

[v] Although several meetings were held with most of the stakeholders contacted in the second round of interviews, only one meeting per stakeholder has been considered for this purpose.

ecosystems to achieve climate neutrality (Energy, Industry, Buildings, Mobility, Land-use & Agri-food, and Digital) for that transition.

The independent statistical audit performed by the JRC validated the statistical methodology and the robustness of the Index (see Annex X: JRC statistical audit of the Competitive Sustainability Index). However, the novelty of the approach and the data disaggregation requirement for the analysis at ecosystem level bring some limitations to the framework that need to be kept in mind when analysing the results.

First, the main data source for the indicators measuring performance at innovation ecosystem level is Eurostat's Community Innovation Survey (CIS)[vi] as data disaggregation at NACE[vii] code level is required to build the ecosystems. This biannual survey did not take place in 2020 as planned, so the latest available data from this source corresponds to the 2018 round.

Second, the construction of the ecosystems could not exactly mirror the list of economic activities and associated NACE codes from the EU Taxonomy. This is because the data sources identified do not offer the same level of data disaggregation for most of the indicators included in the CSI. Thus, the methodology for the construction of the Taxonomy indicators had to be adjusted to the data reporting limitations presented (see Annex IV: Integrating the EU Taxonomy into the Index).

Third, data availability in the economic activities eligible under EU Taxonomy Regulation is still low, but it is expected to improve as the transition to a sustainable and climate neutral economy gathers pace.

Fourth, the Covid-19 pandemic has had an impact on the CSI as it has unevenly affected the different indicators that make up the Index. Examples include the entry year of the latest available data point, and the potential delay in capturing the full effects from this massive global shock in some of the dimensions, in particular those in the Society/Fairness dimension.

Lastly, the impact of the Russian invasion of Ukraine on countries' competitive sustainability is not visible in this edition of the CSI as data is reported with a delay. The effects of the decisions made to respond to that aggression may still take some years to completely unfold.

However, the JRC audit confirms that the CSI sufficiently meets international quality standards for statistical soundness and offers a sound starting point for more informed discussions on national competitive sustainability in the EU.

As argued by Gus O'Donnell, the former UK cabinet secretary, in 2020: "Of course measurement is hard. But roughly measuring the right concepts is a better way to make policy choices than using more precise measures of the wrong concepts."

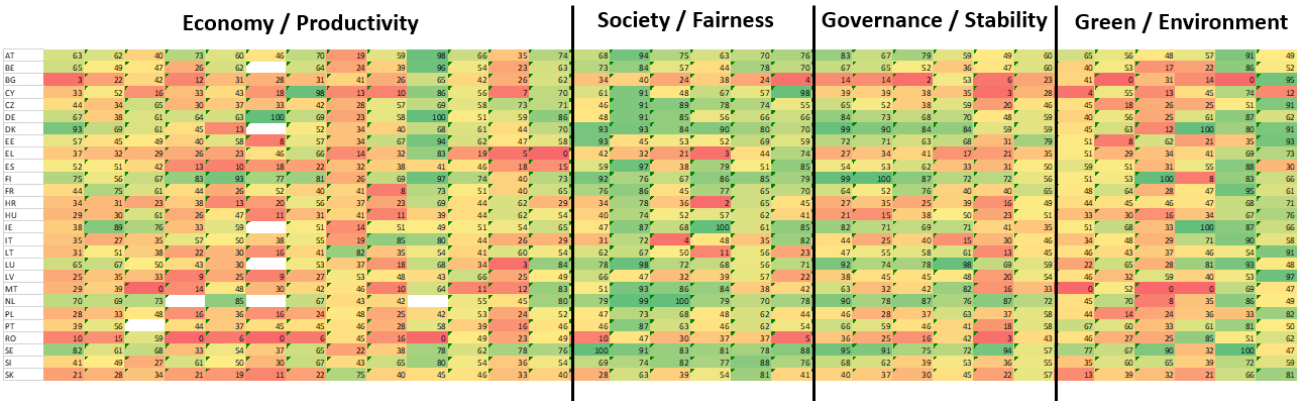
The CSI, like any composite indicator, will benefit from further improvements in the future, as it scrutinised, used and updated with new data.

[vi] More details on the Community Innovation Survey available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Community_Innovation_Survey_%E2%80%93_new_features

[vii] Nomenclature of Economic Activities (NACE) is the statistical classification of economic activities in the European Community. More details on the NACE classification available at: https://nacev2.com/en

4 Index findings[viii]

Figure 9: Overall impression of countries' performance across the Competitive Sustainability Index dimensions



Source: Competitive Sustainability Index 2022

The CSI indicates that overall, EU countries are collectively performing competitively better on Society and Governance dimensions of the transition compared to Economy and Environment dimensions. Among them, four countries are leaders in the overall index (Sweden, Finland, Denmark and the Netherlands). All of them, and Luxembourg, are leaders in the Governance dimension, **but none of these (or any others) performs as a leader in the Environment dimension**.

Only one country (Finland) is a leader in three dimensions, while eight countries perform strongly or as leaders overall, a group that includes Austria, Ireland and Germany in addition to those already mentioned above. Conversely, there is only one country lagging in all dimensions (Bulgaria), two that perform poorly overall (Greece and Romania) and three that are only just ahead of them (Slovakia, Croatia and Hungary).

Table 3: Performance of countries on the Competitive Sustainability Index and dimensions

Economy / Productivity		Society / Fairness		Governance / Stability		Green / Environment		Index	
FI	72	SE	87	NL	82	SE	69	SE	74
NL	67	DK	85	FI	81	IE	68	FI	73
DE	64	NL	84	SE	81	DK	65	DK	70
AT	60	FI	81	DK	79	AT	61	NL	70
SE	58	SI	78	LU	79	FI	60	AT	65
IE	53	IE	75	DE	67	PT	59	IE	64
DK	52	AT	74	AT	66	FR	57	LU	64
EE	52	LU	74	EE	64	LU	56	DE	63
BE	50	CZ	72	IE	62	DE	55	SI	59
SI	50	CY	70	FR	56	SI	55	FR	58
CZ	48	FR	70	BE	54	IT	55	EE	56
FR	47	DE	68	SI	52	LV	55	BE	54
LU	45	ES	68	EU-27	51	HR	53	CZ	52
EU-27	44	BE	68	PT	48	LT	53	EU-27	52
IT	44	MT	66	ES	47	ES	52	PT	52
PT	42	EU-27	62	CZ	47	EU-27	51	ES	49
LT	41	EE	62	LT	47	EL	50	LT	46
CY	40	PT	60	PL	45	RO	49	IT	44
HU	39	PL	57	MT	45	NL	49	CY	44
HR	35	HU	54	LV	42	EE	45	PL	44
PL	34	SK	51	SK	39	BE	45	LV	43
LV	33	IT	45	IT	33	HU	43	MT	43

[viii] Scores reflect performance across Member States compared to their peers. Therefore, they do not assess a country's absolute performance but rather the level of performance of that country compared to the best and worst EU performers (seeAnnex IX: Technical notes for details on computations). Results are all available as an open-source resource here

MT	32	LT	45	HU	33	CZ	43		HU	42
SK	32	LV	44	HR	32	SK	42		HR	41
BG	31	HR	43	CY	30	PL	39		SK	41
ES	29	EL	36	EL	29	CY	34		EL	36
EL	28	RO	28	RO	27	BG	30		RO	31
RO	21	BG	27	BG	19	MT	28		BG	27

Source: Competitive Sustainability Index 2022

Score legend: ■ 'Leader' [70-100]; ■ 'Strong performer' [60-69]; ■ 'Good performer' [50-59]; ■ 'Moderate performer' [40-49]; ■ 'Weak performer' [0-39].

In the dimension most usually associated with competitiveness, namely the **economy, three countries (Finland, Germany and the Netherlands) are clear leaders** in both overall economy-wide transition performance as well as the specific climate neutral innovation ecosystems at the core of a successful transition. A further group of three countries (Austria, Belgium and Sweden) are close behind, and three more (Estonia, Slovenia and Luxembourg) similarly just behind them. In most cases, these same countries perform well at both overall ecosystem and whole economy level, but Italy has a strong ecosystem innovation performance overall, which suggests it may improve in due course. The strength of Germany's performance in the Economy dimension is also significant, given its size and influence on overall EU performance.

For the four leaders, a relatively strong performance in the Society and Governance dimensions does not appear to be the consequence of a greater emphasis on these aspects to the detriment of the Economy and Environment dimensions. Conversely, it suggests that they are approaching the transition in a manner integrated with their competitive advantage overall.

It is noteworthy too that smaller countries that have identified and pursued a sustainability agenda for a longer period appear to perform more competitively overall, as well as in the Economy dimension. These are generally in Northern and Western Europe. However, there are signs that some newer Member States of the EU are performing more strongly – both Estonia and Slovenia do well in the Economy dimension in particular. However, **weaker performers tend to be found in southern and eastern areas of the EU**. This suggests that targeted policy interventions to support both economic and other transition dimensions remain very important for the EU overall for its performance to improve.

The following sections outline EU countries' relative performance among the 27 countries, meaning that the scores reflect performance across Member States compared to their peers. Thus, **scores do not assess a country's absolute performance but rather the level of performance of that country compared to the best and worst EU performers**.[ix]

4.1 Economy/'Productivity' dimension

In the context of an energy crisis and increasingly binding resource constraints, future prosperity and well-being in Europe will not only depend on higher productivity and economic growth. **The transition to a climate neutral economy entails a profound transformation that requires a fundamental rethink about the productivity concept and how we measure economic development.**

The net zero race will reshape global competitiveness and offers a huge opportunity to build competitive advantages in the decarbonisation pathway. The magnitude of the changes that are ahead of us will provide significant benefits to those territories and businesses that are able to adapt faster to the new competitive sustainability paradigm and develop the solutions that will allow a net zero economy to be achieved.

[ix] All indicator scores are normalised. This means that for each indicator the best performance is scaled to be 100 and the worst performance is scaled to be 0, and the scores of EU countries are then computed and compared to that (seeAnnex IX: Technical notes for details on computations).

Table 4: Performance of countries on the Economy/Productivity sub-dimensions

	Framework conditions	Innovation enablers	Outputs	Impacts
AT	55	67	58	59
BE	54	44	56	47
BG	22	21	38	44
CY	34	38	45	44
CZ	48	33	46	67
DE	55	64	70	66
DK	74	29	48	58
EE	50	49	52	56
EL	32	24	48	8
ES	48	12	30	27
FI	66	88	70	62
FR	60	35	43	52
HR	29	25	41	45
HU	40	36	27	53
IE	68	46	42	57
IT	32	53	55	33
LT	40	26	46	52
LU	61	36	44	40
LV	31	17	36	47
MT	23	31	38	35
NL	71	85	51	60
PL	36	26	31	43
PT	48	41	44	34
RO	28	3	13	40
SE	70	43	48	72
SI	39	56	57	48
SK	28	20	39	40
EU-27	46	39	45	48
Best	DK	FI	DE + FI	SE

	Economy / Productivity
FI	72
NL	67
DE	64
AT	60
SE	58
IE	53
DK	52
EE	52
BE	50
SI	50
CZ	48
FR	47
LU	45
EU-27	44
IT	44
PT	42
LT	41
CY	40
HU	39
HR	35
PL	34
LV	33
MT	32
SK	32
BG	31
ES	29
EL	28
RO	21

Source: Competitive Sustainability Index 2022

Score legend: ■ 'Leader' [70-100]; ■ 'Strong performer' [60-69]; ■ 'Good performer' [50-59]; ■ 'Moderate performer' [40-49]; ■ 'Weak performer' [0-39].

EU average performance on the Economy/Productivity dimension is significantly lower than in the other three dimensions, and is below 50 points. Only one country (Finland) qualifies as 'Leader' and a further three Member States are 'Strong' performers (the Netherlands, Germany and Austria). On the other hand, 17 countries are either 'Moderate' or 'Weak' performers, which reflects a lower general performance than in the other dimensions.

Countries' performance on outputs and outcomes are generally better than on inputs (*framework conditions* and *innovation enablers*). In particular, as will be analysed in more detail in the coming sections, innovation inputs on Taxonomy-eligible economic activities is the lowest performing economic sub-dimension, with a total of 16 Member States qualifying as 'Weak' performers.

However, some countries have an outstanding performance on the different economic elements considered in the analysis. Denmark is the country with the best economic *framework conditions* in general, while, as will be outlined in the next sections, Finland has the strongest overall *innovation enablers* and *outputs* (together with Germany) when considering all six economic ecosystems analysed (Energy, Industry, Mobility, Buildings, Land-use & Agri-food, and Digital). Lastly, Sweden is the country with higher levels of overall economic *impacts.*

A breakdown of the different components making up the economic *framework conditions* and *impacts* shows some nuances in the overall picture presented below (see Table 5).

Table 5: Performance on the country-level components of the Economy/Productivity sub-dimensions

	Framework conditions			Impacts		
	Innovation readiness	Human capital	Business fabric	Wealth	Industrial structure	Jobs
AT	63	62	40	66	35	74
BE	65	49	47	54	23	63
BG	3	22	42	42	26	62
CY	33	52	16	56	7	70
CZ	44	34	65	58	73	71
DE	67	38	61	51	59	86
DK	93	69	61	61	44	70
EE	57	45	49	62	47	58
EL	37	32	29	19	5	0
ES	52	51	42	46	18	15
FI	75	56	67	74	40	73
FR	44	75	61	51	40	65
HR	34	31	23	44	62	29
HU	29	30	61	44	62	54
IE	38	89	76	51	54	65
IT	35	27	35	44	26	29
LT	31	51	38	41	60	54
LU	65	67	50	34	3	84
LV	25	35	33	66	25	49
MT	29	39	0	11	12	83
NL	70	69	73	55	45	80
PL	28	33	48	53	24	52
PT	39	56		39	16	46
RO	10	15	59	49	23	49
SE	82	61	68	62	78	76
SI	41	49	27	54	36	54
SK	21	28	34	46	33	40
EU-27	45	47	46	49	36	57
Best	DK	IE	IE	FI	SE	DE

Economy / Productivity	
FI	72
NL	67
DE	64
AT	60
SE	58
IE	53
DK	52
EE	52
BE	50
SI	50
CZ	48
FR	47
LU	45
EU-27	44
IT	44
PT	42
LT	41
CY	40
HU	39
HR	35
PL	34
LV	33
MT	32
SK	32
BG	31
ES	29
EL	28
RO	21

Source: Competitive Sustainability Index 2022

Score legend: ■ 'Leader' [70-100]; ■ 'Strong performer' [60-69]; ■ 'Good performer' [50-59]; ■ 'Moderate performer' [40-49]; ■ 'Weak performer' [0-39].

Within the **economic inputs**, EU Member States show a 'Moderate' performance across all three components. In terms of *innovation readiness,*[x] Denmark is the top performer, but it is worth highlighting the overall low level of people with advanced ICT skills across European countries. Ireland leads in both *human capital*[xi] and *business fabric*[xii] components, where the **overall low levels of entrepreneurial culture are worrying** given the significant number of technologies that need to be developed and marketed for the net zero economy to be achieved**. Europe should reinforce its entrepreneurial culture if it is to lead the sustainable transition and prevent third countries from reaping the competitiveness benefits of EU research and innovation (R&I) efforts**.

[x] Innovation readiness measures the levels of people ICT skills, public R&D expenditure and broadband penetration (see annexes for details on indicators).

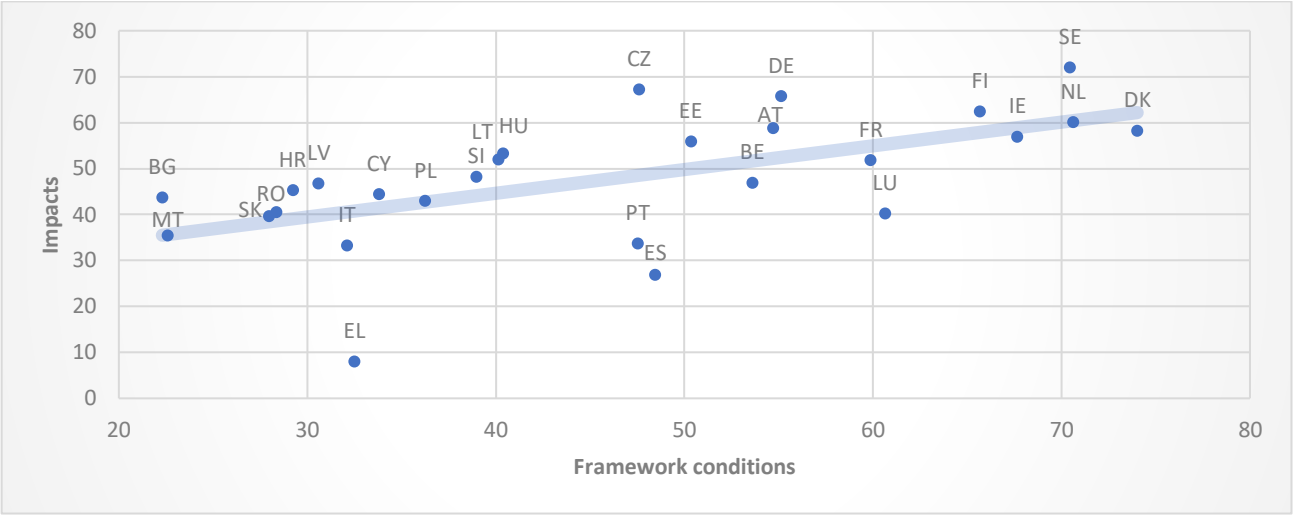
[xi] Human capital measures the share of population with tertiary education with a particular focus on science, technology, engineering and mathematics (STEM) and the quality of doctoral programmes (see annexes for details on indicators).

[xii] Business fabric assesses the share of large companies and the population attitude towards entrepreneurship (see annexes for details on indicators).

Regarding **economic outcomes**, Finland has the highest *wealth*[xiii] levels. This is a result of having higher levels of Taxonomy eligibility and alignment[xiv] of its GDP output than countries which usually top classic wealth rankings focusing exclusively on GDP per capita. Overall the EU's labour market performance is good, although average earnings strongly vary across countries, with Germany particularly excelling regarding *jobs.*[xv]

Lastly, Sweden has the strongest *industrial structure*[xvi] in the EU, leading on both early- and late-stage venture capital in clean technologies. **General low levels of cleantech's venture capital activity in most EU countries also send a clear signal about the need to double down the efforts to underpin Europe's positioning as the global front-runner in the green transition.**

Figure 10: Correlation between 'Framework conditions' and 'Impacts' sub-dimensions in Economy/Productivity dimension



Source: Competitive Sustainability Index 2022

In that regard, Figure 10 illustrates that Member States with higher economic *framework conditions* consistently achieve higher economic *impacts*. Furthermore, some countries prove to be more efficient in translating economic inputs into outcomes. Sweden, the Czech Republic and Bulgaria are good examples of achieving higher levels of economic outcomes than other Member States with stronger framework conditions.

4.1.1 Innovation ecosystems

The paradigm shift towards a new economic model clearly requires significant innovation. These efforts need to be ideally focused on the economic activities that will be instrumental for achieving climate neutrality within the value chains and industrial ecosystems that are critical to deliver a net zero economy (namely Energy, Industry, Buildings, Mobility, Land-use & Agri-food, and Digital). This will maximise the competitive benefits attained in the course of this transition. The EU Taxonomy provide an important toolkit to recognise those activities and prevent devoting resources to assets at risk of becoming stranded.

The performance assessment of the key innovation ecosystems for achieving climate neutrality is exclusively based on the analysis of the economic activities considered eligible under EU Taxonomy

[xiii] Wealth measures the level of GDP per capita but also the share of Taxonomy eligibility and alignment of GDP output (see annexes for details on indicators).
[xiv] Taxonomy-eligible activities are the economic activities that are described and have technical screening criteria set out in the EU Taxonomy. Taxonomy-aligned activities are the economic activities that make a substantial contribution to at least one of the climate and environmental objectives, while also doing no significant harm to the remaining objectives in the EU Taxonomy.
[xv] Jobs measures the level and quality of employment (see annexes for details on indicators).
[xvi] Industrial structure measures venture capital activity as well as the level of complexity of the economy (see annexes for details on indicators).

Regulation. This is a first of its kind approach, and even taking into account the immaturity of the data involved, constitutes one of the main added values of the CSI (see Section 2.2 Innovation ecosystems) compared to other current indexes.

The ecosystem level analysis aims at helping countries to assess the relative strengths and weaknesses of their economies. This will enable them to identify where they need to concentrate their efforts to boost their performance in the key innovation ecosystems under the new competitive sustainability paradigm.

Table 6: Performance of EU countries in the innovation ecosystems

Country	Energy	Industry	Mobility	Buildings	Land-use & Agri-Food	Digital and others	Country average
AT	59	47	56	55	5	61	47
BE	53	68	45	57	60	61	58
BG	33	32	23	31	31	35	31
CY	35	57	57	35	40	57	47
CZ	41	32	29	42	46	36	38
DE	74	51	45	73	53	64	60
DK	45	41	28	44	26	36	37
EE	45	52	53	45	31	56	47
EL	41	36	31	44	46	43	40
ES	27	34	19	21	15	38	26
FI	72	60	65	75	11	77	60
FR	55	60	37	43	25	52	45
HR	35	38	29	37	53	49	40
HU	36	28	28	35	81	36	41
IE	53	30	19	38	5	54	33
IT	58	54	41	57	41	56	51
LT	41	41	33	32	30	49	38
LU	51	35	42	50	70	30	46
LV	39	34	24	31	56	33	36
MT	45	29	31	28	25	44	34
NL	56	57	71	55	34	75	58
PL	37	24	21	35	17	30	27
PT	45	44	36	46	51	52	46
RO	12	25	18	8	61	30	26
SE	49	46	38	45	32	60	45
SI	48	48	54	56	14	56	46
SK	33	20	27	30	17	37	27
EU-27	45	42	37	43	36	48	42

Source: Competitive Sustainability Index 2022

Score legend: ■ 'Leader' [70-100]; ■ 'Strong performer' [60-69]; ■ 'Good performer' [50-59]; ■ 'Moderate performer' [40-49]; ■ 'Weak performer' [0-39].

The average performance of EU countries[xvii] in the innovation ecosystems (see Table 6) shows **stronger results in the Digital and Energy ecosystems and lower scores in the Mobility and Land-use & Agri-food ecosystems.** These results seem to be in line with the European Commission's sustained efforts to foster the energy transition over many years now, and to integrate the digital transition throughout. However, they suggest that other ecosystems are lagging in their development and progress, a point further borne out by differences in performance between these ecosystems and the economy as a whole (see below).

No country manages to be a 'Leader' or 'Strong performer' in all six ecosystems, and there is a diversity of leading performers across the ecosystems. Germany and Finland are the best performers when analysing all ecosystems combined (see Table 6), but no country qualifies as 'Leader' when considering the average performance in the six innovation ecosystems. Even the 'Strong performer' category is close to not having any representative. In fact, **22 out of the 27 countries are either 'Moderate' or 'Weak' performers.**

[xvii] EU-27 average performance for this report has been calculated in all cases as the arithmetic average of the scores of the 27 countries.

Although EU average performance is similar in both levels, as shown in Table 7, there is a 12-point gap between the best performing country in the Economy/Productivity dimension (Finland) and that in the innovation ecosystems combined (Germany). In fact, overall scores at the ecosystem level are lower than those obtained for the whole economy in most countries. All this suggests a **general underperformance in R&I on sustainable economic activities compared to the other components of the countries' economies**.

Table 7: Performance of EU countries in Innovation ecosystems and Economy/Productivity dimension[xviii]

Country	Innovation ecosystems	Country	Economy/Productivity
DE	60	FI	72
FI	60	NL	67
NL	58	DE	64
BE	58	AT	60
IT	51	SE	58
EE	47	IE	53
AT	47	DK	52
CY	47	EE	52
LU	46	BE	50
SI	46	SI	50
PT	46	CZ	48
FR	45	FR	47
SE	45	LU	45
EU-27	42	EU-27	44
HU	41	IT	44
HR	40	PT	42
EL	40	LT	41
LT	38	CY	40
CZ	38	HU	39
DK	37	HR	35
LV	36	PL	34
MT	34	LV	33
IE	33	MT	32
BG	31	SK	32
SK	27	BG	31
PL	27	ES	29
RO	26	EL	28
ES	26	RO	21

Source: Competitive Sustainability Index 2022
Score legend: ■ 'Leader' [70-100]; ■ 'Strong performer' [60-69]; ■ 'Good performer' [50-59]; ■ 'Moderate performer' [40-49]; ■ 'Weak performer' [0-39].

That is particularly evident in the case of Finland, Austria, Sweden, Ireland and Denmark, with differences over ten points in their respective scores at both levels. On the contrary, some of the countries below EU average for the Economy/Productivity dimension seem to be performing much better in delivering the R&I required for a sustainable economy (eg Italy, Cyprus, Croatia and particularly Greece). Thus, they are expected to improve their overall economic performance over time, reducing the gap with best performing Member States.

A closer look at EU countries' performance on the different input and output components of the six innovation ecosystems shows that **some Member States consistently outperform their peers in certain areas** (see following sections for details by ecosystem). In terms of **R&I inputs**, Finland is the most consistent performer in both *Business R&D investment* and *Innovation capacity*[xix] across all of the ecosystems.

[xviii] Innovation ecosystems average has been calculated as the arithmetic average of country scores in all six ecosystems.
[xix] Innovation capacity assesses the share of companies in Taxonomy-eligible activities with ongoing R&D activities and not finding barriers for their innovation activities (see Annex V: Structure of the Index for details on indicators).

However, it is noteworthy that **private research and development (R&D) on sustainable economic activities is generally low, with the EU-27 average[xx] score below 40 in all the innovation ecosystems** (see Table 8).

Regarding **innovation outputs**, Germany leads the EU on *Intellectual Property Rights* and *Employment* (in this case sharing the lead with Belgium) within the sustainable activities that will drive the net zero transition. Despite having a mixed performance across ecosystems, the Netherlands is the strongest performer on *Trade* of sustainable products. Lastly, some 'unusual suspects' such as Cyprus and Lithuania excel when it comes to *Innovation*[xxi] and *Entrepreneurial*[xxii] activities respectively. However, **overall performance on *IPR, Entrepreneurial activity* and *Trade* components is consistently low, with EU average scores below 40 in most (if not all) innovation ecosystems. Conversely, average performance on *Employment* in innovative companies within Taxonomy-eligible activities is generally high across ecosystems.**

Table 8: EU average performance on the components of the innovation ecosystems

	Innovation enablers		Outputs				
	Business R&D investment	Innovation capacity	IPR	Innovation activity	Entrepreneurial activity	Trade	Employment
Energy	36	47	32	54	34	46	73
Industry	33	48	30	45	43	30	58
Mobility	29	39	28	42	35	27	61
Buildings	37	45	30	47	36	37	65
Agri-food	36	48	30	43	34	28	43
Digital	38	60	38	52	49	37	60
Average	35	48	31	47	38	34	60

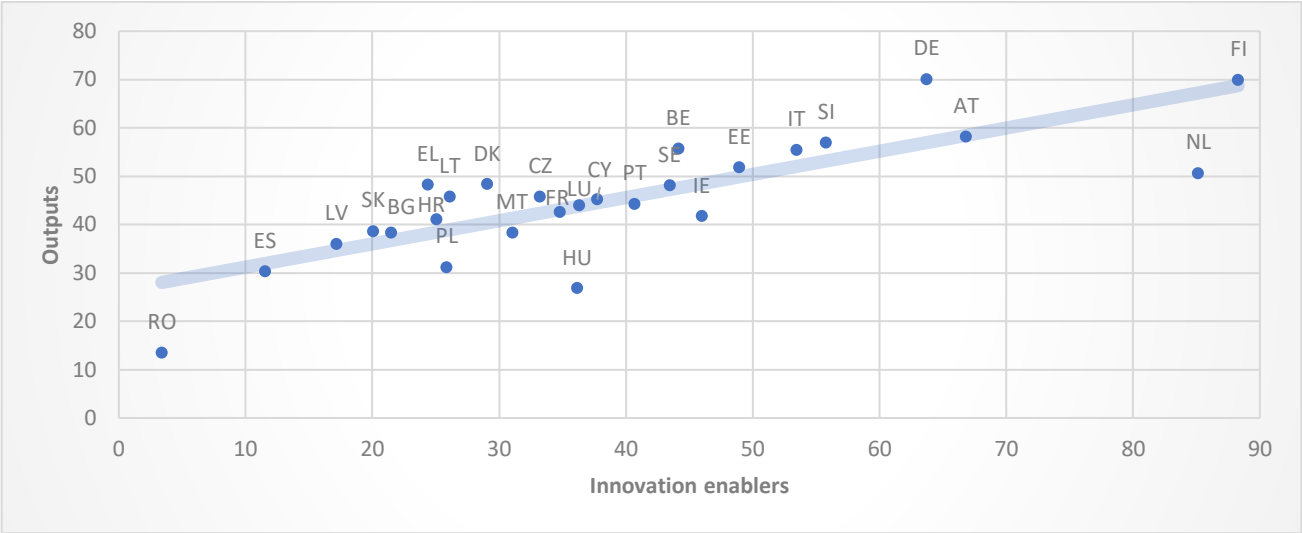
Source: Competitive Sustainability Index 2022
Score legend: ■ 'Leader' [70-100]; ■ 'Strong performer' [60-69]; ■ 'Good performer' [50-59]; ■ 'Moderate performer' [40-49]; ■ 'Weak performer' [0-39].

These results illustrate the current state of play of innovation performance in the ecosystems that will be essential to effectively achieve a climate neutral economy. They show that there is still a substantial way to go to achieve high levels of performance in those critical areas (with a few notable exceptions, which are outlined in the next sections). Consequently, **Europe should significantly improve its R&I performance on these six key ecosystems if it is to benefit from its front-runner efforts and policy leadership in the global race to achieve a net zero economy.**

In that sense, although no causality can be inferred from CSI results, Figure 11 suggests that **countries with higher *Innovation enablers* inputs consistently achieve higher innovation *outputs*** (and ultimately *Impact* outcomes) as they manage to reap the benefits from the competitive advantages developed as a result of their R&I efforts. Moreover, in general, some countries prove to be more efficient in transforming R&I inputs (*Innovation enablers*) into innovation outputs (see Figure 11). In that sense, when analysing all six ecosystems together, Belgium, Denmark, Greece and especially Germany show particular efficiency in terms of input–output conversion. However, most efficient countries differ in each of the ecosystems analysed as outlined in the following sections.

[xx] EU-27 average score calculated as the arithmetic average of the scores of the 27 countries.
[xxi] Innovation activity assesses the level of business collaboration as well as economic and innovation results achieved by companies in Taxonomy-eligible activities (see Annex V: Structure of the Index for details on indicators).
[xxii] Entrepreneurial activity assesses business creation and survival rates in Taxonomy-eligible activities (see Annex V: Structure of the Index for details on indicators).

Figure 11: Correlation between 'Innovation enablers' and 'Outputs' sub-dimensions of all innovation ecosystems aggregated



Source: Competitive Sustainability Index 2022

This set of findings would suggest that **there are significant learning opportunities between different EU Member States clustered closely together rather than far apart**. Assuming that overall best performing countries must be the benchmark for all the other nations can lead to a collaboration trap with limited results. Learning from comparable territories that are attaining better results seems like a a more sensible approach. This has been successful in enhancing innovation in other geographies where the EU has been supportive (for example in various South American countries[xxiii]).

This therefore opens the door for a collaborative approach. The most effective Member States in terms of delivering innovation outputs could share their best practices with other countries with a similar level of R&I conditions to enhance the EU's overall innovation performance in these critical ecosystems. **This approach should be further refined to consider other structural characteristics and contextual factors, but can offer an initial recommendation of potential collaboration clusters**.

Following this logic, the innovation ecosystems analysis below provides, among others, a suggestion of the clusters of countries that could benefit most from peer learning on each of the ecosystems, based on their level of R&I conditions (Innovation enablers).

4.1.1.1 Energy ecosystem

The provision of energy produces 26 per cent of the EU's greenhouse gas emissions and is the single most significant source of emissions in its economy.[11] Moreover, the war in Ukraine has exposed the risks of Europe's high dependence on fossil fuels, especially from unreliable foreign suppliers. This has raised increasing awareness about the need to accelerate the energy transition, notably by increasing the domestic production of renewable energy, a more integrated demand-responsive power grid and much improved energy efficiency in buildings and industry, in order to strengthen the EU's strategic autonomy.

A massive renewable energy increase is therefore necessary, but it will not be enough. Energy demand is expected to increase 50 per cent by 2050 without significant policy changes or technological breakthroughs.[12] Therefore, in order to reach the net zero target, **there is also a clear need to develop new ways to generate, store and use low carbon electricity.**

[xxiii] EU-CELAC Innov-AL platform is a project supported by the Directorate General for Regional and Urban Policy (DG REGIO) of the European Commission. More information available at: https://www.innoval2.eu/innovalplatform/english/home_186_1_ap.html

Table 9: Performance of countries on the Energy ecosystem

	Innovation enablers		Outputs				
	Business R&D investment	Innovation capacity	IPR	Innovation activity	Entrepreneurial activity	Trade	Employment
AT	67	60	41	61	15	67	93
BE	25	74		72	30	31	95
BG	16	23	37	38	37	41	81
CY	39	18	15	88	25	8	71
CZ	29	41	27	45	25	66	74
DE	72	84	99	77	8	66	100
DK	52	19		57	28	56	77
EE	29	60	0	49	55	51	76
EL	24	35	55	77	3	43	86
ES	19	26	25	28	6	48	52
FI	63	96	64	78	20	65	93
FR	61	62	65	52	17	31	83
HR	42	11	17	59	33	39	74
HU	29	49	7	30	41	52	40
IE	14	76		73	23	64	82
IT	62	62	43	65	4	69	88
LT	35	30	24	62	65	28	67
LU	50	33		52	24	72	93
LV	18	44	15	36	92	36	59
MT	17	63	36	56	60	8	87
NL		70		38	52	34	
PL	20	44	15	31	68	45	51
PT	41	44	38	51	35	45	65
RO	3	6	2	2	63	35	0
SE	26	61	64	80	11	34	86
SI	55	48	17	63	16	54	77
SK	25	32	7	26	50	47	54
EU-27	36	47	32	54	34	46	73
Best	DE	FI	DE	CY	LV	LU	DE

Energy	
DE	74
FI	72
AT	59
IT	58
NL	56
FR	55
BE	53
IE	53
LU	51
SE	49
SI	48
EE	45
EU-27	45
DK	45
PT	45
MT	45
CZ	41
EL	41
LT	41
LV	39
PL	37
HU	36
HR	35
CY	35
BG	33
SK	33
ES	27
RO	12

Source: Competitive Sustainability Index 2022

Score legend: ■ 'Leader' [70-100]; ■ 'Strong performer' [60-69]; ■ 'Good performer' [50-59]; ■ 'Moderate performer' [40-49]; ■ 'Weak performer' [0-39].

Although **EU average performance**[xxiv] **in the Energy ecosystem is the second highest of all six ecosystems (only behind Digital), it only attains a 'Moderate performer' score**. There are only two countries (Germany and Finland) qualifying as 'Leader' and no countries as 'Strong performer'. A total of 18 countries are either 'Moderate performer' (Sweden, Slovenia, Estonia, Denmark, Portugal, Malta, Czech Republic, Greece and Lithuania) or 'Weak performer' (Latvia, Poland, Hungary, Croatia, Cyprus, Bulgaria, Slovakia, Spain and Romania). These results reflect a **poor overall performance, with a couple of countries performing very well** in delivering R&I for the energy transition.

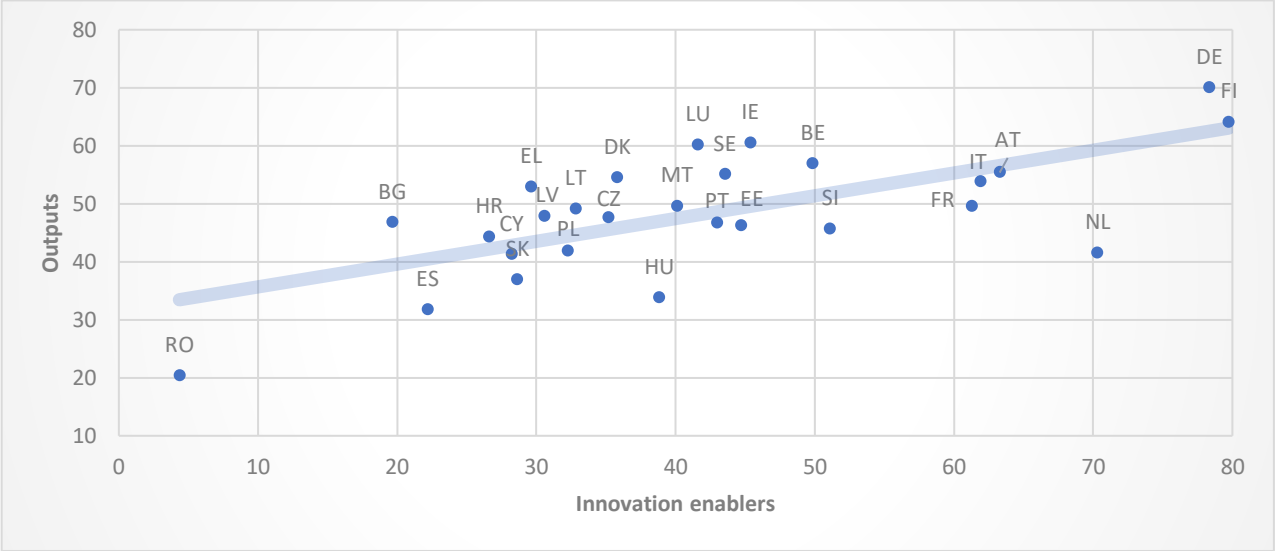
With respect to R&I **inputs**, Germany and Austria are the best performers on private R&D investment, with the average performance on this component being weak. Finland stands out for its excellent *Innovation capacity*, something at which German businesses operating in the energy ecosystem also excel. With respect to innovation **outputs**, Germany leads in terms of *Intellectual Property Rights* (IPR) and employment in sustainable activities, but has very poor *Entrepreneurial activity* in those fields, which is an element in which Latvia shows significant strength. Both *IPR* and *Entrepreneurial activity* components display low average

[xxiv] EU-27 average performance calculated as the arithmetic average of the scores of the 27 countries.

performance, whereas *Employment* in innovative companies within the sustainable economic activities of the Energy ecosystem is an area where most countries perform very well.

Cyprus is the best performer on *Innovation activity*, mainly due to the high level of collaboration between sustainable energy companies and the proportion of them delivering product innovations. On the other hand, Luxembourg is the country with higher performance in terms of *Trade* of products in Taxonomy-eligible economic activities within the energy ecosystem. Lastly, it is worth noting that Finland (one of the 'Leaders' in the ecosystem) has a good performance across all output components (except *Entrepreneurial activity*) but fails to lead in any of them.

Figure 12: Correlation between 'Innovation enablers' and 'Outputs' sub-dimensions in Energy ecosystem



Source: Competitive Sustainability Index 2022

Regarding the efficiency in delivering energy innovation outputs, as shown in Figure 12, besides Germany there are some countries that prove to be very efficient at delivering outputs regardless of their innovation enabling capacities. Countries that show similar or even better performance on innovation outputs than other countries with higher levels of innovation enablers include Ireland, Luxembourg, Greece and Bulgaria. These countries manage to get the most out of their energy innovation capacities, even though these capacities are not always the best.

Consequently, following the possibility to identify clusters of countries most likely to benefit from collaborative learning in these areas, four groups present themselves from the analysis, as indicated below.

Table 10: Potential collaboration clusters on Energy innovation

	Best practice	*Cluster members*
Cluster 1	*DE*	*FI, NL, AT, IT, FR*
Cluster 2	*LU*	*SI, BE, IE, EE, SE, PT*
Cluster 3	*EL*	*MT, HU, DK, CZ, LT, PT, LV*
Cluster 4	*BG*	*SK, CY, HR, ES, RO*

Source: Competitive Sustainability Index 2022

4.1.1.2 Industry ecosystem

Industry (ie materials processing and manufacturing) represents 22 per cent of the EU's greenhouse gas emissions.[13] The 'fourth industrial revolution' will entail broader factors than a merger of technologies and

embedded connectivity to increase productivity: it will demand a transformation of production processes in most industries, and also needs to be mission-oriented towards achievement of sustainability goals.

In order to meet the EU's 2050 targets, there is a need to advance and deploy at scale decarbonisation technologies across (heavy) industry sectors, which in turn entails accelerating innovation cycles. The 'Fit for 55' policy package must be an enabler for EU companies to lead the transition from carbon to electrons and boost the demand for clean technologies in order to accelerate their development.

The ability to adapt to the new competitive sustainability paradigm will determine companies' survival over the medium to long term, and in some cases even the short term too, given how rapidly changes are now occurring. However, set against these short-term risks, the transition to climate neutrality is also an opportunity to engage in a transformation pathway that will certainly bring long-term opportunities and benefits, as new global markets are defined and rapidly develop.

Table 11: Performance of countries on the Industry ecosystem

	Innovation enablers		Outputs				
	Business R&D investment	Innovation capacity	IPR	Innovation activity	Entrepreneurial activity	Trade	Employment
AT	54	50	24	49	12	49	71
BE	41	100		78	32	52	100
BG	9	60	11	22	45	18	48
CY	65	52	3	90	36	61	90
CZ	15	44	40	28	34	24	44
DE	36	52	79	62	21	37	88
DK	31	12		60	59	45	79
EE	56	21		66	42	70	87
EL	35	30	29	55	16	26	75
ES	30	39	31	22	32	25	53
FI	54	91	26	70	34	23	80
FR	70	50	85	55	44	37	78
HR	38	36	0	46	37	60	50
HU	16	45	21	28	41	11	23
IE	0	58		41	23	16	48
IT	55	65	51	57	29	24	77
LT	39	36	19	38	96	22	50
LU	47	32		32	36	3	52
LV	14	46	1	29	77	36	41
MT	17	36	32	26	49	14	35
NL		71		57	47	24	
PL	12	32	7	13	62	17	29
PT	39	50	30	41	61	26	52
RO	0	51		9	50	40	0
SE	29	60	52	69	24	17	79
SI	41	68	41	46	39	30	48
SK	16	11	15	16	73	5	21
EU-27	33	48	30	45	43	30	58
Best	FR	BE	FR	CY	LT	EE	BE

Industry	
BE	68
FR	60
FI	60
CY	57
NL	57
IT	54
EE	52
DE	51
SI	48
AT	47
SE	46
PT	44
EU-27	42
LT	41
DK	41
HR	38
EL	36
LU	35
ES	34
LV	34
CZ	32
BG	32
IE	30
MT	29
HU	28
RO	25
PL	24
SK	20

Source: Competitive Sustainability Index 2022

Score legend: ■ 'Leader' [70-100]; ■ 'Strong performer' [60-69]; ■ 'Good performer' [50-59]; ■ 'Moderate performer' [40-49]; ■ 'Weak performer' [0-39].

EU average performance[xxv] in the Industry ecosystem is 'Moderate'. No country qualifies as 'Leader' and only three Member States qualify for the 'Strong performer' category (Belgium, France and Finland). Conversely, six countries are 'Moderate' performers (Slovenia, Austria, Sweden, Portugal, Lithuania and

[xxv] EU-27 average performance calculated as the arithmetic average of the scores of the 27 countries.

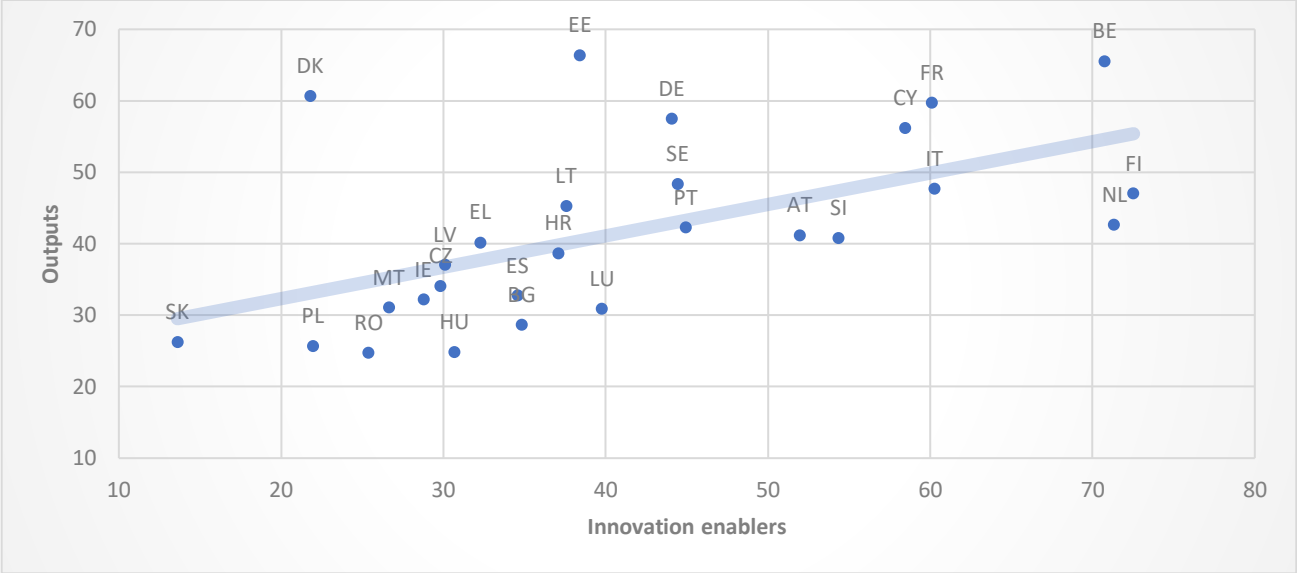
Denmark) and 13 countries are 'Weak' performers (Croatia, Greece, Luxembourg, Spain, Latvia, Czech Republic, Bulgaria, Ireland, Malta, Hungary, Romania, Poland and Slovakia).

Moreover, the gap between the best and worst performers is one of the lowest across the six ecosystems, showing a more compact level of performance among EU economies (although clustered towards the lower end). These results reflect a **poor overall performance, with a few countries performing better but no country excelling** in R&I performance related to sustainable industrial activities.

Deep diving into the ecosystem's results, it can be observed that France is the best performer in terms of *Business R&D investment* and *Intellectual Property Rights* in the sustainable industry activities. However, interestingly, overall performance on these two components is quite poor. Germany is the other Member State which also performs strongly on industrial *IPR*. Belgium leads on the *Innovation capacity* component, with Finland also having a remarkable performance regarding business innovation facilitation.

Cyprus is again (as in the Energy ecosystem) the best performing country on *Innovation activity*, excelling on the level of business collaboration and the share of companies with product innovations within the sustainable economic activities related to industry. Lithuania has the strongest *Entrepreneurial activity* in the Industry ecosystem, with Latvia also performing well. Estonia is the country with better *Trade* results, although general performance on this component is weak. Finally, Belgium has the highest share of *Employment* in innovative companies within the industrial sustainable economic activities.

Figure 13: Correlation between 'Innovation enablers' and 'Outputs' sub-dimensions in Industry ecosystem



Source: Competitive Sustainability Index 2022

As shown in Figure 13, two countries (Estonia and Denmark) stand out because of their extreme effectiveness in delivering innovation outputs, although they do not have particularly strong innovation enablers. Other countries with a remarkable performance in terms of output conversion on industry include Belgium, France and Germany.

Table 12: Potential collaboration clusters on Industry innovation

	Best practice	*Cluster members*
Cluster 1	*FR*	*BE, FI, NL, IT*
Cluster 2	*EE*	*CY, SI, AT, PT, SE, DE, LU, LT, HR*
Cluster 3	*DK*	*BG, ES, EL, HU, LV, CZ, IE, MT, RO, PL, SK*

Source: Competitive Sustainability Index 2022

4.1.1.3 Mobility ecosystem

Transport represents 22 per cent of the EU's greenhouse gas emissions.[14] Decarbonising the mobility ecosystem will require a complete transformation of the way goods and people move from place to place. To meet the climate neutrality objective, all transport modes need to become not just zero emissions but also more sustainable in their use of other physical resources.

From urban mobility to the proper functioning of passenger transport and global supply chains, zero-emissions mobility requires the development of new solutions that help to significantly reduce greenhouse gas emissions in this ecosystem, while also becoming much more circular in their material use. The sustainable mobility transition is already transforming the automotive industry and will touch all other modes too, and in the process generate new markets that will grow exponentially as the 2050 deadline approaches.

Table 13: Performance of countries on the Mobility ecosystem

	Innovation enablers		Outputs					
	Business R&D investment	Innovation capacity	IPR	Innovation activity	Entrepreneurial activity	Trade	Employment	Mobility
AT	71	57	44	59	25	32	79	
BE	41	39		53	26	22	100	
BG	0	50	4	9	46	2	44	
CY	63	56	20	82	12	75	86	
CZ	13	41	21	26	26	10	69	
DE	43	29	73	56	18	30	92	
DK	31	6		38	35	16	59	
EE	34	21		97	34	93	94	
EL	19	26	36	54	12	17	78	
ES	14	14	16	16	30	16	38	
FI	60	96	44	84	21	17	92	
FR	42	24	53	33	40	12	64	
HR	28	10	12	53	34	23	73	
HU	13	48	12	22	38	2	51	
IE	0	34		27	13	4	39	
IT	35	47	17	49	23	51	69	
LT	18	35	16	32	78	28	45	
LU	56	39		39	32	25	48	
LV	6	23	0	18	61	43	47	
MT	12	45	27	29	42	17	51	
NL		74		66	39	100		
PL	6	34	11	12	47	4	32	
PT	35	32	34	36	42	16	60	
RO	3	47		4	43	1	0	
SE	21	52	27	58	23	13	75	
SI	65	50	76	61	34	17	61	
SK	14	20	13	14	75	50	33	
EU-27	29	39	28	42	35	27	61	
Best	AT	FI	SI	EE	LT	NL	BE	

	Mobility
NL	71
FI	65
CY	57
AT	56
SI	54
EE	53
BE	45
DE	45
LU	42
IT	41
SE	38
EU-27	37
FR	37
PT	36
LT	33
MT	31
EL	31
HR	29
CZ	29
DK	28
HU	28
SK	27
LV	24
BG	23
PL	21
IE	19
ES	19
RO	18

Source: Competitive Sustainability Index 2022

Score legend: ■ 'Leader' [70-100]; ■ 'Strong performer' [60-69]; ■ 'Good performer' [50-59]; ■ 'Moderate performer' [40-49]; ■ 'Weak performer' [0-39].

EU average performance[xxvi] **in the Mobility ecosystem is 'Weak'** and is the second lowest among the six ecosystems analysed, only above the average score in Land-use & Agri-food. Only one country (the Netherlands) scores as 'Leader' and one (Finland) as 'Strong performer'. A total of 21 countries score below 50, with four Member States qualifying as 'Moderate performer' (Belgium, Germany, Luxembourg and Italy)

[xxvi] EU-27 average performance calculated as the arithmetic average of the scores of the 27 countries.

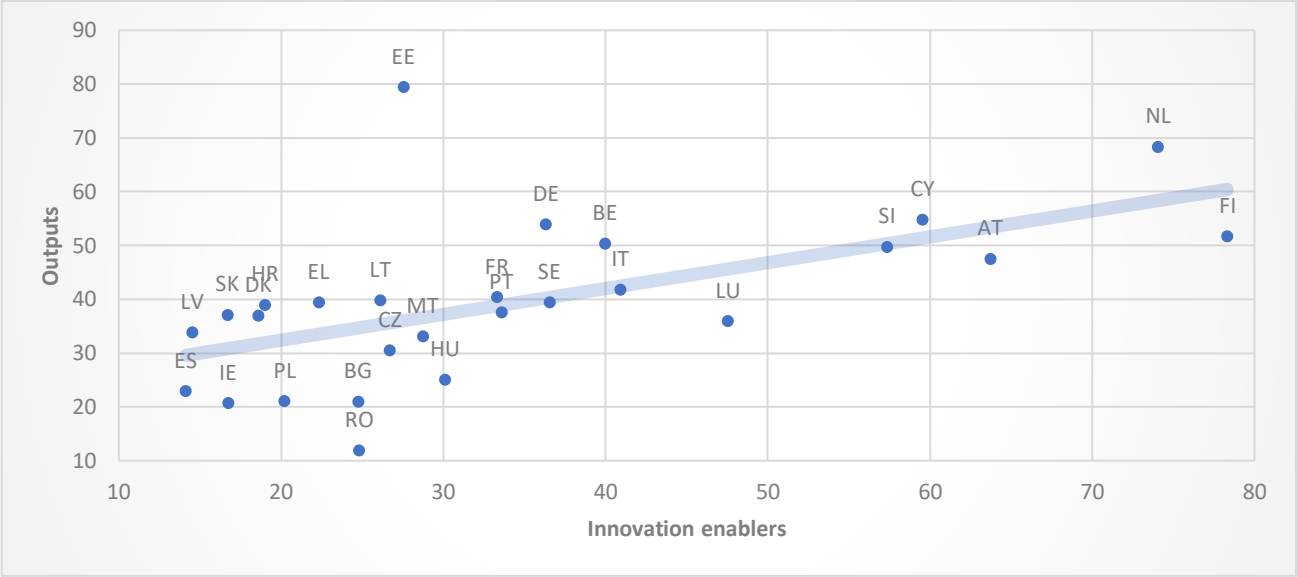
and up to 17 as 'Weak performer' (Sweden, France, Portugal, Lithuania, Malta, Greece, Croatia, Czech Republic, Denmark, Hungary, Slovakia, Latvia, Bulgaria, Poland, Ireland, Spain and Romania). These results reflect a **very poor overall performance in Mobility ecosystems across most EU countries, with only a couple of Member States performing well,** although still far from achieving top levels of R&I performance in this ecosystem.

It is worth noting that **there is a wide variety of leading countries on Mobility R&I performance, with no country leading in more than one component**. In terms of **inputs**, Austria is leading on *Business R&D investment* for this ecosystem, with Slovenia, Cyprus and Finland performing well on private R&D. Besides these countries, general performance on this component is very poor.

Finland again performs extremely well on *Innovation capacity* (as in Energy and Industry ecosystems), with the Netherlands coming second at a significant distance. Regarding innovation **outputs**, Slovenia is the best performer on sustainable mobility *IPR*, with Germany also achieving strong IPR results. Estonia leads on *Innovation activity*, with Finland and Cyprus also performing very well on this component. Eastern countries (Lithuania, Slovakia and to a lesser extent Latvia) stand out in terms of *Entrepreneurial activity*. The Netherlands and Estonia do extremely well on sustainable mobility *Trade*, with Cyprus also being a strong performer. However, **average performance on these two components (*Entrepreneurial activity* and *Trade*) is weak.**

Finally, Belgium, Estonia, Finland and Germany lead in terms of *Employment* in innovative companies within the sustainable mobility economic activities. Overall performance on the *Employment* component is actually significantly better than on all the other components.

Figure 14: Correlation between 'Innovation enablers' and 'Outputs' sub-dimensions in Mobility ecosystem



Source: Competitive Sustainability Index 2022

When it comes to analysing effectiveness, Figure 14 shows that Estonia (as in the Industry ecosystem) stands out for its exceptional production of innovation outputs, despite not performing that strongly at the input level. Other Member States with notable capacity to deliver innovation outputs in the Mobility ecosystem include the Netherlands, Germany and Croatia.

Table 14: Potential collaboration clusters on Mobility innovation

	Best practice	*Cluster members*
Cluster 1	*NL*	*FI, AT, CY, SI*
Cluster 2	*DE*	*LU, IT, BE, SE*

Cluster 3	*EE*	*PT, FR, HU, MT, CZ, LT*
Cluster 4	*HR*	*RO, BG, EL, PL, DK, SK, IE, LV, ES*

Source: Competitive Sustainability Index 2022

4.1.1.4 Buildings ecosystem

Residential and commercial buildings represent 13 per cent of the EU's greenhouse gas emissions.[15] Seventy-five per cent of the EU's building stock is inefficient according to current building standards, and only 85–95 per cent of the buildings that exist today will still be standing in 2050.[16]

Reaching climate neutrality in the Buildings ecosystem will offer significant opportunities to develop new solutions that meet future demand. **From more sustainable and circular materials to cleaner industrial processes, there is a multitude of ways to build and use buildings with zero emissions** that offer enormous market opportunities as they scale.

Table 15: Performance of countries on the Buildings ecosystem

	Innovation enablers		Outputs					
	Business R&D investment	Innovation capacity	IPR	Innovation activity	Entrepreneurial activity	Trade	Employment	Buildings
AT	63	59	32	53	19	54	85	
BE	36	83		69	26	26	96	
BG	17	23	33	35	40	31	75	
CY	33	29	10	91	13	7	73	
CZ	36	42	36	44	28	44	72	
DE	75	81	100	72	17	47	100	
DK	57	17		55	34	40	73	
EE	41	52	0	62	36	37	84	
EL	33	40	53	69	11	36	85	
ES	16	15	15	17	32	37	36	
FI	76	96	66	73	27	63	89	
FR	53	33	48	36	36	20	69	
HR	43	22	17	53	36	38	67	
HU	32	48	13	29	44	28	37	
IE	2	72		56	18	34	51	
IT	63	54	42	53	21	88	75	
LT	20	29	11	33	80	24	48	
LU	46	33		56	39	57	86	
LV	15	36	10	28	57	38	49	
MT	13	47	20	24	43	6	40	
NL		74		45	40	24		
PL	23	41	23	28	55	37	49	
PT	49	44	43	46	42	39	58	
RO	2	0	0	4	46	25	0	
SE	33	55	36	60	23	31	76	
SI	69	51	31	63	35	49	79	
SK	25	24	10	18	79	30	44	
EU-27	37	45	30	47	36	37	65	
Best	FI	FI	DE	CY	LT	IT	DE	

FI	75
DE	73
IT	57
BE	57
SI	56
NL	55
AT	55
LU	50
PT	46
EE	45
SE	45
DK	44
EL	44
FR	43
EU-27	43
CZ	42
IE	38
HR	37
HU	35
PL	35
CY	35
LT	32
BG	31
LV	31
SK	30
MT	28
ES	21
RO	8

Source: Competitive Sustainability Index 2022

Score legend: ■ 'Leader' [70-100]; ■ 'Strong performer' [60-69]; ■ 'Good performer' [50-59]; ■ 'Moderate performer' [40-49]; ■ 'Weak performer' [0-39].

EU average performance[xxvii] in the Buildings ecosystem is 'Moderate'. Two countries (Finland and Germany) manage to be 'Leader' in this ecosystem, although no Member State qualifies as 'Strong performer', leaving a significant gap between the leading countries and the rest of the EU economies in the Buildings ecosystem.

[xxvii] EU-27 average performance calculated as the arithmetic average of the scores of the 27 countries.

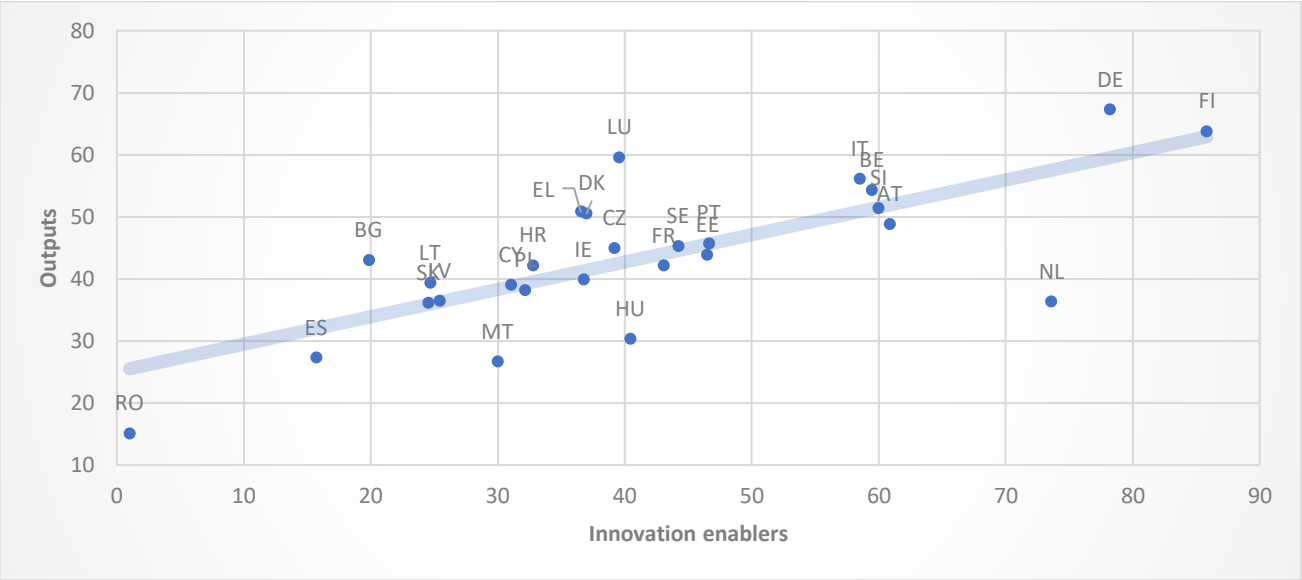
In fact, a total of 19 Member States score under 50, out of which 12 are 'Weak' performers (Ireland, Croatia, Hungary, Poland, Cyprus, Lithuania, Bulgaria, Latvia, Slovakia, Malta, Spain and Romania).

The gap between the best and worst performers is one of the highest in all ecosystems (only behind that in Land-use & Agri-food), which illustrates the wide variability in country performance in the Buildings ecosystem. These results reflect a **poor overall performance in this ecosystem, with only a couple of countries performing very well in delivering sustainable building solutions**.

When analysing data in more detail, Finland is the best performer in both **input** components (*Business R&D investment* and *Innovation capacity*), with Germany also performing very well across innovation enablers. On the **output** side, Germany is the EU's top performer on *IPR*, leading in all patent, trademark and industrial design applications related to sustainable buildings. Cyprus is again (as in the Energy and Industry ecosystems) the best performer on *Innovation activity*, excelling in terms of business collaboration and the share of sustainable companies with product innovations within the Buildings ecosystem.

Overall performance on *Entrepreneurial activity* is again very poor, with only **two countries (Lithuania and Slovakia) doing well on the creation and survival of sustainable buildings enterprises**. Italy leads the *Trade* of sustainable products in this ecosystem, but average performance on this component is again weak. Finally, it is noteworthy that up to 14 countries perform very strongly in terms of *Employment* in sustainable buildings activities, with Germany and Belgium as the top performers.

Figure 15: Correlation between 'Innovation enablers' and 'Outputs' sub-dimensions in Buildings ecosystem



Source: Competitive Sustainability Index 2022

Figure 15 illustrates that Luxembourg stands out for its capacity to achieve a notable level of innovation outputs (third highest only behind Germany and Finland), despite having a moderate level of innovation enablers. Germany, Denmark, Greece and Bulgaria also excel for their efficiency in delivering innovation outputs for their respective levels of innovation inputs.

Table 16: Potential collaboration clusters on Buildings innovation

	Best practice	*Cluster members*
Cluster 1	*DE*	*FI, NL*
Cluster 2	*IT*	*AT, SI, BE*
Cluster 3	*LU*	*PT, EE, SE, FR, HU*

Cluster 4	*EL*	*DK, CZ, IE*
Cluster 5	*BG*	*HR, PL, CY, MT, LV, LT, SK, ES, RO*

Source: Competitive Sustainability Index 2022

4.1.1.5 Land-use & Agri-food ecosystem

Agriculture represents 12 per cent of the EU's greenhouse gas emissions.[17] Without policy action, global agricultural emissions might increase by 15–20 per cent by 2050. By that time, 10 per cent of the global area currently fit for crops and livestock is projected to be climatically unsuitable.[18]

The Land-use & Agri-food ecosystem has enormous potential for developing new technologies that contribute to the net zero target. As food demand and carbon removal targets continue to increase over the coming years, new solutions are required so that the ways in which we farm and use land can be improved.

Only 11 Member States report data for all innovation components analysed, meaning that in most cases data availability to assess a country's R&I performance on Land-use & Agri-food is low. **This limitation should be kept in mind when going through the analysis below.**

Table 17: Performance of countries on the Land-use & Agri-food ecosystem

	Innovation enablers		Outputs					
	Business R&D investment	Innovation capacity	IPR	Innovation activity	Entrepreneurial activity	Trade	Employment	Land-use & Agri-food
AT					10	0		
BE		75		38	19	27	100	
BG					50	12		
CY					25	54		
CZ		61	94	22	17	26	0	
DE	42	70	62	68	16	28	77	
DK					27	25		
EE					36	26		
EL					0	91		
ES	15	7	0	29	24	18	22	
FI					16	6		
FR	38	11	20	28	26	13	44	
HR	39	68		32	50	93	35	
HU	93	100	100	69	63	58	42	
IE					7	3		
IT	33	60	8	48	19	59	45	
LT	11	26	18	30	100	23	40	
LU	100			77	27	4	56	
LV					53	58		
MT	10	36	9	28	45	20	34	
NL					33	36		
PL	6	12	23	0	71	10	15	
PT	46	75	20	59	43	26	61	
RO				100	56	27		
SE	25	50	6	50	7	8	59	
SI					22	6		
SK	6	28	2	10	52	7	16	
EU-27	36	48	30	43	34	28	43	
Best	LU	HU	HU	RO	LT	HR	BE	

HU	81
LU	70
RO	61
BE	60
LV	56
HR	53
DE	53
PT	51
CZ	46
EL	46
IT	41
CY	40
EU-27	36
NL	34
SE	32
BG	31
EE	31
LT	30
DK	26
FR	25
MT	25
SK	17
PL	17
ES	15
SI	14
FI	11
AT	5
IE	5

Source: Competitive Sustainability Index 2022

Score legend: ■ 'Leader' [70-100]; ■ 'Strong performer' [60-69]; ■ 'Good performer' [50-59]; ■ 'Moderate performer' [40-49]; ■ 'Weak performer' [0-39].

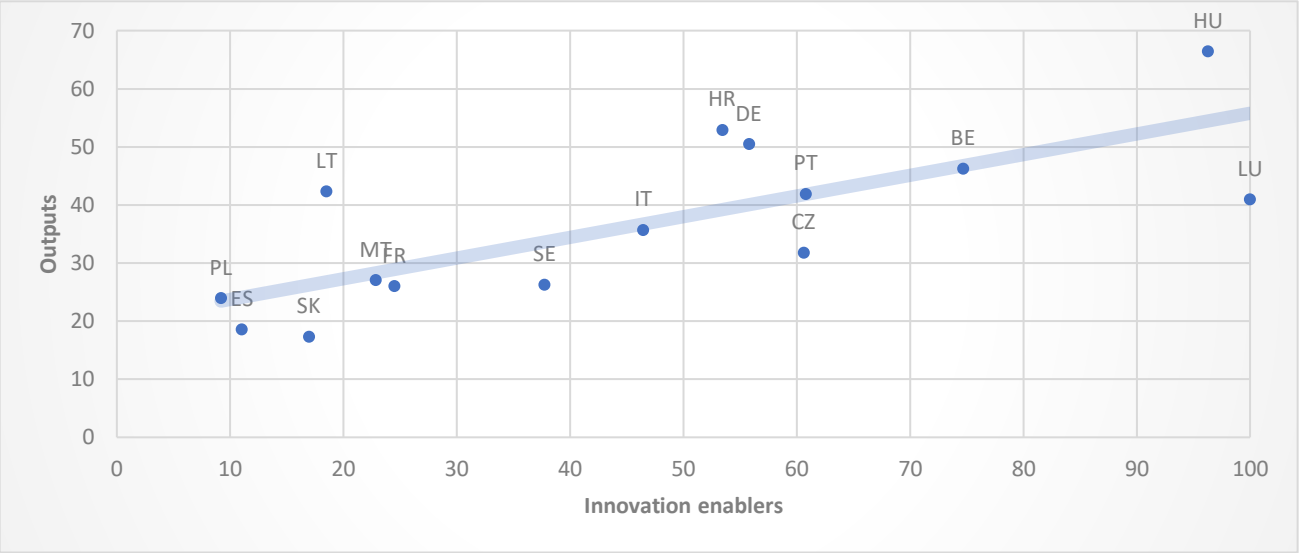
EU average performance[xxviii] in the Land-use & Agri-food ecosystem is 'Weak', being the lowest in all six ecosystems analysed. Two countries (Hungary and Luxembourg) are 'Leaders' and two further Member States (Romania and Belgium) are 'Strong' performers. Conversely, four countries are 'Moderate' performers (Czech Republic, Greece, Italy and Cyprus) and 15 are 'Weak' performers (Netherlands, Sweden, Bulgaria, Estonia, Lithuania, Denmark, France, Malta, Slovakia, Poland, Spain, Slovenia, Finland, Austria and Ireland).

The gap between the best and worst performers is the highest in all six ecosystems. This shows great variability in country performance on this ecosystem, which is to a certain extent due to the data availability limitation. These results reflect a **very poor overall performance in this ecosystem, with a couple of countries performing very well and two further performing strongly on Land-use & Agri-food R&I**.

A deeper analysis of performance in the different components (see Table 17) shows that Luxembourg is the best performer on *Business R&D investment*, with Hungary also performing very strongly. Moreover, Hungary leads in terms of *Innovation capacity* and *Intellectual Property Rights* in the Agri-food ecosystem, with the Czech Republic also delivering excellent IPR results. Romania takes the lead on *Innovation activity*, excelling on the share of sustainable companies with product innovations.

Lithuania is the leading EU country regarding *Entrepreneurial activity*, whereas Croatia and Greece are the top performers when it comes to *Trade* in the sustainable Land-use & Agri-food economic activities. However, general performance on both *Entrepreneurial activity* and *Trade* components is once again quite poor. Finally, Belgium is the Member State with higher levels of *Employment* in innovative companies within the ecosystem, followed at some distance by Germany.

Figure 16: Correlation between 'Innovation enablers' and 'Outputs' sub-dimensions in Land-use & Agri-food ecosystem



Source: Competitive Sustainability Index 2022

Only 15 countries have reported data for at least one input and output component. Therefore, the analysis of overall efficiency in transforming innovation inputs into outputs is limited to those countries. As shown in Figure 16, Hungary, Croatia, Germany and Lithuania prove their competence delivering strong innovation outputs for their respective levels of innovation enablers.

Table 18: Potential collaboration clusters on Land-use & Agri-food innovation

	Best practice	*Cluster members*
Cluster 1	*HU*	*LU, BE*

[xxviii] EU-27 average performance calculated as the arithmetic average of the scores of the 27 countries.

Cluster 2	*HR*	*PT, CZ, DE*
Cluster 3	*LT*	*IT, SE, FR, MT, SK, ES, PL*

Source: Competitive Sustainability Index 2022

4.1.1.6 Digital ecosystem

Until 2030, most of the emissions reductions will come from technologies already available. Yet, climate neutrality by 2050 will be enabled by the development of new technologies, currently at the experimental, demonstration or prototype phase.[19]

This includes numerous digital technologies that might foster emissions reduction across all sectors. In particular, digital technologies will play a key role in achieving climate neutrality, enabling more sustainable Energy, Industry, Buildings, Mobility, and Land-use & Agri-food ecosystems.

Besides its essential role as enabler of the net zero transition in the five most relevant ecosystems in terms of emissions, the Digital ecosystem has a role to play on its own under the new competitive sustainability paradigm. Information and communications technology (ICT) is currently responsible for 5–9 per cent of global electricity use and around 3 per cent of greenhouse gas emissions.[20] Unless digital technologies are made more energy efficient, their widespread use is expected to significantly increase energy consumption and overall ICT carbon footprint.[21]

Table 19: Performance of countries on the Digital ecosystem

	Innovation enablers		Outputs				
	Business R&D investment	Innovation capacity	IPR	Innovation activity	Entrepreneurial activity	Trade	Employment
AT	68	71	52	70	20	32	91
BE	31	87		70	33	58	91
BG	21	36	41	37	50	21	59
CY	40	77	33	100	41	14	89
CZ	28	52	51	31	35	15	29
DE	49	81	66	74	32	41	100
DK	34	15		45	51	32	65
EE	38	77	9	83	60	26	92
EL	34	33	45	64	29	50	76
ES	29	45	28	24	38	60	50
FI	91	87	75	70	36	52	87
FR	31	61	81	55	52	21	84
HR	26	55	19	75	61	52	81
HU	27	61	16	41	49	9	27
IE	94	72		25	23	54	0
IT	50	77	23	72	34	27	88
LT	21	70	36	48	96	37	48
LU	32	31		39	41	11	25
LV	13	54	18	37	55	35	21
MT	24	52	50	52	67	10	73
NL		83		56	44	100	
PL	19	47	8	18	62	20	27
PT	38	64	75	45	71	21	48
RO	19	48	5	9	55	49	11
SE	53	62	49	79	28	75	80
SI	58	64	40	61	60	33	61
SK	15	50	15	18	85	39	46
EU-27	38	60	38	52	49	37	60
Best	IE	BE	FR	CY	LT	NL	DE

Digital and others	
FI	77
NL	75
DE	64
AT	61
BE	61
SE	60
CY	57
IT	56
SI	56
EE	56
IE	54
FR	52
PT	52
LT	49
HR	49
EU-27	48
MT	44
EL	43
ES	38
SK	37
DK	36
HU	36
CZ	36
BG	35
LV	33
LU	30
PL	30
RO	30

Source: Competitive Sustainability Index 2022

Score legend: ■ 'Leader' [70-100]; ■ 'Strong performer' [60-69]; ■ 'Good performer' [50-59]; ■ 'Moderate performer' [40-49]; ■ 'Weak performer' [0-39].

Although 'Moderate', the EU's average performance[xxix] in the Digital ecosystem is the highest among all ecosystems analysed. Yet only two Member States (Finland and the Netherlands) qualify as 'Leader' and four countries (Germany, Austria, Belgium and Sweden) manage to be 'Strong' performers. As a result, this is the ecosystem with a higher number of Member States in the top two performance categories. Moreover, it is also the ecosystem with the lowest number of countries (14) with either 'Moderate' (Lithuania, Croatia, Malta and Greece) or 'Weak' performances (Spain, Slovakia, Denmark, Hungary, Czech Republic, Bulgaria, Latvia, Luxembourg, Poland and Romania).

Accordingly, the gap between the best and worst performers is the lowest across the six ecosystems, showing a more compact level of performance among EU economies. Thus, results reflect a **relatively good overall performance** on digital activities, with almost half of the Member States scoring over 50 and **a larger than usual group of strongly performing countries** in this ecosystem.

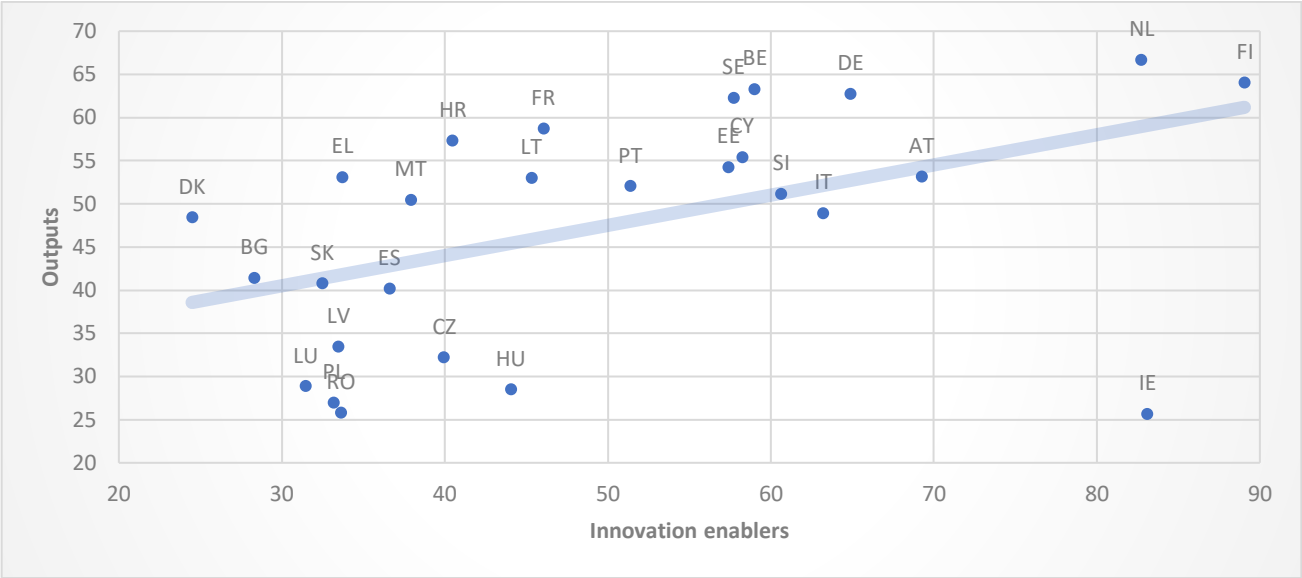
A more detailed analysis of the R&I components (see Table 19) shows that Ireland is the EU's top performer regarding *Business R&D investment*, with Finland also showing great strength in this area. It is noteworthy that overall performance on digital R&D in most countries seems to be poor compared to the two champions. In terms of *Innovation capacity*, overall performance is notably better than in other ecosystems, with Belgium and Finland outperforming EU colleagues, although the Netherlands and Germany are not far behind.

Regarding innovation outputs, France is the best performer on digital *IPR*, with Finland and Portugal also delivering good results. In terms of *Innovation activity*, Cyprus again shows excellent performance of its businesses operating in sustainable digital activities, with Estonia also performing very strongly. *Entrepreneurial activity* in the Digital ecosystem is remarkably better than in other ecosystems, although still not great. However, **Lithuania and Slovakia again (as in most ecosystems) perform very well in terms of business creation and survival in the sustainable economic activities within the Digital ecosystem**. With regard to *Trade*, general performance is also poor, with the notable exceptions of Sweden and especially the Netherlands showing impressive strength in trade indicators.

Finally, *Employment* on the innovative enterprises within digital sustainable economic activities is again the component with better overall performance (along with *Innovation capacity* this time). In particular, Germany, Estonia, Austria and Belgium perform very well here.

[xxix] EU-27 average performance calculated as the arithmetic average of the scores of the 27 countries.

Figure 17: Correlation between 'Innovation enablers' and 'Outputs' sub-dimensions in Digital ecosystem



Source: Competitive Sustainability Index 2022

With regard to countries' efficiency in transforming digital R&I conditions (Innovation enablers) into outputs, Belgium proves to be very efficient in delivering digital innovation outputs (see Figure 17). Other countries showing outstanding performance here include the Netherlands, Sweden, Croatia and Denmark.

Ireland is an interesting case showing that despite having an excellent level of innovation enablers, the innovation outputs delivered are quite low. This may be the result of hosting the EU headquarters of most of the US big tech companies (and associated R&D investment) but not having a strong digital innovation ecosystem as such in place.

Table 20: Potential collaboration clusters on digital innovation

	Best practice	*Cluster members*
Cluster 1	*NL*	*FI, IE*
Cluster 2	*BE*	*AT, DE, IT, SI, CY, EE, SE*
Cluster 3	*HR*	*PT, FR, LT, HU, CZ, HR*
Cluster 4	*EL*	*MT, ES, SK, LV, PL, RO*
Cluster 5	*DK*	*LU, BG*

Source: Competitive Sustainability Index 2022

4.2 Society/'Fairness' dimension

To ensure inclusive growth and a just transition to an economy that works for people as well as for the planet, EU countries must fully deliver on the principles of the European Pillar of Social Rights, the European interpretation of the global United Nations Sustainable Development Goals (SDGs).

Table 21: Performance on the Society/Fairness sub-dimensions

	Framework conditions			Impacts		
	Education	Basic needs	Social mobility	Inclusivity	Equality	Health
AT	68	94	75	63	70	76
BE	73	84	57	44	78	70
BG	34	40	24	38	24	4

	Society / Fairness
SE	87
DK	85
NL	84

CY	61	91	48	67	57	98
CZ	46	91	89	78	74	55
DE	48	91	85	56	66	66
DK	93	93	84	90	80	70
EE	93	45	53	52	69	59
EL	42	32	21	3	44	74
ES	59	97	38	79	51	85
FI	92	76	67	86	85	79
FR	76	86	45	77	65	70
HR	34	78	36	2	65	45
HU	40	74	52	57	62	41
IE	47	87	68	100	61	85
IT	31	72	4	48	35	82
LT	62	67	50	11	56	23
LU	78	98	72	68	56	71
LV	66	47	32	39	57	22
MT	51	93	86	84	38	42
NL	79	99	100	79	70	78
PL	47	73	68	48	62	44
PT	46	87	63	46	62	54
RO	10	47	30	37	37	5
SE	100	91	83	81	78	88
SI	69	74	82	77	88	76
SK	28	63	39	54	81	41
EU-27	58	77	57	58	62	59
Best	SE	NL	NL	IE	SI	CY

FI	81
SI	78
IE	75
AT	74
LU	74
CZ	72
CY	70
FR	70
DE	68
ES	68
BE	68
MT	66
EU-27	62
EE	62
PT	60
PL	57
HU	54
SK	51
IT	45
LT	45
LV	44
HR	43
EL	36
RO	28
BG	27

Source: Competitive Sustainability Index 2022

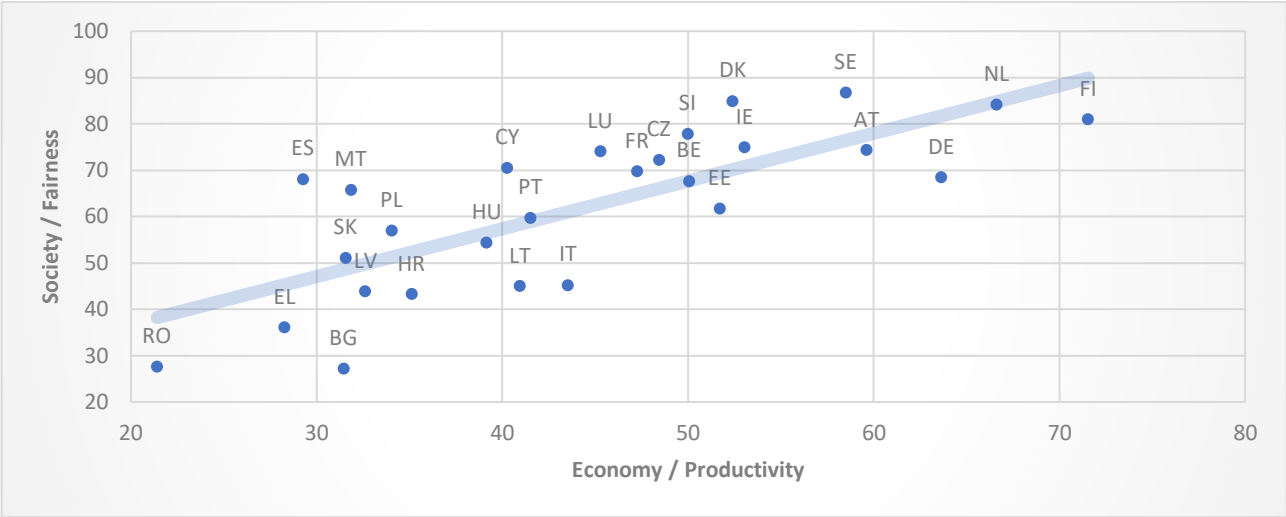
Score legend: ■ 'Leader' [70-100]; ■ 'Strong performer' [60-69]; ■ 'Good performer' [50-59]; ■ 'Moderate performer' [40-49]; ■ 'Weak performer' [0-39].

EU average performance on the Society/Fairness dimension is the highest among the four CSI dimensions, reaching levels of 'Strong' performance. Eleven Member States (Sweden, Denmark, the Netherlands, Finland, Slovenia, Ireland, Austria, Luxembourg, Czech Republic, Cyprus and France) manage to qualify as 'Leader' and a group of six qualify as 'Strong' performers (Germany, Spain, Belgium, Malta, Estonia and Portugal). Conversely, only three countries are 'Weak' performers (Greece, Romania and Bulgaria) and four are 'Moderate' performers (Italy, Lithuania, Latvia and Croatia). These results evidence the best collective performance across CSI dimensions.

Overall performance on framework conditions is slightly better, but still general impacts scores show a clear EU strength. In terms of **social inputs**, Sweden has the highest *education* performance, with Denmark, Estonia and Finland also excelling in that respect. The Netherlands is the best performer facilitating *social mobility* and covering the *basic needs* of its population, an area on which Luxembourg, Spain and Austria also show great results (see Annex VI: Sources and definitions for details on the indicators considered).

Regarding **social outcomes**, Ireland leads on *inclusivity*, with Denmark also showing excellent performance here. Slovenia is the most *equal* EU country and Cyprus has the *healthiest* society, with Sweden, Ireland and Spain following at some distance.

Figure 18: Correlation between Economy/Productivity and Society/Fairness dimensions

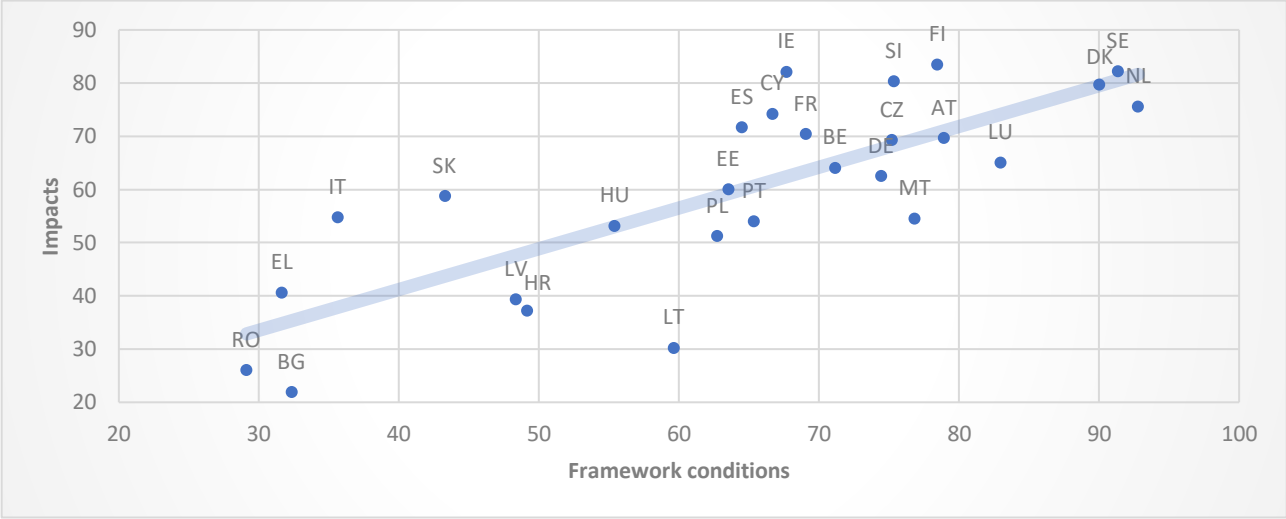


Source: Competitive Sustainability Index 2022

The correlation between the Economy and Society dimensions (see Figure 18) shows **the positive relationship between economic development and social welfare**, with some countries such as Denmark, Cyprus and Spain particularly excelling in attaining significant levels of welfare state with 'limited' economic conditions.

The social input–outcome relationship (see Figure 19) also shows some good examples of 'social efficiency'. Finland, Ireland and Italy prove to have an outstanding capacity to deliver social impacts, while not always having extraordinary framework conditions.

Figure 19: Correlation between 'Framework conditions' and 'Impacts' sub-dimensions in Society/Fairness dimension



Source: Competitive Sustainability Index 2022

4.3 Governance/'Stability' dimension

The competitive sustainability transition requires institutional stability. This is a precondition to ensure resilience against future shocks and facilitate the already ongoing transformation.

Table 22: Performance on the Governance/Stability sub-dimensions

Framework conditions			Impacts			
Fundamental rights	**Transparency**	**Institutional efficacy**	**Sound governance**	**Citizen engagement**	**Security and resilience to external shocks**	**Governance / Stability**

AT	83	67	79	59	49	60
BE	67	65	52	36	47	60
BG	14	14	2	53	6	23
CY	39	39	38	35	3	28
CZ	65	52	38	59	20	46
DE	84	73	68	70	48	59
DK	99	90	84	84	59	59
EE	72	71	63	68	31	79
EL	27	34	41	17	21	35
ES	54	53	62	33	31	50
FI	99	100	87	72	72	56
FR	64	52	76	40	40	65
HR	27	35	25	39	16	49
HU	21	15	38	50	23	51
IE	82	71	69	71	41	35
IT	44	25	40	15	30	46
LT	47	55	58	61	13	45
LU	92	74	78	98	69	59
LV	38	45	45	48	20	54
MT	63	32	42	82	16	33
NL	90	78	87	76	87	72
PL	46	28	37	63	37	58
PT	66	59	46	41	18	58
RO	36	25	16	42	3	43
SE	95	91	75	72	94	57
SI	68	62	39	53	36	55
SK	40	37	30	45	22	57
EU-27	60	54	52	55	35	52
Best	FI + DK	FI	FI + NL	LU	SE	EE

NL	82
FI	81
SE	81
DK	79
LU	79
DE	67
AT	66
EE	64
IE	62
FR	56
BE	54
SI	52
EU-27	51
PT	48
ES	47
CZ	47
LT	47
PL	45
MT	45
LV	42
SK	39
IT	33
HU	33
HR	32
CY	30
EL	29
RO	27
BG	19

Source: Competitive Sustainability Index 2022

Score legend: ■ 'Leader' [70-100]; ■ 'Strong performer' [60-69]; ■ 'Good performer' [50-59]; ■ 'Moderate performer' [40-49]; ■ 'Weak performer' [0-39].

EU average performance on the Governance/Stability dimension is 'Good'. Five countries (the Netherlands, Finland, Sweden, Denmark and Luxembourg) manage to be 'Leader', whereas a group of four are 'Strong' performers (Germany, Austria, Estonia and Ireland). On the other hand, a total of 15 countries score below 50, out of which seven qualify as 'Moderate' performers (Portugal, Spain, Czech Republic, Lithuania, Poland, Malta and Latvia) and eight are 'Weak' performers (Slovakia, Italy, Hungary, Croatia, Cyprus, Greece, Romania and Bulgaria).

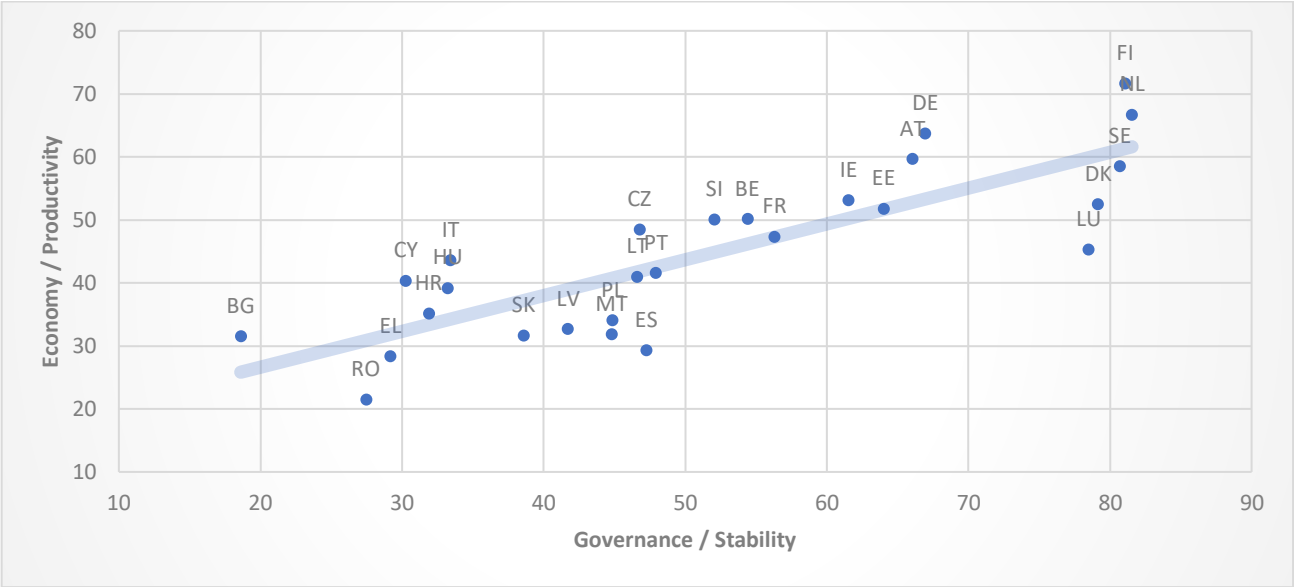
The gap between the best and worst performers is the largest of all four dimensions. This illustrates the wide variability in country performance regarding governance, where some countries show excellent performance while others fail to attain anticipated European standards.

In general, scores on governance inputs are higher than on outcomes. Within the framework conditions, Finland and Denmark perform extremely well on *fundamental rights*, with Sweden and Luxembourg also achieving remarkable results on this component. Finland again proves to be the most transparent EU country, with Sweden and Denmark on the *transparency* podium. Finland completes its extraordinary governance inputs recital with another top performance (shared with the Netherlands in this case) on *institutional efficacy*.

Regarding governance impacts, Luxembourg leads the EU in terms of *sound governance*, with the highest level of trust in their national government. This is an indicator showing worrying levels of mistrust across Member States. Sweden is the Member State with higher *citizen engagement*. However, **overall performance of EU countries on this component is poor, with particularly low scores on active citizenship suggesting a worrying disconnect between civil society and policymaking from a governance perspective**. Lastly, Estonia is the top performer when it comes to *security and resilience to external shocks*, where the

general low rates of circular materials use and the overall high levels of cybersecurity protection are noteworthy (see Annex VI: Sources and definitions for details on the indicators considered).

Figure 20: Correlation between Governance/Stability and Economy/Productivity dimensions

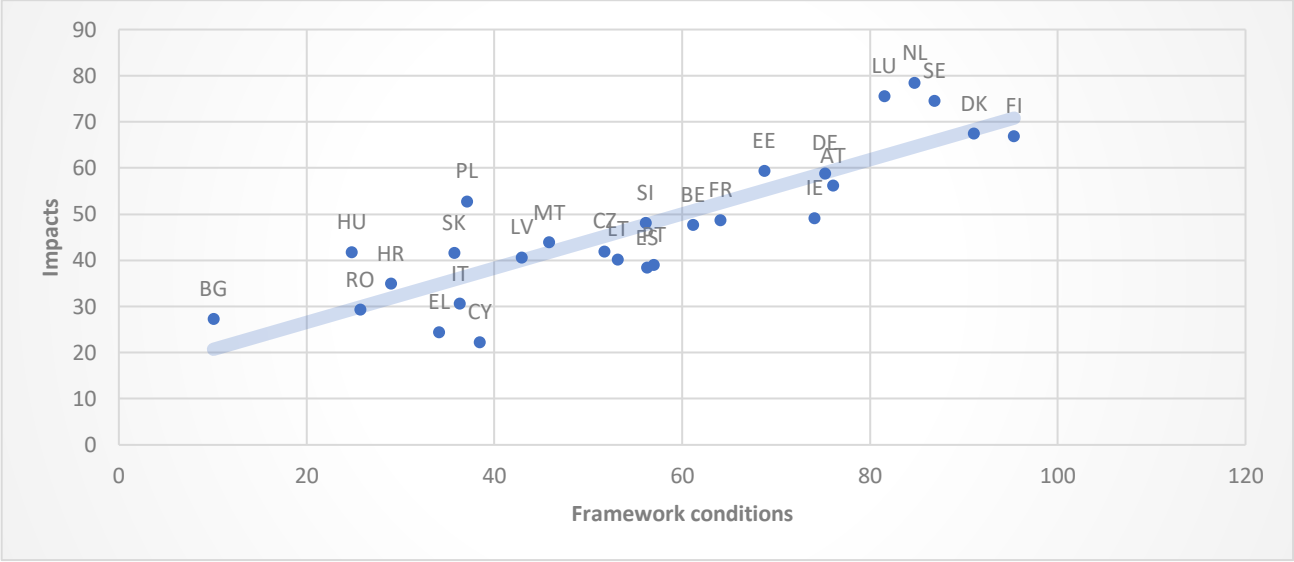


Source: Competitive Sustainability Index 2022

Figure 20 illustrates that **robust governance levels are strongly associated with high economic performance**, with some notable examples (such as Finland, Germany and Italy) of remarkable economic achievements for their respective levels of governance.

Moreover, Figure 21 shows that countries such as the Netherlands, Luxembourg and Poland can be considered best practice examples regarding governance input–outcome efficiency.

Figure 21: Correlation between 'Framework conditions' and 'Impacts' sub-dimensions in Governance/Stability dimension



Source: Competitive Sustainability Index 2022

4.4 Green/'Environment' dimension

Tackling the triple planetary crisis (climate, biodiversity and resource depletion) is now widely recognised as extremely urgent, as well as an enormous challenge. From a time when the environment was not considered relevant from an economic perspective, or simply a 'free good', it is now well understood that the global economy cannot be competitively sustainable if planetary boundaries are not respected. It is also understood that each national economy needs to transition rapidly to ensure that all economies operate

within these limits as soon as possible. The timeframe varies for different countries, but for developed economies such as that of the EU, the period up to 2050 is now widely recognised as the key timeframe within which to achieve this.

Table 23: Performance on the Green/Environment sub-dimensions

	Framework conditions			Impacts		
	Renewable energies	Sustainability transition commitment	Natural resources	Resource productivity	Climate emissions	Biodiversity
AT	65	56	48	57	91	49
BE	40	53	17	22	86	52
BG	41	0	31	14	0	95
CY	4	55	13	45	74	12
CZ	45	18	26	25	51	91
DE	40	56	25	61	87	62
DK	45	63	12	100	80	91
EE	51	8	62	21	35	93
EL	51	29	34	41	69	73
ES	59	51	31	55	88	30
FI	51	53	100	8	83	66
FR	48	64	28	47	95	61
HR	44	45	46	47	68	71
HU	33	30	16	34	67	76
IE	51	68	33	100	87	66
IT	34	48	29	71	90	58
LT	46	43	37	46	54	91
LU	22	65	28	81	93	48
LV	46	32	59	40	53	97
MT	0	52	0	0	69	47
NL	45	70	8	35	86	49
PL	44	14	24	36	33	82
PT	67	60	33	61	81	50
RO	46	27	25	85	51	62
SE	77	67	90	32	100	47
SI	35	60	65	39	72	59
SK	13	39	32	21	66	81
EU-27	42	45	35	45	71	65
Best	SE	NL	FI	DK + IE	SE	LV

Green / Environment	
SE	69
IE	68
DK	65
AT	61
FI	60
PT	59
FR	57
LU	56
DE	55
SI	55
IT	55
LV	55
HR	53
LT	53
ES	52
EU-27	51
EL	50
RO	49
NL	49
EE	45
BE	45
HU	43
CZ	43
SK	42
PL	39
CY	34
BG	30
MT	28

Source: Competitive Sustainability Index 2022

Score legend: ■ 'Leader' [70-100]; ■ 'Strong performer' [60-69]; ■ 'Good performer' [50-59]; ■ 'Moderate performer' [40-49]; ■ 'Weak performer' [0-39].

EU average performance on the Green/Environment dimension is 'Good'. Despite having 16 countries scoring above 50 and a similar average score to the Governance dimension, results suggest a lower overall performance on this dimension. Only five countries (Sweden, Ireland, Denmark, Austria and Finland) are 'Strong' performers and no Member State qualifies as 'Leader' in Environment. Conversely, the number of countries that score under 50 is the second lowest in all four dimensions (only behind Society). However, seven Member States are 'Moderate' performers (Romania, the Netherlands, Estonia, Belgium, Hungary, Czech Republic and Slovakia) and a further group of four are 'Weak' performers (Poland, Cyprus, Bulgaria and Malta).

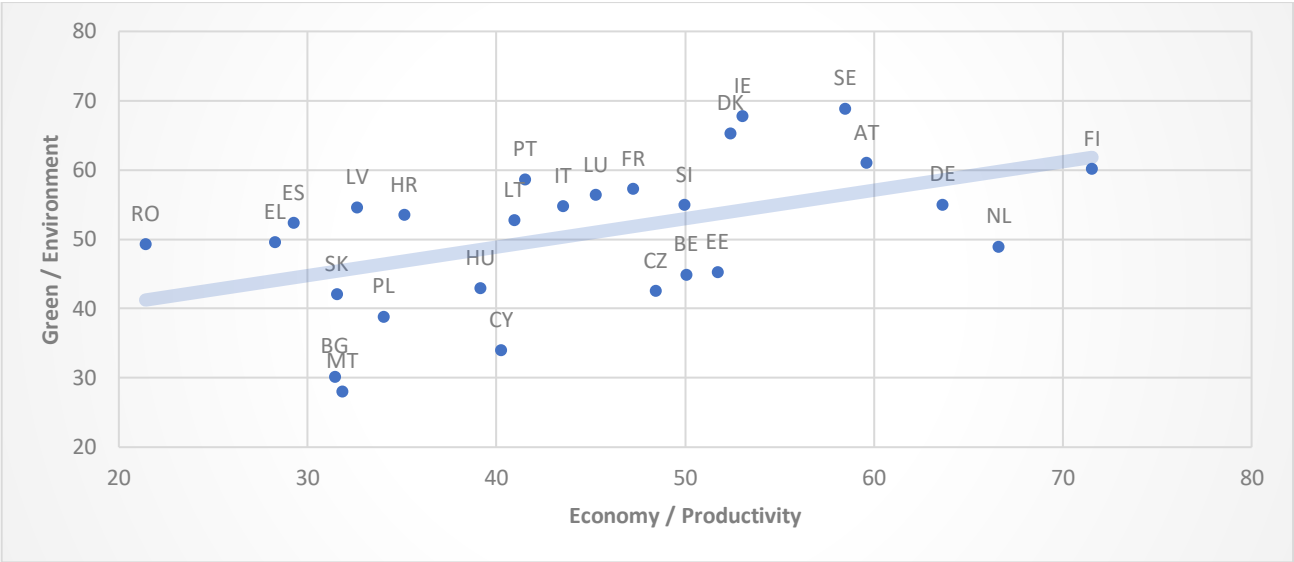
Five out of the 15 indicators considered under this dimension achieve an average score for EU countries below 40, and the gap between the best and worst performers is the smallest of all four dimensions. Taking into account the above, this suggests that **overall performance is clustered towards the lower end of the spectrum, with most countries showing a good performance nonetheless, but no country excelling**.

European Member States achieve generally better scores on environmental outcomes than they do on the input side (see Table 23), where *natural resources* show an overall weak performance. **Only Finland and Sweden seem to have excellent levels of *natural resources*, while the average score for freshwater**

availability is the lowest of all 84 indicators considered. Sweden also stands out for its performance on *renewable sources*, with the highest share of energy from renewable sources in the EU – another indicator that shows poor overall scores across Member States.

The Netherlands has the most consistent performance on sustainability transition commitment, despite not leading in any of the indicators considered under this component. Luxembourg is the country with the most effective carbon rates, and Sweden has the lowest subsidies to fossil fuels and the highest share of population perceiving climate change as a priority. The latter is also an indicator showing very low average levels of awareness of the implications of the climate crisis.

Figure 22: Correlation between Economy/Productivity and Green/Environment dimensions

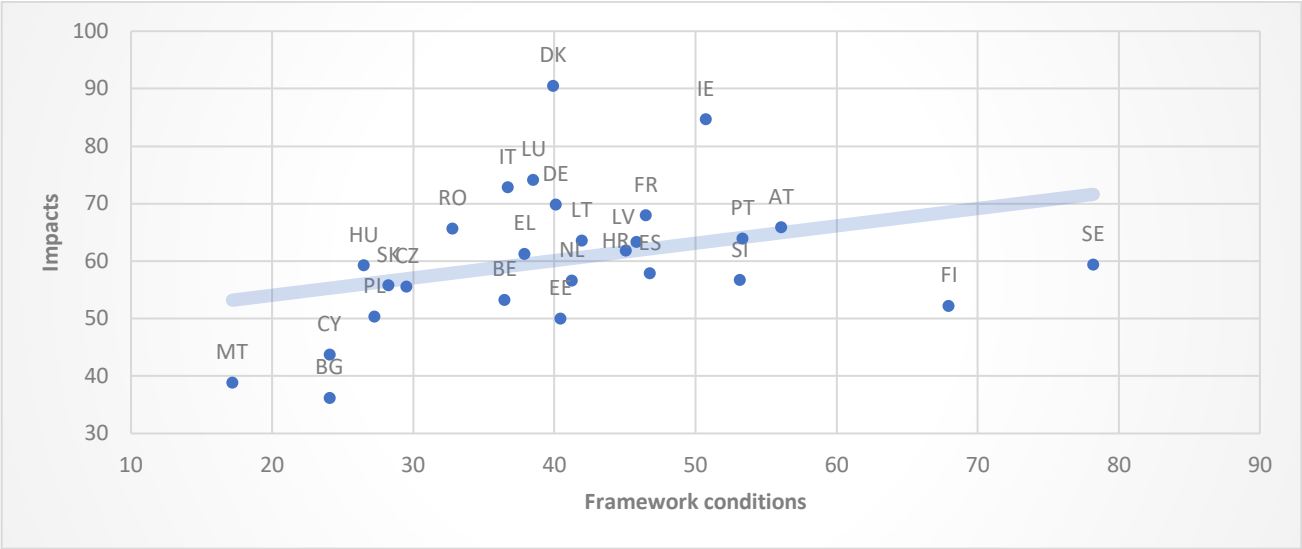


Source: Competitive Sustainability Index 2022

Contrary to the belief that achieving positive environmental outcomes must come at the expense of economic growth, **Figure 22 shows that when looking at economic development through the lens of sustainability (EU Taxonomy) there is a positive relationship between the Economy and Environment dimensions.** This suggests that economic development does not have to come at the cost of environmental externalities, and that not only are they compatible but that they positively reinforce each other. In fact, some countries (such as Sweden, Ireland and Finland) prove to be particularly good at combining economic development and environmental welfare.

Regarding efficiency in delivering environmental outcomes regardless of the level of framework conditions, Figure 23 suggests that Denmark and Ireland are clear best practice examples.

Figure 23: Correlation between 'Framework conditions' and 'Impacts' sub-dimensions in Green/Environment dimension



Source: Competitive Sustainability Index 2022

5 Conclusions, policy implications and next steps

This first edition of the Competitive Sustainability Index (CSI) offers a **new picture of the competitive performance of EU countries in relation to their transition to sustainability, with a climate neutral economy at its core**. Unlike other assessments of competitiveness, its integrated and comprehensive approach to addressing the four relevant dimensions of sustainable development (Economy, Society, Governance and Environment) **builds deliberately on the Commission's own framework** of the same name, and therefore offers a more holistic view of how countries are performing overall as well as in each dimension. The resulting picture should help to confirm where synergies are being developed for best performance, but also where negative trade-offs exist but can be avoided, and where poor performance can be improved, especially through targeted collaboration and learning from the most relevant peers. By using a combination of established data sources as well as new ones that draw on the best available metrics and data from the sustainable finance arena, it offers an original insight on 'the big picture' as well as pointing to many details that may deserve further specific attention. **Each individual country profile offers a wealth of information and insight that will be relevant to national policymakers**, especially when compared to other EU Member States – and no two are the same, so each is unique.

The main findings from the CSI are summarised again below, along with some policy reflections and ideas for further refinement of the Index, and related research and measurement work.

Key findings

The CSI indicates that overall, **EU countries are collectively performing competitively better on Society and Governance dimensions of the transition compared to Economy and Environment dimensions**. Among them, four countries are leaders in the overall index (Sweden, Finland, Denmark and the Netherlands). All of them, and Luxembourg, are leaders in the Governance dimension, but none of these or any others performs as a leader in the Environment dimension. Only one country (Finland) is a leader in three dimensions (Economy, Society and Governance), while eight countries perform strongly or as leaders overall, a group that includes Austria, Ireland and Germany in addition to those already mentioned above. Conversely, there is only one country lagging in all dimensions (Bulgaria), two that perform poorly overall (Greece and Romania) and three that are only just ahead of them (Slovakia, Croatia and Hungary).

In the dimension most usually associated with competitiveness, namely the **economy**, **three countries (Finland, Germany and the Netherlands) are clear leaders** in both overall economy-wide transition performance as well as the specific climate neutral innovation ecosystems at the core of a successful transition. A further group of three countries (Austria, Belgium and Sweden) are close behind, and three more (Estonia, Slovenia and Luxembourg) just behind them. In most cases, these same countries perform well at both the overall ecosystem and whole economy levels, but Italy has a stronger ecosystem innovation performance overall, which suggests it may improve in due course. The strength of Germany's performance in the Economy dimension is also significant, given its size and influence on overall EU performance.

For the four leaders, a relatively strong performance in the Society and Governance dimensions does not seem to be the consequence of a greater emphasis on these aspects to the detriment of the Economy and Environment dimensions. Conversely, it suggests that they are approaching the transition in a manner integrated with their competitive advantage overall.

It is noteworthy too that smaller countries that have identified and pursued a sustainability agenda for a longer period appear to perform more competitively overall, as well as in the Economy dimension. Generally these are in Northern and Western Europe. However, there are signs that some newer Member States of the EU are performing more strongly – both Estonia and Slovenia do well in the Economy dimension in particular. However, **weaker performers tend to be found in southern and eastern areas of the EU**,

suggesting that targeted policy interventions to support both economic and other transition dimensions remain very important for the EU overall for its performance to improve.

The average performance of EU countries[xxx] in the innovation ecosystems shows stronger results in the Digital and Energy ecosystems and lower scores in the Mobility, and Land-use & Agri-food ecosystems. These results seem to be in line with the sustained efforts from the European Commission to foster the energy transition over many years now, and to integrate the digital transition throughout. However, they suggest that other ecosystems are lagging in their development and progress, a point further borne out by differences in performance between these ecosystems and the economies as a whole.

No country manages to be a 'Leader' or 'Strong performer' in all six ecosystems, and there is a diversity of leading performers across the ecosystems. Germany and Finland are the best performers when analysing all ecosystems combined, but no country qualifies as 'Leader' when considering the average performance in the six innovation ecosystems. Even the 'Strong performer' category is close to not having any representative. In fact, **22 out of the 27 countries are either 'Moderate' or 'Weak' performers**.

Although EU average performance is similar in both levels, there is a 12-point gap between the best performing country in the Economy/Productivity dimension (Finland) and that in the innovation ecosystems combined (Germany). In fact, overall results at the ecosystem level are lower than those obtained for the whole economy in most countries. All this suggests a **general underperformance in R&I on sustainable economic activities compared to the other components of the countries' economies**.

When considering each of the indicators for the CSI in order to have a picture of EU-wide average performance in them, there are more negative than positive results. This indicates that **there are more areas clustered towards poorer performance than best-in-class.** Of particular note in this respect for the economic competitiveness dimension are those for **entrepreneurial culture, venture capital and gross value added of manufacturing**. The low score for active citizenship also suggests a **worrying disconnect between civil society and policymaking** from a governance perspective, despite the generally better performance in this and the Society dimension. This is especially so when taken together with **poor performance regarding public perception of climate change as a priority**. A number of areas in the Environment dimension give cause for concern, including circular material use, effective carbon rates and water productivity, and **renewable freshwater availability and energy from renewable sources indicators have both particularly low average scores**.

Moreover, **eight of the 31 components** (namely Innovation readiness, Human capital, Education, Social mobility, Fundamental rights, Transparency, Institutional efficacy, and Citizen engagement) are found to **have a transversal impact across three dimensions of competitive sustainability**, and are therefore the best predictors for a country's competitive sustainability in the European Union.

Policy reflections

In terms of the EU's overall approach to the transition to sustainability through the European Semester, and the strategy and framework of the European Commission for developing competitive sustainability, the CSI indicates that the following are key to the EU's competitive performance: the strength of its social market economy and its ability to provide relatively stable, transparent and inclusive public policymaking, along with relatively strong social outcomes. **The institutional framework developed by the EU and the European Semester process is one that provides a strong basis for doing this**, not least as it also seeks to integrate the two dimensions where the CSI indicates that performance is weaker.

Governance performance seems to be the most relevant driver of competitive sustainability. Thus, having some dedicated funding – potentially from the Directorate-General for Structural Reform Support (DG

[xxx] EU-27 average performance for this report has been calculated in all cases as the arithmetic average of the scores of the 27 countries.

REFORM) – to **ensure capacity building in critical areas of public administration could increase countries' performance on governance framework conditions potentially resulting on enhanced competitive sustainability results**.

However, although the average scores in the Economy and Environment dimensions are lower, the best performing EU country in each indicator is usually also a best-in-class performer at a global level, as far as tentative comparisons with other indices available in these areas allow. This suggests that when the CSI is developed to be able to make wider international comparisons by including other countries, it will indicate that EU countries are likely to generally perform well against their competitors overall. Furthermore, it suggests that **where there are leaders in the EU, these are generally global best performers, offering both insight and learning opportunities for other EU Member States**.

The CSI results also suggest that **innovation performance in the economic ecosystems that are essential to effectively achieve a climate neutral economy is, with some notable exceptions, still lagging behind the economy overall**. They also show that there is still a substantial way to go to achieve high levels of performance in those critical areas. Consequently, **Europe should significantly improve its R&I performance on these six key ecosystems if it is to retain its leadership in the global race to achieve a net zero emissions economy**.

There are several areas of EU public policy where these insights are relevant and which are addressed in the European Semester process. The **CSI could be used as a monitoring tool for the European Green Deal overall**. However, perhaps the most important possibility revealed from the CSI is the **potential of collaborative learning on R&I in these areas** in groups of countries with similar structural conditions, and likewise to target the work and funds of DG REFORM.

While the EU should aim to lead on all six innovation ecosystems, Member States should prioritise their allocation of resources. EU countries (in particular smaller ones) should **leverage CSI data to pick a limited number of innovation ecosystems** where they have the highest potential to lead in the near future, and prioritise R&I investments on those ecosystems. **This approach should ideally be aligned with country's ongoing 'smart specialisation' process.**

In that sense, having a **public spending target for competitively sustainable R&I, enshrined in legally-binding EU law** -such as a reformed Stability and Growth Pact- could ensure that competitively sustainable R&I is deployed at the scale that is required.

The improved and more granular collection and analysis of Taxonomy-related data by Eurostat and the European Central Bank (ECB) will enable better performance assessment by the CSI but also other indices and processes. Rapid progress on the valuation of natural capital is also important for improved measurement of environmental performance, which is crucial to determine ultimate success of the transition.

Index development

There is always scope for indices to evolve and improve, and the CSI is no exception. There are a number of immediate possibilities for a second edition, namely:

- Several data sources were only available for the year prior to the Covid-19 pandemic, which prevented their collection, analysis and reporting. Key among these is data from the usually biennial Community Innovation Survey (CIS), a source used in many indicators in the Economy dimension. This is expected to be available again soon and would therefore update the information by four years, reflecting post-pandemic as well as pre-pandemic situations.
- The data for the innovation ecosystems is based on relatively small sample sizes, as they represent the early development stages of activities eligible for the EU Taxonomy. The amount of data is expected to grow as the economic activities themselves grow. Therefore, the sample size will become larger and provide a clearer picture of competitive performance in relation to the economic transition to climate neutrality. At the same time, there is much ongoing work by Eurostat, the ECB, JRC and others with respect to economic data in these areas, all of which may become available and relevant to the CSI.
- There is an ongoing challenge to value, measure and account for biodiversity and ecosystem services, as well as all types of material resources, and in relation to climate issues. As the metrics and associated data on these areas improve and become available, they can also be incorporated into the existing components or replace some current indicators. This work is complex but advancing at international as well as EU levels, and may soon become available.
- For some of the indicators, there is currently no immediately available international data source or obvious proxy available. However, in some cases this is expected to change – for example as more countries seek to use approaches similar to the EU Taxonomy, and the international equivalent of the NACE codes can be applied to them. The extension of the CSI to a wider, international group of countries is therefore planned, and ultimately it may be possible for it be truly global in scope, like some other indices.
- As the whole 'beyond GDP' research effort in the EU and internationally itself develops, there may be further agreement on metrics and data connected to them that can be useful to the CSI as well as others. However, there is much international discussion about how to better measure and track innovation-related data, which the CSI would also be able to benefit and draw from. A key perspective here, as illustrated in the conclusions from the 2022 Global Innovation Index, is the need to better define and measure productivity itself, an endeavour that links both the 'beyond GDP' and innovation agendas, and which the CSI is actively seeking to contribute to.
- When the new CSI is implemented, time-series data will be available and comparisons will become possible. This means the CSI will also be able to track trends over time and to give indications of changes in competitive performance as well as annual snapshots.
- Possible development of the framework and index could be explored to encompass the micro level, such that it could be applied to and used by companies as well as countries.

In conclusion, **the CSI is a first attempt to offer an integrated approach to measuring competitiveness in the transition to sustainability**. It already demonstrates that it is both possible and offers a more holistic perspective than approaches that do not seek to do this and are therefore partial in their insights and conclusions. It will benefit from further scrutiny, use and application, as well as the development of metrics and data sources by others which will strengthen its approach and outputs. In the meantime, the richness of the picture presented and inspiration for new policy thinking or opportunities for collaboration, learning and investment in the EU are already an important step forward. Much like the sustainability transition itself, the CSI will succeed through innovation and experimentation, with a clear long-term goal to drive its thinking and activities.

Annex I: Review of existing frameworks

Table 1. Existing competitiveness and sustainability frameworks identified in literature review

#	FRAMEWORK	REFERENCE ORGANISATION
1	Global Competitiveness Index	World Economic Forum (WEF)
2	Doing Business	World Bank
3	STIP Compass	OECD + EU Commission (DG Research)
4	World Competitiveness Ranking	IMD World Competitiveness Center
5	Competitive Industrial Performance Index	UNIDO
6	Global Manufacturing Competitiveness Index	Deloitte & US Council on Competitiveness
7	Global Innovation Index	WIPO
8	European Innovation Scoreboard	European Commission (DG Growth)
9	Global Sustainable Competitiveness Index	Solability
10	Green Economy Progress Measurement Framework	Partnership for Action on Green Economy (UN + ILO)
11	Transitions Performance Index	European Commission (DG Research)
12	EU Wheel of Competitiveness	Joint Research Centre (JRC)
13	Smart Specialisation Strategies for Sustainability (S4) Priority Compass	Joint Research Centre (JRC)
14	Balanced Scorecard on industrial competitiveness	European Round Table for Industry (ERT)
15	Green Growth Knowledge Platform (GGKP) framework	OECD, UN Environment, World Bank & Global Green Growth Institute
16	Circles of Sustainability	UN Global Compact Cities Programme + partners
17	UN Global Compact Management Model	UN Global Compact
18	Tetrahedral Model of Sustainability	O'Connor (2007)
19	Green Cube Framework	Merino-Saum et al. (2018)
20	Living Standards Framework	New Zealand Treasury
21	Social Progress Index	European Commission (DG GROW)
22	Human Development Index (HDI)	UNDP
23	Human Capital Index Compass	World Bank
24	World Development Report	World Bank
25	Better Life Index	OECD
26	Framework for Measuring Well-Being and Progress	OECD
27	Quality of Living City Ranking	MERCER
28	Happy Planet Index	New Economics Foundation
29	Environmental Performance Index (EPI)	Yale Center for Environmental Law & Policy
30	Environmental Sustainability Index (ESI)	Yale, Columbia, WEF, JRC
31	Ecological Footprint	Global Footprint Network
32	EU Environment Indicators	European Commission (DG Environment)
33	Eco-innovation index	European Commission (DG Environment)
34	Clean Energy Competitiveness	Joint Research Centre (JRC)
35	Competitiveness Research Network (CompNet)	European System of Central Banks
36	UK Competitiveness Index	Centre for International Competitiveness
37	Principles for Responsible Investment (PRI)	UNPRI

38	IRIS+	Global Impact Investing Network (GIIN)
39	Sustainable Value Creation Framework	World Economic Forum (WEF)
40	Total Societal Impact	Boston Consulting Group (BCG)
41	ESG Framework	McKinsey
42	ESG scores	Bloomberg
43	ESG Risk Ratings	Sustainalytics
44	Societal impact solution	Clarity
45	Mission-oriented innovation	UCL Institute for Innovation and Public Purpose (IIPP)
46	Transform2020	US Council on Competitiveness
47	U.S. Competitiveness Project	HBS - Institute for Strategy and Competitiveness
48	Advanced Technology Manufacturing Firms Competitiveness Framework	U.S. International Trade Commission
49	U.S. Strategy for Innovation	National Economic Council and Office of Science and Technology Policy
48	Industry 5.0	European Commission (DG Research)
49	Circular Transition Indicators (CTI)	WBCSD
50	Circulytics	Ellen MacArthur Foundation
51	EU Circular Economy Monitoring Framework	Eurostat
52	Circular Impact Measurement and Financial Reporting	Circle Economy
53	ASEM Eco-Innovation Index (ASEI)	ASEM SMEs Eco-Innovation Center
54	Global Cleantech Innovation Index	Cleantech
55	Global Green Economy Index	Dual Citizen
56	Renewable Energy Country Attractiveness Index (RECAI)	Ernst & Young
57	G20 low carbon competitiveness report and index	Vivid Economics
58	Catalyzed Emissions Reduction Framework	CDP and Breakthrough Energy

Annex II: Frameworks selected for in-depth analysis

Table 2. Most relevant frameworks identified in the review

#	FRAMEWORK	REFERENCE ORGANISATION
1	EU Competitiveness	EU Competitiveness Council
2	Annual Single Market Report	European Commission (DG GROW)
3	European Innovation Scoreboard	European Commission (DG GROW)
4	Transitions Performance Index	European Commission (DG RTD)
5	Competitiveness in Low-carbon Industries	Joint Research Centre (JRC)
6	Clean Energy Competitiveness	Joint Research Centre (JRC)
7	Clean Energy Innovation Index	European Commission (DG RTD)
8	Eco-Innovation Index	European Commission (DG ENVI)
9	Global Sustainable Competitiveness Index	Solability
10	Competitiveness Assessment Framework	ICF and Cleantech Group
11	Global Cleantech Innovation Index	Cleantech Group
12	Competitiveness for well-being	Orkestra – Basque Institute of Competitiveness
13	Social Progress Index	European Commission (DG GROW)

Annex III: Conceptual framework

ECONOMY / PRODUCTIVITY DIMENSION

Rationale: Independent of considerations of sustainability transitions, innovative capacity rather than a narrow focus on productivity (the rate of output per unit of input) has been increasingly considered a strategic imperative for advanced economies whose advantage in other factors of competitiveness (such as cost, technical effectiveness, proximity to market or brand reputation) may either be lesser, shorter-term in nature or dependent on it.

For any of the world's economies undergoing the transition to climate neutrality and sustainability upon which the global community has embarked, ability to innovate away from unsustainable activities and towards this overarching goal at the requisite pace is increasingly a defining feature of ability to maintain or enhance its competitive performance over time. While productivity remains relevant, without the direction and pace given by the imperative of sustainability transitions, it risks providing a partial or even contradictory indication of progress in a way that purposeful innovation does not. Such innovation is therefore a defining feature of competitive sustainability and the ecosystems and value chains in which it is necessary is equally central to its analysis and assessment.

The innovation ecosystems relevant to the climate neutrality and sustainability transitions are those which have the largest current negative impacts and economic significance for the relevant economy – namely those related to energy, buildings, mobility, industry and agriculture & land-use, and increasingly a range of material and energy-intensive digital economy activities. As each of these ecosystems is embedded in the wider country-level economy, there are some framework conditions and enablers of innovation that will be relevant to each and tracked as such. This framework identifies Business fabric, Human capital and Innovation readiness as the most important components for this. Likewise, the performance of the specific innovation ecosystems will contribute to impacts for the economy overall at country-level, and the framework identifies three components as the most important: Jobs, Wealth and Industrial base.

For the innovation ecosystems, there may be differences relative to the country-level performance, so components have been identified which can track these. The components identified as the key innovation enablers distinct from those for the country-level (business R&D investment and Innovation capacity), and those which track innovation outputs that may also be distinct from country-level performance (Intellectual Property, Innovation activity, Entrepreneurial activity, Trade and Employment) are tracked using indicators and data on EU Taxonomy-eligible activities (see Annex IV: Integrating the EU Taxonomy into the Index for more details on the Taxonomy-eligible activities). By adding the Taxonomy eligibility filter, the innovation analysis is restricted to those economic activities that are sustainable and will not be phased out in the transition, and the market demand for which will grow, implying that competitive advantage should be enhanced as these indicators improve.

The details of each indicator are set out in Annex VI: Sources and definitions.

Framework conditions (at whole economy level)

Innovation readiness

Rationale: this component captures the physical and financial infrastructure and human resources available which make an economy ready for innovation. It comprises the following three indicators: the extent of broadband penetration at home, the percentage of government, higher education and non-profit expenditure on R&D in relation to total R&D expenditure and the percentage of the population with advanced ICT skills. High figures in each indicator are positive indicators of innovation readiness.

Human capital

Rationale: this component captures the availability of a workforce within the economy with innovation-relevant skills, a prerequisite for success innovation. It comprises the following indicators: the percentage of

the population aged 25-34 with tertiary education; the extent of tertiary education graduates in science, mathematics, computing, engineering, manufacturing and construction; and the percentage of doctorate students which is foreign. High figures in each indicator are positive indicators that there is human capital is sufficiently available to drive innovation.

Business fabric

Rationale: this component captures the diversity and culture of the businesses in the economy that are most relevant to their innovative capability and therefore their potential to innovate. It comprises the following indicators: the share of turnover in the economy of large enterprises and the extent to which there is an entrepreneurial culture. High figures in these indicators reflect that the business fabric is favourable for innovation.

Innovation enablers (at innovation ecosystem level)

Rationale: the components and indicators at ecosystem level address more specific enablers of economic innovation and use data that is related to activities from ecosystems whose activities are eligible for the EU Taxonomy. The two components relate to the extent to which there is business R&I investment and innovation capacity available which capture early-stage innovation cycle activities.

Business R&I investment

Rationale: this component captures investment in Research, development and innovation (R&I) which is a key determinant of economic growth and is of fundamental importance in the creation of the knowledge and technologies that are needed to achieve a climate neutral and sustainable economy. It is tracked in this component using five different indicators that address different aspects of R&I investment cycle for activities included in the EU Taxonomy, such as expenditure by business on R&I, public support on R&I for businesses, and financing of R&I for private companies.

Innovation capacity

Rationale: this component captures the capacity of an ecosystem to innovate in practice, which is important in addition to availability of necessary investment. To address this stage of the R&I innovation cycle, the indicators in the component focus on the extent of early-stage activities by companies in the area and conversely the extent to which they feel hampered in these activities for some reason. Higher scores in the former and lower scores in the latter are indicative of greater capacity for innovation.

Outputs (at innovation ecosystem level)

Rationale: the results of the investment and early-stage activity in R&I are addressed in a series of components which are related to measures typically used to track the success in practice of investment and innovation activities – but which are specifically tracked in this Index for economic activities included in the various ecosystems addressed by the EU Taxonomy.

The components included in the innovation outputs sub-dimension cover the extent of applications for Intellectual Property Rights, close to market activity by innovative businesses involved in activities included in the EU Taxonomy, measures of entrepreneurial activity in these areas (covering areas such as new company formations and growth rates) and measures of both trade and employment from these activities. These are typically considered to be core indicators of competitive success and as indicated earlier.

Intellectual property rights (IPR)

Rationale: this component tracks the Patents, trademarks and designs which indicate country's capacity to exploit knowledge and translate it into potential competitive and economic gains. The number of patents, trademarks and designs is often used to assess the inventive performance. The indicators selected measure the number of firms in economic activities considered eligible under EU Taxonomy Regulation filing patent applications under the PCT, at international phase, designating the European Patent Office (EPO), or filing applications for trade-marks or designs with the EUIPO.

Innovation activity

Rationale: this component tracks Innovation activity according to the extent of collaboration between companies in a given ecosystem, which is indicative of higher dynamism, the turnover of innovative companies and the extent of product innovations introduced. The three indicators in this component track each of these aspects, all related once again to economic activities included in the EU Taxonomy.

Entrepreneurial activity

Rationale: this component tracks business creation in Taxonomy-eligible activities which is a good thermometer for the level of development in the economic activities that can make a substantial contribution to the sustainability transition. The indicators selected track this in two different ways: The numbers of new firms and the numbers of such firms that are resilient, which are indicators of stronger competitive performance.

Trade

Rationale: this component measures trade-related activity in economic activities considered eligible under EU Taxonomy Regulation from new or significantly improved products, and is indicative of the competitiveness of the ecosystem internationally. The two indicators address the weight of product innovation and the trade balance in these products. All of these are signs of competitiveness on the global market, as well as indicative of resilience and autonomy because a trade surplus in these critical economic activities is indicative of a better competitive position for the transition to a climate neutral and sustainable economy.

Employment

Rationale: this component tracks levels of employment as these are frequently offered as an indicator of competitive success based on growth of production in a given ecosystem to meet market demand. The aim of measuring the percentage of total employment that is working in innovative companies within the economic activities included in the Taxonomy is to assess the weight of innovation in Taxonomy-eligible activities (in terms of employment). Higher levels of employment in innovative enterprises reflect greater relevance of innovation in these ecosystems.

Impacts (at whole economy level)

Wealth

Rationale: this component tracks wealth generation in terms of GDP but relate it also to the extent of EU Taxonomy eligible and aligned activities in order to reflect the role of these activities in the transition appropriately and uses three indicators to do this. Although the Competitive Sustainability Index adopts a comprehensive and inclusive approach following a 'Beyond GDP' logic, GDP per capita remains a relevant indicator to assess economic growth and wealth in particular. Higher levels of GDP per capita reflect higher levels of wealth. The weight of Taxonomy-eligible activities in the country's economy (in terms of GDP) and higher shares of GDP from Taxonomy-eligible activities reflect higher relevance of those activities in the economic structure of the country. The indicator captures the weight in the economy (in terms of GDP) of the activities substantially contributing to climate change mitigation[xxxi]. Higher shares of GDP from Taxonomy-aligned activities reflect higher relevance of those activities in the economic structure of the country.

Industrial structure

Rationale: This component uses three indicators to track investment levels and complexity of industrial activity. They measure the extent to which there is venture capital investment in cleantech companies as a proportion of GDP, which is indicative of growth industries and markets necessary for the transition to sustainability, and in the extent of complexity of the economy, which is considered to be a good reflection

[xxxi] The methodology used for Taxonomy-alignment estimation only considers one of the six environmental objectives in EU Taxonomy (i.e. climate change mitigation). A more detailed explanation on the methodology is available at: https://joint-research-centre.ec.europa.eu/publications/two-sides-same-coin-green-taxonomy-alignment-versus-transition-risk-financial-portfolios_en

ability to attract new investment, and extent of value added provided to overall GDP by manufacturing, which is indicative of resilience.

Jobs

Rationale: this component tracks three aspects of employment which are relevant to an economy's ability to perform well in competitive sustainability: overall employment rate, average earnings and job security.

Work has obvious economic benefits, but having a job also helps individuals stay connected with society, build self-esteem, and develop skills and competencies. Societies with high levels of employment are also richer, more politically stable and healthier.

The wages and other monetary benefits that come with employment are an important aspect of job quality. Earnings represent the main source of income for most households. Analysing earnings may also suggest how fairly work is remunerated.

Job security is another essential factor of employment quality in terms of expected loss of earnings when someone becomes unemployed. This includes length of unemployment and how much government financial assistance you can expect.

SOCIETY / FAIRNESS DIMENSION

Rationale: this dimension aims at assessing whether economic growth is achieved at the same time as improving society more broadly, notably in relation to equality or 'fairness'. A competitively sustainable economy must ensure that the economic resources that are being generated are used efficiently to fairly meet societal needs. The Index premise is that a fair society must provide a welfare state that includes: (i) suitable education; (ii) basic nutrition, housing and medical care; and (iii) adequate access to work. These are considered to be the fundamental conditions for an (i) inclusive; (ii) equal; and (iii) healthy society, which are considered to be impacts that can be measured for competitive sustainability performance.

Framework conditions (at whole economy level)

Education

Rationale: education is widely considered to be a prerequisite for a sustainable and fair society. Public funding of education is an effective measure of the relevance of education in the political agenda. Having a highly educated society is a competitive advantage with strong social benefits and tracking the highest level of educational attainment is an appropriate measure for that purpose. Moreover, the twin transitions will result in profound shifts in the EU labour market and related skills. Thus, lifelong learning has become a requirement for a competitively sustainable society.

Basic needs

Rationale: an economy that works for the people necessarily needs to cover people's essential day-to-day needs. Basic medical care is an indispensable condition of social progress as it provides the elementary quality of life that advanced societies must strive for. Moreover, adequate nutrition is a basic human right with significant implications on people's health and thus on their living conditions.

Social mobility

Rationale: social mobility is a critical enabling factor in the creation of a society with reduced levels of inequality. Having access to sufficient job opportunities and ensuring that no one is left behind are key ingredients for social cohesion and harmony. Satisfactory working conditions should be accessible to everyone and education plays an essential role for job security and improving social mobility.

Impacts (at whole economy level)

Inclusivity

Rationale: social inclusion is vital in order to strive for a fair society. In order to provide quality inclusion, society needs to tolerate differences and prevent social isolation. An inclusive society may have significant implications achieving higher development outcomes such as economic growth, local service provision, and political stability.

Equality

Rationale: fairness entails monitoring how well countries are doing in reducing inequalities, bridging social gaps and building a recovery that includes everyone. Reducing inequalities and ensuring no one is left behind are integral to achieving competitive sustainability.

Health

Rationale: the COVID-19 pandemic has underlined how good health is one of the most important elements to people's well-being and also brings many other benefits that go beyond the components considered in this dimension. These include enhanced access to education and to the job market, an increase in productivity and wealth, reduced health care costs, good social relations, and of course, a longer life.

GOVERNANCE / STABILITY DIMENSION

Rationale: this dimension aims at assessing the correct functioning of democracy as an essential pillar of competitive sustainability. A resilient and stable governance system requires an efficient use of public resources in a society where everyone feels empowered to act freely and contribute to societal well-being. The extent to which (i) fundamental rights; (ii) transparency; and (iii) institutional efficacy are preserved, provides an adequate framework to ensure that (i) democracy, (ii) community commitment and (iii) strategic autonomy are attained so that macro-economic stability is maintained.

Framework conditions (at whole economy level)

Fundamental rights

Rationale: fundamental rights are a prerequisite for a sound democracy and a basic component of competitive sustainability. The selected indicators measure the extent to which citizens have their institutional rights preserved. Increased voice and accountability are considered vital for the development of institutions that generate equal opportunities and access to resources. Rule of law reflects the confidence and respect citizens have for the rules of their society. And the ability to make decisions of one's own free is an essential pillar of democratic societies.

Transparency

Rationale: transparency is essential to generate trust in public institutions. Open government is increasingly considered a catalyst for public governance, democracy and inclusive growth. Greater transparency is not only key to upholding integrity in the public sector but it also contributes to better governance. Freedom of the press holds structures of power accountable and safeguards the proper functioning of a democratic society.

Institutional efficacy

Rationale: institutional efficacy may contribute to developing competitive advantages and can have a significant impact on a country's capacity to deploy resources and attract investments. The transition to climate neutrality is going to require huge investments in technologies and infrastructures that often depend on public resources. The effectiveness of public services and the legitimacy of public institutions may play an important role in countries' capacity to excel in the net-zero race.

Impacts (at whole economy level)

Sound governance

Rationale: in managing the sustainability transition responsibly, governments need to balance the pace of innovation with public reassurance and institutional stability to reduce other risks involved. Sound governance is tracked in this component through indicators on the extent of public debt and the degree to which there is public trust in their governments.

Citizen engagement

Rationale: as an indicator of the health of civic society and the legitimacy of the relationship between a government and its people, the extent to which there is active citizen engagement in different aspects of public life is important. This component addresses this by tracking polling evidence of active citizenship and volunteering and by turnout in elections.

Security and resilience to external shocks

Rationale: As the economy and society transition to sustainability, there are both public concerns and moments of disruption which can challenge the successful continuation of the process and there will be competitive advantage to those which are most successful in minimising these risks and maximising their resilience. To reduce the risk of these and enhance the resilience of a country to them, there are several dimensions which policy-makers have focused on in relation to security of supply of both energy and materials, as well as to infrastructure, notably digital, and on the reduction of security threats of all kinds, whether military, criminal or civil. This component tracks these different dimensions using four distinct indicators (on energy important dependency, circular material use rate, the cyber-security index and security apparatus index) to provide a picture of the resilience and security of the country overall.

GREEN / ENVIRONMENT DIMENSION

Rationale: The Environment / Climate Neutrality dimension tracks performance with regards to key global and regional public policy goals which seek to ensure that the planetary boundaries which represent the limits of the support that natural ecosystems can provide to maintain viable human society as at present. The interconnected and complex crises of key importance to these planetary boundaries are those related to climate change, biodiversity decline and over-consumption of natural resources, all of which are urgent and require significant changes to human behaviour, society and economic activity in order to rectify.

There are different levels of international consensus with regards to reaching international or global agreements on targets for protection or restoration of each, but the three components selected for measurement in relation to enabling conditions and impacts reflect these priorities and to the extent possible, public goals and metrics agreed for them. This is most advanced and clearest with respect to climate change, where the Paris Agreement provides a clear framework for action to towards mid and longer terms goals and ways of measuring this. Those for biodiversity and resources use are less clearly defined, and the international science and policy around them is still developing, but indicators have been identified within each component to offer reasonable proxies for them.

In summary, the framework considers that an economy that is effectively transitioning to one that operates within planetary environmental boundaries requires (i) a shift to an energy system based on renewable energy sources (ii) having a clear commitment at business, policy and society levels to the sustainability and climate transitions; and (iii) the preservation and enhancement of its natural resources. How these factors are managed should be manifested in a country's (i) higher resource productivity; (ii) rapidly decreasing GHG emissions; and (iii) sustained or enhanced level of biodiversity. Without these indicators improving, even if the economy and innovation indicators are doing so, they are not delivering competitive sustainability.

Framework conditions (at whole economy level)

Rationale: the framework conditions for progress that have been selected reflect the extent to which there are clear available public policy commitments and action on climate and sustainable development, as these

are considered to be an important pre-condition for real-world progress in practice. The two other components selected as framework conditions are the availability of renewable energy and extent of natural ecosystems within the jurisdiction of the relevant country.

Renewable energies

Rationale: the indicators for this component consider the availability of wind and solar resources and the share of renewable energies in the total energy mix and the effective taxation rate of fossil fuels, higher performance in each being considered positive as an indicator of potential to transition to a net-zero emissions energy system.

The extent of installed wind and solar capacity, and the percentage of gross final consumption of electricity coming from renewable sources, are indicative of the potential ability of the economy to achieve net zero GHG emissions from its electricity, which is a key enabler of emissions reduction in end uses such as mobility, buildings and industry.

Sustainability transition commitment

Rationale: the indicators in this component reflect the extent of public and governmental commitment to the sustainability transition, which is important for its future success in action. A high level of public concern about climate change relative to other issues, as evidenced by reliable and regular opinion polling, is typically indicative of a stronger level of policy commitment by the government. Conversely, lower levels of concern are typically indicative of weaker policy commitment. Effective carbon rates and fossil fuel subsidies indicators are a measure of governmental support for this agenda, either positively or negatively so.

The other indicator reflects public opinion and support for action. With government action reflecting its view of the public interest, popular opinion is in many countries, a significant influence on the strength of commitment to a particular issue.

Natural resources

Rationale: The indicators in this component reflect the extent to which natural resources are protected and used in a way that could enable positive outcomes from a natural ecosystem perspective. The extent to which arable land is productive for its population and renewable freshwater are available to them are indicative of natural resources which are already being sustainably managed. The percentage of land area taken by forest is indicative of the capacity of the natural environment to support higher levels of biodiversity and provide natural emissions sinks which are especially relevant to climate change mitigation.

Impacts (at whole economy level)

Rationale: in order to track progress on these, indicators of impacts have been selected to reflect the need to track progress in staying within the three key planetary boundaries of climate, biodiversity and resources. With regards to climate change, success in reducing GHG emissions is clearly the most important measure of progress to track, and metrics that track progress with regards to energy and resource use in relative terms have been identified, along with the extent to which biodiversity and natural ecosystems are maintained or enhanced.

Resource productivity

Rationale: the indicators in this component related to the material, water and energy use and productivity, all three being relevant to the extent to which consumption of resources is moving towards levels that are within planetary boundaries.

Material flows and resource productivity indicators are central to monitoring progress towards a sustainable economy through sustainable production and consumption strategies. The extent to which resource is not wasted and its value is retained indicates a transition to more circularity, which is itself widely recognised as an essential element in efforts to achieve climate neutrality and biodiversity protection. The per capita material footprint targets reflect recently recognised planetary boundaries.

Freshwater use by human societies can puts pressure on natural ecosystems and as availability becomes scarcer and less reliable, water productivity becomes an important indicator of sustainability. High water productivity is indicative of less intensive use so higher levels productivity can be indicative of higher levels environmental protection.

The indicator on productivity of energy consumption provides a picture of the degree of decoupling of energy use from growth in GDP, which is itself indicative of a more sustainable consumption of resources compatible with planetary boundaries.

Climate emissions

Rationale: the indicator in this component is relevant to the transition in climate neutrality in particular but also to reducing air pollution with a negative impact on human health. GHG emissions intensities are relevant for monitoring the interaction between the economy and the environment, in particular in a context of the transition to climate neutrality. A low intensity figure is indicative is higher economic performance with less negative environmental and climate impact, while conversely a higher figure is indicative of lower economic performance with a greater negative environmental and climate impact.

Biodiversity

Rationale: protecting and restoring biodiversity to within planetary boundaries is key for the successful achievement of sustainable development, as without it the survival of humankind in the medium to long term will be compromised. Biodiversity is the key indicator of the health of an ecosystem, as a wide variety of species cope better with threats than a limited variety of species.

There is no single agreed indicator or indeed set of indicators available to measure biodiversity, but to provide a reasonable proxy picture in the absence of this, the component biodiversity is measured here by three indicators considered to be relevant as proxies: (i) protected areas on land, (ii) protected areas in freshwater; and (iii) in the much larger non-protected areas such as farmland with the use of pesticides in cropland.

Annex IV: Integrating the EU Taxonomy into the Index

The EU taxonomy is a classification system, establishing a list of environmentally sustainable economic activities. The Taxonomy Regulation sets out the conditions for an economic activity to be 'taxonomy-eligible' ensuring that the activity makes a substantial contribution to at least one of the environmental objectives and does not significantly harm to any of the other environmental objectives.

This scoreboard develops in two levels. First, all indicators are presented at country level. Second, indicators included in the Economy/Productivity dimension and discuss country performance by focusing on the part of the national economy that is Taxonomy eligible (Innovation enablers and Outputs sub-dimensions), are also presented at ecosystem level.

For each country and Taxonomy-related indicator, the Competitive Sustainability Index observes country performance along six ecosystems:

- Energy;
- Industry;
- Mobility;
- Building and Consumables;
- Land-use and Agri-Food;
- Digital and Others.

Classification of the innovation ecosystems

The six innovation ecosystems have been built using the EU Taxonomy[xxxii] as a method to establish the economic activities that can be considered sustainable as they substantially contribute to the climate objectives and the other environmental objectives of the Taxonomy Regulation.

In particular, the classification process builds on the list of sustainable activities from the EU Taxonomy Compass[xxxiii]. This tool provides a visual representation of the contents of the EU Taxonomy, starting with the Delegated Act on the climate objectives (climate change mitigation and climate change adaptation), as published in the Official Journal on 9 December 2021. The Climate Delegated Act entered into force on 1 January 2022. Economic activities included in the Complementary Climate Delegated Act of March 2022 (nuclear and gas) have not been considered as they were not included in the list of economic activities covered by the EU taxonomy at the time of this analysis.

All the activities listed under the EU Taxonomy Compass at the time of this analysis have been classified into only one of the six innovation ecosystems. Although some of the NACE codes[xxxiv] associated with the Taxonomy activities may be covered in several activities within the same ecosystem, each NACE code has only been considered once in each ecosystem to avoid double counting.

The classification was conducted by a reduced group of experts working closely on the project and then shared with an extended group of experts for its validation. The substantiated feedback obtained in the consultation was then applied to the classification.

The following tables illustrate the economic activities and related NACE codes attributed to each ecosystem.

Table 6. Energy ecosystem

	EU Taxonomy Activity	NACE
3.1	Manufacture of renewable energy technologies	C25, C27, C28
3.2	Manufacture of equipment for the production and use of hydrogen	C25, C27, C28
3.4	Manufacture of batteries	C27.2 and E38.32
3.6	Manufacture of other low carbon technologies	C22, C25, C26, C27, C28
3.10	Manufacture of hydrogen	C20.11
3.11	Manufacture of carbon black	C20.13
4.1	Electricity generation using solar photovoltaic technology	D35.11, F42.22
4.2	Electricity generation using concentrated solar power (CSP) technology	D35.11, F42.22
4.3	Electricity generation from wind power	D35.11, F42.22
4.4	Electricity generation from ocean energy technologies	D35.11, F42.22
4.5	Electricity generation from hydropower	D35.11, F42.22
4.6	Electricity generation from geothermal energy	D35.11, F42.22
4.7	Electricity generation from renewable non-fossil gaseous and liquid fuels	D35.11, F42.22
4.8	Electricity generation from bioenergy	D35.11
4.9	Transmission and distribution of electricity	D35.12, D35.13
4.10	Storage of electricity	
4.11	Storage of thermal energy	
4.12	Storage of hydrogen	

[xxxii] See. EU Taxonomy
[xxxiii] See. EU Taxonomy Compass
[xxxiv] See. NACE

4.14	Transmission and distribution networks for renewable and low-carbon gases	D35.22, F42.21, H49.50
5.6	Anaerobic digestion of sewage sludge	E37.00, F42.99
5.10	Landfill gas capture and utilisation	E38.21

Table 7. Industry ecosystem

	EU Taxonomy Activity	NACE
3.8	Manufacture of aluminium	C24.42 (non-ferrous)
3.9	Manufacture of iron and steel	C24.10, C24.20, C24.31, C24.32, C24.33, C24.34, C24.51, C24.52
3.12	Manufacture of soda ash	C20.13
3.13	Manufacture of chlorine	C20.13
3.14	Manufacture of organic basic chemicals	C20.14
3.15	Manufacture of anhydrous ammonia	C20.15
3.16	Manufacture of nitric acid	C20.15
3.17	Manufacture of plastics in primary form	C20.16
5.1	Construction, extension and operation of water collection, treatment and supply systems	E36.00, F42.99
5.2	Renewal of water collection, treatment and supply systems	E36.00, F42.99
5.3	Construction, extension and operation of waste water collection and treatment	E37.00, F42.99
5.4	Renewal of waste water collection and treatment	s E37.00
5.5	Collection and transport of non-hazardous waste in source segregated fractions	E38.11
5.9	Material recovery from non-hazardous waste	E38.32, F42.99
5.11	Transport of CO2	F42.21, H49.50
9.1	Close to market research, development and innovation	M71.1.2, M72.1
9.1	Engineering activities and related technical consultancy dedicated to adaptation to climate change	M71.12
9.2	Research, development and innovation for direct air capture of CO2	M71.1.2, M72.1

Table 8. Mobility ecosystem

	EU Taxonomy Activity	NACE
3.3	Manufacture of low carbon technologies for transport	C29.1, C30.1, C30.2, C30.9, C33.15, C33.17
4.13	Manufacture of biogas and biofuels for use in transport and of bioliquids	D35.21
6.1	Passenger interurban rail transport	H49.10, N77.39
6.2	Freight rail transport	H49.20, N77.39
6.3	Urban and suburban transport, road passenger transport	H49.31, H49.3.9, N77.39, N77.11
6.4	Operation of personal mobility devices, cycle logistics	N77.11, N77.21
6.5	Transport by motorbikes, passenger cars and light commercial vehicles	H49.32, H49.39, N77.11
6.6	Freight transport services by road	H49.4.1, H53.10, H53.20, N77.12

6.7	Inland passenger water transport	H50.30
6.8	Inland freight water transport	H50.4
6.9	Retrofitting of inland water passenger and freight transport	
6.10	Sea and coastal freight water transport, vessels for port operations and auxiliary activities	H50.2, H52.22, N77.34
6.11	Sea and coastal passenger water transport	H50.10, N77.21, N77.34
6.12	Retrofitting of sea and coastal freight and passenger water transport	
6.13	Infrastructure for personal mobility, cycle logistics	F42.11, F42.12, F43.21, F71.1, F71.20
6.14	Infrastructure for rail transport	F42.12, F42.13, M71.12, M71.20, F43.21, H52.21
6.15	Infrastructure enabling road transport and public transport	
6.15	Infrastructure enabling low-carbon road transport and public transport	F42.11, F42.13, F71.1, F71.20
6.16	Infrastructure for water transport	F42.91, F71.1 or F71.20
6.16	Infrastructure enabling low carbon water transport	F42.91, F71.1 or F71.20
6.17	Low carbon airport infrastructure	F41.20, F42.99
6.17	Airport infrastructure	

Table 9. Buildings ecosystem

	EU Taxonomy Activity	NACE
3.5	Manufacture of energy efficiency equipment for buildings	C16.23, C23.11, C23.20, C23.31, C23.32, C23.43, C.23.61, C25.11, C25.12, C25.21, C25.29, C25.93, C27.31, C27.32, C27.33, C27.40, C27.51, C28.11, C28.12, C28.13, C28.14
3.7	Manufacture of cement	C23.51
4.15	District heating/cooling distribution	D35.30
4.16	Installation and operation of electric heat pumps	D35.30, F43.22
4.17	Cogeneration of heat/cool and power from solar energy	D35.11, D35.30
4.18	Cogeneration of heat/cool and power from geothermal energy	D35.11, D35.30
4.19	Cogeneration of heat/cool and power from renewable non-fossil gaseous and liquid fuels	D35.11, D35.30
4.20	Cogeneration of heat/cool and power from bioenergy	D35.11, D35.30
4.21	Production of heat/cool from solar thermal heating	D35.30
4.22	Production of heat/cool from geothermal energy	D35.30
4.23	Production of heat/cool from renewable non-fossil gaseous and liquid fuels	D35.30
4.24	Production of heat/cool from bioenergy	D35.30
4.25	Production of heat/cool using waste heat	D35.30
7.1	Construction of new buildings	F41.1, F41.2, including also activities under F43
7.2	Renovation of existing buildings	F41, F43
7.3	Installation, maintenance and repair of energy efficiency equipment	F42, F43, M71, C16, C17, C22, C23, C25, C27, C28, S95.21, S95.22, C33.12

7.4	Installation, maintenance and repair of charging stations for electric vehicles in buildings (and parking spaces attached to buildings)	F42, F43, M71, C16, C17, C22, C23, C25, C27 or C28
7.5	Installation, maintenance and repair of instruments and devices for measuring, regulation and controlling energy performance of buildings	F42, F43, M71, C16, C17, C22, C23, C25, C27, C28
7.6	Installation, maintenance and repair of renewable energy technologies	F42, F43, M71, C16, C17, C22, C23, C25, C27 or C28
7.7	Acquisition and ownership of buildings	L68
9.3	Professional services related to energy performance of buildings	M71

Table 10. Land-use and Agri-Food ecosystem

	EU Taxonomy Activity	NACE
1.1	Afforestation	A2
1.2	Rehabilitation and restoration of forests, including reforestation and natural forest regeneration after an extreme event	A2
1.3	Forest management	A2
1.4	Conservation forestry	A2
2.1	Restoration of wetlands	
5.7	Anaerobic digestion of bio-waste	E38.21, F42.99
5.8	Composting of bio-waste	E38.21, F42.99
5.12	Underground permanent geological storage of CO2	E39.00

Table 11. Digital and other ecosystem

	EU Taxonomy Activity	NACE
8.1	Data processing, hosting and related activities	J63.11
8.2	Data-driven solutions for GHG emissions reductions	J61, J62, J63.11
8.2	Computer programming, consultancy and related activities	J62
8.3	Programming and broadcasting activities	J60
10.1	Non-life insurance: underwriting of climate-related perils	K65.12
10.2	Reinsurance	K65.20
11.1	Education	P85
12.1	Residential care activities	Q87
13.1	Creative, arts and entertainment activities	R90
13.2	Libraries, archives, museums and cultural activities	R91
13.3	Motion picture, video and television programme production, sound recording and music publishing activities	J59

Construction of the innovation ecosystems

The EU Taxonomy offers a great level of detail (4-digit NACE granularity) in the description of the activities that are to be considered sustainable. However, the data sources identified don't offer the same level of data disaggregation for most of the indicators included in the Competitive Sustainability Index.

Thus, the methodology for the construction of the Taxonomy indicators had to be adjusted to the data reporting limitations presented by the four data sources used for this part of the analysis:

- Community Innovation Survey (CIS2018)[xxxv]
- Structural Business Statistics (SBS)[xxxvi]
- Annual National accounts (NAMA10)[xxxvii]
- COMEXT[xxxviii]

The adjustment between the classification NACE codes originally listed in the EU Taxonomy and the observed codes available in data sources has been done based on the Taxonomy eligibility criteria of the closer code available to the originally intended. That is, for each NACE code listed in the classification of the innovation ecosystems, data availability was checked. When data was available at the same level of disaggregation, no further adjustment was required. When data was not available at the same level of disaggregation (4 digit), data availability at the superior NACE code level was checked (3, 2 and 1-digit levels). When available, Taxonomy eligibility of the NACE code with data availability was confirmed before its inclusion.

The approach followed tries to mirror as accurately as possible the NACE codes included in EU Taxonomy in each case to capture Taxonomy-eligible activity as precisely as data availability allows. This means that for each data source, the most similar set of NACE codes available has been considered, despite the potential statistical inconsistencies that having different data points for Taxonomy-related indicators may trigger.

Taxonomy eligibility and alignment criteria have been applied following the method developed by Lucia Alessi (European Commission's Joint Research Centre) and Stefano Battiston (University of Zurich and University Ca Foscari of Venice) in their seminal work (Alessi and Battiston, 2021)[xxxix]. Whenever a NACE code presented a majority of subcodes eligible, the code was considered eligible for the purpose of this analysis.

The only exception to this norm has been the inclusion of A (Agriculture, forestry and fishing) data for COMEXT indicators in the Land-use and Agri-food ecosystem as considered extremely relevant for the logic of the ecosystem, although only one (A2 - Forestry and logging) out of the three subcodes is considered eligible.

The table below shows the summary of NACE codes considered for the innovation ecosystems based on data reporting limitations in each data source and avoiding double counting.

Table 12. NACE codes by dataset

Dataset	NACE codes considered for country aggregation
CIS2018	A02, C16, C17, C22, C23, C25, C26, C27, C28, D351, D353, E36, E37, E39, F, H49, H50, H53, J61, J62, L, M71
SBS	C16, C22, C23, C26_C27, C28, D, E, F, H49, H50, H53, L68, M71, M721, N771, N7721, N7734, N7739, J60, J61, J62, P85, Q87, R90, R91.

[xxxv] See. Community innovation survey 2018 (CIS2018) (inn_cis11) (europa.eu)
[xxxvi] See. Structural business statistics (sbs) (europa.eu)
[xxxvii] See. Annual national accounts (nama10) (europa.eu)
[xxxviii] See. International trade in goods - trade by enterprise characteristics (TEC) (ext_tec) (europa.eu)
[xxxix] Alessi and Battiston (2021). Two sides of the same coin: Green Taxonomy alignment versus transition risk in financial portfolios. Retrieved from: https://joint-research-centre.ec.europa.eu/publications/two-sides-same-coin-green-taxonomy-alignment-versus-transition-risk-financial-portfolios_en

NAMA10	A02, C16, C17, C22, C23, C25, C26, C27, C28, E, F, H49, H50, H53, J61, K65, L, M71
COMEXT	A, C16, C17, C22, C23, C25, C26, C27, C28, D, E, F, H, J, L

The above table shows that F42 is not reported by most datasets. F42 is the only NACE code that was estimated as a function of F, using reported shares of F42 (unobserved) in F (observed). The F42 shares are based on Annual detailed enterprise statistics for Construction reported from the Structural business statistics dataset of Eurostat. To derive an appropriate F42 share, we derive different shares for turnover, number of enterprises, employment and production value. On indicators that discuss turnover, the turnover share is used, similarly for number of enterprises, employment and production value. Annex VI: Sources and definitions presents information relating to each Taxonomy indicator, including details on the estimation of F42.

The construction of the country level indicators is done by means of aggregation, based on the list of NACE codes presented in the above table, and controlling for double count. All indicators are observed in units that are possible to aggregate from the level of the observed NACE code to that of the country. Most indicators are observed in absolute terms. The few that are observed in relative terms, are observed as a share of an indicator that remains constant across NACE categories, e.g. GDP that is observed at the country level.

Finally, all indicators are expressed in relative terms to allow for comparisons across countries. Indicators that are not observed in relative terms, are reported in relative terms by dividing with total economic activity within the taxonomy eligible economy. For instance*, Enterprises that received public funding for research and development (R&D) or other innovation activities* is expressed as a share of enterprises in Taxonomy-eligible activities. *Turnover of innovative enterprises in Taxonomy-eligible activities* is expressed as a share of turnover generated in Taxonomy-eligible activities.

The methodology for the construction of the Taxonomy indicators by ecosystem follows a similar approach, taking under consideration the data reporting limitation of each dataset. The tables below present the distribution of NACE codes by ecosystem and dataset.

Table 13. Energy ecosystem

Dataset	NACE codes considered
CIS2018	C22, C25, C26, C27, C28, D351, E37, F42
SBS	C22, C25, C26_C27, C28, D, F42
NAMA10	C22, C25, C26, C27, C28, D, E37, F42
COMEXT	C22, C25, C26, C27, C28, D, F42

Table 14. Industry ecosystem

Dataset	NACE codes considered
CIS2018	E36, E37, F42, M71
SBS	E, F42, M7112, M721
NAMA10	E36, E37, F42, M71

COMEXT	E, F42

Table 15. Mobility ecosystem

Dataset	NACE codes considered
CIS2018	F, H49, H50, H53, M71
SBS	F, H49, H50, H53, M7112, M7120, N7711, N7712, N7721, N7734, N7739
NAMA10	F, H49, H50, H53, M71
COMEXT	F, H

Table 16. Buildings ecosystem

Dataset	NACE codes considered
CIS2018	C16, C17, C22, C23, C25, C27, C28, D351, 353, F, L, M71
SBS	C16, C22, C23, C28, F, L68, M71
NAMA10	C16, C17, C22, C23, C25, C27, C28, D353, F, L, M71
COMEXT	C16, C17, C22, C23, C25, C27, C28, F, L

Table 17. Land-use and Agri-Food ecosystem

Dataset	NACE codes considered
CIS2018	A02, F42, E39
SBS	F42
NAMA10	A02, F42
COMEXT	A

Table 18. Digital and other ecosystem

Dataset	NACE codes considered
CIS2018	J61, J62
SBS	J60, J61, J62, P85, Q87, R90, R91
NAMA10	J61, J62
COMEXT	J

The construction of the ecosystem indicators is done by means of aggregation, based on the list of NACE codes presented in the above ecosystem-specific tables. All indicators are observed in units that are possible to aggregate from the level of the observed NACE code to that of the ecosystem. Most indicators are

observed in absolute terms. The few that are observed in relative terms, are observed as a share of an indicator that remains constant across NACE categories, e.g. GDP that is observed at the country level.

At the level of the ecosystem all indicators are expressed in relative terms to allow for cross-sectional comparisons (country or ecosystem). Indicators that are not observed in relative terms, are reported in relative terms by dividing with total economic activity within the taxonomy eligible economy. For instance, *Jobs created in start-ups in Taxonomy-eligible activities* is expressed as share of jobs created in Taxonomy-eligible activities. Annex VI: Sources and definitions presents information relating to each Taxonomy indicator.

Annex V: Structure of the Index

Dimension	Sub-dimension	Component	Indicator	Source (based on)	Data source	Directionality: What's best
Economy / Productivity	Framework conditions	1.1.1 Innovation readiness	Percentage of people with advanced ICT skills	Transitions Performance Index	ITU	High
			Government, Higher Education and non-profit R&D expenditure (% of GDP)		Eurostat	High
			Broadband at home	European Social Progress Index	Eurostat	High
		1.1.2 Human capital	Population aged 25-34 with tertiary education	European Innovation Scoreboard	Eurostat	High
			Tertiary education graduates in science, math., computing, engineering, manufacturing, construction (per 1000 of population aged 20-29)	EU Competitiveness Council	Eurostat	High
			Foreign doctorate students (% of all doctorate students)	European Innovation Scoreboard	Eurostat	High
		1.1.3 Business fabric	Turnover share large enterprises (%)	European Innovation Scoreboard	Eurostat	High
			Entrepreneurial culture	Global Cleantech Innovation Index	Global Entrepreneurship Monitor	High
	Innovation enablers	1.2.1 Business R&I investment	Expenditure of enterprises on R&D in Taxonomy-eligible activities. (% GDP)		Eurostat (CIS)	High
			Enterprises that received public funding for research and development (R&D) or innovation in Taxonomy-eligible activities (share in enterprises in Taxonomy-eligible activities)		Eurostat (CIS)	High
			Enterprises that use tax incentives or allowances for research and development (R&D) or innovation in Taxonomy-eligible activities (share in enterprises in Taxonomy-eligible activities)		Eurostat (CIS)	High
			Enterprises that obtained debt for R&D or innovation in Taxonomy-eligible activities (per million population)		Eurostat (CIS)	High
			Enterprises that obtained equity finance for R&D or innovation in Taxonomy-eligible activities (per million population)		Eurostat (CIS)	High
		1.2.2 Innovation capacity	Enterprises with research and development (R&D) activities in Taxonomy-eligible activities (share in enterprises in Taxonomy-eligible activities)		Eurostat (CIS)	High
			Enterprises hampered in their innovation activities in Taxonomy-eligible activities due to lack of collaboration partners (share in enterprises in Taxonomy-eligible activities)		Eurostat (CIS)	Low
	Outputs	1.3.1 Intellectual Property Rights (IPR)	Enterprises that applied for a patent in Taxonomy-eligible activities (share in enterprises in Taxonomy-eligible activities)		Eurostat (CIS)	High
			Enterprises that applied for a trademark in Taxonomy-eligible activities (share in enterprises in Taxonomy-eligible activities)		Eurostat (CIS)	High
			Enterprises that applied for an industrial design in Taxonomy-eligible activities (share in enterprises in Taxonomy-eligible activities)		Eurostat (CIS)	High
		1.3.2 Innovation Activity	Enterprises in Taxonomy-eligible activities collaborating on business activities with other enterprises or organisations share in enterprises in Taxonomy-eligible activities)	European Innovation Scoreboard	Eurostat (CIS)	High
			Turnover of innovative enterprises in Taxonomy-eligible activities (share in turnover in Taxonomy-eligible activities)	European Innovation Scoreboard	Eurostat (CIS)	High

			Companies in Taxonomy-eligible activities with product innovations (% of total enterprises in Taxonomy-eligible activities)	European Innovation Scoreboard	Eurostat (CIS)	High
		1.3.3 Entrepreneurial Activity	Enterprises created in Taxonomy-eligible activities (share in active enterprises in Taxonomy-eligible activities)		Eurostat: Business demography data	High
			Enterprises in existence 5+ years in Taxonomy-eligible activities (share in enterprises in Taxonomy-eligible activities)		Eurostat: Business demography data	High
		1.3.4 Trade	Turnover of enterprises from new or significantly improved products in Taxonomy-eligible activities (share in turnover of enterprises in Taxonomy-eligible activities)	European Innovation Scoreboard	Eurostat (CIS)	High
			Trade balance of products from Taxonomy-eligible activities (% GDP)		Eurostat COMEXT	High
		1.3.5 Employment	Employment in innovative enterprises in Taxonomy-eligible activities (% total employment in the economy)	European Innovation Scoreboard	Eurostat (CIS)	High
	Impacts	**1.4.1 Wealth**	Gross domestic product (GDP) per capita	Transitions Performance Index	IMF-WEO	High
			Taxonomy-eligible economy (% GDP)		Self-produced based on Eurostat and JRC	High
			Taxonomy-aligned economy (% GDP)		Self-produced based on Eurostat and JRC	High
		1.4.2 Industrial structure	Early-stage private investment (Venture Capital) in clean technologies		Cleantech Group	High
			Late-stage private investment (Venture Capital) in clean technologies		Cleantech Group	High
			Economic Complexity Index		Harvard Kennedy School of Government	High
			Gross value added of manufacturing (% of GDP)	Transitions Performance Index	Eurostat	High
		1.4.3 Jobs	Employment rate of population 20-64 (%)	Transitions Performance Index	Eurostat	High
			Average earnings (Household income)	How's Life? Well-being	OECD	High
			Labour market insecurity	How's Life? Well-being	OECD	High
Society / Fairness	**Framework conditions**	**2.1.1 Education**	Government expenditure in education per student (% of GDP per capita)	Transitions Performance Index	UNESCO-UIS	High
			Tertiary education attainment	European Social Progress Index	Eurostat	High
			Lifelong learning	European Social Progress Index	Eurostat	High
		2.1.2 Basic needs	Unmet medical needs	European Social Progress Index	EU-SILC	Low
			Insufficient food	European Social Progress Index	EU-SILC	Low
		2.1.3 Social mobility	Job opportunities	European Social Progress Index	Gallup World Poll (WP89)	High
			Young people not in education, employment or training (NEET)	European Social Progress Index	Eurostat	Low
	Impacts	**2.2.1 Inclusivity**	Tolerance towards minorities	European Social Progress Index	Gallup World Poll (WP103)	High
			Quality of support network	How's Life? Well-being	Gallup World Poll	High
		2.2.2 Equality	Gini coefficient of disposable income, post taxes and transfers	Transitions Performance Index	OECD	Low
			Gender employment gap	European Social Progress Index	Eurostat	Low
			Palma ratio	SDG Index	OECD & UNDP	Low
		2.2.3 Health	Healthy life expectancy at birth (years)	Transitions Performance Index	WHO	High

			Self-reported health (Perceived health)	How's Life? Well-being	OECD	High
			Infant mortality rate	European Social Progress Index	Eurostat	Low
Governance / Stability	**Framework conditions**	**3.1.1 Fundamental rights**	Voice and accountability index	Transitions Performance Index	World Bank	High
			Rule of law	European Innovation Scoreboard	World Bank	High
			Freedom over life choices	European Social Progress Index	Gallup World Poll (WP134)	High
		3.1.2 Transparency	Control of Corruption		World Bank	High
			Open Government and Transparency		World Bank	High
			Freedom of Press Index	SDG Index	Reporters without borders	Low
		3.1.3 Institutional efficacy	Government Effectiveness	World Bank		High
			Government Online Service Index	World Bank	WEF	High
			Trust in the legal system	European Social Progress Index	Gallup World Poll (WP138)	High
	Impacts	**3.2.1 Sound governance**	General government gross debt (% GDP)	Transitions Performance Index	IMF-WEO	Low
			Trust in the national government	European Social Progress Index	Gallup World Poll (WP139)	High
		3.2.2 Citizen engagement	Active citizenship	European Social Progress Index	EU-SILC	High
			Volunteering	European Social Progress Index	EU-SILC	High
			Voter turnout	How's Life? Well-being	OECD	High
		3.2.3 Security and Resilience to External Shocks	Energy imports dependency		Eurostat	Low
			Circular material use rate	European Innovation Scoreboard	Eurostat	High
			Global Cybersecurity Index	Resilience Dashboards	ITU	High
			Security Apparatus	Fragile States Index	Fund for peace	Low
Green / Environment	**Framework conditions**	**4.1.1 Renewable Energies**	Availability of wind resources	Competitiveness in Low-carbon Industries	EMHIRES	High
			Availability of solar resources	Competitiveness in Low-carbon Industries	EMHIRES	High
			Share of energy from renewable sources		Eurostat	High
		4.1.2 Sustainability transition commitment	Effective Carbon Rates	GLOBAL ENERGY INNOVATION (GEI) INDEX	OECD Effective Carbon Rates (ECRs) database	High
			Percent of population perceiving climate change as a priority	Competitiveness in Low-carbon Industries	Eurobarometer public opinion surveys on Climate change	High
			Fossil Fuel Subsidies		IMF-Climate change dashboard	Low
		4.1.3 Natural resources	Renewable freshwater availability/capita	Sustainable Competitiveness Index	World Bank	High
			Forest area (% of total land)	Sustainable Competitiveness Index	World Bank	High
	Impacts	**4.2.1 Resource productivity**	Material footprint (MF tonnes per capita)	Transitions Performance Index	UN Global Material Flows Database	Low
			Water productivity (GDP/total fresh water abstraction)	ECO-INNOVATION INDEX	Eurostat	High

			Energy productivity (GDP/gross inland energy consumption)	ECO-INNOVATION INDEX	Eurostat	High
		4.2.2 Climate Emissions	Greenhouse gas emission intensities (grams per euro)	EU Competitiveness Council	Eurostat	Low
		4.2.3 Biodiversity	Terrestrial key biodiversity areas protected (%)	Transitions Performance Index	UN SDGs (Indicator 15.1.2)	High
			Freshwater key biodiversity areas protected (%)	Transitions Performance Index	UN SDGs (Indicator 15.1.2)	High
			Pesticides use per area of cropland (kg/a)	Transitions Performance Index	FAOSTAT	Low

Annex VI: Sources and definitions

ECONOMY / PRODUCTIVITY DIMENSION

Innovation readiness

Percentage of people with advanced ICT skills

This indicator measures the percentage of people who can write a computer program using a specialized programming language.

Rationale: Digital skills have become a critical competence in a context of increased digitisation of the economies. Advanced ICT skills are a requirement to develop technological innovation. Higher percentage of people reflects higher level of (technological) innovation capacity.

Data source: International Telecommunication Union (ITU)

Government, Higher Education and non-profit R&D expenditure (% of GDP)

This indicator measures the percentage of total gross domestic expenditure on R&D (GERD) from Government, Higher Education and non-profit institutions.

Rationale: Businesses are not the only source of R&D. Non-profit, public and Higher Education institutions also are relevant sources of R&D. Higher levels of R&D expenditure from non-private stakeholders reflects higher levels of innovation capacity.

Data source: Eurostat

Broadband at home

This indicator measures the percentage of households with broadband connection and captures the general level of digitisation of society.

Rationale: Connectivity is a key condition for the digital transition and, as the COVID-19 crisis has shown, increasingly essential for resilient societies. Higher number of households with broadband connection reflect higher level of societal digitisation.

Data source: Eurostat

Human capital

Population aged 25-34 with tertiary education (% of population aged 25-34)

This indicator measures the percentage of a certain cohort of the population that has achieved the higher level of education attainment.

Rationale: This reflects the supply of high-skilled human capital to be incorporated into the innovation ecosystem stakeholders. By focusing on a relatively young age cohort of the population we will quickly perceive changes in educational policies leading to more tertiary graduates. Higher levels of tertiary graduates reflect higher levels of high-skilled human capital availability to bring innovation capabilities to stakeholders.

Data source: Eurostat

Tertiary education graduates in science, math., computing, engineering, manufacturing, construction (per 1000 of population aged 20-29)

This indicator measures the level of tertiary graduates in six specific educational fields that are particularly relevant for achieving climate neutrality.

Rationale: Innovation is not limited to science and technical fields, but these fields are very closely related to the six innovation ecosystems considered key to meet 2050 targets (Energy, Industry, Buildings, Mobility, Land-use & agriculture and Digital). Higher levels of tertiary graduates in science, mathematics, computing, engineering, manufacturing and construction reflect higher levels of supply of high-skilled human capital to develop the innovation required for the transition to a sustainable and climate neutral economy.

Data source: Eurostat

Foreign doctorate students (% of all doctorate students)
This indicator illustrates the level of foreign students in doctorate programmes.

Rationale: Attracting high-skilled foreign doctorate students reflects the quality of the doctorate programmes and the share of foreign doctorate students also shows the level of diversity of the human capital to be incorporated into the research system. Diversity is a key driver of innovation and a critical component of high-performing innovation ecosystems. Higher levels of foreign doctorate students reflect higher levels of quality and diversity of the graduated doctorates.

Data source: Eurostat

Business fabric

Turnover share large enterprises (%)
This indicator measures the share of total turnover generated by firms with 250 or more persons employed[xl].

Rationale: Differences in economic structures are important. In particular, differences in the size of the companies making up the business fabric are a relevant factor that can have an impact on a country's economic development. Large enterprises tend to be more resilient in turbulent times and, on average, will have higher R&I expenditures. Higher shares of large enterprises reflect higher levels of resilience and innovation capacity in the business fabric.

Data source: Eurostat - Structural Business Statistics

Entrepreneurial culture
This indicator measures the attitude towards entrepreneurship through the survey question "In my country, the national culture encourages entrepreneurial risk-taking"[xli].

Rationale: Entrepreneurship is important for introducing new innovations on the market. The degree of entrepreneurship support and acceptance has a significant impact on entrepreneurial outcomes. Higher levels of entrepreneurial culture reflect higher levels of positive attitudes towards entrepreneurship and potentially higher levels of future entrepreneurial activity.

Data source: Global Entrepreneurship Monitor

[xl] The number of persons employed should not be confused with employees or full-time equivalents; 'persons employed' includes employees but also working proprietors, partners working regularly in the enterprise and unpaid family workers.
[xli] The survey is administered to a minimum of 2000 adults in each GEM country.

Business R&I investment

Expenditure of enterprises on R&D in Taxonomy-eligible activities. (% of GDP)
This indicator measures the expenditure of firms on activities comprising creative and systematic work undertaken in order to increase the stock of knowledge – including knowledge of humankind, culture and society – and to devise new applications of available knowledge as a percentage of GDP.

Rationale: It captures the formal creation of new knowledge within firms in the economic activities that can have a substantial contribution to climate change mitigation. Many technologies yet need to be developed in order to meet EU's 2050 targets and that requires significant investments from the businesses working in solving the key challenges for a sustainable transition. Higher levels of expenditure reflect higher capacity to create new knowledge in key areas.

Data source: Eurostat – Community Innovation Survey

F42 construction: share of turnover

Enterprises that received public funding for research and development (R&D) or innovation in Taxonomy- eligible activities (share in enterprises in Taxonomy-eligible activities)
This indicator measures the number of firms in economic activities considered eligible under EU Taxonomy Regulation having received any type of public funding for R&D or innovation activities in the reference period.

Rationale: The indicator captures the level of capillarity achieved by public support through direct funding for R&D instruments. Public support of R&I plays a key role assisting firms to reduce both the cost and uncertainty of research and innovation. Higher levels of firms making use of R&I support instruments reflect higher effectiveness of public R&I programmes.

Data source: Eurostat – Community Innovation Survey

F42 construction: share of enterprises

Enterprises that use tax incentives or allowances for research and development (R&D) or innovation in Taxonomy-eligible activities (% of enterprises in Taxonomy-eligible activities)
This indicator measures the number of firms in economic activities considered eligible under EU Taxonomy Regulation having obtained any type of tax incentives or allowances for R&D or innovation activities in the reference period.

Rationale: The indicator captures the level of capillarity achieved by public support through indirect support of R&D via tax incentives. Public support of R&I plays a key role assisting firms to reduce both the cost and uncertainty of research and innovation. Higher levels of firms making use of R&I support instruments reflect higher effectiveness of public R&I programmes.

Data source: Eurostat – Community Innovation Survey

Enterprises that obtained debt for R&D or innovation in Taxonomy-eligible activities (share in enterprises in Taxonomy-eligible activities)
This indicator measures the number of firms in economic activities considered eligible under EU Taxonomy Regulation having obtained debt for R&D or innovation activities in the reference period.

Rationale: The indicator captures the level of capillarity achieved by alternative sources to public support for R&I funding. Public support is not the only funding source for research and innovation. Private sources also play an important role in the innovation ecosystem and innovative firms can find in these instruments a better way to meet their funding requirements. Higher levels of firms getting access to funding reflect stronger innovation ecosystems.

Data source: Eurostat – Community Innovation Survey

F42 construction: share of enterprises

Enterprises that obtained equity finance for R&D or innovation in Taxonomy-eligible activities (share in enterprises in Taxonomy-eligible activities)
This indicator measures the number of firms in economic activities considered eligible under EU Taxonomy Regulation having obtained equity finance for R&D or innovation activities in the reference period.

Rationale: The indicator captures the level of capillarity achieved by alternative sources to public support for R&I funding. Public support is not the only funding source for research and innovation. Private sources also play an important role in the innovation ecosystem and innovative firms can find in these instruments a better way to meet their funding requirements. Higher levels of firms getting access to equity funding reflect stronger innovation ecosystems.

Data source: Eurostat – Community Innovation Survey

F42 construction: share of enterprises

Innovation capacity

Enterprises with research and development (R&D) activities in Taxonomy-eligible activities (share in enterprises in Taxonomy-eligible activities)
This indicator measures the level of engagement of firms in economic activities considered eligible under EU Taxonomy Regulation in research and development (R&D) activities.

Rationale: Research and development (R&D) is the basis for the generation of knowledge and often is the main source of innovation. Higher number of firms with R&D activities reflect a higher level of innovation capacity.

Data source: Eurostat – Community Innovation Survey

F42 construction: share of enterprises

Enterprises hampered in their innovation activities in Taxonomy-eligible activities due to lack of collaboration partners (share in enterprises in Taxonomy-eligible activities)
This indicator measures the degree to which firms in economic activities considered eligible under EU Taxonomy Regulation reported lack of collaboration partners as a barrier to conducting innovation activities.

Rationale: Besides innovation drivers, innovation barriers are also relevant for innovation outcomes. Identifying and removing barriers to business innovation can have significant impact on innovation results.

Data source: Eurostat – Community Innovation Survey

F42 construction: share of enterprises

Intellectual Property Rights (IPR)

Enterprises that applied for a patent in Taxonomy-aligned activities (share in enterprises in Taxonomy-eligible activities)

This indicator measures the number of firms in economic activities considered eligible under EU Taxonomy Regulation filing patent applications under the PCT, at international phase, designating the European Patent Office (EPO). Patent counts are based on the priority date, the inventor's country of residence and fractional counts. A patent is an exclusive right granted for a specified period (generally 20 years) for a new way of doing something or a new technical solution to a problem - an invention. The invention must be of practical use and display a characteristic unknown in the existing body of knowledge in its field.

Rationale: Patents indicate country's capacity to exploit knowledge and translate it into potential competitive and economic gains. Number of patents is often used to assess the inventive performance and thus, a higher share of firms applying for a patent reflects a higher level of inventive performance.

Data source: Eurostat – Community Innovation Survey

F42 construction: share of enterprises

Enterprises that applied for a trademark in Taxonomy-aligned activities (% of enterprises in Taxonomy-eligible activities)

This indicator measures the number of firms in economic activities considered eligible under EU Taxonomy Regulation filing trademark applications at the European Union Intellectual Property Office (EUIPO). A trademark is a distinctive sign which identifies certain goods or services as those produced or provided by a specific person or enterprise. A trademark provides protection to the owner of the mark by ensuring the exclusive right to use it to identify goods or services, or to authorize another to use it in return for payment.

Rationale: Trademarks are an important innovation indicator, especially for the service sector. Trademarks fulfil three essential functions: it identifies the origin of goods and services, guarantees consistent quality through evidence of the company's commitment vis-à-vis the consumer, and it is a form of communication, a basis for publicity and advertising. A higher share of firms applying for a trademark reflects a higher level of innovative performance.

Data source: Eurostat – Community Innovation Survey

F42 construction: share of enterprises

Enterprises that applied for an industrial design in Taxonomy-aligned activities (% of enterprises in Taxonomy-eligible activities)

This indicator measures the number of firms in economic activities considered eligible under EU Taxonomy Regulation filing industrial design applications at the European Union Intellectual Property Office (EUIPO). Industrial designs are applied to a wide variety of industrial products and handicrafts. They refer to the ornamental or aesthetic aspects of a useful article, including compositions of lines or colours or any three-dimensional forms that give a special appearance to a product or handicraft. The holder of a registered industrial design has exclusive rights against unauthorized copying or imitation of the design by third parties.

Rationale: A design is the outward appearance of a product or part of it resulting from the lines, contours, colours, shape, texture, materials, and/or its ornamentation. A product can be any industrial or handicraft item including packaging, graphic symbols and typographic typefaces but excluding computer programmes. It also includes products that are composed of multiple components, which may be disassembled and reassembled. Community design protection is directly enforceable in each Member State, and it provides both the option of an unregistered and a registered Community design right for one area encompassing all Member States. A higher share of firms applying for an industrial design reflects a higher level of innovative performance.

Data source: Eurostat – Community Innovation Survey

F42 construction: share of enterprises

Innovation activity

Enterprises in Taxonomy-eligible activities collaborating on business activities with other enterprises or organisations (% of enterprises in Taxonomy-eligible activities)

This indicator measures the degree to which firms in economic activities considered eligible under EU Taxonomy Regulation are involved in cooperation with other organisations.

Rationale: Collaboration is a significant driver of innovation. Innovation often depends on the ability to draw on diverse sources of information and knowledge, or to collaborate in the development of an innovation. Higher levels of firm collaboration reflect higher dynamism of the innovation ecosystem.

Data source: Eurostat – Community Innovation Survey

F42 construction: share of enterprises

Turnover of innovative enterprises in Taxonomy-eligible activities (% of total turnover of enterprises in Taxonomy-eligible activities)

This indicator measures the weight of innovation in economic activities considered eligible under EU Taxonomy Regulation (in terms of turnover).

Rationale: Overall turnover is equivalent to a firm's total revenues over some period of time. Turnover is considered a good indicator to monitor performance of innovative firms. Higher levels of turnover from innovative firms reflect higher relevance of innovation in Taxonomy-eligible activities.

Data source: Eurostat – Community Innovation Survey

F42 construction: share of turnover

Companies in Taxonomy-eligible activities with product innovations (share of total enterprises in Taxonomy-eligible activities)

This indicator measures the number of firms in economic activities considered eligible under EU Taxonomy Regulation that have introduced at least one new or significantly improved product in the three years of the survey period. A product innovation is a new or improved good or service that differs significantly from the firm’s previous goods or services and that has been introduced on the market. Changes of a solely aesthetic nature and the simple resale of new goods and services purchased from other enterprises are not considered as innovation.

Rationale: Product innovations are a key part of innovation as they can create new markets and solve existing challenges. The transition to climate neutrality is going to require significant amounts of product innovations. Higher shares of product innovators reflect a higher level of innovation activity.

Data source: Eurostat – Community Innovation Survey

F42 construction: share of enterprises

Entrepreneurial activity

Enterprises created in Taxonomy-eligible activities (share of active enterprises in taxonomy eligible activities)

This indicator measures the number of births of enterprises registered in economic activities considered eligible under EU Taxonomy Regulation. A birth amounts to the creation of a combination of production factors with the restriction that no other enterprises are involved in the event. Births do not include entries into the population due to: mergers, break-ups, split-off or restructuring of a set of enterprises. It does not include entries into a sub-population resulting only from a change of activity.

Rationale: Business creation in Taxonomy-eligible activities can be a good thermometer for the level of development in the economic activities that can make a substantial contribution to the sustainability transition. Higher levels of firms created in Taxonomy-eligible activities reflect higher levels of specialisation on these economic activities. Higher number of firms created reflect higher levels of dynamism in those economic activities.

Data source: Eurostat – Structural Business Statistics

F42 construction: share of enterprises

Enterprises in existence 5+ years in Taxonomy-eligible activities (share in enterprises in Taxonomy-eligible activities)

This indicator measures the number of enterprises newly born in t-5 having survived to t in economic activities considered eligible under EU Taxonomy Regulation.

Rationale: Most of start-ups fail during the first 5 years of existence. Start-ups that manage to overcome that threshold often have a proven business model and are ready to scale up. Thus, this indicator assesses the level of resilience and shows the potential of start-ups in the economic activities that can make a substantial contribution to the sustainability transition. Higher levels of start-up survival reflect stronger entrepreneurial ecosystems.

Data source: Eurostat – Structural Business Statistics

F42 construction: share of enterprises

Trade

Turnover of enterprises from new or significantly improved products in Taxonomy-eligible activities (share in total turnover of enterprises in Taxonomy-eligible activities)

This indicator measures the share of total sales in economic activities considered eligible under EU Taxonomy Regulation from new or significantly improved products. Changes of a solely aesthetic nature and the simple resale of new goods and services purchased from other enterprises are not considered as new products.

Rationale: The indicator captures the weight of product innovation in Taxonomy-eligible activities (in terms of sales). Higher shares of product innovation reflect a higher level of innovation potentially addressing some of the sustainability transition challenges.

Data source: Eurostat - Community Innovation Survey

F42 construction: share of turnover

Trade balance of products from Taxonomy-eligible activities (% GDP)
This indicator measures the difference in value between a country's product imports and exports in economic activities considered eligible under EU Taxonomy Regulation.

Rationale: It captures the level of dependency or autonomy of a country on the economic activities that are going to be key in the transition to a climate neutral and sustainable economy. The higher trade surplus in these critical economic activities the better competitive position for the transition to a climate neutral and sustainable economy.

Data source: Eurostat - COMEXT

F42 construction: share of production value

Employment

Employment in innovative enterprises in Taxonomy-eligible activities (share in total employment in enterprises in Taxonomy-eligible activities)
This indicator measures the number of persons employed in innovative enterprises in economic activities considered eligible under EU Taxonomy Regulation. Enterprises are classified as innovative if during the reference period it introduced successfully a product or process innovation, had ongoing innovation activities, abandoned innovation activities, completed but yet introduced the innovation or was engaged in in-house R&D or R&D contracted out.

Rationale: Measuring the percentage of total employment that is working in innovative companies within the economic activities included in the Taxonomy we aim to assess the weight of innovation in Taxonomy-eligible activities (in terms of employment). Higher levels of employment in innovative enterprises reflect greater relevance of innovation in these innovation ecosystems.

Data source: Eurostat - Community Innovation Survey

F42 construction: share of employment

Wealth

Gross domestic product (GDP) per capita
This indicator measures the country's GDP, current prices, expressed in purchasing power parity (PPP) dollars divided by total population.

Rationale: Although the Competitive Sustainability Index adopts a comprehensive and inclusive approach following the 'Beyond GDP' logic, GDP per capita remains a relevant indicator to assess economic growth and wealth in particular. Higher levels of GDP per capita reflect higher levels of wealth.

Data source: IMF-WEO

Taxonomy-eligible economy (% GDP)

This indicator measures the percentage of a country's GDP that is generated from the economic activities considered eligible under EU Taxonomy Regulation. Taxonomy eligibility criteria has been applied following the methodology developed by Lucia Alessi (European Commission's Joint Research Centre) and Stefano Battiston (University of Zurich and University Ca Foscari of Venice) in their seminal work (Alessi and Battiston, 2021)[xlii].

Rationale: The indicator captures the weight of Taxonomy-eligible activities in the country's economy (in terms of GDP). Higher shares of GDP from Taxonomy-eligible activities reflect higher relevance of those activities in the economic structure of the country.

Data source: Eurostat for GDP output data and Alessi & Battiston (2021) for taxonomy-eligibility data

Taxonomy-aligned economy (% GDP)

This indicator measures the percentage of a country's GDP that is generated from the economic activities meeting the specific requirements and thresholds for an activity to be considered Taxonomy-aligned. Taxonomy alignment criteria has been applied following the method developed in Alessi and Battiston (2021)[xliii].

Rationale: The indicator captures the weight in the economy (in terms of GDP) of the activities substantially contributing to climate change mitigation[xliv]. Higher shares of GDP from Taxonomy-aligned activities reflect higher relevance of those activities in the economic structure of the country.

Data source: Eurostat for GDP output data and Alessi & Battiston (2021) for taxonomy-alignment data

Industrial structure

Early-stage private investment (Venture Capital) in clean technologies

Amount of venture capital invested in Seed and Series A rounds in cleantech companies as a proportion of GDP (PPP).

Rationale: Venture capital plays a key role in the (technology) innovation and entrepreneurship ecosystems. Venture capitalists provide funds and assist in the formation of new (technology) business accelerating the process of technological change. The green transition requires the development of new technologies to overcome existing challenges to effectively become a climate neutral and sustainable economy. Early-stage Venture Capital funds start-ups with a potentially viable technology that is poised to drive the green transition. Higher levels of early-stage venture capital in clean technologies reflect greater investment in key technologies development.

[xlii] Alessi and Battiston (2021). Two sides of the same coin: Green Taxonomy alignment versus transition risk in financial portfolios. Retrieved from: https://joint-research-centre.ec.europa.eu/publications/two-sides-same-coin-green-taxonomy-alignment-versus-transition-risk-financial-portfolios_en

[xliii] Alessi and Battiston (2021). Two sides of the same coin: Green Taxonomy alignment versus transition risk in financial portfolios. Retrieved from: https://joint-research-centre.ec.europa.eu/publications/two-sides-same-coin-green-taxonomy-alignment-versus-transition-risk-financial-portfolios_en

[xliv] The methodology used for Taxonomy-alignment estimation only considers one of the six environmental objectives in EU Taxonomy (i.e. climate change mitigation). A more detailed explanation on the methodology is available at: https://joint-research-centre.ec.europa.eu/publications/two-sides-same-coin-green-taxonomy-alignment-versus-transition-risk-financial-portfolios_en

Data source: Cleantech Group

Late-stage private investment (Venture Capital) in clean technologies
Amount of venture capital invested in Series B and Growth Equity rounds in cleantech companies as a proportion of GDP (PPP).

Rationale: Late-stage start-ups have already proven the viability of their product or service and are ready to grow their business and scale up. Technologies funded at this stage have a clear market demand and are due to solve the technological challenges for a successful transition to climate neutrality. Higher levels of late-stage venture capital in clean technologies reflect greater results in key technologies deployment and scale up.

Data source: Cleantech Group

Economic Complexity Index
The Economic Complexity Index (ECI) assess the current state of a country's productive knowledge, through the number and complexity of the products they successfully export.

Rationale: The complexity of a country's exports is found to highly predict current income levels, or where complexity exceed expectations for a country's income level, the country is predicted to experience more rapid growth in the future. Economic development requires the accumulation of productive knowledge and its use in both more and more complex industries. Countries that are able to sustain a diverse range of productive know-how, including sophisticated, unique know-how, are found to be able to produce a wide diversity of goods, including complex products that few other countries can make. Higher levels of economic complexity reflect higher levels of economic development.

Data source: Harvard Kennedy School of Government

Gross value added of manufacturing (% of GDP)
This indicator measures the gross value added of manufacturing (based on NACE category C - Manufacturing) expressed as a percentage of GDP.

Rationale: The COVID-19 crisis and the Russian invasion of Ukraine have shown that the resilience of an economy also depends on its capacity to: (i) respond quickly to local needs; (ii) maintain sufficient capacity of production locally (or within the single market); and (iii) in certain cases have a sufficient degree of technological sovereignty to prioritise emerging needs. Therefore, the development of a strong industrial base in Europe is key for a competitively sustainable economy. Higher shares of manufacturing value added reflect greater strength of the industrial base.

Data source: Eurostat

Jobs

Employment rate
This indicator measures the number of persons aged 20-64 in employment as a share of the total population of the same age group.

Rationale: Work has obvious economic benefits, but having a job also helps individuals stay connected with society, build self-esteem, and develop skills and competencies. Societies with high levels of employment are also richer, more politically stable and healthier.

Data source: Eurostat – EU Labour Force Survey

Average earnings

This indicator is obtained by dividing the national-accounts-based total wage bill by the average number of employees in the total economy, which is then multiplied by the ratio of the average usual weekly hours per full-time employee to the average usually weekly hours for all employees.

Rationale: The wages and other monetary benefits that come with employment are an important aspect of job quality. Earnings represent the main source of income for most households. Analysing earnings may also suggest how fairly work is remunerated.

Data source: OECD – Better Life Index

Labour market insecurity

This indicator measures the expected earnings loss, measured as the percentage of the previous earnings, associated with unemployment. This loss depends on the risk of becoming unemployed, the expected duration of unemployment and the degree of mitigation against these losses provided by government transfers to the unemployed (effective insurance).

Rationale: Job security is another essential factor of employment quality in terms of expected loss of earnings when someone becomes unemployed. This includes length of unemployment and how much government financial assistance you can expect.

Data source: OECD – Better Life Index

SOCIETY / FAIRNESS DIMENSION

Education

Government expenditure in education per student (% of GDP per capita)

This indicator measures the average general government expenditure (current, capital, and transfers) per student in the given level of education, expressed as a percentage of GDP per capita.

Rationale: Education is a collective good providing many spillover benefits and a prerequisite for a sustainable and fair society. Therefore, on top of the legitimate private funding already measured in per capita GDP, public funding of education is a valid measure of the collective effort in favour of education.

Data source: UNESCO Institute for Statistics

Tertiary education attainment

This indicator measures the percentage of population aged 25-64 with tertiary education (ISCED 5-6) attainment.

Rationale: Educational attainment refers to the highest level of education that an individual has completed. Tracking tertiary education attainment levels across countries and over time provides relevant insights into the benefits that can arise from having a highly educated population not only for economic growth but for increasing the well-being of societies at large.

Data source: Eurostat

Lifelong learning

This indicator measures the percentage of people aged 25 to 64 who stated that they had received education or training in the four weeks preceding the survey, with respect to the total population of the same age group.

Rationale: The pace of change in global development has accelerated exponentially in the recent past and that makes lifelong learning a requirement for social progress. High levels of educational attainment are no longer enough to produce long-term benefits for society.

Data source: Eurostat

Basic needs

Unmet medical needs

This indicator measures the percentage of people reporting to have experienced unmet medical needs because of: financial reasons (affordability) or a long waiting list (efficiency) or too far to travel (accessibility) or did not know a good doctor (trust/quality).

Rationale: Basic medical care is an indispensable condition for a sustainable society as it improves the quality of life and helps prevent premature loss of life. Society has an obligation to make access to an adequate level of care available to all its members. A society and economy that work for people must strive to improve people's health.

Data source: Eurostat -SILC survey

Insufficient food

This indicator measures the percentage of people claiming they are living in a household that cannot afford a meal with meat, chicken, fish (or vegetarian equivalent) every second day.

Rationale: Adequate nutrition is a basic human need that has significant impact on our health and a clear indicator of a sustainable society. The COVID-19 crisis and the war in Ukraine have increased the tensions on the global food supply chains and as a consequence the prices of some basic products in a healthy diet have become unattainable on a regular basis for a growing part of the population in EU countries. The effects of climate change could aggravate this trend, putting food security in the most vulnerable regions at risk.

Data source: Eurostat -SILC survey

Social mobility

Job opportunities

This indicator measures the share of respondents who think it is a good time to find a job in the city or area where they live.

Rationale: Having access to more job opportunities can have significant impact on our well-being because it affects our opportunity to pursue life goals and is often a key to upward social mobility and economic security. Social mobility is closely linked to job occupation and job opportunities can help us measure the level of existing development prospects.

Data source: Gallup World Poll

Young people not in education, employment or training (NEET)

This indicator measures young people, aged between 15 and 24, not in employment or education and training.

Rationale: This indicator provides information on the transition from education to work and focuses on the number of young adults who find themselves disengaged from both education and the labour market. Young people who are neither in employment nor in education or training are at risk of becoming socially excluded because they are jobless and often lack the skills to improve their economic situation. The NEET indicator shows whether young people are economically independent or at risk of failing to gain autonomy.

Data source: Eurostat

Inclusivity

Tolerance towards minorities

This indicator measures the percentage of people who claimed that they live in a good place for minorities from other countries.

Rationale: Social inclusion is crucial for development outcomes such as economic growth, local service provision, and political stability. Tolerance, understood as non-discrimination against minority groups, is vital to achieve an inclusive society. Acceptance of differences related to belief, education and culture, different points of view and thoughts is part of basic values that encourage individuals from each part of the society to live together.

Data source: Gallup World Poll

Quality of support network

This indicator measures the percentage of people who believe they can rely on their friends in case of need. The indicator is based on the question: “If you were in trouble, do you have relatives or friends you can count on to help you whenever you need them, or not?” and it considers the respondents who respond positively.

Rationale: A strong social network, or community, can provide emotional support during both good and bad times as well as access to jobs, services and other material opportunities. A weak social network can result in limited economic opportunities, a lack of contact with others, and eventually, feelings of isolation. Social isolation may follow family breakdown, the loss of a job, illness or financial difficulties. Once socially isolated, individuals may face greater difficulties not only reintegrating society as a contributing member, but also fulfilling personal aspirations with respect to work, family and friends.

Data source: Gallup World Poll

Equality

Gini coefficient

The Gini coefficient measures the extent to which the distribution of income (or, in some cases, consumption expenditure) among individuals or households within an economy deviates from a perfectly equal distribution. The Gini coefficient is based on the comparison of cumulative proportions of the population against cumulative proportions of income they receive, and it ranges between 0 in the case of perfect equality and 1 in the case of perfect inequality.

Rationale: Advanced societies have often sought to reduce inequality of income. Fairness in salaries, redistribution, and progressive taxes contribute to this goal. The Gini coefficient is the most common measure of income inequality as it measures not only the wealth gap between the richest and poorest members of society, but also the distribution of wealth across the

board. This is especially relevant today when technological change is happening at an unprecedented speed, affecting the salaries of the workforce.

Data source: OECD

Gender employment gap

This indicator measures the difference between male and female employment rates.

Rationale: Gender equality is not only a fundamental human right, but a necessary foundation for a prosperous society. Having a job is necessary to have a regular income, advance in society, and build achievements with social value. Access to labour market is often a good measure to monitor gender inequality in modern societies.

Data source: Eurostat

Palma ratio

The Palma ratio is the share of all income received by the 10% people with highest disposable income divided by the share of all income received by the 40% people with the lowest disposable income.

Rationale: Gini coefficient is often criticised for being an imperfect measure as it ignores the informal economy and flattens distortions in the income distribution, leading to non-intuitive interpretations. The Palma ratio is an alternative income inequality measure which is considered to overcome Gini's weaknesses to weight observed income distributions using a simple and easy-to-understand ratio.

Data source: OECD

Health

Healthy life expectancy at birth

This indicator measures the average number of years that a person can expect to live in 'full health' by taking into account years lived in less than full health due to disease and/or injury.

Rationale: Life expectancy is the most widely used measure of health, although it only takes into account the length of people's life and not their quality of life. Healthy life expectancy at birth, as opposed to plain life expectancy, also includes the worrying challenge of mental-health problems, which affect a growing share of the population worldwide, as well as other negative long-term effects on health.

Data source: WHO

Self-reported health

This indicator measures the percentage of adult population reporting their health to be "good" or "very good".

Rationale: Despite the subjective nature of self-perceived health status, it has been found to be a good predictor of people's future health care use and therefore overall health status. Thus, older people report poorer health, as do those who are unemployed, or who have less education or income. Cultural and framing factors such as a age and social status have an impact self-reported health condition.

Data source: OECD

Infant mortality rate (IMR)

This indicator measures the number of deaths of children under one year of age, expressed per 1 000 live births. Some of the international variation in infant mortality rates is due to variations among countries in registering practices for premature infants.

Rationale: Infant mortality is regarded as an important indicator of population health, reflecting the intuition that structural factors affecting the health of entire populations have an impact on the mortality rate of infants. A general measure of population health is useful for comparing the health status of a population over time, or between populations at a single point in time. It permits comparisons of health systems and programmes, and may highlight populations in need of particular attention from health services[xlv].

Data source: Eurostat

GOVERNANCE / STABILITY DIMENSION

Fundamental rights

Voice and accountability

This indicator measures the perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media.

Rationale: Voice and accountability cover a wide range of ideas about how citizens can express preferences, secure their rights, make demands on the state and ultimately achieve better development outcomes. Governments that can be held accountable for their actions are more likely to respond to the needs and demands articulated by their population. Citizens' voice is viewed as a precondition for equitable access to and quality of public goods and services, thereby supporting improved health and education outcomes[xlvi]. Increased voice and accountability are also considered vital for the development of institutions that generate equal opportunities and access to resources, the development of more inclusive political settlements and ultimately the delivery of a 'just transition'.

Data source: World Bank - Worldwide Governance Indicators

Rule of law

This indicator measures the perceptions of: (i) the extent to which respondents have confidence in – and abide by – the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts; and (ii) the likelihood of crime and violence.

Rationale: Rule of law is the foundation for communities of justice, opportunity, and peace. The rule of law implies that the creation of laws, their enforcement, and the relationships among legal rules are themselves legally regulated, so that no one is above the law. Thus, it provides the necessary legal security for sustainable development and promotes respect for

[xlv] Murray CJL. Rethinking DALYs. In: Murray CJL, Lopez AD, eds. The global burden of disease: a comprehensive assessment of mortality and disability from diseases, injuries, and risk factors in 1990 and projected to 2020. Cambridge, MA: Harvard School of Public Health, 1996:1–98

[xlvi] Rocha Menocal, A. & Sharma, B. (2008). *Joint Evaluation of Citizens' Voice and Accountability: Synthesis Report*. London: DFID.

fundamental rights. Rule of law is intrinsically related to higher economic growth, better education, less inequality, improved health outcomes, and greater peace.

Data source: World Bank - Worldwide Governance Indicators

Freedom over life choices

This indicator measures the share of respondents answering satisfied to the question, 'Are you satisfied or dissatisfied with your freedom to choose what you do with your life?'

Rationale: Freedom of choice is an essential pillar of democratic societies. The ability to make decisions of one's own free is a fundamental right and a prerequisite for a sustainable society. Freedom of choice within the available resources is considered as the means of individual's realisation through the capacity to let people choose for themselves whatever best serves his or her interests. This is true with respect to material goods, and it is also true with respect to what people want from their work, their educational opportunities, their public institutions, their medical care, and just about every life choice. Effective protection of the right to freedom of speech and assembly strengthens democracies underpinning a culture of open participation in public affairs. Thus, freedom of choice is a mechanism that promotes well-being and reinforces the feeling of freedom enjoyed by individuals in a society.

Data source: Gallup World Poll

Transparency

Control of Corruption

This indicator measures the perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.

Rationale: The perception of public corruption is a good indicator of whether citizens trust the behaviour of their administration and public authorities. Corruption undermines public institutions credibility and fosters disengagement and anger in society, so preventing corruption is critical to the achievement of competitive sustainability. Effective control of corruption has positive effects on economic growth as well as social development.

Data source: World Bank

Open Government and Transparency

This indicator measures the opening of all government affairs for citizens to be aware of them and able to take part with solvency in decisions concerning them. This indicator is part of the Quality of Democracy Pillar of the Sustainable Governance Indicators (SGI). The SGI relies on a combination of qualitative and quantitative data.

Rationale: Countries are increasingly acknowledging the role of open government and transparency as catalysts for public governance, democracy and inclusive growth. Transparency is government's obligation to share information with citizens to be held accountable. In a suitable governance system, information on how public institutions work and spend taxpayers' money must be readily available and easily understood. Greater transparency is not only key to upholding integrity in the public sector; it also contributes to better governance. Indeed, openness and transparency can ultimately improve public services by minimising the risk of fraud, corruption and mismanagement of public funds.

Data source: World Bank

Freedom of Press Index

The Freedom of Press Index measures the ability of journalists as individuals and collectives to select, produce, and disseminate news in the public interest independent of political, economic, legal, and social interference and in the absence of threats to their physical and mental safety. The Freedom of Press Index is calculated based on a combination of qualitative and quantitative data.

Rationale: A free press helps maintain the balance of power in government and is an essential part of a healthy democracy. Freedom of the press ensures that the civil society receives information that is not manipulated or serving a particular person, entity or interest. It holds structures of power accountable and safeguards the proper functioning of a democratic society, revealing the truth and providing fair information about what is really happening.

The Freedom of Press Index is a point of reference that is quoted by media throughout the world and is used by diplomats and international human rights entities.

Data source: Reporters without borders

Institutional efficacy

Government Effectiveness

This indicator measures the perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.

Rationale: Governments play an important role in enhancing the capacities of an economy to excel in the transition to climate neutrality and contributing to increase society's well-being more broadly. Providing public services effectively could become a competitive advantage especially in the advent of the energy transition that the EU is to achieve in the coming years.

Data source: World Bank

Government Online Service Index

The Government Online Service Index measures the quality of government's delivery of online services on a 0-to-1 (best) scale.

Rationale: Online service delivery is a factor of a country's institutional capacity to fully leverage information and communication technologies (ICTs) for increased competitiveness and well-being. Government online services or e-government improves efficiency and cost-effectiveness of public services as well as increases transparency in the process reducing the chances of corruption. Effective digitisation of the public sector helps modernize administration procedures, improving service delivery and accessibility.

Data source: World Bank

Trust in the legal system

This indicator measures the share of people who have confidence in their country's judicial system and courts.

Rationale: In a democratic society it is essential that citizens accept the legal institutions as having a legitimate right to exercise authority and that they perceive them as impartial,

efficient and effective. Monitoring levels of public trust and confidence in the justice system is a measure of the quality and legitimacy of the 'third power' in the country.

Data source: Gallup World Poll

Sound governance

General government gross debt (% GDP)

This indicator measures the General government gross debt, expressed as a percentage of GDP. Gross debt consists of all liabilities that require payment or payments of interest and/or principal by the debtor to the creditor at a date or dates in the future. This includes debt liabilities in the form of special drawing rights (SDRs); currency and deposits; debt securities loans; insurance; pensions and standardised guarantee schemes; and other accounts payable.

Rationale: Societies face profound transformations, and the temptation is great to finance these by endangering the stability of public finances. This presents two serious costs, both of which add to the burden faced by future generations. Firstly, by delaying difficult but necessary choices, the proper management of this transformation is compromised. Secondly, the present generation could maintain its advantages by adding to public debt, leaving the bill to future generations.

Data source: IMF

Trust in the national government

This indicator measures the share of people who have confidence in their national government.

Rationale: Trust in government is essential for social cohesion and well-being. Today, more than ever, citizens demand greater transparency from their governments. Information on the who, why and how of decision making is essential to hold government to account, maintain confidence in public institutions and support a level playing field for business.

Data source: Gallup World Poll

Citizen engagement

Active citizenship

This indicator measures the share of people who claimed they had participated in any of the following activities: activities in a political party or local interest group; public consultation; peaceful protest or demonstration, including signing a petition; writing a letter to a politician or to the media (voting in an election excluded).

Rationale: Active citizenship means citizens become actively involved in defining and tackling the problems of their communities and improving society's well-being. Public engagement in decision making promotes government accountability, a friendly business environment and public trust in government institutions. Indeed, high levels of active citizenship is a key signal of a democratic and sustainable society.

Data source: Eurostat -SILC survey

Volunteering

This indicator measures the percentage of people who claimed they participated in voluntary activities (formal or informal).

Rationale: Volunteering is the ultimate proof of citizen engagement and can have a significant impact on the society. Volunteering helps build a more cohesive, safer, stronger community, increase the social network between communities and neighbourhoods contributing to the development of a resilient society. Resilient societies have higher capacity to adapt flexibly to new situations and deliver inclusive and sustainable economic growth.

Data source: Eurostat -SILC survey

Voter turnout

This indicator measures the percentage of registered voters who voted during recent elections.

Rationale: Voter turnout is a measure of citizens' participation in the political process. Even if the right to vote is universal in all the countries covered by the CSI, not everyone exercises this right. High voter turnout is desirable in a democracy because it increases the chance that the political system reflects the will of a large number of individuals, and that the government enjoys a high degree of legitimacy.

Data source: OECD - How's Life? Well-Being

Security and resilience to external shocks

Energy imports dependency

This indicator measures the share of total energy needs of a country met by imports from other countries.

Rationale: The war in Ukraine has made evident the risks of Europe's high dependence on energy imports, particularly oil and natural gas, which has raised increasing awareness about the need to accelerate the energy transition to strengthen EU's open strategic autonomy. This indicator is a proxy for assessing progress towards the energy security goal.

Data source: Eurostat

Circular material use rate

This indicator measures the share of material recycled and fed back into the economy - thus saving extraction of primary raw materials - in overall material use. This indicator is thus defined as the ratio of the circular use of materials (U) to the overall material use (M).

Rationale: Public awareness about the implications of EU's dependence on oil and gas imports is rising, but Europe might soon find itself in an even weaker position in an essential field for its strategic autonomy. Critical raw materials are key enablers of the green and digital transitions and EU's natural reserves of rare earths and critical raw materials are not expected to be sufficient to cover its increasing demand.

A higher circular material use rate value indicates more secondary materials substituting for primary raw materials, avoiding the environmental impacts of extracting primary material whereas also reducing our strategic dependency on materials mostly imported from politically unstable regions.

Data source: Eurostat

Global Cybersecurity Index

This Index measures cybersecurity relying on five pillars – (i) legal measures, (ii) technical measures, (iii) organizational measures, (iv) capacity building, and (v) cooperation – and then aggregated into an overall score.

Rationale: Cybersecurity is essential for building a resilient, green and digital Europe. Critical sectors such as transport, energy, health, finance and industry are increasingly dependent on digital technologies and that poses a challenge to EU's strategic dependency. As cyberattacks and cybercrime are growing in number and sophistication, countries need to reinforce their ability to make autonomous choices in the area of cybersecurity to minimise the exposure of their economies and societies to cyber threats.

Data source: ITU

Security Apparatus

This indicator measures the security threats to a state, such as bombings, attacks and battle-related deaths, rebel movements, mutinies, coups, or terrorism. The Security Apparatus indicator also takes into account serious criminal factors, such as organized crime and homicides, and perceived trust of citizens in domestic security.

Rationale: The range of security threats that can have a significant impact on a country's competitive sustainability goes beyond energy sources, critical raw materials and digital exposure. The Security Apparatus indicator is considered a good complement to assess a broader set of security threats not covered by the indicators addressing specific fields of EU's strategic autonomy.

Data source: Fund for peace

GREEN / ENVIRONMENT DIMENSION

Renewable energies

Availability of wind resources

This indicator measures the extent of the installed base available to generate wind power.

Rationale: When considered alongside the equivalent for solar power, is indicative of the potential ability of the economy to achieve net zero GHG emissions from its electricity, which is a key enabler of emissions reduction in end uses such as mobility, buildings and industry.

Data source: EMHIRES dataset

Availability of solar resources

This indicator measures the extent of the installed base available to generate solar power.

Rationale: Especially when considered alongside the equivalent for wind power, is indicative of the potential ability of the economy to achieve net zero GHG emissions from its electricity, which is a key enabler of emissions reductions in end uses such as mobility, buildings and industry.

Data source: EMHIRES dataset

Share of energy from renewable sources

This indicator measures the percentage of gross final consumption of electricity coming from renewable sources. Renewable energy sources, also called renewables, are energy sources

that replenish (or renew) themselves naturally. Typical examples are solar energy, wind and biomass.

Rationale: The share of primary energy coming from renewable power sources is set against the share of primary energy from fossil fuels. As such, it is an indicator of the enabling potential for the economy overall to achieve net zero GHG emissions in a sustainable way.

Data source: Eurostat

Sustainability transition commitment

Effective Carbon Rates

This indicator measures carbon pricing of CO2-emissions from energy use. The dataset provides a comprehensive view on carbon pricing, including fuel excise taxes, carbon taxes and tradable emission permit prices.

Rationale: The direct physical proportionality of the tax or permit base to CO2 has an important economic implication: Each component of the Effective Carbon Rates makes low- and zero- carbon energy more competitive by increasing the price of high-carbon alternatives, encouraging energy users to curtail their use of high carbon energy and switch to low- or zero-carbon options.

Data source: OECD

Percentage of population perceiving climate change as a priority

This indicator measures the attitude towards climate change through the survey question "Which of the following do you consider to be the single most serious problem facing the world as a whole?" and it considers the respondents who select climate change as an answer.[xlvii]

Rationale: With government action reflecting its view of the public interest, popular opinion is in many countries, a significant influence on the strength of commitment to a particular issue. A high level of public concern about climate change relative to other issues, as evidenced by reliable and regular opinion polling, is typically indicative of a stronger level of policy commitment by the government. Conversely, lower levels of concern are typically indicative of weaker policy commitment.

Data source: Eurobarometer survey

Fossil Fuel Subsidies

This indicator measures the estimated value of explicit and implicit government subsidies related to fossil fuels (coal, natural gas, petroleum and electricity). Total subsidies equal implicit plus explicit subsidies. The economic concept and the model-based estimates of subsidies should not be confused with subsidies defined in government finance statistics.

Rationale: The value of explicit and implicit government subsidies related to fossil fuels is indicative of the extent of public commitment to achieve climate neutrality, with higher levels of subsidy indicative of lower levels of commitment, and vice-versa. Explicit subsidies reflect under-pricing due to supply costs being greater than prices paid by users. Implicit subsidies reflect the difference between supply costs and socially inefficient prices (incorporating the

[xlvii] Survey covers the population of the respective nationalities of the European Union Member States, resident in each of the 27 Member States and aged 15 years and over.

cost of negative externalities of fossil fuel use and foregone consumption tax revenues), exclusive of any explicit subsidy.

Data source: IMF – Climate Change Dashboard

Natural resources

Renewable freshwater availability/capita

This indicator measures internal renewable resources (internal river flows and groundwater from rainfall) in the country (cubic meters). Renewable internal freshwater resources per capita are calculated using the World Bank's population estimates.

Rationale: The extent of renewable freshwater availability per capita is indicative of a natural resource relevant to the provision of safe, secure and sufficient hydration and hygiene to the population. A per capita measurement indicates the productivity of the renewable freshwater available. The higher the productivity, the less that this resource is needed for the same hydration or hygiene goals. This means other natural resources or biodiversity is less likely to be exploited or compromised.

Data source: World Bank

Forest area (% of total land)

This indicator measures land under natural or planted stands of trees of at least 5 meters in situ, whether productive or not, and excludes tree stands in agricultural production systems (for example, in fruit plantations and agroforestry systems) and trees in urban parks and gardens.

Rationale: The percentage of land area taken by forest is indicative of the capacity of the natural environment to support higher levels of biodiversity and provide natural emissions sinks which are especially relevant to climate change mitigation. Low and declining levels of forest cover are indicative of over-exploitation of the natural resource at the expense of biodiversity and earth systems whilst high and increasing levels are indicative of more sustainable management of natural resources and earth systems capable of mitigating climate change.

Data source: World Bank

Resource productivity

Material footprint (MF tonnes per capita)

This indicator measures the amount of domestic and foreign extraction of materials (biomass, fossil fuels, metal ores and nonmetal ores) used to meet domestic final demand for goods and services within a country.

Rationale: Material flows and resource productivity indicators are central to monitoring the changing patterns of resource use as global economies develop. They are essential for monitoring progress towards a sustainable economy through sustainable production and consumption strategies, in particular the extent to which resource is not wasted and its value is retained indicates a transition to more circularity. Per capita material footprint targets that reflect planetary boundaries are being developed by the International Resource Panel's Global Materials Flow database and are now also included in the European Commission's 2021 edition of the Transition Performance Index.

Data source: UN Global Material Flows Database

Water productivity (GDP/total fresh water abstraction)

This indicator measures how much economic output is produced per cubic meter of fresh water abstracted (in EUR per m3 or PPS per m3). Total fresh water abstraction includes water removed from any fresh water source, either permanently or temporarily. Mine water and drainage water as well as water abstractions from precipitation are included, whereas water used for hydroelectricity generation (in situ use) is excluded.

Rationale: The indicator serves as a measure of the efficiency of water use. Water productivity is strongly influenced by the economic structure and the proportion of water intensive industries. A lower water productivity primarily means that the economic and industrial structure of the country is water use intensive. A less water-consuming economy would show a relatively high water productivity. The change in water productivity is influenced by both 'real' productivity improvements and deteriorations, as well as by changes in economic and industry structure.

For the calculation of water productivity, Eurostat uses the GDP either in the unit of EUR in chain-linked volumes to the reference year 2010 at 2010 exchange rates or in the unit PPS (Purchasing Power Standard). The unit EUR in chain linked volumes allows observing the water productivity trends over time in a single geographic area, whereas the unit PPS allows to compare countries for the same year. Since GDP is measured in million EUR or million PPS and water abstraction in million cubic meters, water productivity is available in both EUR per m3 and PPS per m3.

Data source: Eurostat

Energy productivity (GDP/gross inland energy consumption)

This indicator measures the GDP generated by the gross available energy for a given calendar year. The gross available energy is calculated as: Primary production + Recovered & recycled products + Imports – Exports + Stock changes.

Rationale: The indicator measures the productivity of energy consumption and provides a picture of the degree of decoupling of energy use from growth in GDP. The unit euro in chain linked volumes allows observing the energy productivity trends over time in a single geographic area, whereas the unit PPS allows comparison between countries for the same year.

Data source: Eurostat

Climate emissions

Greenhouse gas emission intensities (grams per euro)

This indicator measures the intensity of GHG emissions in grams per euro. Greenhouse gases constitute a group of seven gases: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF6), nitrogen trifluoride (NF3).

Rationale: GHG emissions intensities are relevant for monitoring the interaction between the economy and the environment, in particular in a context of the transition to climate neutrality. This indicator is also a good measure to monitor the energy transition in particular. A low intensity figure is indicative is higher economic performance with less negative environmental and climate impact, while conversely a higher figure is indicative of lower economic performance with a greater negative environmental and climate impact.

Data source: Eurostat

Biodiversity

Terrestrial key biodiversity areas protected (%)

This indicator measures the proportion of important sites for terrestrial biodiversity that are covered by protected areas.

Rationale: Protected areas, as defined by the International Union for Conservation of Nature (IUCN), are clearly defined geographical spaces, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values. Protected areas not only contribute to essential regulating ecosystem services, such as climate regulation and water purification, but may also support local and national economies through tourism and the supply of forest products, fish and other resources.

Data source: SDGs database - Indicator 15.1.2

Freshwater key biodiversity areas protected (%).

This indicator measures the proportion of important sites for freshwater biodiversity that are covered by protected areas.

Rationale: Freshwater ecosystems may well be the most endangered ecosystems in the world. Declines in biodiversity are far greater in fresh waters than in the most affected terrestrial ecosystems. Freshwater areas are often highly connected to the dynamics of the wider terrestrial (or land-based) environments that they drain. As such, the health of freshwater ecosystems is often closely linked to the health of the wider

Data source: SDGs database - Indicator 15.1.2

Pesticides use per area of cropland (kg/ha)

This indicator measures the use of pesticides per area of cropland (which is the sum of arable land and land under permanent crops) at national level, expressed in kg/ha.

Rationale: Changes in land and pesticide use are key drivers of change in farmland biodiversity, particularly farmland birds. Pesticides can negatively impact biodiversity due to increased toxicity in the environment and nutrient enrichment, oxygen depletion in aquatic ecosystems, soil or water acidification, or by multiplying the impact of other stressors such as pathogens, invasive species, and climate change[xlviii].

Data source: FAOSTAT

[xlviii] OECD (2018), *Pesticide and fertiliser trends and policies across selected OECD countries: Overview and insights*, OECD internal document.

Annex VII: Country coverage

The Index covers EU member states. The aim of the Competitive Sustainability Index is to track the relative performance of economies in relation to the transition to sustainable development and in particular the goal of achieving climate neutrality as set out in the Paris Agreement.

The method followed for this purpose relies on the availability of data with NACE granularity as a method to incorporate Taxonomy criteria to establish the economic activities that can be considered sustainable. The required data disaggregation per NACE code has only been found available in a limited number of data sources mostly covering only EU countries.

Geographical coverage of the Competitive Sustainability Index may be expanded in future editions to allow for international comparison if a suitable data source is available.

Table 19. Country coverage

Country	Code	Country	Code
Belgium	BE	Lithuania	LT
Bulgaria	BG	Luxembourg	LU
Czechia	CZ	Hungary	HU
Denmark	DK	Malta	MT
Germany	DE	Netherlands	NL
Estonia	EE	Austria	AT
Ireland	IE	Poland	PL
Greece	EL	Portugal	PT
Spain	ES	Romania	RO
France	FR	Slovenia	SI
Croatia	HR	Slovakia	SK
Italy	IT	Finland	FI
Cyprus	CY	Sweden	SE
Latvia	LV		

Annex VIII: Country profiles

How to read the country profiles

This annex provides detailed profiles for each of the 27 countries of the European Union (EU) in the Competitive Sustainability Index 2022. Please see Annex IX: Technical notes for details on computations for normalisation, aggregation, etc. and refer to Annex VI: Sources and definitions for details on indicators.

Rows present the CSI (index), the four dimensions (single-digit code), the 10 sub-dimensions (two-digit code), 31 components (three-digit code) and the 84 indicators.

Regarding columns, each 'score' is the normalised score of the indicator value. 'EU average' is the simple arithmetic average of the scores of the 27 countries. Then, 'rank' is the rank of the 'score' in each dimension, sub-dimension, component and indicator among the scores of the 27 countries.

Scores are normalised in the [0-100] range and rankings range from 1 to 27. Scores are colour-coded into five 'performance groups' based on fixed values: 'Leader', in dark green ■, for scores greater than or equal to 70, and less than or equal to 100 ([70-100]); 'Strong performer', in light green ■, for scores greater than or equal to 60, and less than 70 ([60-69]); 'Good performer', in yellow ■, for scores greater than or equal to 50, and less than 60 ([50-59]); 'Moderate performer', in orange ■, for scores greater than or equal to 40, and less than 50 ([40-49]); and 'Weak performer', in red ■, for scores greater than or equal to 0, and less than 40 ([0-39]).

Indicators for which no score is presented indicate that the country does not report any data for it.

Country: Austria		Score	EU Average	Rank
Index	**COMPETITIVE SUSTAINABILITY INDEX**	64	**52**	**5**
1	**Economy / Productivity**	60	**44**	**4**
1.1	**Framework conditions**	55	**46**	**9**
1.1.1	*Innovation readiness*	63	45	8
	Percentage of people with advanced ICT skills	48	38	8
	Government, Higher Education and non-profit R&D expenditure	79	46	4
	Broadband at home	61	51	11
1.1.2	*Human capital*	62	47	6
	Population aged 25-34 with tertiary education	46	52	18
	Tertiary education graduates in STEM	59	43	6
	Foreign doctorate students	79	45	5
1.1.3	*Business fabric*	40	46	17
	Turnover share large enterprises	40	52	18
	Entrepreneurial culture		37	
1.2	**Innovation enablers**	67	**39**	**3**
1.2.1	*Business R&I investment*	73	35	2
	Expenditure of enterprises on R&D in Taxonomy-eligible activities (% GDP)	31	29	10
	Enterprises that received public funding for R&I in Taxonomy-eligible activities	73	45	4
	Enterprises that use tax incentives or allowances for R&I in Taxo-eligible activities	99	33	2
	Enterprises that obtained debt finance for R&I in Taxonomy-eligible activities	64	42	8
	Enterprises that obtained equity finance for R&I in Taxonomy-eligible activities	100	26	1
1.2.2	*Innovation capacity*	60	41	5
	Enterprises with R&D activities in Taxonomy-eligible activities	61	33	5
	Enterprises in Taxonomy-eligible activities hampered in their innovation activities	60	46	9
1.3	**Outputs**	59	**45**	**3**
1.3.1	*Intellectual Property Rights (IPR)*	46	31	4
	Enterprises that applied for a patent in Taxonomy-eligible activities	53	25	3
	Enterprises that applied for a trademark in Taxonomy-eligible activities	64	43	5
	Enterprises that applied for an industrial design in Taxonomy-eligible activities	22	28	10

1.3.2 *Innovation Activity*	70	50	3
Enterprises in Taxonomy-eligible activities collaborating with other organisations	35	28	9
Turnover of innovative enterprises in Taxonomy-eligible activities	98	70	2
Companies in Taxonomy-eligible activities with product innovations	75	50	7
1.3.3 *Entrepreneurial Activity*	21	36	23
Enterprises created in Taxonomy-eligible activities	7	34	25
Enterprises in existence 5+ years in Taxonomy-eligible activities	34	38	16
1.3.4 *Trade*	59	38	5
Turnover of enterprises from new products in Taxonomy-eligible activities	42	33	9
Trade balance of products from Taxonomy-eligible activities (% GDP)	76	44	4
1.3.5 *Employment*	98	67	2
Employment in innovative enterprises in Taxonomy-eligible activities	98	67	2
1.4 Impacts	59	**48**	**6**
1.4.1 *Wealth*	66	49	2
Gross domestic product (GDP) per capita	44	30	5
Taxonomy-eligible economy (% GDP)	81	63	6
Taxonomy-aligned economy (% GDP)	73	55	5
1.4.2 *Industrial structure*	35	36	14
Early-stage private investment (Venture Capital) in clean technologies	5	33	16
Late-stage private investment (Venture Capital) in clean technologies	12	27	11
Economic Complexity Index	85	53	3
Gross value added of manufacturing (% of GDP)	40	33	8
1.4.3 *Jobs*	74	57	6
Employment rate of population 20-64	73	65	12
Average earnings (Household income)	56	34	3
Labour market insecurity	94	72	5
2 Society / Fairness	74	**62**	**7**
2.1 Framework conditions	79	**64**	**5**
2.1.1 *Education*	68	58	10
Government expenditure in education per student	66	64	11

	Tertiary education attainment	65	64	14
	Lifelong learning	72	47	8
2.1.2	*Basic needs*	94	77	4
	Unmet medical needs	99	75	4
	Insufficient food	89	79	11
2.1.3	*Social mobility*	75	57	8
	Job opportunities	67	54	10
	Young people not in education, employment or training (NEET)	82	61	7
2.2	**Impacts**	70	**60**	**10**
2.2.1	*Inclusivity*	63	58	13
	Tolerance towards minorities	70	56	13
	Quality of support network	56	63	15
2.2.2	*Equality*	70	62	8
	Gini coefficient of disposable income, post taxes and transfers	63	60	14
	Gender employment gap	66	60	12
	Palma ratio	80	67	6
2.2.3	*Health*	76	59	8
	Healthy life expectancy at birth (years)	76	61	13
	Self-reported health (Perceived health)	74	55	6
	Infant mortality rate	79	65	9
3	**Governance / Stability**	66	**51**	**7**
3.1	**Framework conditions**	76	**55**	**6**
3.1.1	*Fundamental rights*	83	60	7
	Voice and accountability index	92	70	6
	Rule of law	70	50	9
	Freedom over life choices	86	61	8
3.1.2	*Transparency*	67	54	9
	Control of Corruption	88	53	3
	Open Government and Transparency	43	50	18
	Freedom of Press Index	69	58	10

3.1.3	*Institutional efficacy*	79	52	4
	Government Effectiveness	86	58	6
	Government Online Service Index	67	52	8
	Trust in the legal system	83	48	4
3.2	**Impacts**	56	**47**	**8**
3.2.1	*Sound governance*	59	55	13
	General government gross debt (% GDP)	66	70	19
	Trust in the national government	52	40	9
3.2.2	*Citizen engagement*	49	35	6
	Active citizenship	34	29	8
	Volunteering	47	37	9
	Voter turnout	66	48	7
3.2.3	*Security and Resilience to External Shocks*	60	52	5
	Energy imports dependency	45	45	15
	Circular material use rate	36	30	10
	Global Cybersecurity Index	83	74	15
	Security Apparatus	76	57	5
4	**Green / Environment**	58	**50**	**5**
4.1	**Framework conditions**	56	**41**	**3**
4.1.1	*Renewable Energies*	65	42	3
	Availability of wind resources	80	51	3
	Availability of solar resources	61	55	10
	Share of energy from renewable sources	52	28	4
4.1.2	*Sustainability transition commitment*	56	45	9
	Effective Carbon Rates	47	35	7
	Percent of population perceiving climate change as a priority	26	33	13
	Fossil Fuel Subsidies	95	69	3
4.1.3	*Natural resources*	48	35	6
	Renewable freshwater availability/capita	32	24	8
	Forest area (% of total land)	63	46	6

4.2	**Impacts**	59	**59**	**13**
4.2.1	*Resource productivity*	37	42	16
	Material footprint (MF tonnes per capita)	18	48	23
	Water productivity (GDP/total fresh water abstraction)		31	
	Energy productivity (GDP/gross inland energy consumption)	57	45	8
4.2.2	*Climate Emissions*	91	71	4
	Greenhouse gas emission intensities (grams per euro)	91	71	4
4.2.3	*Biodiversity*	49	65	21
	Terrestrial key biodiversity areas protected (%)	25	57	25
	Freshwater key biodiversity areas protected (%)	55	69	20
	Pesticides use per area of cropland (kg/ha)	68	70	15

Click here to view more country profiles

Annex IX: Technical notes

Annex IX describes the steps towards the construction of the Competitive Sustainability Index, based on the conceptual framework presented in Annex III. This chapter develops in five sections. Section 1 discusses missing data and the imputation of missing observations. Section 2 presents the methodology that is employed for the identification of outliers, the list of indicators with outliers and how these outliers were treated. Section 3 discusses the normalisation method and how it was applied in the case of the Competitive Sustainability Index to ensure country performance comparability across the various indicators. Section 4 presents the approach to aggregate and the chosen weighting method to go from the level of indicators to the overall index. Section 5 reiterates in brief key findings of the JRC statistical audit of the Competitive Sustainability index, a summary of which is available in Annex X. Each section includes information relating to the treatment of the country-level indicator and the indicators presenting country performance at the innovation ecosystem level.

1. Missing data and imputation

Country level

The Competitive Sustainability Index is based on data from 2015 to 2021. Data availability across indicators presents some variation, with 70% of available data referring to the period between 2019 and 2021. Care will need to be taken when interpreting the results, considering the large number of indicators included in the scoreboard and the noted differences in the reporting year. The theoretical framework makes it clear that there is not an assumption of any direct cause-effect link between input and output indicator results, these differences will also need to be taken into account in any interpretation of their relationship.

The scoreboard uses the latest year available to construct the reported scores. Missing data were imputed using the cold deck imputation method. This method was selected to accommodate the high number of indicators included in the index. After cold deck imputation, the data availability by indicator is checked so that the threshold of 63% data available per indicator is respected. Since the threshold was met at indicator level, it was decided not to impute the rest of the missing data to ensure that the index is easier to interpret.

Overall, data availability across countries, appears satisfactory. The only countries with score in fewer than 90% of the indicators included in the Competitive Sustainability Index are Cyprus (89%), Malta (83%), the Netherlands (84%) and Romania (89%). To safeguard the transparency and replicability of the pilot version of the index missing data were not estimated.

Innovation ecosystem level

For the innovation ecosystem indicators, the decision not to impute the missing observations was made for various reasons. First, at industry level data availability is scarce. Given the granularity level required for the construction, it was difficult to understand which observations were not available due to sampling issues and which ones were true zeros. Third, since the theoretical methodology to calculate the ecosystem indicators based on the NACE sectors is assuming that unavailability of the eligible activity is possible, imputing missing observations might undermine the interpretation of the performance of the country in the ecosystem.

The data used to construct the innovation ecosystem indicators of the Competitive Sustainability Index are based on data from 2018 to 2020. Data availability across indicators can vary – primarily between 2018 and 2020. The great majority of indicators are reported for 2018.

The index uses the latest available year to construct the reported scores. In most cases, this is also the only year available given the reliance of the analysis on survey data – CIS dataset. For the purposes of the construction of the normalised innovation ecosystem indicators the latest year available at ecosystem is used.

When the availability of data for the 18 indicators across the 6 ecosystems (108 data columns) is reviewed, 23 instances are identified for which an estimate is missing for more than 40% of the countries included in the Competitive Sustainability Index. Only Spain, France, Italy, Malta, Portugal, Poland, Sweden and Slovakia report a value for more than 90% of the indicator – ecosystem combinations.

2. Outliers

For the treatment of outliers, the OECD-JRC recommended approach is employed, which is based on kurtosis and skewness.[xlix] An indicator is affected by outliers if:

- skewness > 2 and absolute value of kurtosis >3.5; or
- kurtosis > 10

The indicators affected by outliers, are treated through winsorisation, i.e. extreme values are replaced by the closest neighbour. Values are replaced iteratively, until the skewness and kurtosis of the indicator meet the above criteria.

Country level

Table 24 Indicators treated for outliers

Treated indicators	Value chosen
Foreign doctorate students (% of all doctorate students)[l]	Highest value (Luxembourg) was replaced by the closest (the Netherlands) neighbouring observation
Enterprises that obtained equity finance for R&D or other innovation activities	Highest (Luxembourg) and second highest (Austria) values were replaced by the closest (Finland) neighbouring observation
Enterprises hampered in their innovation activities in Taxonomy-eligible activities due to lack of collaboration partners (share in enterprises in Taxonomy-eligible activities)	Highest value (Denmark) was replaced by the closest (Greece) neighbouring observation
GDP per capita, current dollars (PPP$)	Highest value (Luxembourg) was replaced by the closest (Ireland) neighbouring observation
Labour market insecurity	Highest value (Greece) was replaced by the closest (Spain) neighbouring observation

[xlix] See. Handbook on Constructing Composite Indicators: Methodology and User Guide (oecd.org)
[l] In this case, skewness is very close to 2 and kurtosis is much higher than 3.5.

Fossil fuel subsidies	Highest value (Bulgaria) was replaced by the closest (Estonia) neighbouring observation
Water productivity	Highest value (Luxembourg) was replaced by the closest (Malta) neighbouring observation
Energy productivity	Highest value (Ireland) was replaced by the closest (Denmark) neighbouring observation
Unmet medical needs	Highest value (Estonia) was replaced by the closest (Greece) neighbouring observation

Source: Cambridge Econometrics calculations

Innovation ecosystem level

Outlier treatment is applied to the ecosystem scores, following the same approach as the country level. The table below presents the indicator-ecosystem combinations that were treated for outliers.

Table 25 Indicators at ecosystem level treated for outliers

Treated indicators	Value chosen
Enterprises that obtained equity finance for R&D or innovation in Buildings and Consumables	Highest value (Luxembourg) was replaced by the closest (Austria) neighbouring observation
Enterprises that applied for a patent in Buildings and Consumables	Highest value (Germany) was replaced by the closest (Finland) neighbouring observation
Enterprises hampered in their innovation activities in Buildings and Consumables due to lack of collaboration partners	Highest value (Denmark) was replaced by the closest (Germany) neighbouring observation
Enterprises hampered in their innovation activities in Digital, Finance and Others due to lack of collaboration partners	Highest value (Denmark) was replaced by the closest (Greece) neighbouring observation
Trade balance of products from Digital, Finance and Others	Highest value (Sweden) was replaced by the closest (the Netherlands) neighbouring observation
Enterprises hampered in their innovation activities in Industry due to lack of collaboration partners	Highest value (Denmark) was replaced by the closest (Estonia) neighbouring observation
Enterprises that obtained debt finance for R&D or innovation in Land-use and Agri-Food	Highest value (Luxembourg) was replaced by the closest(France) neighbouring observation
Enterprises that obtained equity finance for R&D or innovation in Land-use and Agri-Food	Highest value (Luxembourg) was replaced by the closest (Germany) neighbouring observation
Turnover of enterprises from new or significantly improved products in Land-use and Agri-Food	Highest value (Hungary) was replaced by the closest (Italy) neighbouring observation
Enterprises that obtained equity finance for R&D or innovation in Mobility and Communications	Highest value (Luxembourg) was replaced by the closest (Austria) neighbouring observation

Turnover of enterprises from new or significantly improved products in Mobility and Communications	Highest value (Italy) was replaced by the closest (Estonia) neighbouring observation
Enterprises hampered in their innovation activities in Mobility and Communications due to lack of collaboration partners	Highest value (Denmark) was replaced by the closest (Estonia) neighbouring observation
Trade balance of products in Mobility and Communications	Highest value (Cyprus) was replaced by the closest (the Netherlands) neighbouring observation
Enterprises hampered in their innovation activities in Energy due to lack of collaboration partners	Highest value (Denmark) was replaced by the closest (Croatia) neighbouring observation

Source: Cambridge Econometrics calculations

3. Normalisation

To ensure the comparability and interpretation of the results across indicators/ components/ sub-dimensions/ dimensions, the indicators are rescaled to a 0 -100 scale, with 0 representing the lowest score achieved in the indicator and 100 the highest. This is applied on both levels of analysis, country and innovation ecosystem.

The min-max normalisation is the normalisation method chosen in this case. This involves identifying a minimum and maximum value for each indicator (after outliers were treated). The normalisation method takes into account positive and negative interpretation of the best performance, i.e. directionality. The following formula was used:

$$score_{i,j} = \frac{value_{i,j} - poorest\ performance_i}{best\ performance_i - poorest\ performance_i}$$

Indicators with negative values undergo additional treatment before normalisation. This treatment entails rescaling that turns all values to positive without affecting the performance differences between countries. This is applied only to the World Governance Indicators included in the scoreboard: rule of law; control of corruption; government effectiveness which were produced as z-scores.

4. Aggregation and weighing

Country level

The aggregation of results from indicator to component, sub-dimension, dimension and index is done through the use of an arithmetic mean. Simple arithmetic mean can compensate a comparative disadvantage on many indicators, as noted by the JRC audit, and can mask differences in data availability between countries for each level of aggregation. Nevertheless, the use of arithmetic mean is often preferred in the pilot stage. In the future, it is recommended to investigate the use of alternative methods of aggregation and different weights based on feedback from key stakeholders and field experts.

The JRC has already checked impact on this modelling assumption (i.e. simple arithmetic mean) and found that is does not impact significantly the ranks.

Innovation ecosystem level

The aggregation of results from indicator to component, sub-dimension, dimension and ecosystem is based on the use of an arithmetic mean. Here, the same strengths and weaknesses apply. Note that aggregation to a single Index number cannot be achieved due to the existence of overlap between the industrial codes comprising the various ecosystems. On this basis, the highest aggregate figures reported for each country are the 6 ecosystem scores.

5. Statistical coherence

As noted by the JRC statistical audit of the Competitive Sustainability Index, for the reliability of the index it is necessary to safeguard the coherence between the different elements of the conceptual framework – 84 indicators grouped into 31 components, 10 sub-dimensions, 4 dimensions and an index.

Please read the JRC statistical audit for information of the statistical coherence of the Index.

Annex X: JRC statistical audit of the Competitive Sustainability Index

Abstract

'Competitive sustainability' is to be understood as the ability of an economy, companies and industrial ecosystems to excel relative to international competitors in their transition to sustainable economy – with climate neutrality at its core – through investment in the necessary innovation. The competitive sustainability concept is a term first used by the European Commission in its 2020 Annual Sustainable Growth Strategy. In November 2021 the Competitiveness Council called for new performance indicators to measure the success of its industrial policy. The Cambridge Institute for Sustainability Leadership, following a working paper on the rationale for competitive sustainability[li], operationalised the concept by developing the Competitive Sustainability Index to provide EU Member States with a tool to measure and benchmark competitive sustainability as determining element of a country' ability to be competitive and to grow in a sustainable way.

This first edition of the Competitive Sustainability Index builds on four dimensions: Economy/Productivity, Society/Fairness, Governance/Stability, and Green/Environment. The conceptual framework is populated with 84 indicators, further aggregated into 31 components, 10 sub-dimensions, 4 dimensions, and finally into an overall index. This statistical audit, conducted by the European Commission's Joint Research Centre (JRC), aims at maximising the reliability and transparency of the Competitive Sustainability Index framework. This statistical quality check should enable policy analysts and researchers alike to draw more relevant and meaningful advice to improve or fully unleash the competitive sustainability potential of the EU Member States.

1 Introduction

'Competitive sustainability' is to be understood as the ability of an economy, companies and industrial ecosystems to excel relative to international competitors in their transition to sustainable economy – with climate neutrality at its core – through investment in the necessary innovation. The competitive sustainability concept is a term first used by the European Commission in its 2020 Annual Sustainable Growth Strategy (Figure 1) and it is captured by four dimensions: Productivity, Fairness, Stability and Environment. In November 2021 the Competitiveness Council called for new performance indicators to measure the success of its industrial policy.

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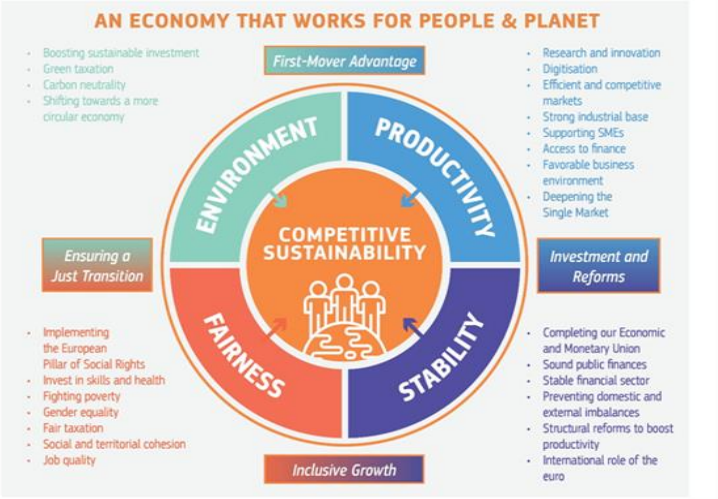
University of Cambridge Institute for Sustainability Leadership (CISL). (2020). Developing the EU's 'competitive sustainability' for a resilient recovery and dynamic growth. Cambridge, UK: the Cambridge Institute for Sustainability Leadership. https://www.cisl.cam.ac.uk/resources/low- carbon-transformation-publications/developing-the-eus-competitive-sustainability-for-a- resilient-recovery-and-dynamic-growth

Figure 1: Commission's concept for Competitive Sustainability in the 2020 Annual Sustainable Growth Strategy



Source: 2020 Annual Sustainable Growth Strategy

The Cambridge Institute for Sustainability Leadership, following a working paper on the rationale for competitive sustainability, operationalised the concept by developing the Competitive Sustainability Index to provide EU Member States with a tool to measure and benchmark competitive sustainability as determining element of a country's ability to be competitive and to grow in a sustainable way.

The Joint Research Centre (JRC) has been invited to audit this first edition of the Competitive Sustainability Index. The present JRC assessment of the 2022 edition of the Competitive Sustainability Index focuses on two main issues: (1) the statistical coherence of the indicator framework and (2) the impact of key modelling assumptions on the Competitive Sustainability Index scores and ranks. The JRC analysis complements the reported country rankings for the overall Competitive Sustainability Index, and for the four dimensions of competitive sustainability, with confidence intervals in order to better appreciate the robustness of these ranks to the computation methodology (in particular, the missing data estimation, weights, and aggregation formula). Furthermore, the JRC analysis includes an assessment of the added value of the Competitive Sustainability Index and a comparison with other global measures of attractiveness, competitiveness, and innovation.

Given that the present statistical analysis of the Competitive Sustainability Index will mostly, though not exclusively, be based on correlations, the correspondence of the Competitive Sustainability Indicator Framework to a real-world phenomenon needs to be critically addressed because correlations need not necessarily represent the real influence of the individual indicators on the phenomenon being measured. In this respect, the Competitive Sustainability Index has been developed following an iterative process that went back and forth between the theoretical understanding of competitiveness and sustainability on the one hand, and empirical observations on the other. The Competitive Sustainability Index needs thus to continuously be nurtured by a dynamic iterative dialogue between the principles of statistical soundness and conceptual relevance.

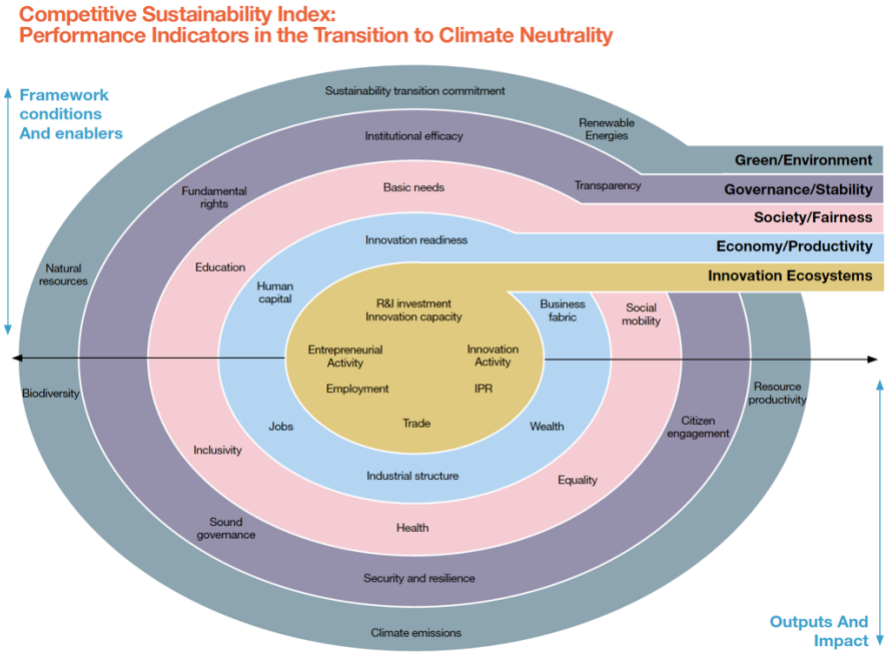
The JRC's statistical assessment aims at maximising the reliability and transparency of the Competitive Sustainability Index framework. The statistical quality checks and findings herein should enable policy analysts and researchers alike to draw more relevant and meaningful

insights to improve or fully unleash the competitive sustainability potential of the EU Member States.

2 Conceptual framework and statistical coherence

This first edition of the Competitive Sustainability Index benchmarks EU Member States' performance on four dimensions of competitive sustainability: Economy/Productivity, Society/Fairness, Governance/Stability, and Green/Environment. The conceptual framework is populated with 84 indicators, further aggregated into 31 components, 10 sub-dimensions, 4 dimensions, and finally into an overall index (Figure 2).

Figure 2: Competitive Sustainability Index framework

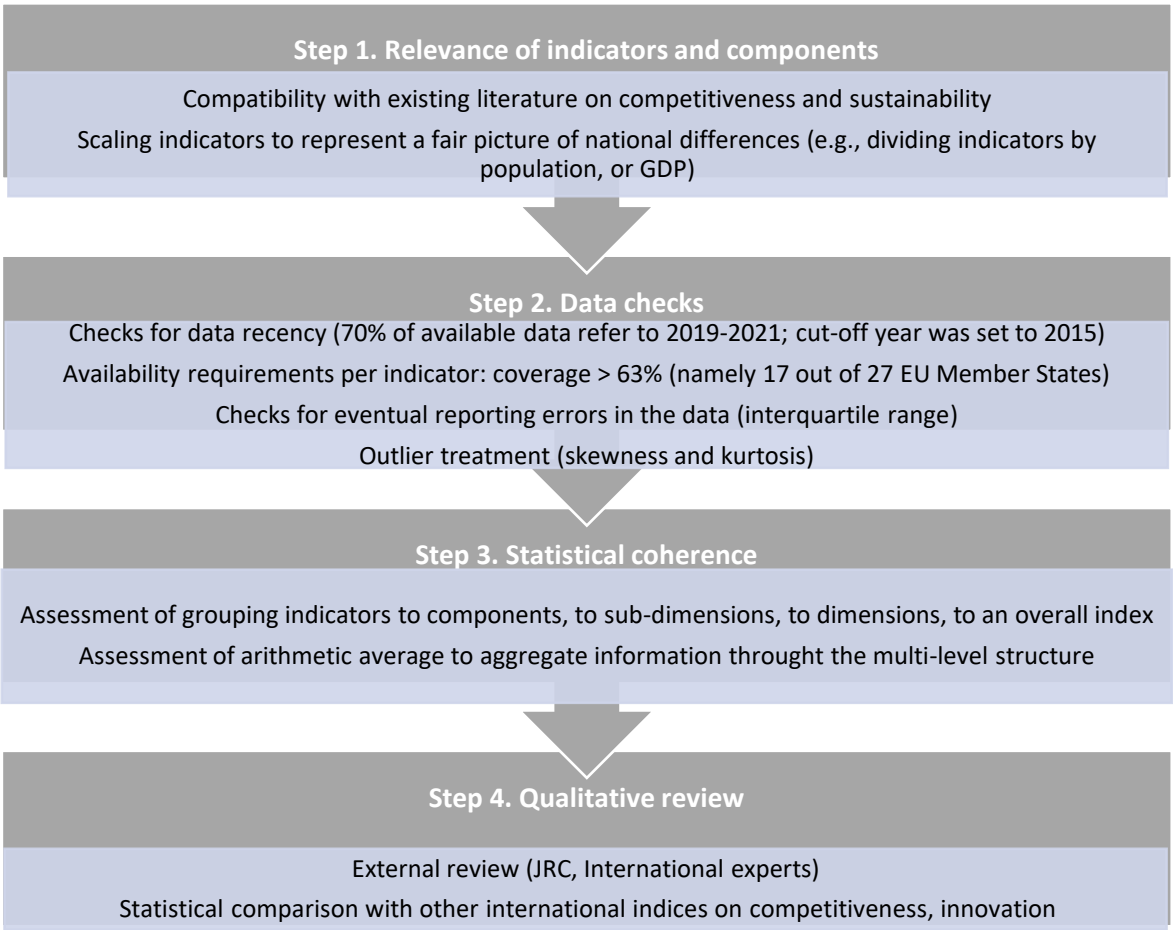


Source: Cambridge Institute for Sustainability Leadership

Both the concepts and indicators underlying the Competitive Sustainability Index benefitted from expert workshops organised by the developers in September and December 2021, whereby the JRC was invited to attend. Following an invitation by the index developers, the JRC also undertook an initial assessment of the Competitive Sustainability data set in July–September 2022. The revised indicator framework provided by the development team to the JRC largely incorporated the issues identified and discussed in earlier versions of the framework, with particular attention to the exclusion or substitution of indicators that were proven not to add to the coherence of the framework or to be not influential on the final values of the index.

Following the iterative process during which the indicator framework was fine-tuned, the JRC assessment of the statistical coherence in this final version of the Competitive Sustainability framework followed four steps (Figure 3).

Figure 3: Conceptual and statistical coherence Competitive Sustainability Index framework



Source: European Commission's Joint Research Centre, 2022.

Step 1: Relevance

Almost 430 indicators were initially screened by the index developers for their relevance to the four dimensions of competitive sustainability on the basis of literature review and expert consultation in 2021-2022. After screening for data coverage and timeliness, and subsequently testing for statistical coherence, 84 indicators were selected. To represent a fair picture of country differences, indicators were scaled either at the source or by the developing team as appropriate and where needed.

Step 2: Data checks

The most recently released data within the period 2015–2021 were used for each EU Member State to reflect the latest updates issued by Eurostat and other leading international statistical bodies from which the database is derived.

Indicators were included if data availability was at least 63% (namely 17 out of the 27 EU Member States). As a result, the Competitive Sustainability dataset data set has 94.7% data coverage across the 27 EU Member States and 84 indicators. The impact of missing values on the competitive sustainability results is further discussed in Section 2.

Potentially problematic indicators that could bias the overall results were identified by the development team, as per the JRC guidelines, on the basis of two measures related to the shape of the indicators' distribution: skewness and kurtosis. Values were treated if the

indicators had absolute skewness greater than 2 and absolute value of kurtosis greater than 3.5 (or only kurtosis greater than 10). The indicators affected by outliers were treated through winsorisation, i.e. extreme values were replaced by the closest neighbour. Values were replaced iteratively, until the skewness and kurtosis of the indicator met the above criteria. This data treatment, which is common in a composite indicator context, is undertaken with a view to avoid that few very high or very low values result in polarised indicators and scores, and introduce distortion in the correlation coefficients that are subsequently used for the analysis of the statistical coherence in the competitive sustainability framework.

Step 3: Statistical Coherence

The reliability of the Competitive Sustainability Index depends, inter alia, on the degree of coherence between the conceptual framework – 84 indicators grouped into 31 components, 10 sub-dimensions, 4 dimensions and finally into an index – and the statistical relations of the data. The more the statistical structure of the selected dataset is compatible with the conceptual framework for measuring Competitive Sustainability, the higher will be the reliability of the Index ranks and of the dimensions ranks. The statistical coherence of the indicator framework was assessed by analysing whether the 84 indicators and 31 components explain a sufficient amount of variation in the aggregate scores (either in the dimensions or the overall index) by means of correlation, cross-correlation, and principal component analysis.

Given that the analysis of statistical coherence of the Competitive Sustainability Index is based on correlations, the correspondence of the index to a real-world phenomenon needs to be critically addressed by experts in the field because 'correlations need not necessarily represent the real influence of the individual indicators on the phenomenon being measured'[lii]. The point made here is that the validity of the indicator framework underpinning the Competitive Sustainability Index relies on the combination of both statistical soundness and conceptual relevance. In this respect, the Competitive Sustainability framework has been developed following an iterative process that went back and forth between the theoretical understandings of competitive sustainability on the one hand, and data observations on the other.

Principal component analysis was used to assess the extent to which the conceptual framework underpinning the Competitive Sustainability Index is compatible with the data statistical properties. Results suggest that the expectation of a single statistical dimension (i.e., no more than one principal component with eigenvalue greater than 1.0) is confirmed for 24 of the 31 components, for 8 of the 10 sub-dimensions, for all 4 dimensions, and for the overall index. The presence of more than one "statistical dimensions" suggests that some of the information content of some indicators and components in the Competitive Sustainability framework does not arrive at the higher aggregation levels. This finding is discussed in more detail later in this section.

A more detailed analysis of the correlation structure within and across the four dimensions of Competitive Sustainability confirms the expectation that the 31 components are generally more correlated to their own dimension than to any other (see Table 1). This result suggests that the allocation of the 31 components to a specific dimension of a country's competitive sustainability is consistent both from conceptual and statistical perspectives. Furthermore, most associations between components and the respective dimension are statistically

[lii] See (OECD-JRC, 2008).

significant, and most correlation coefficients within a dimension are close to or greater than 0.70, which suggests that at least half of the variance in the dimension scores can be explained by the underlying components.

The four dimensions of Competitive Sustainability share a single statistical dimension. The Competitive Sustainability Index captures 75% of the total variance in the four dimensions, and the four correlation coefficients (between the index and each dimension) are sufficiently high, 0.90 or greater for the first three dimensions, and 0.68 for the Green/Environment dimension. This result supports the aggregation of the four dimensions into one number and suggests that all four dimensions of a country's competitive sustainability can explain more than half of the variation of the Index scores, and vice versa. The reliability of the Competitive Sustainability Index, measured by the Cronbach- alpha value, is very good at 0.84—well above the 0.7 threshold for a reliable aggregate of the four dimensions[liii].

Table 1. Statistical coherence in the Competitive Sustainability framework: correlations between components with the dimensions and with the overall index

Dimensions	Sub-dimensions	Components	Economy / Prosperity	Society / Fairness	Governance / Resilience	Green / Environment	Competitive Sustainability Index
Economy / Prosperity	Framework conditions	1.1.1 Innovation readiness	0.78	0.81	0.90	0.58	0.90
		1.1.2 Human capital	0.61	0.76	0.74	0.59	0.79
		1.1.3 Business fabric	0.55	0.37	0.55	0.51	0.55
	Innovation enablers	1.2.1 Business R&I investment	0.83	0.55	0.58	0.51	0.70
		1.2.2 Innovation capacity	0.81	0.53	0.54		0.59
	Outputs	1.3.1 Intellectual Property Rights (IPR)	0.70	0.43	0.55	0.40	0.60
		1.3.2 Innovation Activity	0.67	0.53	0.41		0.53
		1.3.3 Entrepreneurial Activity	-0.36	-0.33			-0.31
		1.3.4 Trade	0.53		0.32	0.38	0.40
		1.3.5 Employment	0.71	0.47	0.43		0.50
	Impacts	1.4.1 Wealth	0.58	0.41	0.44	0.40	0.52
		1.4.2 Industrial structure	0.47			0.34	0.38
		1.4.3 Jobs	0.62	0.59	0.60		0.57
Society / Fairness	Framework conditions	2.1.1 Education	0.67	0.75	0.81	0.41	0.78
		2.1.2 Basic needs	0.50	0.79	0.57		0.64
		2.1.3 Social mobility	0.65	0.81	0.73		0.72
	Impacts	2.2.1 Inclusivity	0.52	0.81	0.60		0.65
		2.2.2 Equality	0.63	0.69	0.62	0.42	0.69
		2.2.3 Health	0.58	0.74	0.53	0.42	0.66
Governance / Resilience	Framework conditions	3.1.1 Fundamental rights	0.81	0.86	0.96	0.58	0.95
		3.1.2 Transparency	0.82	0.80	0.93	0.67	0.94
		3.1.3 Institutional efficacy	0.77	0.78	0.92	0.64	0.91
	Impacts	3.2.1 Sound governance	0.49	0.55	0.71		0.59
		3.2.2 Citizen engagement	0.77	0.75	0.90	0.57	0.88
		3.2.3 Security and Resilience to External Shocks	0.51	0.45	0.65	0.40	0.59
Green / Environment	Framework conditions	4.1.1 Renewable Energies	0.30		0.32	0.65	0.36
		4.1.2 Sustainability transition commitment	0.50	0.67	0.60	0.60	0.68
		4.1.3 Natural resources	0.35		0.31	0.49	0.34
	Impacts	4.2.1 Resource productivity				0.60	0.19
		4.2.2 Climate Emissions	0.48	0.63	0.55	0.63	0.65
		4.2.3 Biodiversity		-0.40		-0.04	-0.22
		Dimensions of Competitive Sustainability					
			Economy / Prosperity	**Society / Fairness**	**Governance / Resilience**	**Green / Environment**	**Competitive Sustainability Index**
		Economy / Prosperity	1.00	0.77	0.83	0.50	0.90
		Society / Fairness	0.77	1.00	0.84	0.41	0.90
		Governance / Resilience	0.83	0.84	1.00	0.60	0.96
		Green / Environment	0.50	0.41	0.60	1.00	0.68

[liii] See Nunnally (1978).

Notes: Numbers represent the Pearson correlations coefficients between the Competitive Sustainability Index (and its four dimensions) with the underlying 31 components for the latest year available (2015-2021) for the 27 EU Member States. Shaded areas show the conceptual grouping of the components into dimensions. Values greater than 0.7 (in the shaded areas) are desirable because they imply that the competitive sustainability dimension (or index) captures at least 50% (≈ 0.7×0.7) of the variation in the underlying components. Values between 0.3 and 0.7 are acceptable. Instead, values lower than 0.3 are not presented because they are considered to be negligible.

Source: European Commission's Joint Research Centre, 2022.

Thus far, the statistical coherence tests corroborate the multi-level structure in the Competitive Sustainability Index framework. At the same time, a critical review of the results in Table 1 evidences issues that are worth of further reflection by the index developers, either because they indicate avenues for refining the indicator framework in next releases of the index or because they point interesting avenues for policy analysis.

First, eight of the 31 components are found to have a transversal impact across three dimensions in the Competitive Sustainability framework. Innovation readiness (1.1.1), which is part of the Framework conditions for Economy/Productivity (with correlation 0.78), it is also found to have strong statistical association to Society/Fairness (correlation 0.81) and to Governance/Stability (correlation 0.90). Similarly, Human capital (1.1.2), which is also part of the Framework conditions for Economy/Productivity (correlation 0.61), is also found to have a good correlation to Society/Fairness and to Governance/Stability (correlation about 0.75). The other six components in the framework with such a transversal impact across three dimensions of competitive sustainability are: Education (2.1.1), Social Mobility (2.1.3), Fundamental rights (3.1.1), Transparency (3.1.2), Institutional efficacy (3.1.3), and finally Citizen engagement (3.2.2). The transversal impact of these eight components of competitive sustainability may be worth of further reflection and analysis by the index developers, as it may offer additional insights on EU Member States competitive sustainability attributes. In fact, given this transversal impact across three dimensions, these eight components – Innovation readiness, Human capital, Education, Social Mobility, Fundamental rights, Transparency, Institutional efficacy, and Citizen engagement – are also found to be the best predictors for a country's competitive sustainability in the European Union.[liv]

Second, there are three components of competitive sustainability that do not significantly correlate either with the respective dimension, or with the overall index. These are Entrepreneurial activity (1.3.2) that is part of the Outputs of Economy/Productivity, and Resource productivity (4.2.1) and Biodiversity (4.2.3) that are both part of the Impacts of Green/Environment. Although conceptually enriching the Competitive Sustainability framework, these three components (and some of their underlying indicators) are found not to co-vary with the overall index. This means that EU Member States may achieve high Competitive Sustainability scores despite of poor performance in Entrepreneurial activity, Resource productivity, and Biodiversity. On one hand, the poor correlation between Entrepreneurial activity and the Competitive Sustainability Index may be attributed to the calculation of the indicators underlying Entrepreneurial activity. The JRC recommendation to the developing team is to consider whether a different formulation or different data sources for these indicators may be more appropriate. On the other hand, the poor correlation

[liv] The correlation coefficients between these components with the Competitive Sustainability Index range from about 0.78 (in the case of Education or Human capital) to about 0.95 (in the case of Fundamental rights or Transparency).

between Resource productivity and Biodiversity (and also Renewable energies, and Natural resources) with the overall Competitive Sustainability Index is more worrisome, yet not surprising. This finding is in line with relevant scientific literature and a recent article in Nature Communications[lv], and it points towards a masking - rather than a synergistic effect - of competitiveness on environmental protection, and the more worrisome finding that up until 2021 there has not been sufficient integration of environmental priorities into EU Member States' growth and competitiveness plans.

Overall, the statistical coherence tests corroborate the multi-level structure in the Competitive Sustainability Index framework, whereby the desired unidimensionality is confirmed for 24 of the 31 components, 8 of the 10 sud-dimensions, all four dimensions and for the overall index. Furthermore, most components in the Competitive Sustainability framework are found to be influential, having statistically significant correlations with the dimensions, and their influence arrives up to the overall index. This is a desirable outcome as it suggests that the information content in most of the underlying indicators and components is maintained at all levels of aggregation in the Competitive Sustainability framework.

Step 4: Qualitative Review

The Competitive Sustainability Index results for the EU Member States were also evaluated by an ad-hoc Advisory Panel and by international experts invited by the Cambridge Institute for Sustainability Leadership to verify that they are, to a great extent, consistent with current evidence, existing research and prevailing theory.

To complement this qualitative evaluation, the Competitive Sustainability Index results are compared herein vis-à-vis other similar international indices. The expectation is that the Competitive Sustainability Index correlates strongly to other international indices on competitiveness and innovation. Table 2 compares the Competitive Sustainability Index for the EU Member States with the most recent versions of four relevant international indices— the World Intellectual Property Organization (WIPO)'s 2022 Global Innovation Index; the European House Ambrosetti's 2022 Global Attractiveness Index; the International Institute for Management Development (IMD)'s 2022 World Competitiveness Index; and INSEAD's Global Talent Competitiveness Index—using the most recent rankings for the EU Member States extracted from these projects' websites. The rank correlation between the Competitive Sustainability Index and all four international indices is substantially high (correlation ranges 0.81-0.94), which suggests that the Competitive Sustainability Index framework is consistent with the frameworks on global innovation, global attractiveness, and global competitiveness. At the same time, looking at the shifts in rankings, 30%, 59%, 19% and 19% of the EU Member States that feature in the other four international indices differ in ranking by 4 or more positions when comparing the Competitive Sustainability Index with the four selected international indices. This indicates that the Competitive Sustainability Index offers additional insights into EU Member States competitive sustainability compared to the 2022 Global Innovation Index, the 2022 Global Attractiveness Index, the 2022 World Competitiveness Index, and the 2022 Global Talent Competitiveness Index.

[lv] Zeng et al., 2020

Table 2. Statistical consistency between the Competitive Sustainability Index and relevant international indices

Rank differences with respect to the Competitive Sustainability Index (CSI)	Global Innovation Index 2022 (Cornell, INSEAD, WIPO)	Global Attractiveness Index 2022 (The European House Ambrosetti)	World Competitiveness Index 2022 (IMD)	Global Talent Competitiveness Index 2022
6 or more positions	15%	26%	12%	7%
4 or 5 positions	15%	33%	8%	11%
4 or more positions *	**30%**	**59%**	**19%**	**19%**
3 positions	22%	7%	12%	11%
1 or 2 positions	33%	19%	50%	52%
0 positions	15%	15%	19%	19%
Total	100%	100%	100%	100%
Pearson correlation coefficient with the CSI	0.84	0.69	0.93	0.95
Spearman rank correlation coefficient with the CSI	0.86	0.81	0.92	0.94
Common countries with the CSI	27	27	26	27

Notes: The comparison between the Competitive Sustainability Index and the other international indices was based on the common set of countries (27 EU Member States, except for the World Competitive Index where Malta is not included).
(*) This row is the sum of the two rows above.

Source: European Commission's Joint Research Centre, 2022.

Notwithstanding these statistical tests and the positive outcomes regarding the statistical soundness and conceptual relevance of the Competitive Sustainability Index, it is important to mention that the index and its indicator framework has to remain open to future improvements as better data, more comprehensive surveys and assessments, and new relevant research studies and data become available.

3 Impact of modelling assumptions in the Competitive Sustainability Index

Assessing the effect of varying the modelling assumptions in the Competitive Sustainability Index inside plausible ranges is an important part of the statistical audit. The rationale for the choices made by the developing team is manifold. For instance, literature review and expert opinion on competitive sustainability, coupled with statistical analysis, is behind the selection of the 84 indicators and the multi-level structure of the index; common practice and easy of interpretation suggests the use of a min-max normalization approach in the [0–100] range for the indicators; statistical analysis guides the choice on the treatment of outliers; and simplicity seems to advocate for not estimating missing data, assigning equal weights at all levels and adopting an arithmetic average formula.

Despite the well-substantiated rationale for the choices made during the Competitive Sustainability Index development, there is an unavoidable subjectivity (or uncertainty), which is accounted for in the robustness assessment carried out by the JRC. More precisely, the uncertainly analysis is conducted herein in order to allow for the joint analysis of the impact of the modelling choices on the index results, resulting in error estimates and confidence intervals calculated for the 27 EU Member States included in the Competitive Sustainability Index.

As suggested in the relevant literature on composite indicators[lvi], the robustness assessment of the Competitive Sustainability Index was based on Monte Carlo simulation and multi-modelling approaches, applied to 'error-free' data where eventual errors and typos have already been corrected in a preliminary stage. In particular, the three key modelling issues considered in the assessment of the index were the treatment of missing data, the aggregation formula and weights at the sub-dimension and at dimension level.

Missing data. The Competitive Sustainability Index developers, for transparency and replicability and following common practice on composite indicator development, opted not to estimate missing data. Technically, the 'no imputation' choice is equivalent to replacing an indicator's missing value for a given country with the respective component score. Hence, the available data (indicators) in the incomplete component of competitive sustainability may dominate the results, sometimes biasing the ranks up or down. Furthermore, the 'no imputation' choice might encourage countries not to report low data values. To test the impact of the 'no imputation' choice, the JRC estimated missing values in the Competitive Sustainability dataset using the Expectation Maximization (EM) algorithm that was applied in the entire set of 84 indicators.[lvii]

Aggregation. Regarding the aggregation formula, decision-theory practitioners challenge the use of simple arithmetic averages because of their fully compensatory nature, in which a comparative high advantage on a few indicators can compensate a comparative disadvantage on many indicators.[lviii] To assess the impact of this compensability issue, the strong perfect substitutability assumption inherent in the arithmetic average was relaxed in this analysis; instead the geometric average within each of the four dimensions and across them was considered as an alternative. Nevertheless, the arithmetic average has been maintained at the indicator level and component levels, where full compensability may be justifiable. The geometric average is a partially compensatory approach that rewards countries with balanced profiles, and motivates other countries to improve in the Competitive Sustainability sub-dimensions and dimensions in which they perform poorly, and not just in any Competitive Sustainability dimension.[lix]

Weights. While the term multi-modelling refers to testing alternative assumptions—that is, an alternative aggregation method, and missing data estimation method—the Monte Carlo simulation explored the issue of weighting and comprised 1,000 runs, each corresponding to a different set of weights for the 10 sub-dimensions and 4 dimensions, randomly sampled from uniform continuous distributions centred in the reference values (equal weighting within and across dimensions). The choice of the range for the weights' variation was driven by two

[lvi] Saisana et al., 2005; Saisana et al., 2011; Vértesy 2016; Vértesy and Deiss, 2016
[lvii] The Expectation-Maximization (EM) algorithm (Little and Rubin, 2002; Schneider, 2001) is an iterative procedure that finds the maximum likelihood estimates of the parameter vector by repeating two steps. Step 1: The expectation E-step: Given a set of parameter estimates, such as a mean vector and covariance matrix for a multivariate normal distribution, the E-step calculates the conditional expectation of the complete-data log likelihood given the observed data and the parameter estimates. Step 2: The maximization M-step: Given a complete-data log likelihood, the M-step finds the parameter estimates to maximize the complete-data log likelihood from the E-step. The two steps are iterated until the iterations converge.
[lviii] Munda, 2008.
[lix] In the geometric average, pillars are multiplied as opposed to summed in the arithmetic average. Pillar weights appear as exponents in the multiplication. A constant of 0.001 was added to the pillar scores to avoid zero values that would have led to zero geometric averages.

opposite needs: to ensure a wide enough interval to have meaningful robustness checks, and to respect the rationale of the Competitive Sustainability Index that places equal importance on all sub-dimensions and dimensions. Given these considerations, limit values of uncertainty intervals for the sub-dimension and dimension weights are presented in Table 3. In all simulations, sampled weights are then rescaled so that they always sum to 1.

Table 26. Uncertainty parameters in the Competitive Sustainability Index: missing values, weights, aggregation

		Reference	Alternative
I. Uncertainty in the treatment of missing values		No estimation of missing data	Expectation Maximization (EM)
II. Uncertainty in the aggregation formula at pillar level		Arithmetic average	Geometric average
IIIa. Uncertainty in the weights (within a dimension)			
Dimension	*Sub-dimension*	*Reference value for the weight*	*Distribution assigned for robustness analysis*
Economy & Prosperity	Framework conditions	0.25	U[0.15, 0.35]
	Innovation enablers	0.25	U[0.15, 0.35]
	Outputs	0.25	U[0.15, 0.35]
	Impacts	0.25	U[0.15, 0.35]
Society & Fairness	Framework conditions	0.50	U[0.40, 0.60]
	Impacts	0.50	U[0.40, 0.60]
Governance & Resilience	Framework conditions	0.50	U[0.40, 0.60]
	Impacts	0.50	U[0.40, 0.60]
Green & Environment	Framework conditions	0.50	U[0.40, 0.60]
	Impacts	0.50	U[0.40, 0.60]
IIIb. Uncertainty in the weights (when calculating the index)			
		Reference value for the weight	*Distribution assigned for robustness analysis*
Economy & Prosperity		0.25	U[0.15, 0.35]
Society & Fairness		0.25	U[0.15, 0.35]
Governance & Resilience		0.25	U[0.15, 0.35]
Green & Environment		0.25	U[0.15, 0.35]

Source: European Commission's Joint Research Centre (2022)

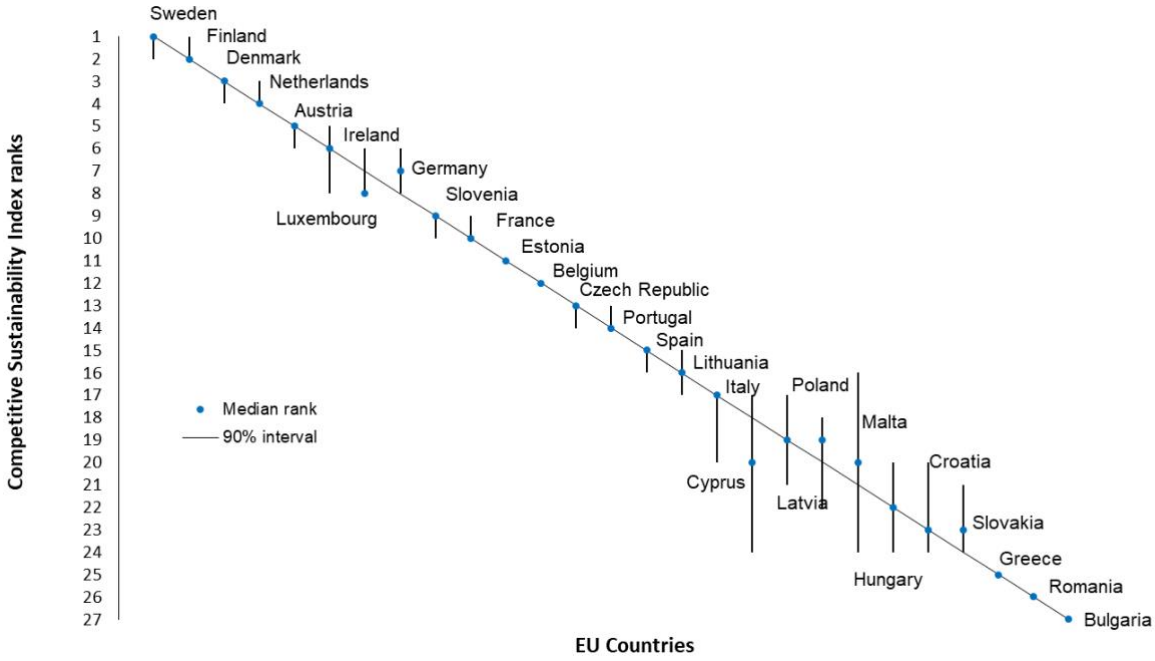
Four models were tested based on the combination of no imputation versus EM imputation at the indicator level, arithmetic versus geometric average at the sub-dimension and dimension levels. Combined with 1,000 simulations per model (random weights versus fixed weights), a total of 4,000 simulations for the Competitive Sustainability Index were run.

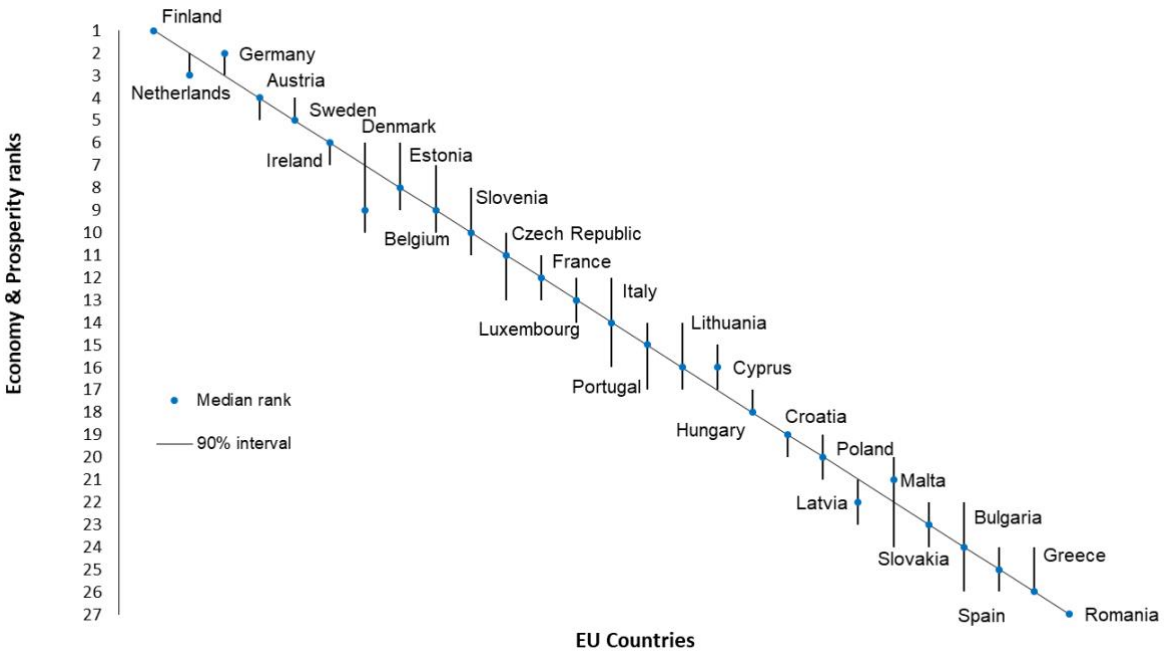
For full transparency and information, the main results of the robustness analysis are shown in Figure 4 with median ranks and the 90% confidence intervals computed across the 4,000 Monte Carlo simulations for the Competitive Sustainability Index and its four dimensions. EU Member States are ordered from higher to lower performance according to their reference rank (black line), the dot being the median rank over the simulations.

All published Competitive Sustainability Index ranks lay within the simulated 90% confidence intervals, and for all EU Member States these ranks can be considered as representative of the plurality of scenarios simulated herein. Taking the median rank as the yardstick for a country's expected rank in the realm of the unavoidable methodological uncertainties, almost all EU Member States are found to shift 1 position or no shift with respect to the median rank in the Competitive Sustainability Index (with the exception of Cyprus that shifts 2 positions compared to the median rank in the simulations). Furthermore, for 25 of the 27 EU Member States the simulated rank intervals are narrow enough for meaningful inferences to be drawn. For these

countries, there are fewer than 4 positions shift. Yet, two countries experience significant changes in rank with variations in weights and aggregation formula and because of the estimation of missing data. These two countries – Cyprus and Malta – have 90 percent confidence interval widths around 7-8 positions. Consequently, their Competitive Sustainability Index ranks – at the 18th position for Cyprus and 21st for Malta – should be interpreted cautiously and certainly not taken at face value. The uncertainty analysis results for the four dimensions of competitive sustainability are also reassuring. For most countries, there are fewer than 4 positions shift across all four dimensions of competitive sustainability, except for Malta (6 positions in the Governance/Stability dimension), and Italy and Croatia (6 and 5 positions, respectively, in the Green/Environment dimension).

Figure 24. Robustness analysis in the Competitive Sustainability Index and its four dimensions




Economy & Prosperity ranks
1
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4
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6
7
8
9
10
11
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13
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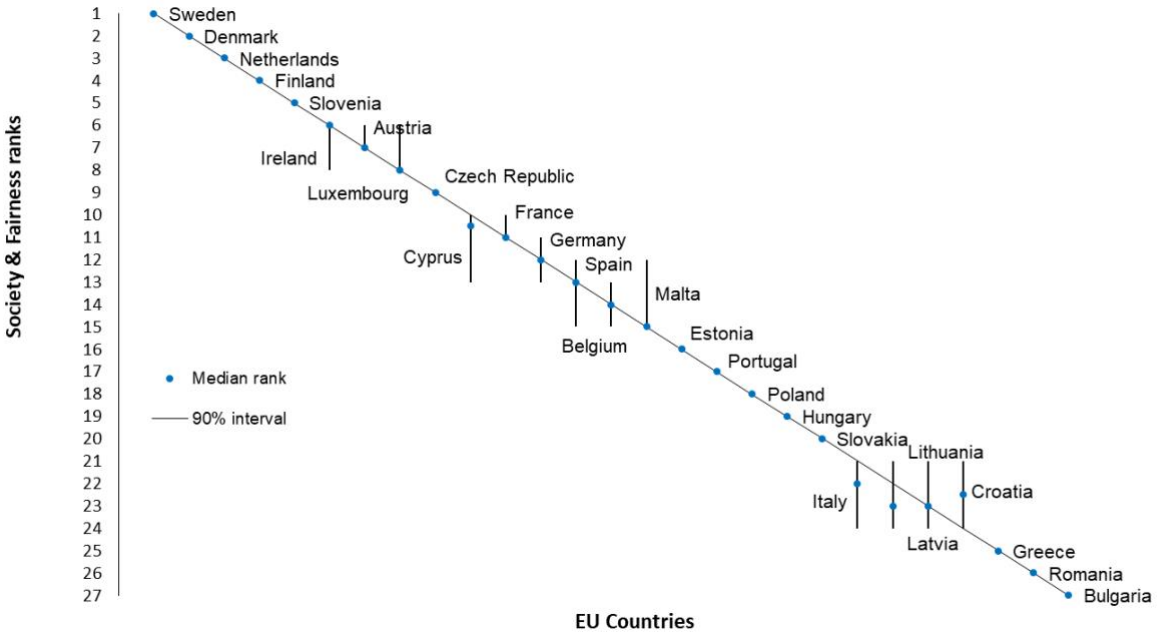
19
20
21
22
23
24
25
26
27
Finland
Germany
Netherlands
Austria
Sweden
Denmark
Ireland
Estonia
Slovenia
Belgium
Czech Republic
France
Italy
Luxembourg
Lithuania
Cyprus
Portugal
Hungary
Croatia
Poland
Malta
Latvia
Bulgaria
Slovakia
Greece
Spain
Romania
Median rank
90% interval
EU Countries


Society & Fairness ranks
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11
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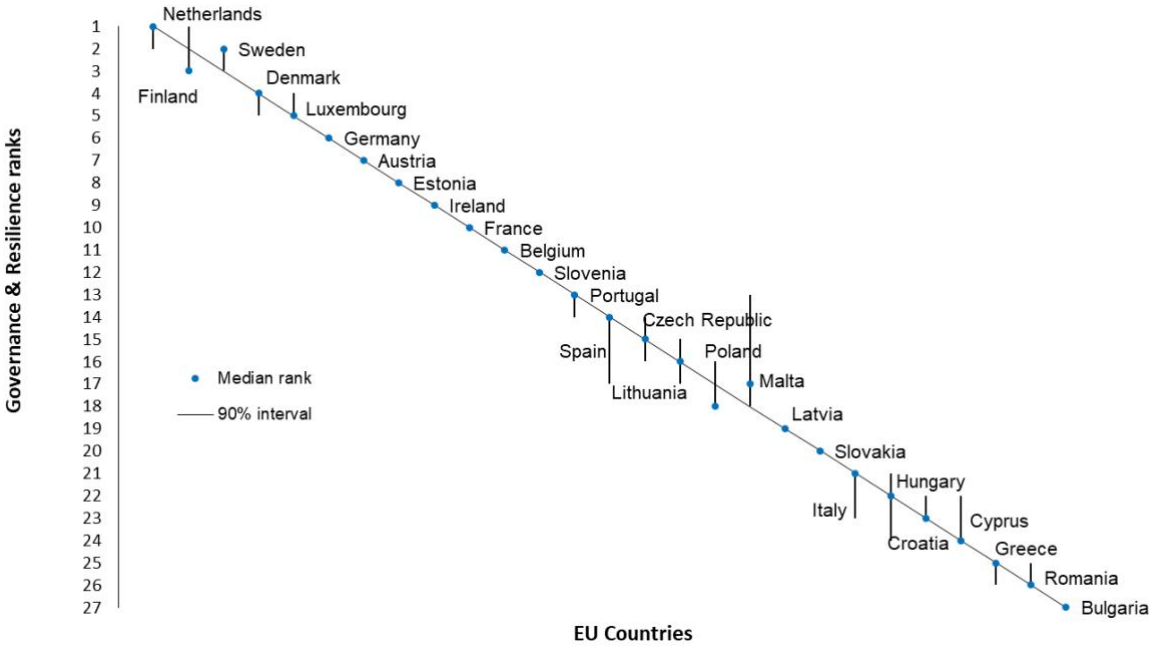
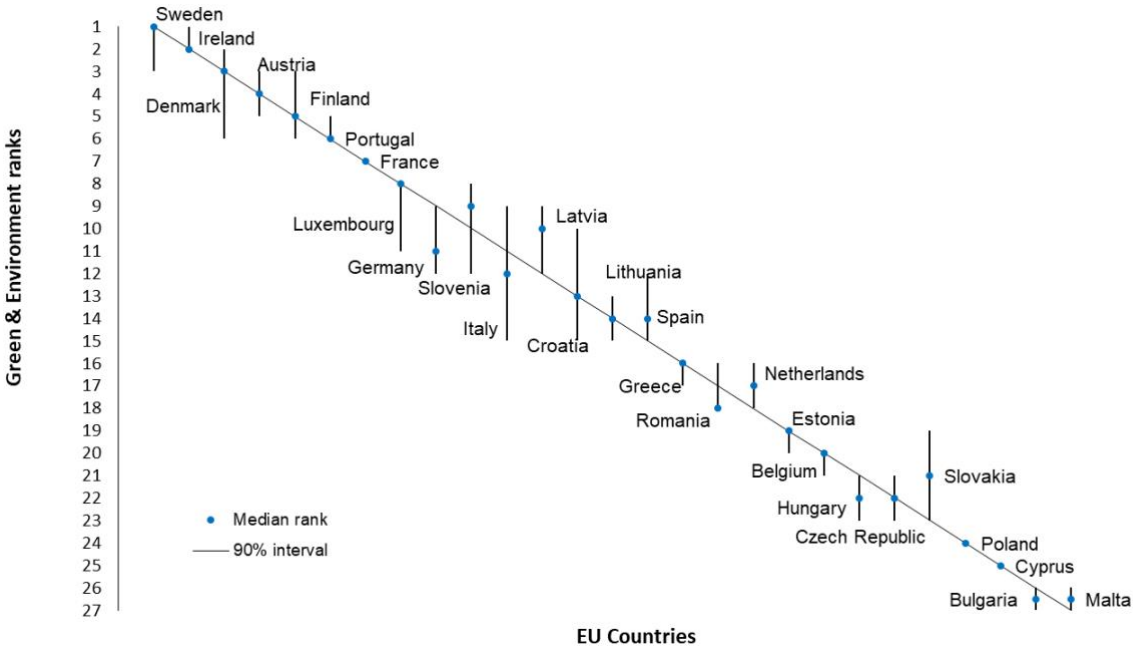
19
20
21
22
23
24
25
26
27
Sweden
Denmark
Netherlands
Finland
Slovenia
Austria
Ireland
Luxembourg
Czech Republic
France
Germany
Cyprus
Spain
Malta
Belgium
Estonia
Portugal
Poland
Hungary
Slovakia
Lithuania
Croatia
Italy
Latvia
Greece
Romania
Bulgaria
Median rank
90% interval
EU Countries





Notes: Median ranks and intervals are calculated over 4,000 simulated scenarios based on imputing (or not) missing values, random weights plus/minus 25% around the reference weights, and aggregation formula at the sub-dimension and dimension level (see Table 3 for the uncertainty parameters). The Spearman rank correlation between the median rank of the simulations and the overall Competitive Sustainability Index and any of its four dimensions in greater than 0.994.

Source: European Commission's Joint Research Centre, 2021.

Next, the impact of not estimating missing values in the Competitive Sustainability Index is analysed in more detail. The 2015-2021 dataset has very good coverage: 94.7% data available across the 27 EU Member States and 84 indicators. It is reassuring that none of the 5.3%

missing values (120 missing data points) are found to have a strong impact either on the Competitive Sustainability Index ranks or any of its dimensions. In all cases, the imputed values by the JRC (using the EM algorithm, as described earlier) result in shifts in country ranks up to 3 positions (for Croatia in the Society/Fairness dimension) and 4 positions (for Slovakia in the Green/Environment dimension).

Concluding, the Competitive Sustainability Index ranks (and those of the four dimensions) are reliable and for all EU Member States the simulated 90% confidence intervals are narrow enough for meaningful inferences to be drawn. Some caution is only needed when interpreting the performance of Cyprus and Malta in the overall Competitive Sustainability Index, of Malta in the Governance/Stability dimension, and of Italy and Croatia in the Green/Environment dimension because of a relatively higher impact of the uncertainty assumptions.

For the readers and policy analysts of the Competitive Sustainability Index report, the recommendation is to consider country ranks for the overall index and its four dimensions within the 90% confidence intervals in order to better appreciate to what degree an EU Member State's rank depends on the three key modelling choices accounted for, namely the estimation of missing data, weights and aggregation formula (at the sub-dimension and dimension level).

4 Added value of the Competitive Sustainability Index: Measuring competitive sustainability with one number?

This last section aims at touching upon the added value of the Competitive Sustainability Index as a summary measure of the four dimensions.

Table 3 shows that Competitive Sustainability Index ranking differs from any of the four dimension rankings by 4 positions or more in at least 11% of the 27 EU Member States, peaking at 52% of the EU Member States in the case of the Green/Environment dimension. This is a desired outcome because it evidences the added value of the Competitive Sustainability Index ranking, which helps to highlight aspects of a country's competitive sustainability that do not emerge directly by looking into the four dimensions separately. At the same time, this result also points towards the value of duly taking into account the individual indicators, components, sub-dimensions and dimensions of Competitive Sustainability on their own merit in order to see which components are driving a country's competitive sustainability.

Table 3. Distribution of differences between the Competitive Sustainability Index rankings and its four dimensions

	Dimensions of Competitive Sustainability			
Rank differences with respect to the Competitive Sustainability Index	**Economy / Prosperity**	**Society / Fairness**	**Governance / Resilience**	**Green / Environment**
6 or more positions	7%	11%	4%	44%
4 or 5 positions	19%	22%	7%	7%
4 or more positions *	**26%**	**33%**	**11%**	**52%**
3 positions	15%	11%	19%	7%
1 or 2 positions	52%	37%	41%	30%
0 positions	7%	19%	30%	11%
Total	100%	100%	100%	100%
Spearman rank correlation coefficient with the Competitive Sustainability Index	0.91	0.91	0.96	0.70

Note: * This row is the sum of the two rows above.
Source: European Commission's Joint Research Centre (2022).

Conclusions

The Competitive Sustainability Index, developed by the Cambridge Institute for Sustainability Leadership (CISL), enables analysts, academics and other interested stakeholders to measure and benchmark EU Member States on a number of aspects that together provide a representative profile of the competitive sustainability. With a view to maximise the reliability and transparency of the Competitive Sustainability Index, CISL invited the JRC to assess the statistical coherence and the impact of the methodological choices made in the development of the index. More specifically, in the present report, the JRC delves into the statistical properties of the data and the methodology used in the construction of the Competitive Sustainability Index and provides advice for further improvements. Overall, the analysis herein confirms that the Competitive Sustainability Index framework is well-designed, and that a lot of thought and preparation has been undertaken by the index developers to identify the multiple determinants of an EU Member State's competitive sustainability and the best available data sources to measure this concept.

The key findings of the JRC's statistical assessment of the Competitive Sustainability Index can be summarised as follows:

1 Competitive Sustainability Index: A statistically coherent monitoring framework

The analysis of the correlation structure finds the conceptual grouping of the 84 indicators into 31 components, 10 sub-dimensions, 4 dimensions and one overall index, largely justifiable from a statistical point. It also shows that the overall Competitive Sustainability Index, which is the average of four key dimensions measuring Economy/Productivity, Society/Fairness, Governance/Stability, and Green/Environment is unidimensional and has high statistical reliability (Cronbach alpha 0.84) well above the recommended threshold (0.7) for a reliable aggregate. The vast majority of the 31 components in the Competitive Sustainability framework are also found to be influential all the way up to the index level.

2 Some competitive sustainability components to be kept under the spotlight

Eight of the 31 components are found to have a transversal impact across three dimensions of Competitive sustainability. Although assigned to one dimension in the conceptual framework, these eight components – Innovation readiness, Human capital, Education, Social Mobility, Fundamental rights, Transparency, Institutional efficacy, and Citizen engagement – are found to correlate strongly to the dimensions capturing Economy/Productivity, Society/Fairness, and Governance/Stability. Consequently, they are also found to be the best predictors for a country's competitive sustainability in the European Union.

Three components of competitive sustainability do not correlate significantly either with the respective dimension, or with the overall index. These are Entrepreneurial activity (within Economy/Productivity), and Resource productivity and Biodiversity (within Green/Environment). This means that EU Member States may achieve high Competitive Sustainability scores despite of poor performance in Entrepreneurial activity, Resource productivity, and Biodiversity. On one hand, the poor correlation between Entrepreneurial activity and the Competitive Sustainability Index may be attributed to the calculation of the indicators underlying Entrepreneurial activity. The JRC recommendation to the developing team is to consider whether a different formulation or different data sources for these indicators may be more appropriate. On the other hand, the poor correlation between Resource productivity and Biodiversity (and to some extent also Renewable energies, and Natural resources) with the overall Competitive Sustainability Index is more worrisome, yet not surprising. This finding, which is in line with relevant scientific literature, evidences that up until 2021 there has not been sufficient integration of environmental priorities into EU Member States' growth and competitiveness plans.

3 Negligible impact of missing data on shifts in the Competitive Sustainability rankings

The Competitive Sustainability dataset has very good data coverage: 94.7% of the data available in 2015-2021 across 84 indicators and 27 EU Member States. Uncertainty and sensitivity analysis have shown that none of the 5.3% missing values (120 missing data points) are found to have a strong impact either on the Competitive Sustainability Index ranks or any of its dimensions. In all cases, the statistical estimates for the missing values result in shifts in country ranks up to 3 positions (for Croatia in the Society/Fairness dimension) and 4 positions (for Slovakia in the Green/Environment dimension).

4 The Competitive Sustainability Index allows to reliably benchmark national competitive sustainability in the vast majority of the EU Member States

Compared to the reference Competitive Sustainability rank, 25 of the 27 EU Member States are found to have simulated rank intervals less than 4 positions wide over 4,000 simulations. Some caution is needed for two countries – Cyprus and Malta – that have confidence interval widths around 7-8 positions, and their index ranks should thereafter not be taken at face value. The uncertainty analysis results for the four dimensions of competitive sustainability are also reassuring. For most countries, there are fewer than 4 positions shift across all four dimensions of competitive sustainability, except for Malta (6 positions in the Governance/Stability dimension), and Italy and Croatia (6 and 5 positions, respectively, in the Green/Environment dimension). Thereafter, the Competitive Sustainability Index and its four dimensions allow to reliably benchmark competitive sustainability at national level in the vast majority of the EU Member States.

5 The Competitive Sustainability Index offers new insights on EU Member States competitive sustainability, while at the same time receives external statistical validity

Last but not least, there is an added value in referring to the Competitive Sustainability Index results in order to identify aspects of EU competitive sustainability that do not directly emerge by looking into the four dimensions separately. In fact, the Competitive Sustainability Index ranking and any of the four dimension rankings differ by 4 positions or more for at least 11% up to 52% of the 27 EU Member States.

Also, the external statistical validity testing of the Competitive Sustainability Index confirms the high degree of association (correlation ≈ 0.8 to 0.9) to the latest releases of four relevant international indices: the IMD World Global Competitiveness Ranking, the Cornell University, INSEAD, and WIPO's Global Innovation Index, the European House Ambrosetti's Global Attractiveness Index, and the INSEAD's Global Talent Competitiveness Index. At the same time, one finds that 30% up to 59% of the EU Member States that feature in these four international indices differ in ranking by more than 4 positions when comparing the Competitive Sustainability Index with the recent releases of these international indices. This latter finding means that the Competitive Sustainability Index offers additional insights into national competitive sustainability across the EU that complement and go beyond the findings of other international indices.

6 The JRC audit confirms that the Competitive Sustainability Index sufficiently meets international quality standards for statistical soundness

Overall, the JRC audit confirms that the Competitive Sustainability Index sufficiently meets international quality standards for statistical soundness. Consequently, the Competitive Sustainability Index by the Cambridge Institute for Sustainability Leadership offers a sound starting point for more informed discussions on national competitive sustainability in the EU. Academics and policy analysts should also check the Competitive Sustainability Index results beyond the index scores (and ranks) as the 84 indicators, 31 components, 10 sub-dimensions and four dimensions can offer more in-depth insights on the areas to be more carefully addressed for policy action.

The Competitive Sustainability Index represents a well-designed operational indicator framework that can help to stimulate public interest and help focus policy discussions on the multiple aspects that shape a country's competitive sustainability. Still, the Competitive Sustainability Index, as any other indicator framework aimed at capturing a complex, multidimensional and evolving reality, needs to remain open to improvement. The Competitive Sustainability Index developers intend to keep improving the indicator framework in line with the theoretical advancement in the field and the availability of new (and relevant) data.

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