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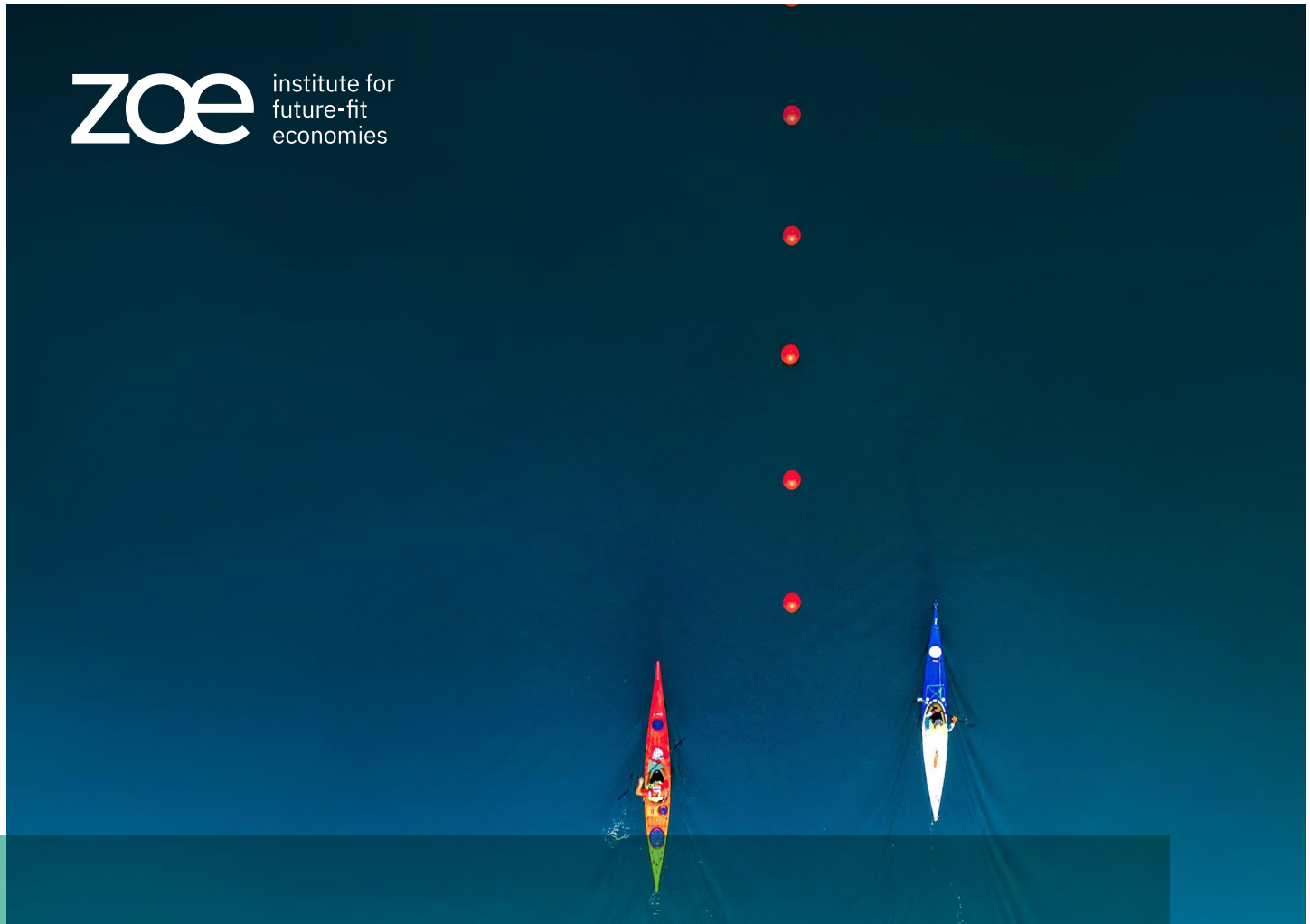

The Economic Resilience Index

Assessing the ability of EU economies to thrive in times of change

ZOE Institute for Future-fit Economies

Imprint

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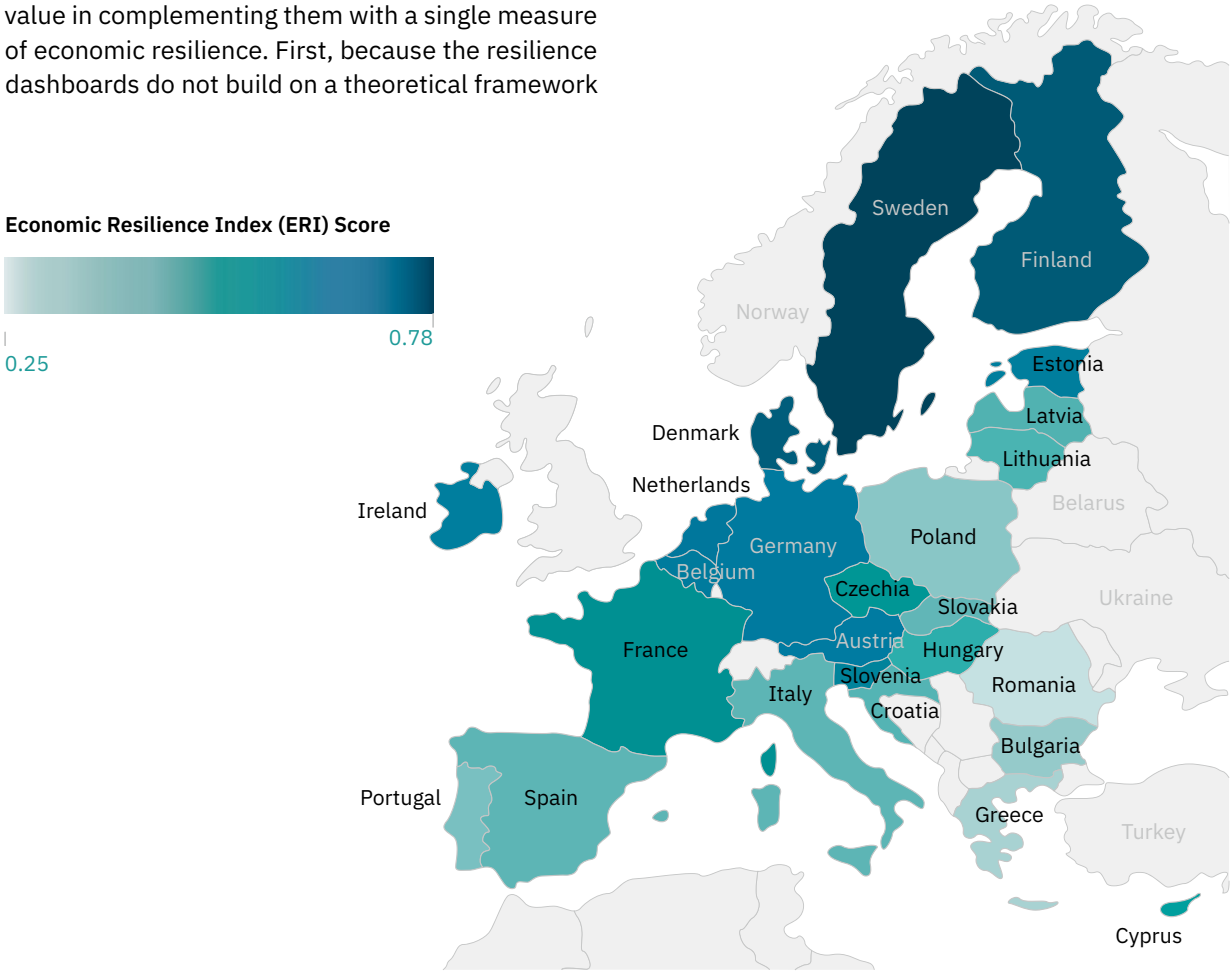
Summary

The dramatic impact of compounding crises on societies and economies has magnified the importance of economic resilience. Governments across the world have channelled immense amounts of resources to mitigate the devasting consequences of present crises. At the same time, re-constructing the status-quo will not be enough to make societies and economies resilient to looming, larger crises, not least the accelerating climate and ecological crises.

To build economic resilience, policymakers need to be able to measure it. The European Commission is currently using the resilience dashboards as one of their prominent compasses to build resilience. While the resilience dashboards are an essential tool, to increase their usefulness in legislations and to simplify cross-country comparison, there is value in complementing them with a single measure of economic resilience. First, because the resilience dashboards do not build on a theoretical framework of economic resilience. Second, because the dashboards include more than 100 indicators, which limits their usefulness to policymakers and other actors. The Economic Resilience Index (ERI), which derives all its indicators from a theoretical framework of economic resilience and aggregates them into a single, composite indicator, aims to fill this gap.

The ERI assesses the economic resilience of 25 European Member States, mostly in the years 2020 and 2021. The ERI is composed of 27 indicators divided into six vital resilience dimensions: Economic Independence, Education & Skills, Financial Resilience, Governance, Production Capacity, and Social Progress & Cohesion.



Map showing Economic Resilience Index scores of EU economies – darker colours correspond to higher resilience scores

Across the EU, Scandinavian countries score the highest among their peers while lower-income countries score the lowest. There is however only a weak correlation between the ERI and GDP. Indeed, large, high-income countries such as France, Spain, and Italy, rank in the middle, or lowest, groups. Additionally, the ERI is also weakly correlated with CO_2 emissions per capita. This suggests that building economic resilience does not come at the expense of climate change mitigation and environmental protection.

The ERI results highlight the importance of adopting a holistic approach to economic resilience. Economies can simultaneously perform strongly in specific resilience dimensions and weakly in others. For example, Italy and Romania have high economic independence scores but low scores for all other dimensions. Contrary to current political discussions, this showcases that economic resilience is not only about import and export market diversity, or energy independence, but is also about other dimensions such as education and skills, or social progress and cohesion.

The divergence in scores across the EU highlights the need for an EU-wide coordinated approach to economic resilience. There is an important divergence in scores between the best and worst performing countries. However, low resilience in certain EU economies causes vulnerabilities for all other European countries. Indeed, economic shocks can easily spill-over to other EU economies in highly integrated EU markets. As such, EU economic resilience can only be increased by supporting convergence and increasing the resilience of the lowest-performing Member States.

1. Introduction

"Resilience refers to the ability not only to withstand and cope with challenges but also to transform in a sustainable, fair, and democratic manner."

(European Commission, 2021a, p. 6)

The COVID-19 pandemic, the cost-of-living crisis, and the escalating climate and environmental emergencies are stark reminders that crises have become an integral part of our everyday lives. At present, the scope of policymakers is largely focused on short-term responses to mitigate the negative impacts of lived crises as they happen[1]. Given that larger crises loom on the horizon, not least the accelerating climate and ecological crises, it is vital that the scope of policymakers expands to account for long-term resilience-building.

Economic resilience has gained significant importance both in the public debate and in the EU policy-making agenda. Resulting policy examples include the Recovery and Resilience Facility (RRF) which aims to address the economic and social impact of the COVID-19 pandemic by making European economies more resilient. Additionally, the European Commission has proposed a Single Market Emergency Instrument which aims to enhance the Single Market's resilience through appropriate and necessary crisis preparedness and crisis management (European Commission, 2021c).

The creation of resilient economies involves an understanding of what a resilient economy looks like. Over the past decades, it has become increasingly clear that the narrow focus on GDP growth has left economies inadequately prepared to deal with shocks and crises. Indeed, climate change and other ecological crises, as well as social and spatial inequality, have been steadily intensifying. Recognising

1 Examples include price-caps on fossil energy e.g., gasoline and natural gas in Spain, as well as temporary tax reductions on consumer goods in Germany, and providing liquidity for households and companies throughout the EU.

this, the need to move beyond GDP is being actively discussed at the EU level[2]. These discussions feed into a vision of economies that can contribute to ensuring a good life for all within planetary boundaries. Such economies should not only be able meet this aim in 'normal time', but should also be capable of either maintaining it, or recovering it, amidst compounding disturbances.

Building on this economic vision, Hafele et al. (2022) developed a theoretical framework able to assess economies' resilience. This theoretical framework can help quantify an indicator that is able to measure and compare the resilience of EU economies. At present, the European Commission uses the resilience dashboards, which include economic resilience as one of four dimensions. The resilience dashboards are useful tools for policymakers to monitor resilience broadly, as they assess a wide range of dimensions. However, to increase their usefulness in legislations, there is value in complementing the resilience dashboards by a single measure of economic resilience. This is for two reasons; 1) the resilience dashboards do not build on a theoretical framework of economic resilience, and 2) the dashboards include more than 100 indicators, which limits their usefulness to policymakers and other actors. To fill this two-fold gap, this paper introduces the Economic Resilience Index (ERI) for EU Member States. The ERI derives all its indicators from the theoretical framework of economic resilience developed in Hafele et al. (2022) and aggregates them into a single, composite indicator.

The structure of this paper is as follows. Chapter 2 sets out the relevance of the ERI for policymakers and other stakeholders. **Chapter 3** demonstrates the gap which the ERI fills when it comes to measuring economic resilience. After presenting the methodology and data in **chapter 4**, the final results are presented in **chapter 5** and discussed in **chapter 6**.

2. Relevance for policymakers and stakeholders

The European Commission has demonstrated with the RRF that recovering from a crisis is not just about quickly restarting economic growth. The distribution of the recovery funds is linked to achieving common green and digital goals as well as advancing social goals to build long-term resilient and regenerative economies. However, beyond tracking the progress of the RRF towards its objectives, a clear and coherent picture of what it means to work towards a resilient economy is needed in the recovery from crises.

The European Commission lists resilience as a priority policy objective for the European economy, and international organisations such as the UN, the G20 and the OECD call for a gradual change in global economic policies to increase resilience to economic shocks (OECD, 2021). However, there is a lack of a unified definition and approach to economic resilience, so working towards a resilient future remains rather selective and vague in the current debate[3].

Over time, the EU has developed a large set of indicators to track the progress of its political action, from the EU Semester to the resilience dashboards, the Social Scoreboard, the Recovery and Resilience Scoreboard and the UN Sustainable Development Goals (SDGs). While each of them has their strengths and weaknesses, what is missing is a synthesised measure that can guide economic policy decisions towards a resilient future. At the same time, such an indicator can also support the commitment of EU Member States to measure welfare and progress beyond GDP growth (Council of the European Union, 2021a; Council of the European Union, 2021b).

2 The Beyond GDP agenda is gaining momentum. Various recent initiatives at the EU level call for wellbeing and sustainability to be taken into account in economic governance and accounting through the beyond GDP indicator framework. To name a few: the Council Conclusions on the economy of wellbeing, the Porto Declaration, the European Economic and Social Committee's work on a sustainable Europe 2030 and beyond GDP, the 8th Environment Action Programme (EAP), and the recently concluded Conference on the future of Europe.

3 Current policy efforts to strengthen resilience particularly focus on Europe's strategic independence in supply chains and on guaranteeing the functioning of the EU Single Market to be able to react quickly to emergencies and crises.

The application of measuring economic resilience is particularly relevant for public finances. This is because the exposure of economies to large and potentially catastrophic risks has direct and indirect effects on public finances. In such unexpected and crisis events, the state often acts as an insurer of last resort. It was the state that stepped in during the COVID-19 pandemic to support health care and to compensate for income losses. Contingency measures have driven up public debt ratios across the EU. Such crisis events therefore have implications for financial sustainability. Building economic resilience and being better prepared for crises can therefore be an integral part of the pursuit of sound public finances[4].

Information from rating agencies on a government's ability and willingness to repay its public debt helps investors and financial markets to assess risk and can thus have a direct impact on a country's cost of borrowing. However, credit rating often over-emphasises short-term economic concerns and underweight longer-term risks (UN DESA 2022). Thus, an index of economic resilience can also serve as a basis for financial market decisions, especially regarding sovereign credit ratings. In the assessment of credit risks, rating agencies consider political factors pertaining to institutional and governance quality as well as macroeconomic aspects such as GDP growth, fiscal positions, and monetary stability (Griffith-Jones & Kraemer, 2021). What is missing from current assessment methodologies is an information on the composition of the economy in the light of multiple crises, taking into account the preparedness to deal with the consequences of possible future shocks. A consideration of long-term challenges, including social and environmental risks as well as investments in resilience and sustainability is a gap in credit risk assessment that a focus on GDP growth as an indicator of economic vitality cannot capture. Thus, including an index of economic resilience in sovereign bond ratings can help to shift their focus on enhancing resilience rather than increasing GDP at all costs. In other words: If the credit rating also includes economic resilience, this will lead to favourable refinancing conditions for resilient countries, not only for countries with a high GDP level.

3. Measuring Economic Resilience

Several attempts have been made to measure economic resilience. One of the more prominent ones are the European Commission resilience dashboards. Amidst the COVID-19 crisis, the resilience dashboards were developed as a monitoring tool to assess EU Member States' resilience performance across four dimensions: social and economic, environmental, digital, and geopolitical (European Commission, 2020). Each of these dimensions is constituted of three or four subcategories, which utilise around 120 indicators to assess a given country's ability to react to crisis or changes (European Commission, 2021c).

The social and economic dimension of the resilience dashboards measures "the ability to tackle economic shocks and achieve long-term structural change in a fair and inclusive way" by utilising 34 indicators (European Commission, 2021c, p. 12). The dimension has three subcategories; the first is 'Inequalities and Social Impact of the Transitions'. It includes indicators such as risk of poverty or social exclusion rate and household saving rate. The second subcategory is 'Health, Education, and Work'. It includes aspects such as the long-term unemployment rate and average scores on the PISA test. The third subcategory is focused on 'Economic and Financial Stability and Sustainability'. It includes indicators such as government debt and government investment to GDP ratio (European Commission, 2021c).

4 The European Commission's DirectorateGeneral for Economic and Financial Affairs (DG ECFIN) already considers the risks of climate change for public finances, for instance by creating a definition of a conceptual framework of how to introduce climate-related risks into the DSA framework (European Commission, 2020). Other examples comprise stylised stress tests on the fiscal impact of extreme weather events in the EU (Gagliardi et al., 2022) or examining the impact of transition risks from climate change on public finances in the EU (this is work in progress and is expected to be published in the course of 2023).

The resilience dashboards have been used in the European Semester Country 2022 Reports for nine countries, such as Denmark, Finland, and Estonia, to evaluate different resilient elements in each country[5]. Indeed, the resilience dashboards provide a comprehensive and detailed tool for policymakers to assess a country's resilience. However, the resilience dashboards' impact is relatively limited as they are not yet consistently integrated in countries' Semester reports. To address this challenge, two gaps impeding the dashboards' successful use by policymakers need to be filled.

First, the resilience dashboards do not allow for a measure of economic resilience which can be aggregated into a single, composite number. While aggregating indicators into one composite indicator has significant weaknesses (Joint Research Centre-European Commission, 2008), a single composite indicator is easier to communicate to non-policy actors in public and private spheres. The latter is well demonstrated by GDP. By aggregating all monetary flows into one single number, GDP is a simple measure of economic activity. Consequently, it has found its way into many pieces of legislation. An important example is GDP's application to the EU fiscal rules[6]. Additionally, GDP also plays a crucial role across the private sector, be it in financial markets where GDP determines, for instance, the rating of sovereign bonds, or in strategic decisions of businesses where GDP forecasts determine turnover and profitability expectations. As such, the real-world impact of the dashboards would significantly increase with the development of a complementary, single indicator. Indeed, the Strategic Foresight report itself mentions that the resilience dashboards could pave the road for a synthetic resilience index that would allow comparability on an EU level and complement insights from the dashboards (European Commission, n.d.)

The second gap of the resilience dashboards is its lack of a consistent definition of the economy in its assessment of economic resilience. This gap parallels the absence of a common approach to economic resilience in the academic literature (Martin & Sunley, 2015; Manca et al., 2017; Alessi et al., 2020). Before assessing how to make economies resilient, it is necessary to first understand *what* is to be made resilient. Indeed, resilience is always assessed against a reference value (Vugrin et al., 2010; Francis & Bekera, 2014). The reference value is implicitly understood as the performance level of the system under consideration[7]. In other words, the elements entailed in the system, which must be resilient to disturbances. In this context, resilience is understood as the magnitude and duration of deviation from a system's performance level (Vugrin et al., 2010). Subsequently, to assess economic resilience, it is first needed to understand the performance level of the economy. Given the lack of a common understanding on the performance level of the economy, economic resilience is commonly equated to the GDP performance level (Briguglio et al., 2009; Oprea et al., 2020; Pontarollo & Serpieri, 2020). Considering the various critiques of using GDP as synonymous with the purpose of the economy (Costanza et al., 2009; Stiglitz et al., 2009), this economic resilience understanding clearly lacks a consistent definition of the economy to be made resilient. The following chapter demonstrates how the ERI fills the two gaps as identified above. Indeed, it builds on a coherent theoretical framework of economic resilience to then aggregate all the information into a single, composite indicator.

5 This included e.g., assessing digitalisation in the case of Denmark or assessing resource productivity in the case of Estonia (Saisana et al., 2022).

6 The well-known Maastricht criteria, which are enshrined in the European treaties, limit a country's nominal budget deficit and government debt to 3% and 60 % of GDP, respectively. Additionally, numerous fiscal rules in secondary legislation refer to GDP.

7 For instance, using the analogy of Meadows (2009), a system could be a football team. If the purpose of the football team is to win games, then the performance level of the football team can be understood as how many games the team is winning over time (Meadows, 2009).

4. Methodology and Data

4.1 Theoretical Framework

The theoretical framework to assess an economy's resilience is developed following a two-step process which has been established in a conceptualisation of economic resilience (see Hafele et al., 2022). The first step focuses on understanding the workings of the economic system that need to be made resilient. This framework then informs the assessment of economic resilience, i.e., what needs to be restored when an economy is negatively impacted by a crisis. In this way, economic resilience is defined as the magnitude and duration of deviation from the economy achieving its purpose in times of crises (building on the definition of Vugrin et al., 2010).

In Hafele et al. (2022), the purpose of the economy is defined as "providing goods and services at appropriate quantity and quality for society". Additionally, given the economy's embeddedness within society and the environment, a higher-level purpose is defined as "providing wellbeing for present and future generations while remaining the planetary boundaries". The economy's purpose can therefore be understood as solely being a contribution to this broader, higher-level purpose. As such, two constraints on the purpose of the economic system can be drawn from this relationship: 1) minimise negative social consequences that deteriorate wellbeing and 2) respect the hard environmental limits on economic activities imposed by planetary boundaries. Figure 1 portrays the economy's purpose as interconnected to its relationship with society and the environment.

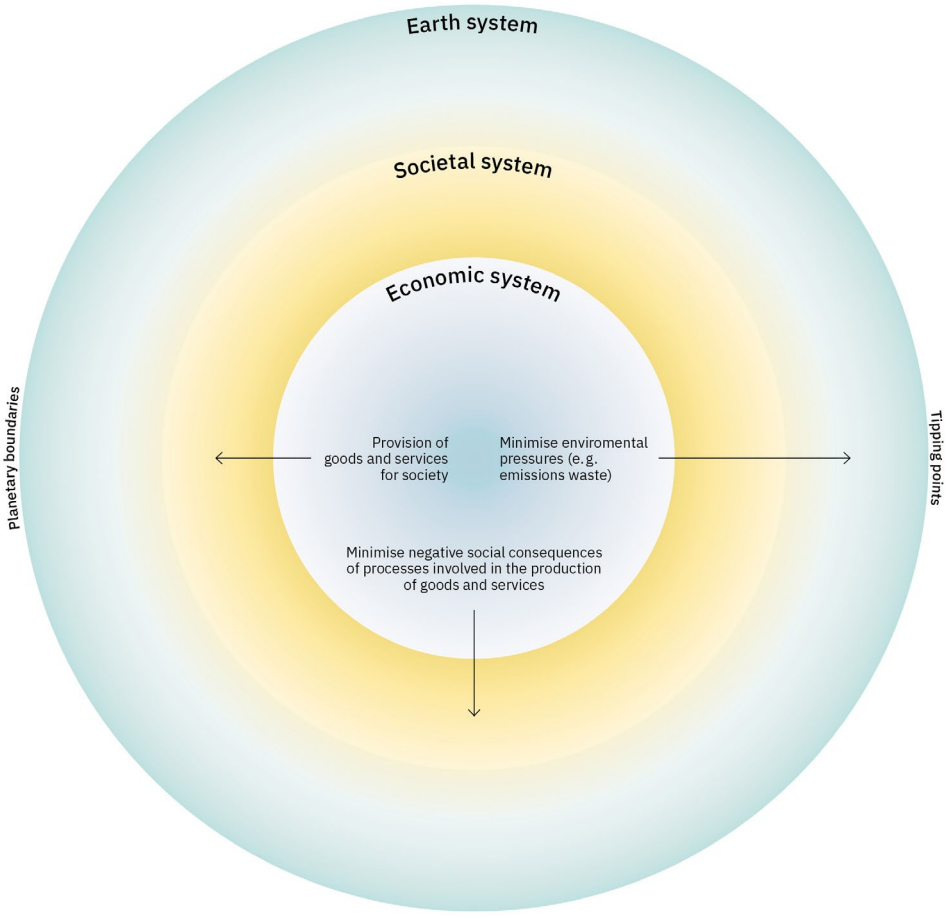


Figure 1: Purpose of the economy in relation to society and the environment, setting the reference value to assess economic resilience (Hafele et al., 2022).

Additionally, elements of the economy undertake activities to achieve the economy's purpose. Four elements can be identified in the provision of goods and services: households, communities, businesses, and the state. These elements can be defined as **provisioning actors** (Hafele et al., 2022). Provisioning is grounded in monetary or non-monetary interconnections within and between provisioning actors, defined as **flows** (Phelan, 1999). Lastly, building on the above, provisioning actors need a distinct set of eight **abilities**[8] that enable them to adequately conduct their interconnected activities. For instance, provisioning actors need to be able to access natural resources, or to create, disseminate, and use knowledge (Hafele et al., 2022).

The second step in developing the theoretical framework with which to assess economic resilience turns to understanding *how* the economic system can be resilient to different shocks and disturbances. A system is considered resilient when it has one or more of these three **capacities**: absorb, recover, and adapt (following works such as Manca et al., 2017; Martin & Sunley, 2015). First, resilience is assessed by the capacity of a system to absorb a shock. Absorption refers to the capacity to bounce-back to a pre-shock performance level in **the short-term**. If the shock is not able to be absorbed by the system because it is too long, and/or too intense, then the system can either recover or adapt to the shock in the **medium to long-term**. On one hand, the capacity to recover from a shock denotes the capacity to regain pre-shock performance level in the medium to long-term. On the other hand, the capacity to adapt to a shock refers to the capacity to obtain a new, post-shock performance level in the medium to long-term.

Specific economic characteristics can enable these three resilience capacities. Resilience characteristics are underlying features of the economy that explain why certain economies are better at absorbing, recovering and/or adapting to crises (Alessi et al., 2020). These characteristics are defined as **macro-level patterns**. For instance, the characteristic of diversity enables the economy to be better at recovering from, or adapting to a shock. Indeed, trade diversification fortifies the capacity of supply chains to overcome supply shortages in times of crisis.

Resilience characteristics are distinct to each provisioning actor in the economy and depend both on the abilities and the capacities (absorption, recovery, adaptation) aiming to be enabled. **Table 1** exemplifies the resilience characteristics of the provisioning actor 'businesses' for one of the eight resilience abilities, namely the ability to develop, transfer, and use suitable skills. Examples of resilience characteristics for all resilience abilities of all provision actors can be found in Hafele et al. (2022).

4.2 Data Selection

The selection of indicators in the ERI builds on the theoretical framework defined above. More precisely, it builds on each provisioning actor's resilience abilities and resilience capacities. For all provisioning actors, one or multiple determinants can measure each combination of resilience ability and resilience capacity. Thus, a determinant can be understood as a measurable and resilience-enhancing property of an economy. Table 1 demonstrates this. For example, to absorb a shock, and maintain its ability to develop, transfer, and use suitable skills, an economy needs a spare workforce with skills relevant for businesses, which can be measured by the number of employees and their skills. To recover from the same shock, an economy needs diverse training opportunities which can be measured by the availability of reskilling opportunities. An economy further needs cohesion, understood as employee's satisfaction with overall work, which can be measured through the employment quality and the degree of economic participation. Finally, to adapt to the same shock, the economy needs knowledge about what kind of skills will be needed in the future, which can be measured by education and research and development.

8 The eight abilities are: 1. Ability to develop, distribute, and use technology, 2. Ability to develop, transfer, and use right skills, 3. Ability to access financial resources, 4. Ability to access natural resources, 5. Ability to create, disseminate and use knowledge, 6. Ability to ensure stable institutions (transparent, robust, and reliable institutions), 7. Ability to innovate, 8. Ability to distribute acknowledged and less acknowledged activities.

Resilience characteristics and determinants for businesses			
	Absorption	**Recovery**	**Adaptation**[9]
	Redundancy	Diversity, Cohesion	Adaptability, Diversity, Cohesion
Resilience characteristics	Spare workforce with skills for relevant businesses	– People are equipped with diverse skill sets, diverse training opportunities; strong job-matching institutions; short-time working schemes, flexible working contracts – Satisfaction with work overall	Knowing what kind of skills will be needed in the future, compensation, transition, and acknowledgement + Skill-training, acquiring new skills
Resilience determinants	Employment Skills	Employment Skills Reskilling Economic participation Employment Quality	Reskilling Education Quality Research & Development

Table 1: Example of resilience characteristics and determinants (provisioning actor: businesses, resilience ability: ability to develop, transfer, and use suitable skills)

The entire allocation of determinants to resilience abilities and capacities can be found in appendix 2[10]. In total, 27 determinants were identified (see **table 2**). They differ partially from provisioning actor to provisioning actor, yet strong overlaps can be drawn between the four provisioning actors. To measure the 27 determinants, specific indicators were collected[11].

The process of developing the index based on the theoretical framework is presented in **figure 2**. The eight resilience abilities of the four provisioning actors and the three resilience capacities capture what an economy needs to be resilient with respect to fulfilling its purpose, providing goods and services at appropriate quantity and quality for society, while minimising the negative social and environmental impacts of its processes. From this, 96 resilience characteristics are derived, which are measured by 27 resilience determinants and their corresponding indicators. These were then grouped into six dimensions of economic resilience, according to their conceptual similarity. For example, indicators measuring financial equality and indicators measuring public finances were grouped into a dimension called 'Financial Resilience'.

9 Since the macro-level patterns underlying "Recovery" are also underlying "Adaptation", all resilience characteristics and determinants under recover are relevant for adaptation as well.

10 In general, the determinants measure what provisioning actors need in order to maintain the resilience abilities after shocks, instead of measuring the outcomes that the abilities create. For example, maintaining the ability to access natural resources while adapting to a shock requires, among others, anticipating the impact of the shock on resource extraction and waste on other provisioning actors, society and environment. This ability to anticipate is measured by determinants on research and development, and education. Measuring the outcome of that would require directly measuring the access to natural resources, but would not measure the ability to anticipate and to adapt to future shocks.

11 Since the ERI aims to complement the resilience dashboards, most determinants are measured by indicators from the resilience dashboards. However, to ensure strong alignment with the theoretical framework, not all determinants could be measured by indicators from the resilience dashboards. In these cases, literature research informed the selection of indicators. A total of 100 indicators were listed in relevance to the determinants. The top two to three indicators were prioritized as the best fit in relation to the determinant and conceptual framework. These were screened in terms of country coverage, recent years, and reliable sources. About 80 % of the indicators are objective indicators, for instance the investment share of GDP. The remaining indicators are subjective, for instance survey responses to the question "How much do you trust your national government?". Data mostly comes from Eurostat, OECD, and World Bank. For more detailed information about the data sources please contact the authors.

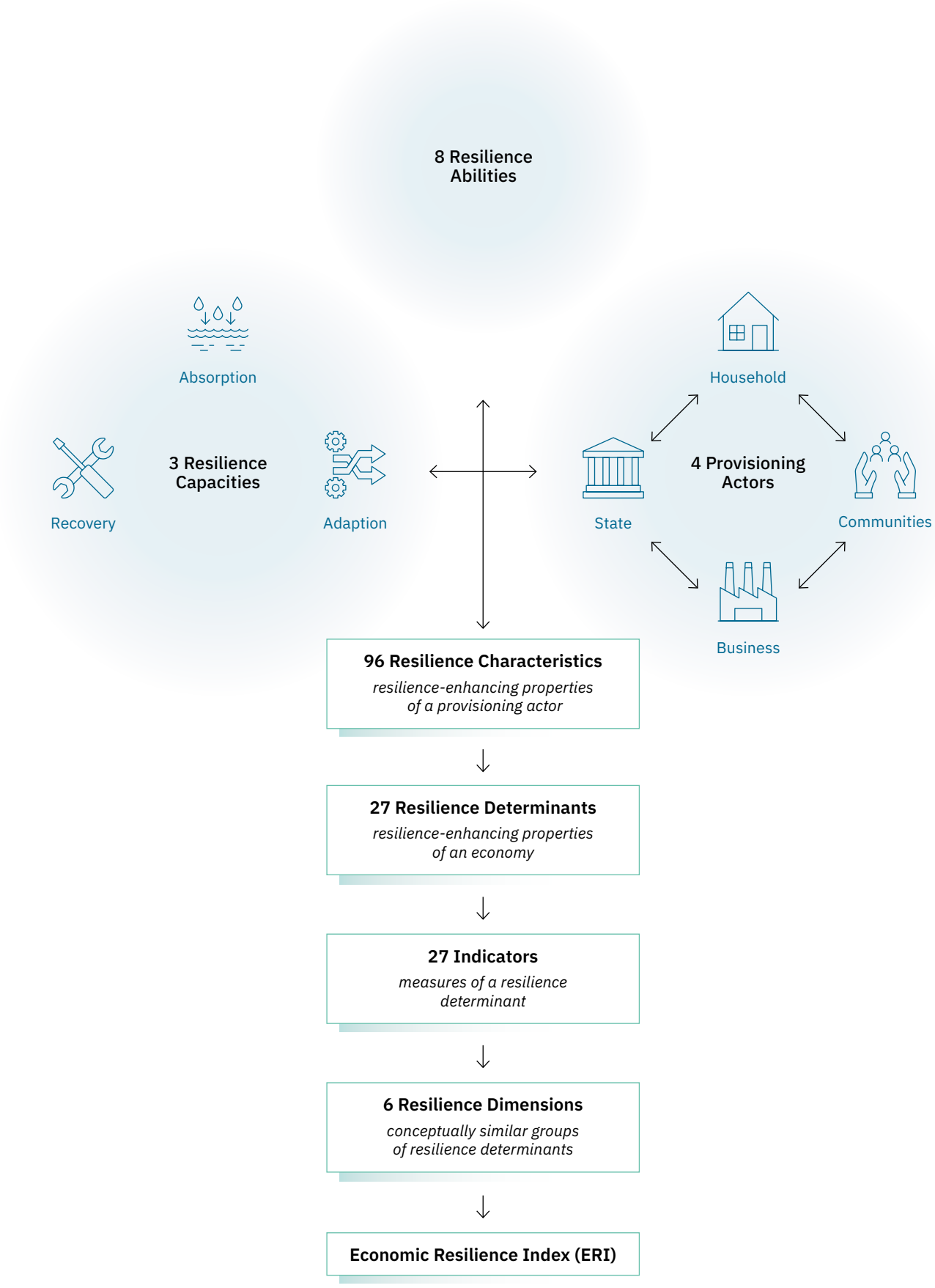


Figure 2: ERI Methodology

The final ERI thus consists of 6 resilience dimensions with 27 corresponding indicators. Building on the ERI's underlying theoretical framework all indicators can additionally be assigned to one of the concept's three economic resilience capacities. For instance, an indicator, whose associated determinant is most frequently linked to absorption in the theoretical framework, is assigned to the absorption category. This allows grouping each indicator into one of the three resilience capacities, and thus for calculating not only resilience dimension scores, but also resilience capacity scores.

The ERI measures the economic resilience of EU25 countries. Malta and Luxembourg are exempt because of insufficient data availability[12]. The ERI is a cross-section score that compares economic resilience across countries in a certain year. Depending on data availability, the data is mostly from 2020 or 2021[13].

4.3 Technical Index Construction

The ERI construction follows the OECD guidelines for constructing composite indicators which includes a ten steps process (Joint Research Centre-European Commission, 2008). The first step is to develop a theoretical framework (discussed in **chapter 4.1**) which the index builds on. This is followed by indicator selection and missing data imputation. For the second step, a multivariate analysis is conducted to examine the data in terms of variations, outliers, and correlations. After ensuring the quality of the data and indicator suitability, the data is then normalised based on the z-score method to allow comparability. The results are then aggregated to create the composite score based on equal weights. Moreover, each of the 27 indicators was assigned to the relevant dimension to create the aggregate dimension score. Finally, the correlation of the composite score to other indices such as the Transitions Performance Index and indicators such as CO_2 emissions per capita was analysed to test the strength of the ERI's concept. A detailed description of the technical steps can be found in appendix 1.

5. The ERI

5.1 Dimensions, Determinants & Indicators

In the following, the six dimensions of the ERI are introduced. For each of these dimensions, the corresponding determinants (in bold), and their underlying indicators (in brackets), are described.

12 Data availability for Malta and Luxembourg was less than 95 % and missing values could not be reliably imputed.

13 26 % of the indicators are pre-2020 as updated data were not available.

Economic independence

Economic complexity *(Economic Complexity Index):* Economic complexity refers to the sophistication of an economy's production processes. Higher production capabilities (technologies, production know-how, infrastructure, institutions) facilitate the development of not yet obtained production capacities which gives a country the flexibility to produce other goods and services after a shock more easily.

Energy independence *(Energy imports dependency):* A high domestic energy production avoids dependence on other countries for energy imports.

Export market diversity[14] *(Export partner concentration):* A diversified export market ensures revenues generated through international trade, even when a country loses certain export markets after a shock[15].

Supply chain vulnerability *(Import partner concentration):* A diversified import market ensures a functioning supply chain, even when a country loses certain import markets after a shock.

Natural resource access *(Resource productivity):* A high resource productivity allows for value creation from natural resources, even when supply is low.

Education & Skills

Skills[16] *(Brain retention):* A skilled workforce does not only produce goods and services of high quality but can also help attract high value-added industries.

Reskilling *(Adult participation rate in education and training):* Adult participation in education and training increases the skill level of the workforce and enables a swift adaptation to changed circumstances, thereby increasing the competitiveness of industries.

Education quality[17] *(Programme for International Student Assessment (PISA)):* A highly educated population does not only contribute to the skill-level but also improves the ability of all provisioning actors to anticipate future trends and shocks.

Research & Development *(Scientific publications):* Comprehensive and high-quality research and development does not only create knowledge and supports high-quality education but can also drive innovation and thereby constitute a determinant of competitiveness.

14 The EU resilience dashboards measures trade vulnerabilities through Extra-EU export and import partner concentration. However, this could distort the results as it ignores the share of EU countries in the overall trading partners. For example, a country, that has a large and diversified trade network within the EU and relies to a very small extent on a non-diversified network of extra-EU trade partners would get a low score. To address this, the ERI measures overall export and import market concentration.

15 While a lack of diversification in trade partners may be beneficial because countries only trade with partners which offer the most competitive prices (higher prices for exported goods and services, lower prices for imported goods and services), it also decreases resilience. Indeed, being dependent on a few partners for the import of critical goods and services or for export sources increases the chances of being adversely affected. Trade diversification therefore makes for strong supply chains that can overcome shortages during shocks (Jayasinghe et al., 2022).

16 The EU resilience dashboards measures the economy's level of skills through macroeconomic skills mismatch rate to identify the needed changes in the education system in order to better cope with the changing nature of work. However, the ERI focuses on brain retention as a proxy for the economy's ability to provide the required level of skills for resilience.

17 Furthermore, the more skilled and better educated the workforce is, the better their ability to innovate and thus improve the overall innovation performance becomes (Castellaci, 2011; Keller, 1996).

Financial Resilience

Corporate finances *(Firms financial constraints):* Financial resources of businesses are a precondition for providing goods and services as well as employment and income.

Household finances *(Household saving rate):* Financial resources of households are a precondition to access goods and services.

Public finances *(Refinancing cost):* Financial resources of public entities are a precondition for the welfare state, for providing public employment as well as for government investment and consumption.

Financial equality *(Income quintile share ratio S80/S20):* Financial resilience does not only concern the total amount but also the distribution of financial resources.

Governance

Government effectiveness[18] (*Trust in government*): An effective government implements sound policies which benefits citizen's wellbeing. For instance, during the COVID-19 pandemic, vertical cohesion (or trust) between the state and its citizens ensured voluntary rule abidance, such as mask-wearing, and thereby helped tackling the health crisis.

Institutional quality *(Regulatory quality):* Aspects of institutional quality – such as low levels of corruption, political stability, rule of law enforcement and freedom of expression – are beneficial for economic development and associated with a higher degree of economic resilience (Acemoglu et al., 2003; Sánchez et al., 2017).

International collaboration *(International co-operation in research):* In a globalised society and economy, international collaboration represents a crucial tool for addressing international or global challenges. For instance, tackling the climate crisis requires global collaboration.

Welfare state quality *(Government expenditure on health, education, and social protection):* Extensive welfare state arrangements are crucial for macroeconomic performance, as publicly funded education and health care support human capital formation and thus enhance productivity. Moreover, welfare state programmes act as automatic stabilisers and hence support an economy's recovery following a recession (Büchs, 2021).

18 Governmental effectiveness is understood as to what extent a government achieved its desired outcome (Schneider, 1995). Little consensus however exists how that can be measured and quantified (Thompson, 2009). This paper utilises the trust of citizens in their national government as a proxy given that their satisfaction depends on the degree a government is able to achieve their goals.

Production Capacity

Employment *(Long term unemployment rate):* Labour serves as a factor of production. At the same time, being employed builds skills and gives people purpose.

ICT capacity *(ICT service sector in GDP):* In an increasingly digitised society and economy, ICT capacities can increase efficiency. Having a strong ICT sector also increases competitiveness and builds digital skills.

Innovation[19] *(Innovative enterprises):* Innovation generally helps solving challenges. It also creates value-added, employment, and increases competitiveness.

Investment[20] *(Investment share of GDP):* By replacing and increasing the capital stock, investment builds up crucial resources for the future. It also generates employment.

Social Progress & Cohesion

Economic participation *(Employees in trade unions):* Economic participation, measured by the representation in trade unions , democratises the economy and contributes to balancing power between employers and employees.

Employment quality[22] *(Job satisfaction):* Job satisfaction directly improves people's wellbeing. It also increases motivation and is therefore a crucial asset for employers.

Gender equality *(Gender employment gap):* Gender equality does not just increase societal cohesion but also allows using all the economy's available resources and capabilities.

Social cohesion *(People at risk of poverty or social exclusion):* Social cohesion, measured by people at risk of poverty[23], directly impacts the society's ability to collectively address crises[24].

Regional cohesion *(Regional dispersion of income):* Regional cohesion does not only contribute to social cohesion, but also ensures that not only certain parts of a country are resilient, while others are not.

Trust *(Trust among people in neighbourhood):* Trust builds and improves relationships and is a precondition for any collaboration or cooperation.

19 Since not all innovative advancements are patented and not all patents have a valuable contribution to the points mentioned above (Gittelmann, 2008; Motohashi, 2004; Nagaoka et al., 2010), this paper orientates itself at innovative enterprises instead of the number registered patents.

20 The EU resilience dashboards focus on government investment. However, the ERI includes both public and private investments in order to cover all resilience-enhancing investments.

21 While trade unions do not address all relevant aspects of economic participation, they provide one of the most important aspects by negotiating inflation adjustments of wages.

22 The EU resilience dashboards include employment in manufacturing with high automation risk as a measure of social impacts of transitions. The ERI focuses on job satisfaction as a proxy for employment quality as a more fitting measure for social progress and cohesion.

23 Since there is no perfect quantitative measure of social cohesion, poverty is used as a proxy as it risks excluding people from society.

24 For instance, during the COVID-19 pandemic, young generations were willing to drastically change their everyday lives to protect the elderly.

Dimension	Determinant	Indicator	Resilience Capacity
Economic Independence	Economic Complexity	Economic Complexity Index	Recovery
	Energy independence	Energy imports dependency	Recovery
	Export market diversity	Export partner concentration	Recovery
	Supply chain vulnerability	Import partner concentration	Recovery
	Natural resources access	Resource productivity	Recovery
Education & Skills	Skills	Brain retention	Recovery
	Reskilling	Adult participation rate in education and training	Absorption
	Education quality	Programme for International Student Assessment (PISA)	Adaptation
	Research & Development	Scientific publications	Adaptation
Financial Resilience	Corporate finances	Firm's financial constraints[25]	Absorption
	Household finances	Household saving rate	Recovery
	Public finances	Refinancing cost	Absorption
	Financial equality	Income quintile share ratio S80 / S20	Recovery
Governance	Government effectiveness	Trust in government	Adaption
	Institutional quality	Regulatory quality	Recovery
	International collaboration	International co-operation in research	Recovery
	Welfare state quality	Government expenditure on health, education, and social protection	Absorption
Production Capacity	Employment	Long term unemployment rate	Recovery
	ICT capacity	ICT service sector in GDP	Recovery
	Innovation	Innovative enterprises	Recovery
	Investment	Investment share of GDP	Absorption
Social Progress and Cohesion	Economic participation	Employees in trade unions[26]	Recovery
	Employment quality	Job satisfaction	Recovery
	Gender equality	Gender employment gap	Recovery
	Social cohesion	People at risk of poverty or social exclusion	Adaptation
	Regional cohesion	Regional dispersion of income	Recovery
	Trust	Trust among people in neighbourhood	Recovery

Table 2: Overview of Resilience Dimensions, Determinants, Indicators & Capacities

Table 2 presents an overview of the six resilience dimensions with the corresponding 27 resilience determinants and underlying indicators[27]. Additionally, each determinant and indicator are linked to a specific resilience capacity[28]. A description of all indicators can be found in appendix 3.

25 All monetary indicators are expressed in real terms which is why, despite currently attracting a lot of attention, price stability is not included as a determinant or indicator.

26 Country data include years between 2016–2020 as updated was not available. Majority of data were from 2019 followed by 2016 and 2018.

27 Country data include years between 2016–2020 as updated was not available. Majority of data were from 2019 followed by 2016 and 2018.

28 Most determinants and indicators refer to more than one resilience capacity. While recognising these links, the table links each determinant and indicator only to its most closely related capacity.

5.2 Results

Table 3 presents the overall country ranking as well as the scores per dimension for each country. The composite score can be understood as both the average of all 27 indicators as well as the average of the six dimensions. Each country score can take on a value between zero and one. A country would have a score of zero if, in comparison to other countries, it had the worst possible performance for each indicator and a value of one if it had the best possible performance for each indicator.

While table 3 compares the composite scores to the dimension scores, **table 4** compares the composite scores to the resilience capacity scores.

To visualise these results, **figure 3** presents the overall scores of EU countries in a map. Scandinavian countries dominate the ranking, while Bulgaria, Greece, and Romania occupy the bottom of the ranking. Comparing large and populous countries, Germany performs rather well, France can be found in the middle range, and Spain, Italy, and Poland towards the bottom of the rating. Estonia is the best-performing Eastern European country.

Figure 4 presents the composition of country scores by resilience dimension. The higher the dimension score of a country, the larger the area within the country's bar. While some countries (like Sweden) show a very balanced score in all resilience dimensions, other countries perform well in certain dimensions while performing considerably worse in others.

To zoom in to countries with unequal dimension scores, **figure 5** illustrates the divergence in the six-dimension scores for Austria, Italy, and Romania. Austria performs competently in five resilience dimensions with a particularly strong governance performance. At the same time, it exhibits a low economic independence score with only three of the 25 countries performing worse in this dimension. Italy, on the other hand, shows a reversed pattern. While performing very well in terms of economic independence, with only three of the 25 countries performing better in this dimension, it performs rather poorly in all other dimensions, dragging it down to a low score in the overall ranking. A similar pattern can be observed for Romania for which the results suggest that despite being the least-resilient country overall, it has a high level of economic independence, with only seven out of 25 countries having a higher economic independence score.

Figure 6 plots the spread of country scores per dimension. It suggests that the level of divergence of countries' performance differs among the resilience dimensions. While the difference between the best-performing country and the worst-performing country is relatively high for Education & Skills and Governance, it is notably lower for the other four dimensions.

Finally, similar to the segmentation of the overall scores into resilience dimension scores, the ERI also allows to segment the overall scores into resilience capacity scores. **Figure 7** illustrates the composition of overall scores with respect to the capacity scores as shown in table 4. While the scores generally seem more equally composited by the resilience capacities than by the resilience dimensions, some interesting patterns emerge. For example, the results suggest that Romania builds most of its resilience on its capacities to absorb and recover while it performs very poorly in terms of adaptation. To a similar, but less pronounced extent, this is also true for Bulgaria. Cyprus, on the other hand, performs significantly better in terms of recovery and adaptation than in terms of absorption.

Rank	Composite score		Economic Independence	Education & Skills	Financial Resilience	Governance	Production Capacity	Social Progress & Cohesion
1	**Sweden**	**0.78**	0.74	0.90	0.73	0.79	0.78	0.75
2	**Denmark**	**0.74**	0.59	0.88	0.63	0.90	0.62	0.81
3	**Finland**	**0.74**	0.60	0.92	0.59	0.90	0.69	0.75
4	**Netherlands**	**0.67**	0.49	0.86	0.77	0.79	0.60	0.61
5	**Germany**	**0.65**	0.75	0.60	0.70	0.75	0.62	0.53
6	**Austria**	**0.64**	0.41	0.67	0.69	0.82	0.61	0.70
7	**Ireland**	**0.63**	0.42	0.76	0.66	0.62	0.74[29]	0.66
8	**Belgium**	**0.63**	0.46	0.62	0.67	0.75	0.63	0.69
9	**Estonia**	**0.62**	0.56	0.72	0.60	0.61	0.78	0.53[30]
10	**Slovenia**	**0.62**	0.66	0.58	0.73	0.44	0.45	0.76
11	**France**	**0.56**	0.72	0.49	0.55	0.69	0.56	0.38[31]
12	**Czechia**	**0.51**	0.44	0.48	0.71	0.37	0.70	0.43
13	**Cyprus**	**0.49**	0.35	0.47	0.35	0.43	0.61	0.66[32]
14	**Hungary**	**0.45**	0.44	0.25	0.61	0.29	0.56	0.53
15	**Lithuania**	**0.41**	0.42	0.30	0.47	0.40	0.42	0.45
16	**Latvia**	**0.41**	0.45	0.32	0.46	0.30	0.45	0.46[33]
17	**Croatia**	**0.40**	0.46	0.22	0.47	0.23	0.46	0.52
18	**Spain**	**0.39**	0.53	0.45	0.34[34]	0.44	0.16	0.40
19	**Italy**	**0.39**	0.67	0.34	0.30	0.38	0.28	0.34
20	**Slovakia**	**0.38**	0.44	0.19	0.67[35]	0.29	0.24	0.42
21	**Portugal**	**0.35**	0.17	0.55	0.24	0.37	0.37	0.39
22	**Poland**	**0.32**	0.34	0.39	0.34	0.22	0.32	0.31
23	**Bulgaria**	**0.29**	0.53	0.10	0.32[36]	0.12	0.41[37]	0.22
24	**Greece**	**0.28**	0.47	0.20	0.09	0.35	0.25	0.28
25	**Romania**	**0.25**	0.56	0.06	0.22[38]	0.07	0.40[39]	0.17

Table 3: ERI Ranking with Dimension Scores

29 ICT sector share in GDP. Value from Predict.

30 Regional dispersion of income: No NUTS-2 regional classification. Value from Estonia's official statistics office regional classification, 2019.

31 France lowest rank because an underlying indicator on regional income inequality is a ratio of richest to poorest region and France have an oversea territory with very low income. The richest region is Île-de-France (21,000 at purchasing power standard annual disposable income per inhabitant) while the poorest is Mayotte (5,900 at purchasing power standard annual disposable income per inhabitant).

32 Regional dispersion of income: No NUTS-2 regional classification. Value is average of Estonia, Latvia, Lithuania and Slovenia.

33 Regional dispersion of income: No NUTS-2 regional classification. Value from Latvia's official statistics office's regional classification, 2019.

34 Refinancing cost: average of 2017–2020 while the other countries have 2011–2020 average due to missing data.

35 Income quintile share ratio S80/S20: 2020 data.

36 Household saving rate: 2017 from ECB.

37 Investment in GDP: 2017 data.

Rank	Composite score		Absorption	Recovery	Adaption
1	**Sweden**	**0.78**	0.80	0.77	0.77
2	**Denmark**	**0.74**	0.77	0.70	0.85
3	**Finland**	**0.74**	0.76	0.70	0.89
4	**Netherlands**	**0.67**	0.64	0.65	0.83
5	**Germany**	**0.65**	0.61	0.67	0.64
6	**Austria**	**0.64**	0.73	0.60	0.72
7	**Ireland**	**0.63**	0.43	0.67	0.74
8	**Belgium**	**0.63**	0.32	0.64	0.63
9	**Estonia**	**0.62**	0.76	0.60	0.57
10	**Slovenia**	**0.62**	0.51	0.63	0.69
11	**France**	**0.56**	0.64	0.55	0.50
12	**Czechia**	**0.51**	0.53	0.50	0.55
13	**Cyprus**	**0.49**	0.20	0.56	0.50
14	**Hungary**	**0.45**	0.47	0.46	0.40
15	**Lithuania**	**0.41**	0.54	0.40	0.30
16	**Latvia**	**0.41**	0.45	0.43	0.28
17	**Croatia**	**0.40**	0.36	0.43	0.33
18	**Spain**	**0.39**	0.45	0.39	0.34
19	**Italy**	**0.39**	0.38	0.41	0.31
20	**Slovakia**	**0.38**	0.41	0.37	0.38
21	**Portugal**	**0.35**	0.35	0.31	0.48
22	**Poland**	**0.32**	0.24	0.30	0.49
23	**Bulgaria**	**0.29**	0.32	0.32	0.09
24	**Greece**	**0.28**	0.20	0.33	0.18
25	**Romania**	**0.25**	0.33	0.28	0.05

Table 4: ERI Ranking with Capacity Scores

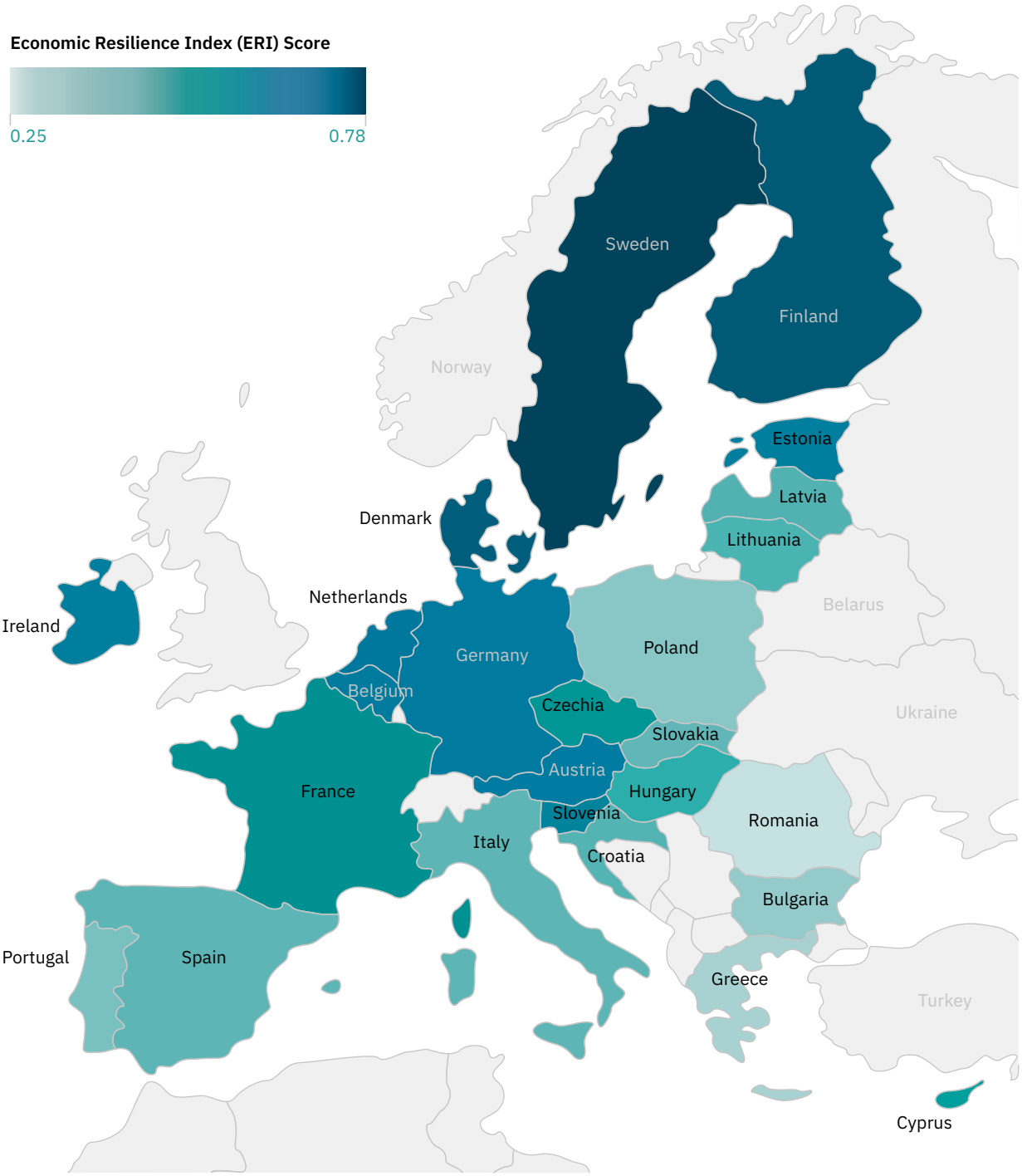


Figure 3: Map showing Economic Resilience Index scores of EU economies – darker colours correspond to higher resilience scores

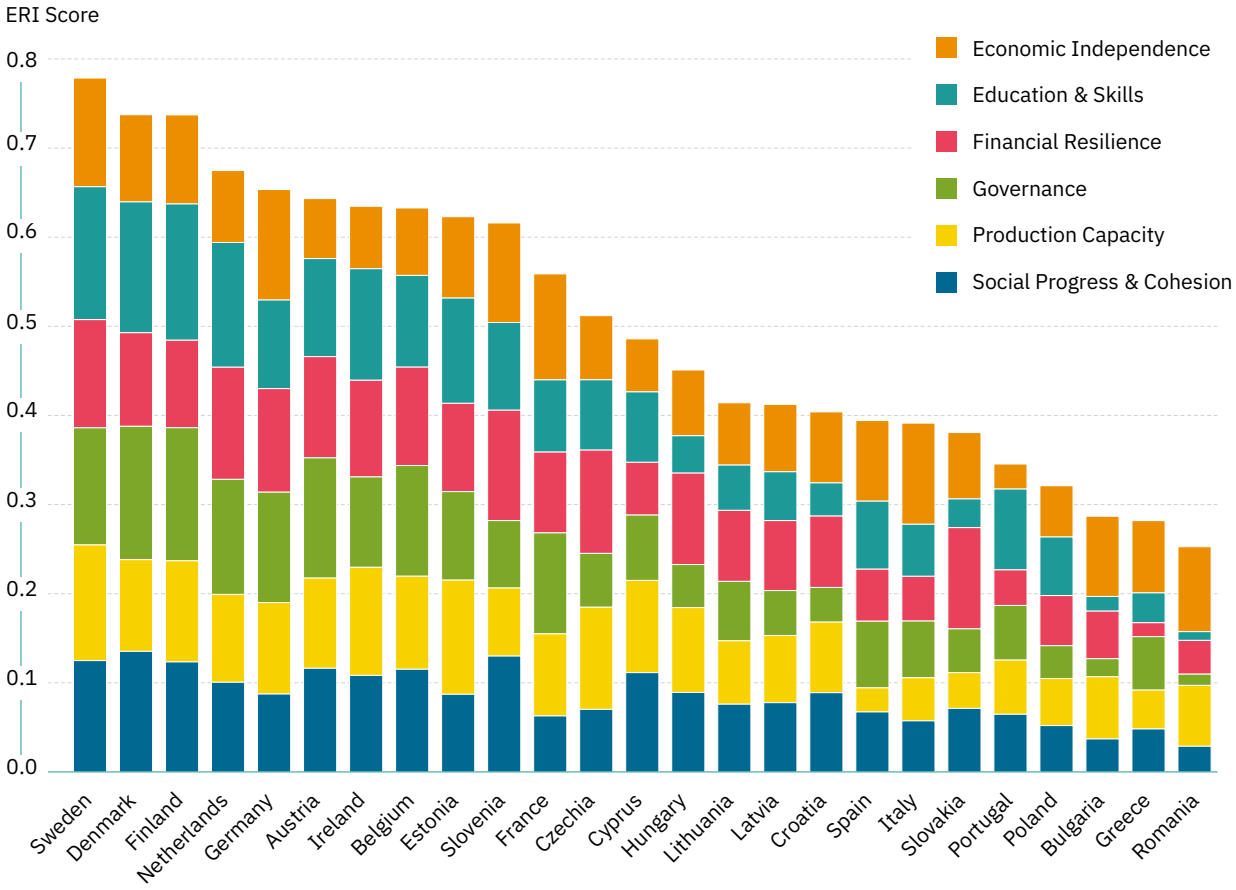


Figure 4: ERI Scores by Country, Divided by Dimensions (%)

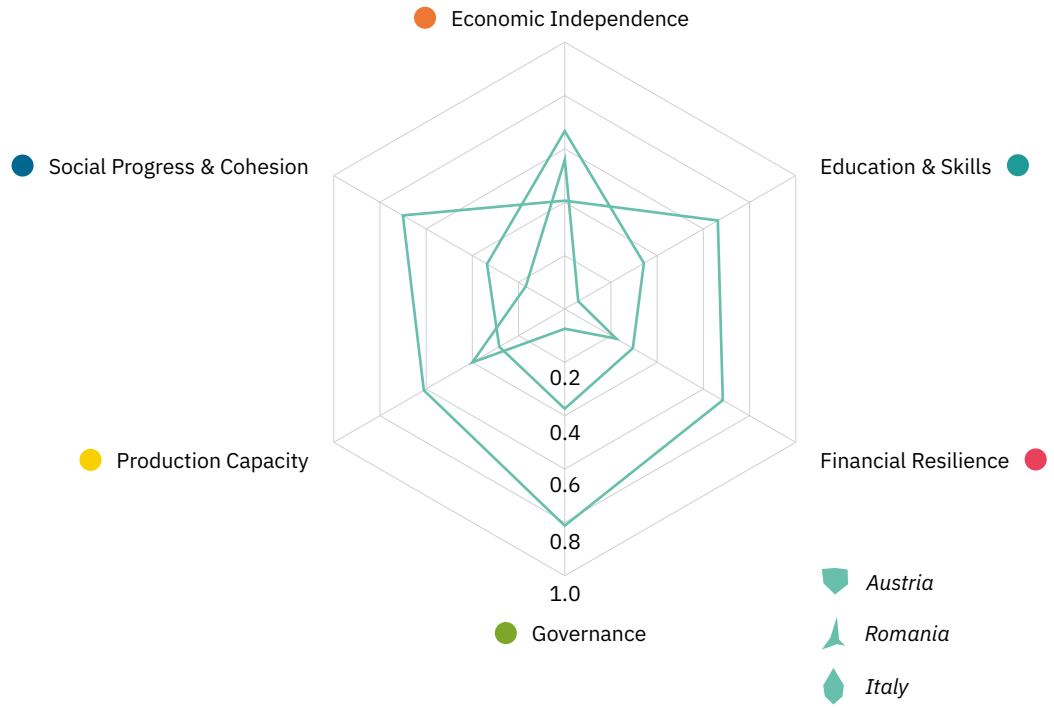


Figure 5: ERI Performance of Austria, Italy and Romania by Dimension

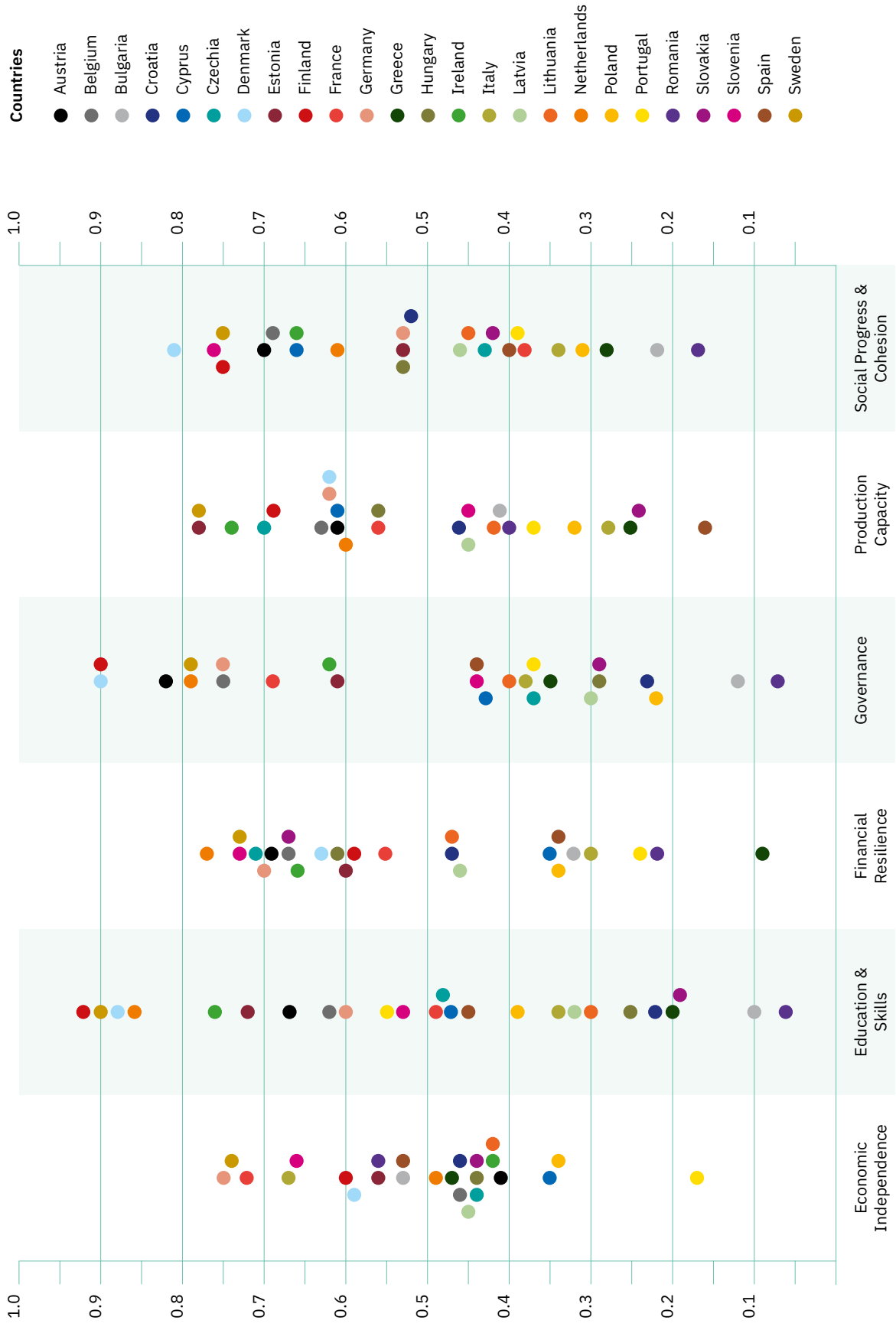


Figure 6: Distribution of ERI Scores by Dimension

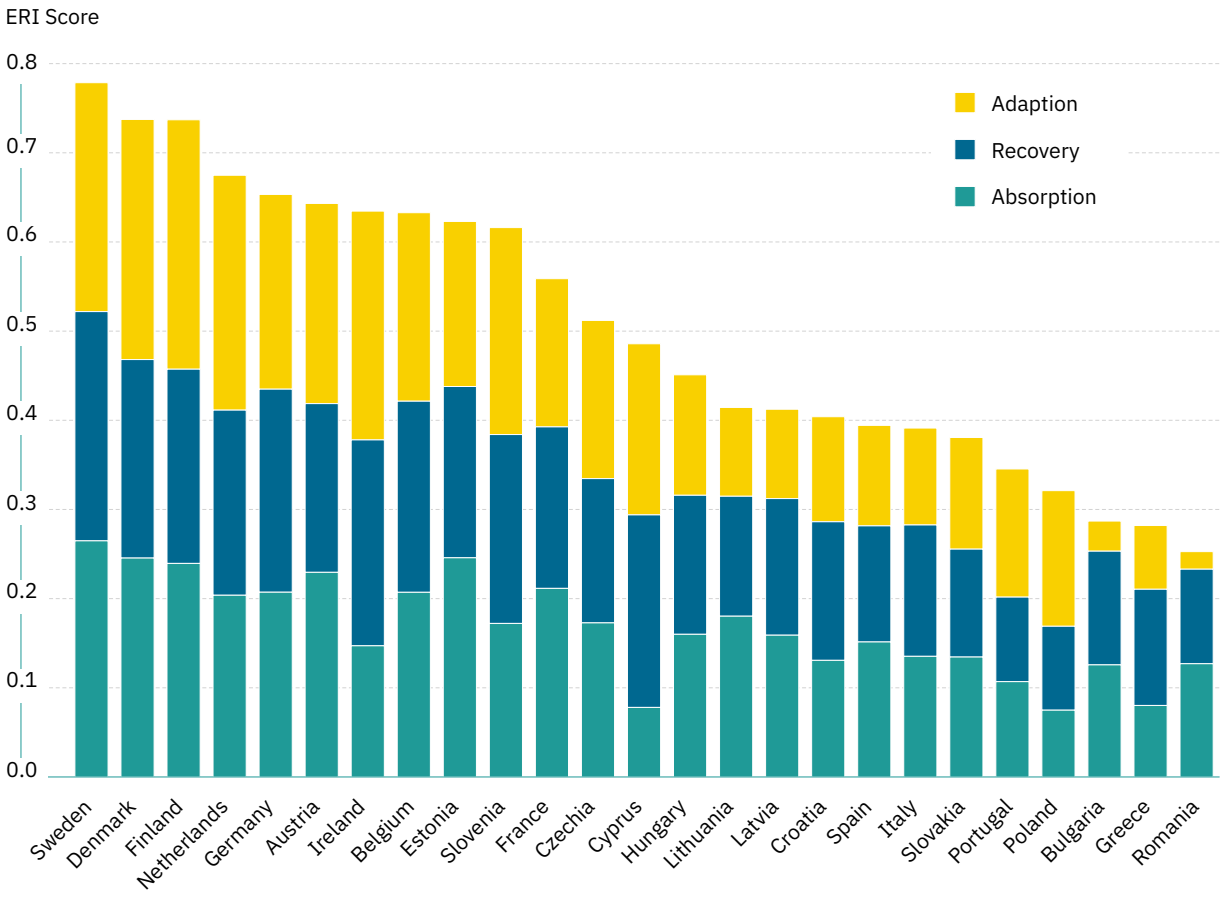


Figure 7: ERI Scores by Country, Divided by Absorption (%), Recovery (%), Adaption (%)

6. Discussion

6.1 Results

At a first glance, the fact that higher-income Scandinavian countries rank first, and lower-income countries rank last, is comparable to GDP ratings. However, the ERI only has a correlation coefficient of 0.66 with GDP per capita, meaning the relationship is not particularly strong. This is in line with the underlying concept of economic resilience which is built both on the abilities of the economy that are directly causal to a high GDP (e.g., accessing financial resources) and on abilities that are independent from GDP (e.g., distribution of unpaid work). Additionally, the overall ERI score and CO_2 emissions per capita have a correlation coefficient of 0.37, meaning they are weakly correlated. This indicates that, according to the ERI, countries' resilience does not come at the expense of higher CO_2 emissions. An explanation for this is that many resilience determinants, for example education, skills, or regulatory quality, do not require high levels of material consumption.

Zooming in from overall ERI scores to dimension scores reveals some striking findings. Indeed, while many countries show balanced performance across the six resilience dimensions, other countries' resilience performance varies considerably across the six dimensions. This is particularly indicative for EU policy decisions. For example, Italy and Romania have high economic independence scores but low scores for all other dimensions. Contrary to current political discussions, this showcases that economic resilience is not only import and export market diversity, or energy independence, but is also about education and skills, or social progress and cohesion. Indeed, the fact that their overall score is rather low despite their high scores in the economic independence dimensions emphasises the importance of other resilience dimensions for economic resilience.

At the same time, variations among countries' dimension scores also reveal country-specific insights. For instance, to increase their overall economic resilience score, Italy and Romania can increase their resilience in the five dimensions other than economic independence. These country-specific findings are of similar interest for countries that only exhibit one poor performing resilience dimension. For example, Austria performs strongly in the five other dimensions than economic independence. As such, the country could strongly increase its overall economic resilience by improving its economic independence. Furthermore, the results on the determinant and indicator level add another perspective. Indeed, even though the six resilience dimensions highlight focus areas for economic resilience, a country's score can still vary considerably within dimensions and across indicators. This can be exemplified by zooming in to the economic independence dimensions for the countries discussed above. Italy's relatively high economic independence score originates from a strong performance with respect to export market diversity, supply chain vulnerability, and resource productivity. However, Italy performs very weakly in terms of energy independence. In contrast, Romania's relatively high economic independence score comes from a very high energy independence, despite weak performance in resource productivity, and an average performance for other indicators in the economic independence dimension. On the other hand, Austria has a very high economic complexity score, but exhibits weaker performance with respect to other indicators in the economic independence dimension. This is what results in a poor performance overall in Austria's economic independence dimension.

Given the gap between highest and lowest ranked countries with respect to the economic resilience performance, increasing economic resilience in the EU specifically requires supporting low-resilience countries. Analysing the spread of countries' scores across dimensions highlights that the country differences for Education & Skills and Governance are significantly higher than for other dimensions. As such, this indicates a particularly strong divergence with-

in the EU with respect to Education & Skills and Governance. These findings can steer EU policy towards increasing cohesion in the EU by adequately supporting poorly performing countries.

Moreover, the findings of **figure 7** show divergence among resilience capacity scores for some countries. This emphasises the relevance of distinguishing these 3 forms of resilience. Indeed, for countries that exhibit this divergence (e.g., Cyprus, Bulgaria, Romania), their overall economic resilience score can be improved by improving their performance with respect to one specific resilience capacity.

6.2 Limitations

Constructing an index to measure economic resilience comes with substantial challenges when it comes to methodology and data selection. First, by building the index on the concept of economic resilience by Hafele et al. (2022), the index inherits both the methodological strengths and weaknesses of this concept[40]. Additionally, while it provides a coherent theoretical framework, quantifying this concept is challenging. For example, abilities of provisioning actors to anticipate future trends and shocks play an important role in the concept but they cannot de directly measured in the index due to a lack of quantitative indicators. As a result, these had to be measured by reasonable proxies, in this case the proxies were education, research and development. On top of that, some characteristics could not be measured at all. While the economic independence dimension quantifies dependencies among countries, it can not measure the quality of these dependencies. For example, two countries with the same diversity of export and import partners could still have different resilience levels if one country trades with very resilient countries whereas the other country trades with low-resilience countries. However, this only applies to the economic independence dimension, but not to other dimensions. When it comes to public finances, the selected indicator of refinancing costs is not the only relevant measure. The existence and design of fiscal rules can also be considered an important determinant of economic resilience. This is because very strict fiscal rules could undermine a country's fiscal flexibility while the complete absence of fiscal rules could set wrong incentives in a monetary union. However, given that the stringency of fiscal rules is hard to quantify, especially with many different national and sub-national fiscal rules, no reliable indicator could be included. Nonetheless, most characteristics of the concept of economic resilience could either be measured or approximated.

With respect to technical limitations, the focus on EU countries made the inclusion of EU membership, which as a resilience determinant would by definition have no variation among EU countries, impossible. However, EU membership could be considered a relevant determinant of economic resilience. Although this is not an issue with respect to comparing the economic resilience of EU countries, it generally obscures a relevant determinant of economic resilience when communicating the index to non-EU countries.

In terms of data collection, a couple of obstacles were faced. One obstacle is that Malta and Luxembourg are exempt from the EU27 country coverage as data was missing from several indicators. Moreover, the indicator data are not all based on the same year; eleven indicators are based on 2021, nine are based on 2020, three from 2019, and two from 2018. As long as all countries' performances for a given indicator are measured in the same year this does not cause any issues with respect to relative resilience. However, in very few cases, different base years within indicators were used according to data availability. For example, financial constraints and trade union data cover a range of years as no source had consistent years across countries[41]. In other rare

40 A discussion of this concept can be found in Hafele et al. (2022).

41 Since the trade union data span a relatively short period of time prior to the COVID-19 years, no significant bias in the results is expected. The financial constraints data also span a relatively short period of time. In this case, however, the data are from before and after the COVID-19 pandemic. Although the weighting of this indicator is relatively low at 1:27 in the overall ranking, this remains an issue to be addressed in later versions of the ERI.

cases, various sources were used to cover the missing data such as for household savings rate where the main source was Eurostat but data for Bulgaria and Romania was acquired through the European Central Bank. In those cases, sources that maintained similar methodologies for consistency were chosen. In general, the ERI has some of the common limitations of data collection for indices, however the overall result is very high data coverage with very few imputations.

Additionally, since the country scores for each indicator were weighted using a z-approach which assumes a normal distribution of the data, the ERI reports relative, not absolute economic resilience. In other words, the ERI allows for an assessment of the economic resilience of countries in relation to each other but does not show whether countries are overall resilient to crises or not. Even though this is a downfall in some respects; it is also useful in other respects. For example, a centrally coordinated EU policy aimed at allocating resources to Member States could base their choice of resource allocation to particularly support Member States with lowest resilience rankings. Additionally, as a measure of relative economic resilience, the ERI could inform sovereign bond ratings which determine the interest that countries pay on their debt based on various criteria, including relative economic resilience.

A multivariate analysis was conducted to ensure the data quality of the ERI. As expected for a dataset with 27 indicators, analysing correlations between indicators showed some correlations with a coefficient of more than 0.7 (see appendix 1). However, given the relatively small sample size of countries, finding correlations between indicators that do not have a strong conceptual similarity can also arise by chance. Indeed, a very strong correlation between two conceptually similar indicators was only detected once[42]. Thus, multivariate analysis does not indicate any major technical weaknesses of the ERI.

All 27 indicators are weighted equally in the index to avoid a normative value-judgement by the authors. However, this does not necessarily lead to an optimal outcome. For instance, in light of the current energy crisis one might argue that energy import dependencies deserve a higher weight. Nonetheless, given that such arguments could be made for almost any indicator, equal weighting was considered a reasonable choice.

Finally, the cross-section data allows for cross-country comparisons but does not enable an observation of a country's development over time. However, this is only due to data availability. Increased data availability with respect to the selected indicators would allow updating the ERI to a panel-data index. This underlines the general importance of data availability for measuring economic resilience.

42 Both financial equality and social cohesion were measured by indicators of income distribution: the income quintile ratio and people at risk of poverty, respectively. The fact that both indicators, directly or indirectly, refer to the distribution of wealth, results in a high correlation. However, the fact that they measure different determinants in different dimensions justifies keeping both indicators instead of dropping them (or adjusting their weights).

7. Conclusion

The profound consequences compounding crises have had on societies revealed substantial cracks in the current workings of economies. As a result, the EU has set economic resilience as the policy-compass for the decades ahead. The focus on building economic resilience encompasses both the ability of economies to swiftly recover from shocks once hit, and holds the potential for economies to adapt, and transform, their current workings to best mitigate the impact of future shocks.

To guide the EU towards this economic vision, policymakers need to both grasp what makes economies resilient, and need to be able to assess and compare countries' resilience performance. To address the latter, this paper develops the ERI. The ERI aims to steer EU policy to build economic resilience by enhancing the legislative usefulness of the European Commission's resilience dashboards. Indeed, the ERI is built on a coherent theoretical framework of economic resilience that quantifies and aggregates the information in a single, composite indicator. As a measure of relative economic resilience, the ERI can be used in various fields, such as in sovereign bond ratings or the allocation keys used in central fiscal capacities.

The results of the ERI reveal crucial insights for policymakers. Most importantly, this includes the urgent gap in addressing score-divergence across the EU by adequately supporting low-resilient economies. Furthermore, this research highlights meaningful opportunities in further developing the ERI. As of now, the ERI only analyses the relative resilience of EU Member States. As such, great potential lies in expanding the ERI to a global context. Additionally, it would be indicative to complement the relative measure of the ERI with an absolute resilience measure that could be tracked over time and space.

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Appendix 1: Steps in technical construction of index

As mentioned in **chapter 4.3**, the ERI construction follows the OECD guidelines for constructing composite indicators which includes a ten-step process. The first steps are concerned with developing a theoretical framework, discussed in **chapter 4.1**, and data selection discussed in **chapter 4.2.** The next paragraphs illustrate the following steps in depth.

Imputation of missing data

For missing data imputation, the following steps were taken. Whenever a datapoint for a country was missing within the indicator, the value from the last available year was used. For some indicators, various sources using the same methodology were used to fill in the missing data points. For example, in household saving rate for Bulgaria and Romania, values from 2017 and 2019 respectively, were acquired from the European Central Bank database[43]. While for ICT services in GDP for Ireland, the missing data was acquired through Predict[44]. For the calculation of regional dispersion of income, small countries in size such as Cyprus, Estonia, and Latvia did not have the NUTS-2 regional division therefore the values had to be replaced. For Estonia and Latvia, the values were acquired from the countries' statistical office division[45]. However, the information was not available for Cyprus therefore an average of several countries was used in order not to skew the results by adding zero.

Multivariate Analysis

Upon completion of a full data set with all missing values computed, we initiated a multivariate analysis to study the underlying structure of the data. Our inquiry focused on identifying any indicators where the distribution of data seemed out of the ordinary. The statistical analysis also included methods to identify any outlier values within each indicator. We examined the six qualitative indicators to determine whether they exhibited a distribution that was statistically different from the quantitative ones. Finally, a correlation analysis was conducted between indicators and the composite score. Our findings concluded the following:

1. Limited number of outliers, defined as +/- 3 standard deviations, such as:

- High share of ICT service sector in GDP for Ireland, which is potentially explained by the low corporate tax rates which attract ICT companies.
- High share of people at risk of poverty and social deprivation in Romania, potentially a result of the relatively low-income level in Romania compared to other EU countries
- Low refinancing cost for Lithuania & Estonia, an observation explained by very low debt-levels
- High resource productivity for the Netherland, which can be explained by the country's long policy tradition of preventing and recycling various waste streams
- High trust in government for Germany which may be explained by the government's response against COVID-19
- High long-term unemployment rate for Greece and Spain, which could be due to long-term effects of the Euro crisis

2. Secondly more variation than expected was observed in qualitative indicators suggesting that these values have a similar impact on the composite score compared to quantitative ones

43 Data for Bulgaria and Romania (European Central Data base).

44 PREDICT project database 2020.

45 Data for Estonia (Statistics Estonia) and Latvia (Official Statistics portal of Latvia).

3. Correlation analysis performed for all indicators relative to the composite score (equal weighting approach):

- Three indicators of the 27 have weak correlation with the composite score, (Energy imports dependency, Export partner concentration, and Import partner concentration). All three of these indicators are contained within the Economic Independence dimension, explaining the dimension's overall weak correlation to the composite score.
- Two indicators in "Education & Skills" have some of the strongest correlations to the composite score (Adult participation rate in education and training and Brain retention), suggesting a strong correlation between this dimension and the composite score. The other two indicators in this dimension (PISA and Scientific publications) also exhibit strong correlation to the composite score

4. Correlation analysis performed for all indicators relative to one another, for the purpose of future discussion and possible alternative weighting approach.

- High correlations were found between several indicators as seen in the table below. In some cases, the high correlations were coincidental such as Scientific Publications and Regional dispersion of income. Others such as Income quintile share ratio S80/S20 and People at risk of poverty or social exclusion had high correlations as their inputs were closely related however in theory are measuring different aspects of resilience

Normalisation

Our approach to normalisation considered both the theoretical framework of the ERI and the emerging statistical insights related to the underlying data. There are multiple methods used for normalisation: one is the simple ranking of each country by indicator (i.e., 1–25). Another is a more complex approach like scaling each indicator value against a target or threshold (e.g., % share of exports annually). However, these targets do not yet exist for most indicators with full acceptance across 25 EU members, therefore we selected the z-score method of normalisation, based upon the following:

- The arithmetic mean and standard deviation were computed for each indicator
- z-scores were calculated to indicate the distribution of each country's score from the mean, accounting for the standard deviation
- Percentiles were calculated from these z-score, scaling each country from 0 to 1

Weighting and Aggregation

As discussed in the theoretical framework, the 27 indicators defining the ERI have been selected due to their descriptive merits of the six main dimensions: Economic Independence, Education & Skills, Financial Resilience, Governance, Production Capacity, Social Progress and Cohesion. While these indicators are not evenly distributed across the 6 dimen-

	ADLEDU	BRNRTN	ECMPLX	ENGIMP	EXPCON	FINCON	FORRES	GNDGAP	GOVSER	HHOSAV	ICTGDP	IMPCON	INCQUI	INOENT	INVGDP	JOBSAT	PISAAV	PPLRSK	REFCOS	REGINC	RESPRO	REGQUA	SCIPUB	TRDUNI	TRSGOV	TRSNGH	UEMLON
ADLEDU	1,00																										
BRNRTN	0,74	1,00																									
ECMPLX	0,22	0,37	1,00																								
ENGIMP	0,19	-0,07	0,28	1,00																							
EXPCON	0,09	-0,09	-0,28	-0,03	1,00																						
FINCON	0,25	0,21	0,41	0,05	-0,30	1,00																					
FORRES	0,72	0,71	0,13	-0,18	0,06	0,31	1,00																				
GNDGAP	0,58	0,36	0,04	0,19	0,13	0,53	0,46	1,00																			
GOVSER	0,52	0,44	0,28	-0,11	0,30	-0,06	0,38	0,18	1,00																		
HHOSAV	0,33	0,56	0,60	-0,15	-0,29	0,46	0,38	0,13	0,25	1,00																	
ICTGDP	0,23	0,37	-0,06	0,17	0,02	0,17	0,35	0,24	-0,44	0,19	1,00																
IMPCON	-0,09	-0,27	-0,27	-0,07	0,77	-0,13	-0,20	-0,03	0,09	-0,09	-0,02	1,00															
INCQUI	0,32	0,54	0,56	0,05	-0,39	0,37	0,53	0,13	0,23	0,49	0,18	-0,48	1,00														
INOENT	0,46	0,61	0,15	-0,27	0,28	0,01	0,72	0,20	0,54	0,31	0,12	0,03	0,37	1,00													
INVGDP	0,46	0,40	0,56	0,40	-0,26	0,41	0,45	0,30	0,10	0,48	0,23	-0,30	0,30	0,21	1,00												
JOBSAT	0,11	-0,01	-0,05	-0,19	0,11	0,39	0,40	0,01	-0,03	0,25	0,18	0,14	0,08	0,13	0,22	1,00											
PISAAV	0,69	0,65	0,42	0,24	-0,30	0,38	0,45	0,50	0,40	0,47	0,05	-0,30	0,53	0,36	0,44	0,02	1,00										
PPLRSK	0,36	0,54	0,54	0,12	-0,35	0,31	0,48	0,22	0,24	0,44	0,14	-0,54	0,95	0,36	0,29	-0,02	0,56	1,00									
REFCOS	0,37	0,28	0,18	0,54	0,22	0,20	0,13	0,55	0,02	-0,07	0,22	0,10	0,06	0,08	0,34	-0,27	0,29	0,19	1,00								
REGINC	0,51	0,61	0,05	-0,22	-0,05	0,39	0,68	0,40	0,26	0,21	0,14	-0,21	0,44	0,66	0,09	0,23	0,50	0,48	0,17	1,00							
RESPRO	0,41	0,56	0,26	-0,47	0,00	0,15	0,40	-0,01	0,55	0,69	-0,02	0,15	0,28	0,40	0,05	0,19	0,32	0,16	-0,22	0,17	1,00						
REGQUA	0,77	0,85	0,36	0,13	-0,05	0,38	0,65	0,59	0,34	0,46	0,34	-0,20	0,46	0,53	0,54	0,03	0,74	0,49	0,60	0,56	0,39	1,00					
SCIPUB	0,71	0,77	0,12	-0,14	0,01	0,23	0,86	0,32	0,36	0,33	0,36	-0,25	0,53	0,68	0,23	0,31	0,48	0,54	0,03	0,81	0,38	0,59	1,00				
TRDUNI	0,41	0,53	0,17	-0,08	0,27	0,02	0,56	0,07	0,45	0,09	0,24	-0,06	0,38	0,53	0,13	0,28	0,15	0,34	-0,05	0,44	0,25	0,31	0,72	1,00			
TRSGOV	0,73	0,86	0,42	-0,08	-0,01	0,38	0,61	0,42	0,48	0,54	0,23	-0,12	0,44	0,44	0,37	0,03	0,55	0,40	0,25	0,45	0,62	0,76	0,58	0,41	1,00		
TRSNGH	0,47	0,72	0,51	-0,06	-0,23	0,51	0,55	0,25	0,23	0,72	0,28	-0,23	0,62	0,33	0,46	0,16	0,46	0,58	0,06	0,46	0,47	0,56	0,56	0,35	0,80	1,00	
UEMLON	0,30	0,48	0,41	0,48	-0,36	0,30	0,23	0,29	-0,16	0,30	0,34	-0,39	0,47	0,07	0,54	-0,14	0,54	0,55	0,49	0,24	-0,11	0,55	0,25	0,04	0,41	0,55	1,00

sions (i.e., some contain 4, some contain 6), our preliminary approach is to weigh each indicator equally to create a composite score. This decision has shortcomings, namely that the equal weighting approach has not passed through an evaluation by experts offering their input on how some indicators may warrant more weight than others. Moreover, the equal weighting approach does not currently correct for some of the results of the multivariate analysis, particularly the high/low correlation of some indicators mentioned above. While we have started to address these issues through alternate approaches to computing the composite indicator (see below: Uncertainty & Sensitivity Analysis), we intend to continue studying the characteristics of each indicator and whether a revised weighting approach might be more suitable in the future.

Uncertainty and Sensitivity Analysis

As part of the uncertainty and sensitivity analysis, we first fine-tuned the list of indicators by including and excluding certain indicators to improve the index' performance. After having a final list of indicators, we pursued an alternative approach to computing the composite indicator, which is unequal weighting of indicators with weights of indicators determined by their share in the theoretical framework. We counted the share of each determinant in all resilience characteristics across the provisional actors and applied the weight to the related indicator which resulted in slightly different composite scores. The reasoning behind this calculation method is that given the analytical rigor of the theoretical framework, it is worth exploring whether indicators that link more frequently to the resilience characteristics should be weighted more heavily, while those appearing less should be weighted less. However, since this led to very strongly diverging weights for the indicators, we decided to report the equal weights[46].

Back to the details

Looking at the equal weighting approach, the correlation analysis suggests one dimension stands out as having a lower correlation to the composite score which is Economic Independence. This observation is consistent with the correlation analysis by indicator, as many of the indicators with lower correlation to the composite are grouped in this dimension. It is important to note that this observation does not imply this dimension is not descriptive of the theme of economic resilience; rather, it suggests that when considered in the context of the other dimensions, it correlates less with the composite indicator. While this observation requires further discussion, one initial explanation is that the Economic Independence dimension leans heavily on data related to trade (including energy imports dependency), which is a particularly salient resilience topic in the EU.

Links to other indicators

We explored in the correlation analysis the link to other indicators, both in terms of composite indices looking at similar resilience topics and external variables:

- The composite indicator is highly correlated to both the Covid Economic Recovery Index and the Transitions Performance Index. While this result is not surprising, correlation analysis like this between two composite indices can be complicated by the diverse methodological decisions index publishers make.
- The composite indicator is less correlated with GDP per capita and CO_2 emissions per capita, suggesting the economic resilience of a country does not necessarily track national wealth or carbon efficiency.

46 The scores from unequal weighting can be accessed via the publications section of the website of ZOE Institute for Future-fit Economies or by contacting the authors.

Appendix 2: Resilience characteristics tables for all provisioning actors[47]

Resilience determinants of businesses				
		Absorption	Recovery	Adaptation
		Redundancy	**Diversity, Cohesion**	**Adaptability, Diversity, Cohesion**
Abilities for provisioning actors to work together in providing goods and services at appropriate quantity and quality	*Develop, distribute, and use technology*	Investment Corporate finances	Innovation, Supply chain vulnerability, Investment, Economic complexity, Social Cohesion, Financial Equality, ICT Capacity, Regional Cohesion	Education quality, Research & Development, Employment, Social Cohesion, ICT Capacity, Regional Cohesion, Innovation
	develop, transfer, and use suitable skills	Employment, Skills	Employment, Skills, Reskilling, Employment quality, Economic Participation	Education quality, Research & Development, Reskilling
	access financial resources	Corporate finances	Export market diversity, Corporate finances, Innovation, Investment	Innovation, Education quality, Research & Development, Financial Equality, Regional Cohesion
	access natural resources	Natural Resources access, Supply chain vulnerability, Investment	Natural Resources access, Energy independence, Supply chain vulnerability, Innovation, Natural Resources access	Innovation, Education quality, Research & Development, Financial Equality, Regional Cohesion
	create, disseminate, and use knowledge	Research & Development, ICT Capacity	Education quality, Research & Development, ICT Capacity, Innovation, Employment quality, International collaboration	Innovation, Education quality, Research & Development
	ensure stable institutions	Innovation, Trust	Trust, Employment quality	Education quality, Research & Development
	distribute paid and unpaid work	Welfare State Quality	Gender Equality, Economic participation, Employment quality	Education quality, Research & Development
	innovate	Innovation	Innovation, International collaboration, Skills, Trust, Research & Development	Innovation, Skills, Gender Equality, Research & Development

47 Since the macro-level patterns underlying "Recovery" are also underlying "Adaptation", all resilience characteristics and determinants under recover are relevant for adaptation as well.

Resilience determinants of the state				
		Absorption	Recovery	Adaptation
		Redundancy	**Diversity, Cohesion**	**Adaptability, Diversity, Cohesion**
Abilities for maintaining provisioning functions	*Develop, distribute, and use technology*	Investment, Public finances	Research & Development, Institutional quality	International collaboration, Economic complexity
	develop, transfer, and use suitable skills	Skills, Reskilling	Employment, Education quality, Skills, Economic complexity	Education quality, Research & Development, International collaboration, Government effectiveness
	access financial resources	Welfare State Quality, Public finances	Welfare State Quality, International collaboration, Public finances	Education quality, Research & Development, Public finances, Government effectiveness
	access natural resources	Natural Resources access, Supply chain vulnerability, Investment	Export market diversity, Natural Resources access, Energy independence, Supply chain vulnerability	Education quality, Research & Development, Government effectiveness, Financial Equality, Natural Resources access, Regional Cohesion
	create, disseminate, and use knowledge	Research & Development, ICT Capacity	Education quality, Research & Development, ICT Capacity	Education quality, Research & Development, Government effectiveness
	ensure stable institutions	Institutional quality, Government effectiveness	Institutional quality, Government effectiveness	Education quality, Research & Development, Government effectiveness
	distribute paid and unpaid work	Welfare State Quality, Employment, Employment quality	Gender Equality, Institutional quality, Economic participation, Employment, Social Cohesion	Education quality, Research & Development, Government effectiveness
	innovate	Research & Development, Public finances	Government effectiveness, Innovation, ICT Capacity, Economic complexity	Education quality, Research & Development, Government effectiveness

Resilience determinants of households				
		Absorption	Recovery	Adaptation
		Redundancy	**Diversity, Cohesion**	**Adaptability, Diversity, Cohesion**
Abilities for maintaining provisioning functions	*develop, distribute, and use technology*	Skills, Research & Development, ICT Capacity, Economic complexity	Innovation, Financial Equality, Skills, Institutional quality, Private finances	Innovation, Education quality, Research & Development
	develop, transfer, and use suitable skills	Employment, Skills, Reskilling	Employment, Skills, Economic participation, Reskilling	Education quality, Research & Development
	access financial resources	Employment, Financial Equality, Welfare State Quality, Private finances	Employment, Financial Equality, Welfare State Quality, Gender Equality, Employment quality, Private finances	Education quality, Research & Development
	access natural resources	Natural Resources access, Supply chain vulnerability, Investment	Natural Resources access, Energy independence, Supply chain vulnerability	Education quality, Research & Development
	create, disseminate, and use knowledge	Education quality, Research & Development, ICT Capacity, Regional Cohesion	Education quality, Research & Development, ICT Capacity, Regional Cohesion	Education quality, Research & Development
	ensure stable institutions	Social Cohesion, Trust, Regional Cohesion, Economic participation	Social Cohesion, Trust, Regional Cohesion, Institutional quality, Economic participation	Education quality, Research & Development
	distribute paid and unpaid work	Welfare State Quality	Employment, Trust, Gender Equality, Employment quality, Economic participation	Education quality, Research & Development
	innovate	Innovation, Education quality	Employment, Education quality, Skills	Education quality, Skills, ICT Capacity, Institutional quality, Reskilling

Resilience determinants of communities				
		Absorption	Recovery	Adaptation
		Redundancy	**Diversity, Cohesion**	**Adaptability, Diversity, Cohesion**
Abilities for maintaining provisioning functions	*develop, distribute, and use technology*	Skills, Research & Development, ICT Capacity, Economic complexity	Innovation, Skills, Institutional quality	Innovation, Education quality, Social Cohesion, Research & Development
	develop, transfer, and use suitable skills	Employment, Skills, Reskilling	Employment, Skills, Economic participation, Reskilling	Education quality, Social Cohesion, Research & Development
	access financial resources	Employment, Financial Equality, Welfare State Quality, Public finances	Employment, Financial Equality, Welfare State Quality, Public finances, Employment quality, Private finances	Education quality, Social Cohesion, Research & Development
	access natural resources	Natural Resources access, Supply chain vulnerability, Investment	Natural Resources access, Energy independence, Supply chain vulnerability	Education quality, Social Cohesion, Research & Development
	create, disseminate, and use knowledge	Education quality, Research & Development, ICT Capacity, Regional Cohesion	Education quality, Research & Development, ICT Capacity, Regional Cohesion	Education quality, Social Cohesion, Research & Development
	ensure stable institutions	Social Cohesion, Trust, Regional Cohesion, Economic participation	Social Cohesion, Trust, Regional Cohesion, Institutional quality, Economic participation	Education quality, Social Cohesion, Research & Development
	distribute paid and unpaid work	Welfare State Quality	Employment, Trust, Gender Equality, Employment quality, Economic participation	Education quality, Social Cohesion, Research & Development
	innovate	Innovation, Investment	Education quality, Social Cohesion, Trust, ICT Capacity, Regional Cohesion	Innovation, Education quality, Social Cohesion, Regional Cohesion

Appendix 3: Description of the ERI indicators

Dimension	Determinant	Indicator	Unit	Direction[48]	Definition
Economic Independence	Economic complexity	Economic Complexity Index	Index score	+	Diversity of a country's export basket, corrected for its complexity. High ECI refers to smaller number of other countries that export the same goods
	Energy independence	Energy imports dependency	%	–	Share of total energy needs of a country met by imports from other countries.
	Export market diversity	Export partner concentration	Score	–	Concentration of exports partners based on Herfindahl index of each member state's export partners. 1 means there is only 1 export partner, values closer to 0 mean more diversification
	Supply chain vulnerability	Import partner concentration	Score	–	Concentration of imports partners based on Herfindahl index of each member state's import partners. 1 means there is only 1 import partner, values closer to 0 mean more diversification
	Natural resources access	Resource productivity	Euro/KG	+	Measure of the effectiveness with which resource consumption produces added value. It is calculated as GDP divided by domestic material consumption (DMC).
Education & Skills	Reskilling	Adult participation rate in education and training	%	+	Share of population aged 25–64 that participated in formal and non-formal education and training four weeks prior to the interview
	Skills	Brain retention	Score	+	Average of the answer to the question: To what extent does your country retain talented people? [1 = not at all — the best and brightest leave to pursue opportunities abroad; 7 = to a great extent — the best and brightest stay and pursue opportunities in the country]
	Education quality	Programme for International Student Assessment (PISA)	Average Score	+	Average PISA scores in reading, mathematics and science, among students aged 15. The three average scores are first calculated separately and then aggregated at the country level.
	Research & Development	Scientific publications	Ratio	+	Number of citable documents published per year relative to the population size

48 A "+" indicates a positive relation to economic resilience, a "–" indicates a negative relation to economic resilience.

Dimension	Determinant	Indicator	Unit	Direction	Definition
Financial Resilience	Corporate finances	Firm's financial constraints	%	–	Percent of firms identifying access to finance as a major constraint
	Household finances	Household saving rate	%	+	The gross saving rate of households is defined as gross saving divided by gross disposable income
	Financial equality	Income quintile share ratio S80 / S20	Ratio	–	The ratio of total income received by the 20 % of the population with the highest income (top quintile) to that received by the 20 % of the population with the lowest income where income is defined as equivalised disposable income.
	Public finances	Refinancing cost	%	–	Interest payments on government debt – including long-term bonds, long-term loans, and other debt instruments – to domestic and foreign residents, as a percentage of revenue
Governance	International collaboration	International co-operation in research	%	+	Share of publications with foreign co-authors based on an abstract and citation database
	Institutional quality	Regulatory quality	Score	+	Based on enterprise, citizen, and expert survey responses, to reflect perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development where –2.5 is weak and is 2.5 strong
	Government effectiveness	Trust in Government	%	+	Share of people answering "A lot" to the question "How about the national government in this country? Do you trust them a lot, some, not much, or not at all?"
	Welfare state quality	Government expenditure on health, education, and social protection	%	+	General government expenditure on health, education, and public services as a share of GDP
Production Capacity	ICT capacity	ICT service sector in GDP	%	+	Share of ICT service sector from total GDP
	Innovation	Innovative enterprises	%	+	Share of enterprises with innovation activities during 2018 and 2020
	Investment	Investment share of GDP by institutional sectors	%	+	Share of investment for the total economy, government, business as well as household sectors from GDP
	Employment	Long term unemployment rate	%	–	The long-term unemployment rate is the share of persons unemployed for 12 months or more in the total number of active persons in the labour market.

Dimension	Determinant	Indicator	Unit	Direction	Definition
Social Progress & Cohesion	Gender equality	Gender employment gap	% point	–	The indicator shows difference between the employment rates of men and women aged 20 to 64
	Employment quality	Job Satisfaction	%	+	Share of employed people with high job satisfaction based on the European Labour Force Survey
	Social cohesion	People at risk of poverty or social exclusion	%	–	Share of people at risk of poverty after social transfers, severely materially and socially deprived or living in households with very low work intensity
	Regional cohesion	Regional dispersion of income	Ratio	–	Spread in the regional averages of disposable household income within the country (ratio between maximum and minimum values)
	Economic participation	Employees in trade unions	%	+	Number of wage and salary earners that are trade union members to the total number of wage and salary earners in the economy.
	Trust	Trust among people in neighbourhood	%	+	Share of people saying “A lot” to the question “How about the people in your neighbourhood? Do you trust them a lot, some, not much, or not at all?”

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