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Analysis of key parameters of Smart Specialisation Strategies (S3)

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Final Report

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Analysis of key parameters of Smart Specialisation Strategies (S3)

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Abstract:

Keywords: smart specialisation, regional funding, innovation policy, prioritisation

This study builds upon the comprehensive set of data which was gathered in the predecessor study "Study on prioritisation in Smart Specialisation Strategies in the EU" and contains key parameters of each strategy. Five core issues are examined in this study based on the previously collected data.

Overall, the S3 and its concept prove to be relevant for a number of EU priority areas. First, it is found that the 185 S3 provide a vast potential for cooperation, however, it is concluded that this potential is still untapped. Second, the priority areas of the 185 S3 of the 2014-2020 period show considerable connections to topics of the Twin Transition. Third, the S3 also have thematic connections to projects of H2020 as well as the key Horizon Europe funding areas which further underlines the potential for synergies between ERDF and Horizon funding. In addition, this study adds to the literature by developing a theory of what is a *good* S3, i.e. tailored to the technological opportunities and capabilities in Member States/regions and gives clear indications about which policy approach specific types of Member States/regions should adopt. Moreover, the study develops an integrated methodology and a single comparative for the S3 Scoreboard that includes all 185 S3.

Overall, this study underlines the usefulness of S3 in broader context (e.g., in contributing to key Commission priorities) and provides guidelines for the further development of the S3 concept.

Zusammenfassung:

Schlagwörter: intelligente Spezialisierung, Regionalpolitik, Innovationspolitik, Priorisierung

Diese Studie baut auf dem umfassenden Datensatz auf, der in der Vorgängerstudie "Study on prioritisation in Smart Specialisation Strategies in the EU" gesammelt wurde, und enthält Schlüsselparameter jeder Strategie. Auf der Grundlage der zuvor erhobenen Daten werden in dieser Studie fünf Kernfragen untersucht.

Insgesamt erweisen sich die S3-Strategien und ihr Konzept als relevant für eine Reihe von EU-Schwerpunktbereichen. Erstens wird festgestellt, dass die 185 S3-Strategien ein enormes Potenzial für die Zusammenarbeit bieten, das jedoch noch weitgehend ungenutzt ist. Zweitens weisen die Prioritätsfelder der 185 S3-Strategien des Zeitraums 2014-2020 erhebliche Überschneidungen mit Themen der Twin Transition auf. Drittens haben die S3-Strategien auch thematische Überschneidungen mit Projekten von H2020 sowie den zentralen Förderbereichen von Horizon Europe, was das Potenzial für Synergien zwischen EFRE- und Horizon-Förderung weiter unterstreicht. Darüber hinaus trägt diese Studie zur Literatur bei, indem sie eine Theorie darüber entwickelt, was eine gute S3-Strategie ist. Dies inkludiert die technologischen Möglichkeiten und Fähigkeiten in den Mitgliedstaaten/Regionen und gibt klare Hinweise darauf, welchen politischen Ansatz bestimmte Arten von Mitgliedstaaten/Regionen verfolgen sollten. Darüber hinaus entwickelt die Studie eine integrierte Methodik und einen einzigen Vergleich für das S3 Strategie Scoreboard, welches alle S3 Strategien umfasst.

Insgesamt unterstreicht diese Studie den Nutzen von S3-Strategien in einem breiteren Kontext (z. B. als Beitrag zu den Hauptprioritäten der Kommission) und liefert Leitlinien für die weitere Entwicklung des S3 Konzepts.

RÉSUMÉ

Mots clés: spécialisation intelligente, financement régional, politique d'innovation, hiérarchisation des priorités

Cette étude s'appuie sur l'ensemble des données recueillies dans l'étude précédente "Study on prioritisation in Smart Specialisation Strategies in the EU" et contient les paramètres clés de chaque stratégie. Cinq questions centrales sont examinées dans cette étude sur la base des données collectées précédemment.

Dans l'ensemble, les stratégies S3 et leur concept s'avèrent pertinents pour un certain nombre de domaines prioritaires de l'UE. Tout d'abord, il s'avère que les 185 stratégies S3 offrent un vaste potentiel de coopération, mais que ce potentiel est largement inexploité. Deuxièmement, les domaines prioritaires des 185 stratégies S3 de la période 2014-2020 présentent des chevauchements significatifs avec les thèmes de la Double Transition. Troisièmement, les stratégies S3 ont également des chevauchements thématiques avec les projets de H2020 ainsi qu'avec les domaines clés de financement d'Horizon Europe, ce qui souligne davantage le potentiel de synergies entre le FEDER et le financement d'Horizon. En outre, cette étude enrichit la littérature en développant une théorie de ce qu'est une bonne S3, c'est-à-dire adaptée aux opportunités et aux capacités technologiques des États membres/régions, et donne des indications claires sur l'approche politique que des types spécifiques d'États membres/régions devraient adopter. En outre, l'étude développe une méthodologie intégrée et un comparatif unique pour le tableau de bord S3 qui inclut toutes les stratégies S3.

Dans l'ensemble, cette étude souligne l'utilité des stratégies S3 dans un contexte plus large (par exemple, en contribuant aux priorités clés de la Commission) et fournit des lignes directrices pour le développement futur du concept S3.

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Glossary

DG	Directorate-General
EC	European Commission
EDP	Entrepreneurial Discovery Process
EIT	European Institute of Innovation & Technology
ERDF	European Regional Development Fund
ESCP-S3	European Cluster Partnerships for smart specialisation investments
EU	European Union
ExACs	Ex ante conditionalities
H2020	Horizon 2020
I3	Interregional Innovation Investments
ICT	Information and Communication Technology
JRC	Joint Research Center
KIC	Knowledge and Innovation Communities
LDA	Latent Dirichlet Allocation
MS	Member States
OP	Operational Programme
R&D	Research & Development
R&I	Research & Innovation
S3	Strategy for smart specialisation

EXECUTIVE SUMMARY

Background and Objectives

This summary relates to the **Analysis of key parameters of Smart Specialisation Strategies (S3)**, undertaken in 2022 by a team led by Prognos AG and experts from the Centre for Industrial Studies (CSIL). The study builds upon the predecessor study on “Prioritisation in Smart Specialisation Strategies in the EU” by Prognos and CSIL. Thereby, the analyses and understanding of smart specialisation strategies across the EU are further refined and deepened. The following five core questions are addressed in this study:

1. **Interregional cooperation potential**: What is the potential for interregional cooperation regarding the S3 and priorities chosen by Member States and regions and in which areas?
2. **Green and digital transition**: How do S3 contribute to key Commission priorities, in particular the Twin Transition (green & digital)? What are the opportunities of S3 to contribute to the Green Deal in rural, less developed, and peripheral regions?
3. **Links to EC research funding**: What is the link between S3 priorities and Horizon 2020 projects? What are possible complementarities with the key Horizon Europe instruments?
4. **Related vs. unrelated diversification**: What determines an ‘good bandwidth’ of S3 and under which conditions is a strategy of related or unrelated diversification a “good” option for a MS/region?
5. **S3 Scoreboard**: What is needed for an integrated methodology leading towards a single comparative map of the S3 Scoreboard?

Key findings

The analysis of this study builds on the 185 S3 of the various EU Member States/regions for the 2014-2020 funding period for which a comprehensive database was established in the predecessor Study on Prioritisation in Smart Specialisation Strategies in the EU by Prognos and CSIL. Although this assessment is based on data for the 2014-2020 period the results are also relevant for the 2021-2027 funding period since overall, the priority setting in the regions did not considerably change.

Potential of S3 for interregional cooperation

The **185 Smart Specialisation Strategies and corresponding priority areas of the 2014-2020 funding period provide significant potential for interregional cooperation**. This potential is assessed in this report from different perspectives. First, based on the various underlying economic sectors of the priority areas, a multitude of connections to the 14 EU Industrial Ecosystems can be established. The largest correspondence of the Industrial Ecosystems and the S3 priority areas can be found in the Industrial Ecosystems “Digital”, “Energy Intensive Industries” and “Cultural and Creative Industries” followed by “Agri-Food” and “Health” – that means, here strategic directions and prioritisation correspond to each other. It is noteworthy though, that the overall differences between Industrial Ecosystems are rather small which can be explained by the overall broadness of the Industrial Ecosystem classification. Overall, it can be concluded that the S3 priorities have profound correspondence to the different Industrial Ecosystems and that the funding activities of Member States/regions in their S3 also contribute to all of the 14 EU Industrial Ecosystems.

Moreover, the priorities addressed by Member States/regions in the 185 S3 frequently **correspond to complementary knowledge stocks**. A database has been created that informs about complimentary knowledge in the priority areas (based on patent data). Together with information on the similarity between the respective priority areas and existing cooperation linkages (based on patents) between the regions, detailed recommendations for interregional cooperation for a respective region can be derived. This database serves as a starting point for identifying relevant regions for interregional collaboration projects, e.g., in the Interregional Investment Initiative (I3) of DG REGIO.

Based on the analysis of complementary knowledge in the priority areas it is found that the largest potential for cooperation is first and foremost found among priorities that address the same overarching topic. This is not surprising, as some of the overarching topics can be regarded as cross-cutting. In addition, the detailed analysis of the potential for interregional collaboration based on complimentary knowledge shows that depending on the degree of similarity between the priority areas and the number of existing cooperation linkages there are varying levels in the potential for cooperation. Since for many regions no or only low numbers of existing cooperation linkages are found in our data, it can be concluded that there are still **vast potentials for interregional cooperation in the context of S3 across European regions**. Overall, the findings suggest that interregional collaboration should further be supported and substantiated.

Opportunities related to the green and digital transition

Overall, the priority areas of the 185 S3 of the 2014-2020 period **show significant connections to topics of the Twin Transition**. On a general level, more than 700 out of 1018 (69%) priority areas have a connection to topics of the green and digital transition. These references vary in their quality since some priority areas can completely address a certain topic of the Twin Transition while others only address certain aspects of a certain topic. On a general level, **more priorities show a (strong) connection to topics of the green transition**. The largest connection between the S3 priorities and topics of the Twin Transition can be found in rather general overarching domains such as ICT, Bioeconomy, or Renewable Energy. Specific topics such as “Blockchain”, “Super & Quantum Computing” or “Clean Tech” are subtopics that are addressed by the S3 priority areas. Moreover, some topics like “ICT” are often either specifically addressed by the priority areas or just mentioned in the description of the priority areas. For instance, some regions focus their priority areas on ICT (e.g., Extremadura has the priority area labelled “ICT”) while in many other priority areas only terms connected to ICT are mentioned (e.g., the priority area “Energy” of the national Portuguese strategy mentions “ICT” in its description).

The study also assessed ERDF projects under Thematic Objective 1 that have been linked to the 185 S3 and their priority areas. The **ERDF R&I projects implemented during the 2014-2020 period considerably contributed to the Twin Transition** since around 35,160 out of the 49,750 projects (71%) that were connected to the priority areas in the predecessor study are generally linked to topics of the green and digital transition. Correspondingly, around €14.9 billion (75%) of the project budget that has been channeled into the priority areas can be generally linked to topics of the Twin Transition. With regards to priority areas that show a high relevance to the topics of the green and digital transition 17,860 of the 49,750 projects (36%) can be connected to such priority areas. More projects can be linked to priority areas with a high relevance to the green compared to the digital transition.

The **overall regional differences in the contribution of S3 to the green and digital transition are rather small**. There is only a small variation in the relevance of the linkages between the S3 priorities and the topics of the Twin Transition among the different regions. Nonetheless, some regional differences on certain topics (e.g., “Bioeconomy” or “Fair, healthy & environmentally-friendly food system”) have been detected. Regarding the projects linked to priority areas among the EU13 Member States/regions, on average more projects and budgets are linked to priority areas that are relevant to the green transition. Among the EU15 Member States/regions more projects and budgets have been linked to priorities with a high relevance to the digital transition.

Correspondence between S3 and Horizon funding

The analysis between S3 and Horizon funding demonstrates a **high degree of thematic correspondence, both when looking at the correspondence between S3 and Horizon 2020 projects as well as potential correspondence with the key funding areas of Horizon Europe**.

Overall, **64% of the analysed H2020 projects can be connected to priority areas of the respective S3**. The share of projects that can be connected to the priority areas is higher than the share of the linked budget. A more granular analysis of the share of H2020 projects linked to S3 priority areas shows that on a general level slightly more H2020 projects are matched in EU13 Member States/regions (66%) compared to EU15 Member States/regions (64%). From a more regional perspective, some variations in the shares of linked projects and budgets emerge. Western European regions (e.g., Germany, France) tend to have higher shares of projects linked to the respective priority areas.

A relatively **stark heterogenous regional distribution of organisations funded by both the ERDF and H2020 is identified**. Overall, at least 3,417 organisations (7% out of the 51,674 organisations identified in the ERDF project database) have also conducted projects funded by Horizon 2020 in the 2014 to 2020 period. The share of organisations that have been funded by both the ERDF and Horizon 2020 is with around 80% among the EU15 Member States/regions significantly higher compared to the share of organisations in EU13 Member States/regions.

Almost all priority areas (924 out of 1018) can be linked to the Horizon Europe key funding areas. This means that topics that are addressed by Horizon Europe key funding areas are also found in many of the S3 priorities which underlines the fundamental potential for creating synergies between the two. Overall, the findings indicate great potential for synergies between S3 and key Horizon Europe instruments such as the Partnerships, Joint Undertakings, Missions and KICs.

Related vs unrelated diversification

Despite prolific academic literature and the availability of guidelines by the European Commission on how to design S3**, there is no theory on what constitutes a good S3 for different types of territories**. Specifically, no indications are given on what degree of selectivity is advisable for different types of Member States/regions, or whether the thematic focus of the S3 for a particular type of MS/region can aim at unrelated diversification or should better stick to related diversification. Some evidence from previous research showed that the priorities selected in most of the EU Member States/regions were not related to their areas of specialisation (Deegan et al., 2022; Di Cataldo et al., 2020; Marrocu et al., 2022; Prognos and CSIL, 2021). Still, no study has discussed whether the degree of relatedness of these strategies was appropriate to the characteristics of the Member State/region, and whether more or less ambition would have been a more suitable choice.

This analysis contributes to the literature by developing a **"theory for a good S3"**, with specific reference to its thematic focus (referred to as "S3 bandwidth") and related vs unrelated diversification goal. After developing a theoretical framework that specifies the most appropriate levels of bandwidth and relatedness that would be advisable for different types of Member States/regions, the actual level of S3 bandwidth and relatedness chosen by S3 published up to 2020 was analysed. From comparing the *degree of* bandwidth and diversification approaches expected from the theory with the *actual* ones adopted in the S3, it is possible to identify which S3 made good choices, i.e. conforming with the postulates in the theory, or deviated from the theoretical expectations and in which way.

We find that **61% of the analysed 162 S3 achieved an *appropriate* level of thematic focus.** In general, small Member States/regions with high R&D intensity are better able to prioritise. Lower quality of institutions is associated with better prioritising, i.e. focus on selected priorities, possibly indicating the stronger incentives of less advanced Member States/regions to comply with the S3 approach fully.

52% of the S3 selected priorities fit well to the regional endogenous capacities and aim for a reasonable degree of diversification. Stronger institutional capacities help achieve an appropriate degree of relatedness and keep ambition under control. Lower institutional capacities are instead associated with too related strategies, i.e. too close to the existing capabilities and strengths and with limited potential for diversification and creation of new engines of innovation-based growth.

Excessive ambition is behind the overly unrelated strategies. These S3 tend to be more frequent when Member States/regions are poorly diversified (hence, do not have many options in terms of areas of strength) and when they do not invest strongly in R&D (i.e., their innovation efforts and capabilities are limited). **In less developed Member States/regions, more prudence** (i.e., a strategy of more related diversification) is therefore advisable to avoid channelling resources into new “cathedrals in the desert” and pursue a more path-dependent and gradual transformation process.

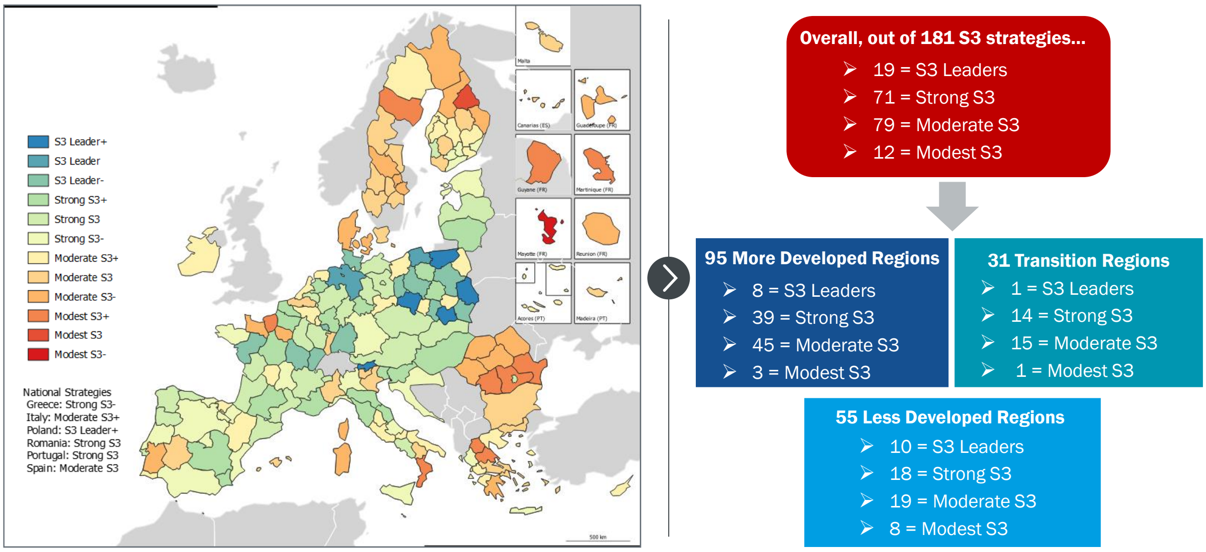
The S3 Scoreboard – assessing the quality of strategies and their implementation prospects

The S3 Scoreboard plays a unique role in the scoreboard landscape and even more in the context of S3 policies. By providing a comparative assessment of all smart specialisation strategies in EU Member States/regions and focusing thereby on central aspects of the S3 approach the S3 Scoreboard **allows examining how the European Member States/regions have followed the ex-ante conditionalities for the Cohesion Policy period 2014-2020**. However, the S3 Scoreboard does not allow to draw conclusions regarding the effectiveness and the impact of the implementation of the strategies.

The S3 Scoreboard 2021 was developed in the predecessor study by Prognos and CSIL as an assessment tool for S3. However, this previous version of the Scoreboard assessed the 185 S3 by Cohesion group. By developing an integrated methodology, a single comparative map for the S3 Scoreboard that includes all the S3 of the respective Member States and regions is provided. At the heart of the refinement of the S3 Scoreboard is the introduction of **three different context criteria** (Maturity of the innovation ecosystem, Intensity of Cohesion Funding, Quality of Government) and the inclusion of the other findings of this study. This concerns especially the findings regarding the **appropriate S3 bandwidth and relatedness**. These updates account for both different levels of development among the Member States/regions and contextual factors that can potentially exert an influence on the S3.

A rather **heterogenous performance of Member States/regions in the S3 Scoreboard** emerges and a clear regional pattern can hardly be detected. Overall, similar to findings in the predecessor Study on Prioritisation in Smart Specialisation Strategies in the EU, we confirm also in the updated S3 Scoreboard that Member States/regions with low innovation capacities and low institutional capacities perform relatively well. These Member States/regions seem to have applied the suggested approach as outlined in the ex-ante conditionality 1.1 in a very comprehensive manner. On the contrary, many regions that usually perform well in terms of their innovative capacities and the quality of their government, do not match this performance in the S3 Scoreboard, formerly called the ’Nordic Paradox’ as it applied to many Scandinavian regions. This is particularly true for the process criteria in the S3 Scoreboard, namely the (reported) “continuity of the EDP” and “S3 selection criteria in calls for proposal” as well as the outcome criteria “share of matched budget”. A possible interpretation for this finding is that these regions have a strong tradition and experience in using their own regional innovation funds for pursuing their smart specialisation strategy.

Figure 1 (ex.sum): The updated S3 Scoreboard



Source: Prognos / CSIL (2022). n = 181 regions. Note: When a region is covered by both a national strategy and a sub-national strategy, the coloured area of the sub-national region refers to the sub-national strategy. The information for the national strategies is provided by the figures on the left. These Member States are Italy, Greece, Spain, Poland, and Portugal. The United Kingdom is not included in the updated S3 Scoreboard

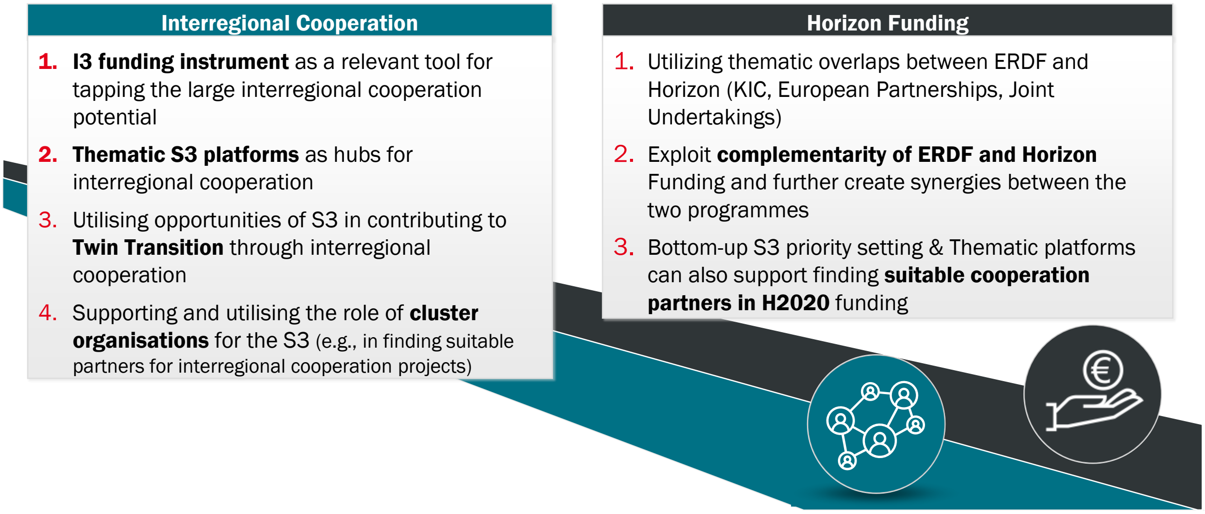
The **S3 Scoreboard is expected to play an important role in the future** of regional innovation policies in the EU. Three different dimensions for improvement and new application of the Scoreboard emerge. These include the exploration of indicators' validity to improve the quality of the Scoreboard, standardizing concepts to deal with subjective data, and the application of the S3 Scoreboard to support continuous S3 monitoring.

Outlook

Several findings have emerged in this study that further refine and deepen the understanding of S3. Based on these findings several **recommendations** are derived that provide guidelines for the further development of the S3 concept. As mentioned before, the findings which are based on the priority areas for the 2014-2020 funding period are also relevant for the 2021-2027 period since most priority areas are not expected to change to a greater extent. Moreover, this study proves that the concept of the S3 has a profound potential to contributing to other key Commission objectives.

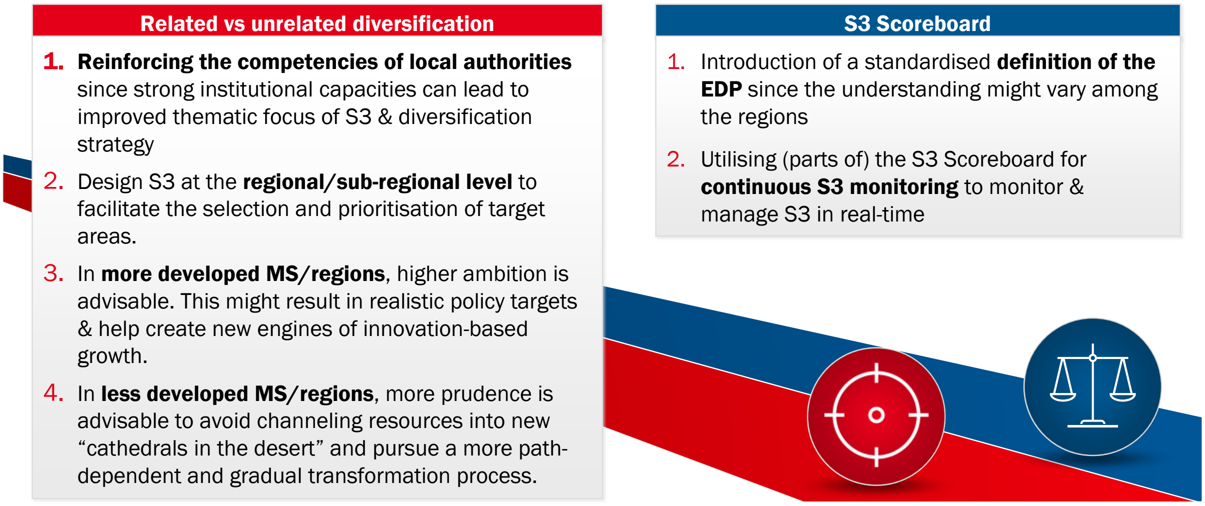
The following **recommendations** are outlined:

Figure 2 (ex.sum): Recommendations on interregional cooperation & exploiting synergies with Horizon Funding



Source: Prognos/CSIL (2022).

Figure 3 (ex.sum): Recommendations on diversification and the S3 Scoreboard



Source: Prognos/CSIL (2022).

ZUSAMMENFASSUNG

Hintergrund und Zielsetzung

Diese Zusammenfassung bezieht sich auf die **Analyse von Schlüsselparametern der Smart Specialisation Strategies (S3)**, die im Jahr 2022 von einem Team unter der Leitung der Prognos AG und Experten des Centre for Industrial Studies (CSIL) durchgeführt wurde.

Die Studie baut auf dem Wissen und den Daten auf, die in der Vorgängerstudie von Prognos und CSIL zur Priorisierung in Smart Specialisation Strategies in der EU erarbeitet wurden. Dadurch werden die Analysen und das Verständnis für intelligente Spezialisierungsstrategien in der EU weiter verfeinert und vertieft. Die folgenden fünf Kernfragen werden in dieser Studie behandelt:

1. **Interregionales Kooperationspotenzial**: Wie groß ist das Potenzial für interregionale Zusammenarbeit in Bezug auf die von den Mitgliedstaaten und Regionen gewählten S3-Strategien und Prioritäten und in welchen Bereichen?
2. **Grüne und digitale Transformation**: Wie tragen die S3-Strategien zu den zentralen Zielen der Kommission bei, insbesondere zur "Twin Transition" (grüner und digitaler Übergang)? Welche Möglichkeiten bietet S3, um den Green Deal in ländlichen, weniger entwickelten und peripheren Regionen zu unterstützen?
3. **Verbindungen zur Forschungsförderung der Kommission**: Welche Verbindung besteht zwischen den Prioritäten der S3 und den Projekten von Horizon 2020? Was sind mögliche Komplementaritäten mit den Schlüsselinstrumenten von Horizon Europe?
4. **Verwandte vs. nicht verwandte Diversifizierung**: Was bestimmt eine "gute Bandbreite" von S3-Strategien und unter welchen Bedingungen ist eine Strategie der verwandten oder nicht verwandten Diversifizierung eine "gute" Option für ein Mitgliedsland/eine Region?
5. **S3-Scoreboard**: Was ist für eine integrierte Methodik erforderlich, die zu einer einzigen vergleichenden Karte für alle Regionen des S3-Scoreboards führt?

Zentrale Ergebnisse

Die Analyse dieser Studie baut auf den 185 S3 der verschiedenen EU-Mitgliedstaaten/Regionen für die Förderperiode 2014-2020 auf, für die in der Vorgängerstudie "Prioritisation in Smart Specialisation Strategies in the EU" von Prognos und CSIL eine umfassende Datenbasis geschaffen wurde. Obwohl diese Bewertung auf Daten für den Zeitraum 2014-2020 basiert, sind die Ergebnisse auch für die Förderperiode 2021-2027 relevant, da sich die Prioritätensetzung in den Regionen insgesamt nicht wesentlich verändert hat.

Potenzial von S3 für die interregionale Zusammenarbeit

Die 185 Smart-Specialisation-Strategien und die entsprechenden Prioritätsfelder der Förderperiode 2014-2020 bieten ein erhebliches Potenzial für interregionale Zusammenarbeit. Dieses Potenzial wird in diesem Bericht aus verschiedenen Perspektiven bewertet. Erstens lassen sich auf der Grundlage der verschiedenen zugrundeliegenden Wirtschaftssektoren der Prioritätsfelder eine Vielzahl von Verbindungen zu den 14 industriellen Ökosystemen der EU herstellen. Die größte Übereinstimmung zwischen den Industriellen Ökosystemen und den S3 Prioritätsfeldern findet sich in den Industriellen Ökosystemen "Digital", "Energieintensive Industrien" und "Kultur- und Kreativwirtschaft", gefolgt von "Agrar- und Ernährungswirtschaft" und "Gesundheit" - d.h. hier stimmen strategische Ausrichtung und Priorisierung überein. Es ist jedoch bemerkenswert, dass die Gesamtunterschiede zwischen den industriellen Ökosystemen eher gering sind, was durch die allgemeine Breite der Klassifizierung der industriellen Ökosysteme erklärt werden kann. Insgesamt kann der Schluss gezogen werden, dass die S3-Prioritäten den verschiedenen industriellen Ökosystemen zutiefst entsprechen und dass die Finanzierungsaktivitäten der Mitgliedstaaten/Regionen in ihren S3 auch zu allen 14 industriellen Ökosystemen der EU beitragen.

Außerdem entsprechen die von den Mitgliedstaaten/Regionen in den 185 S3 behandelten Prioritäten häufig **komplementären Wissensbeständen**. Es wurde eine Datenbank eingerichtet, die über komplementäres Wissen in den Prioritätsfeldern informiert (auf der Grundlage von Patentdaten). Zusammen mit Informationen über die Ähnlichkeit zwischen den jeweiligen Prioritätsfeldern und bestehenden Kooperationsverknüpfungen (auf der Basis von Patenten) zwischen den Regionen können detaillierte Empfehlungen für die interregionale Zusammenarbeit für eine jeweilige Region abgeleitet werden. Diese Datenbank dient als Ausgangspunkt für die Identifizierung relevanter Regionen für interregionale Kooperationsprojekte, z. B. im Rahmen der Interregionalen Investitionsinitiative (I3) der GD REGIO.

Auf der Grundlage der Analyse des komplementären Wissens in den Prioritätsfeldern wird festgestellt, dass das größte Potenzial für eine Zusammenarbeit in erster Linie bei den Prioritätsfeldern zu finden ist, die dasselbe übergreifende Thema behandeln. Dies ist nicht überraschend, da einige der übergreifenden Themen als Querschnittsthemen angesehen werden können. Die detaillierte Analyse des interregionalen Kooperationspotenzials auf der Basis von komplementärem Wissen zeigt darüber hinaus, dass je nach Ähnlichkeitsgrad der Prioritätsfelder und der Anzahl bestehender Kooperationsverknüpfungen unterschiedlich hohe Kooperationspotenziale bestehen. Da für viele Regionen in unseren Daten keine oder nur eine geringe Anzahl bestehender Kooperationsbeziehungen zu finden ist, kann der Schluss gezogen werden, dass es noch **große Potenziale für die interregionale Zusammenarbeit im Rahmen von S3 über europäische Regionen hinweg gibt**. Insgesamt deuten die Ergebnisse darauf hin, dass die interregionale Zusammenarbeit weiter gefördert und gestärkt werden sollte.

Chancen im Zusammenhang mit der grünen und digitalen Transformation

Insgesamt weisen die Prioritätsbereiche der 185 S3 für den Zeitraum 2014-2020 **erhebliche Verbindungen zu Themen des Twin Transition auf**. Auf allgemeiner Ebene haben mehr als 700 von 1018 (69 %) Prioritätsbereichen eine Verbindung zu Themen der grünen und digitalen Transformation. Diese Bezüge variieren in ihrer Qualität, da einige Prioritätsbereiche ein bestimmtes Thema des Twin Transition vollständig behandeln können, während andere nur bestimmte Aspekte eines bestimmten Themas ansprechen. Generell weisen **mehr Prioritäten einen (starken) Bezug zu Themen der grünen Transformation auf**. Die größte Verbindung zwischen den S3-Prioritäten und Themen des Twin Transition findet sich in eher allgemeinen übergreifenden Bereichen wie IKT, Bioökonomie oder erneuerbare Energien. Spezifische Themen wie "Blockchain", "Super & Quantum Computing" oder "Clean Tech" sind Unterthemen, die von den S3 Prioritätsfelder aufgegriffen werden. Darüber hinaus werden einige Themen wie "IKT" oft entweder speziell in den Prioritätsfelder behandelt oder nur in der Beschreibung der Prioritätsfelder erwähnt. So konzentrieren sich einige Regionen in ihren Prioritätsfeldern auf IKT (z. B. hat Extremadura ein Prioritätsfelder mit der Bezeichnung "IKT"), während in vielen anderen Prioritätsfeldern nur Begriffe im Zusammenhang mit IKT erwähnt werden (z. B. erwähnt das Prioritätsfelder "Energie" der nationalen portugiesischen Strategie "IKT" in seiner Beschreibung).

In der Studie wurden auch EFRE-Projekte im Rahmen des Thematischen Ziels 1 bewertet, die mit den 185 S3 und ihren Prioritätsfeldern verknüpft sind. **Die im Zeitraum 2014-2020**

durchgeführten EFRE-F&I-Projekte trugen erheblich zur Twin Transition bei, da rund 35.160 der 49.750 Projekte (71 %), die in der Vorgängerstudie mit den Prioritätsfeldern verknüpft wurden, im Allgemeinen mit Themen des grünen und digitalen Übergangs verbunden sind. Dementsprechend können rund 14,9 Milliarden Euro (75 %) des Projektbudgets, das in die Prioritätsfelder geflossen ist, generell mit Themen des Twin Transition in Verbindung gebracht werden. Bei den Prioritätsfeldern, die eine hohe Relevanz für die Themen der grünen und digitalen Transformation aufweisen, können 17.860 der 49.750 Projekte (36 %) mit solchen Prioritätsfeldern in Verbindung gebracht werden. Es können mehr Projekte mit Prioritätsfeldern mit hoher Relevanz für die grüne Transformation in Verbindung gebracht werden als für den digitalen Wandel.

Die **regionalen Unterschiede in Bezug auf den Beitrag von S3 zur grünen und digitalen Transformation sind insgesamt eher gering**. Die Relevanz der Verknüpfungen zwischen den S3-Prioritäten und den Themen des "Twin Transition" variiert nur geringfügig zwischen den verschiedenen Regionen. Dennoch wurden einige regionale Unterschiede bei bestimmten Themen (z. B. "Bioökonomie" oder "Faires, gesundes und umweltfreundliches Lebensmittelsystem") festgestellt. Was die Projekte in Verbindung mit vorrangigen Bereichen in den EU13-Mitgliedstaaten/Regionen betrifft, so sind im Durchschnitt mehr Projekte und Budgets mit vorrangigen Bereichen verbunden, die für die grüne Transformation relevant sind. In den EU15-Mitgliedstaaten/Regionen wurden mehr Projekte und Budgets mit Prioritäten verknüpft, die für die digitale Transformation von großer Bedeutung sind.

Korrespondenz zwischen S3 und Horizon-Förderung

Die Analyse zwischen S3- und Horizont-Förderung zeigt ein **hohes Maß an thematischer Übereinstimmung, sowohl bei der Betrachtung der Übereinstimmung zwischen S3- und Horizont-2020-Projekten als auch bei der potenziellen Übereinstimmung mit den zentralen Förderbereichen von Horizont Europa**.

Insgesamt lassen sich 64% der analysierten H2020-Projekte mit Prioritätsfeldern der jeweiligen S3 verbinden. Der Anteil der Projekte, die mit den Prioritätsfeldern in Verbindung gebracht werden können, ist höher als der Anteil des damit verbundenen Budgets. Eine detailliertere Analyse des Anteils der H2020-Projekte, die mit den S3 Prioritätsfeldern verknüpft sind, zeigt, dass generell etwas mehr H2020-Projekte in den EU13-Mitgliedstaaten/Regionen (66 %) als in den EU15-Mitgliedstaaten/Regionen (64 %) verknüpft sind. Aus einer eher regionalen Perspektive zeigen sich einige Unterschiede bei den Anteilen der verbundenen Projekte und Budgets. Westeuropäische Regionen (z. B. Deutschland, Frankreich) haben tendenziell einen höheren Anteil an Projekten, die mit den jeweiligen Prioritätsfeldern verbunden sind.

Die **regionale Verteilung der durch den EFRE und H2020 geförderten Organisationen ist relativ heterogen**. Insgesamt haben mindestens 3.417 Organisationen (7 % der 51.674 in der EFRE-Projektdatenbank identifizierten Organisationen) im Zeitraum 2014-2020 auch Projekte durchgeführt, die von Horizont 2020 finanziert wurden. Der Anteil der Organisationen, die sowohl aus dem EFRE als auch aus Horizont 2020 finanziert wurden, ist mit rund 80 % in den EU-15-Mitgliedstaaten/Regionen deutlich höher als der Anteil der Organisationen in den EU-13-Mitgliedstaaten/Regionen.

Fast alle Prioritätsfelder (924 von 1018) können mit den Förderschwerpunkten von Horizont Europa in Verbindung gebracht werden. Das bedeutet, dass Themen, die in den Horizon Europe-Förderschwerpunkten behandelt werden, auch in vielen S3-Prioritäten zu finden sind, was das grundlegende Potenzial für die Schaffung von Synergien zwischen diesen beiden Bereichen unterstreicht. Insgesamt deuten die Ergebnisse auf ein großes Potenzial für Synergien zwischen S3 und den Schlüsselinstrumenten von Horizon Europe wie Partnerschaften, gemeinsame Unternehmen, Missionen und KICs hin.

Verwandte vs. nicht verwandte Diversifizierung

Trotz umfangreicher akademischer Literatur und der Verfügbarkeit von Leitlinien der Europäischen Kommission für die Gestaltung von S3 **gibt es keine Theorie darüber, was eine gute S3 für verschiedene Arten von Gebieten ausmacht**. Insbesondere gibt es keine Hinweise darauf, welcher Grad an Selektivität für verschiedene Arten von Mitgliedstaaten/Regionen ratsam ist, oder ob der thematische Schwerpunkt der S3 für eine bestimmte Art von MS/Region auf eine nicht zusammenhängende Diversifizierung abzielen kann oder besser bei einer zusammenhängenden Diversifizierung bleiben sollte. Einige Erkenntnisse aus früheren Untersuchungen haben gezeigt, dass die in den meisten EU-Mitgliedstaaten/Regionen gewählten Prioritäten nicht mit ihren Spezialisierungsbereichen zusammenhängen (Deegan et al., 2022; Di Cataldo et al., 2020; Marrocu et al., 2022; Prognos und CSIL, 2021). In keiner Studie wurde jedoch erörtert, ob der Grad der Verwandtschaft dieser Strategien den Merkmalen des Mitgliedstaats/der Region angemessen war und ob mehr oder weniger Ehrgeiz eine geeignetere Wahl gewesen wäre.

Die vorliegende Analyse leistet einen Beitrag zur Literatur, indem sie eine "**Theorie für eine gute S3**" entwickelt, und zwar unter besonderer Berücksichtigung des thematischen Schwerpunkts (als "S3-Bandbreite" bezeichnet) und des verwandten bzw. nicht verwandten Diversifizierungsziels. Nach der Entwicklung eines theoretischen Rahmens, der die am besten geeigneten Niveaus von Bandbreite und Verbundenheit spezifiziert, die für verschiedene Arten von Mitgliedstaaten/Regionen ratsam wären, wurde das tatsächliche Niveau der S3-Bandbreite und -Verbundenheit analysiert, das von den bis 2020 veröffentlichten S3 gewählt wurde. Durch den Vergleich des von der Theorie erwarteten Grads der Bandbreite und der Diversifizierungsansätze mit den tatsächlich von den S3 gewählten Ansätzen lässt sich feststellen, welche S3 gute Entscheidungen getroffen haben, d. h. mit den Postulaten der Theorie übereinstimmen, oder von den theoretischen Erwartungen abgewichen sind und auf welche Weise.

Wir stellen fest, dass **61 % der 162 untersuchten S3 einen angemessenen Grad an thematischer Fokussierung erreicht haben**. Im Allgemeinen sind kleine Mitgliedstaaten/Regionen mit hoher FuE-Intensität besser in der Lage, Prioritäten zu setzen. Eine geringere Qualität der Einrichtungen geht mit einer besseren Prioritätensetzung, d. h. einer Konzentration auf ausgewählte Prioritäten, einher, was möglicherweise darauf hindeutet, dass weniger fortgeschrittene Mitgliedstaaten/Regionen stärkere Anreize haben, das S3-Konzept vollständig zu befolgen.

52 % der gewählten Prioritäten passen gut zu den regionalen endogenen Kapazitäten passen und streben einen angemessenen Grad an Diversifizierung an. Stärkere institutionelle Kapazitäten tragen dazu bei, einen angemessenen Grad an Verbundenheit zu erreichen und die Ambitionen unter Kontrolle zu halten. Geringere institutionelle Kapazitäten werden dagegen mit zu eng verwandten Strategien in Verbindung gebracht, d. h. mit einem zu engen Bezug zu den vorhandenen Fähigkeiten und Stärken und mit einem begrenzten Potenzial für die Diversifizierung und die Schaffung neuer Motoren für innovationsbasiertes Wachstum.

Übertriebener Ehrgeiz steckt hinter den zu unverwandten Strategien. Diese S3 treten tendenziell häufiger auf, wenn die Mitgliedstaaten/Regionen wenig diversifiziert sind (d. h. nicht viele Optionen in Bezug auf ihre Stärken haben) und wenn sie nicht stark in FuE investieren (d. h. ihre Innovationsanstrengungen und -fähigkeiten begrenzt sind). In weniger entwickelten Mitgliedstaaten/Regionen ist daher mehr Umsicht (d. h. eine Strategie der stärkeren Diversifizierung) ratsam, um zu vermeiden, dass Ressourcen in neue "Kathedralen in der Wüste" fließen, und einen eher pfadabhängigen und schrittweisen Transformationsprozess zu verfolgen.

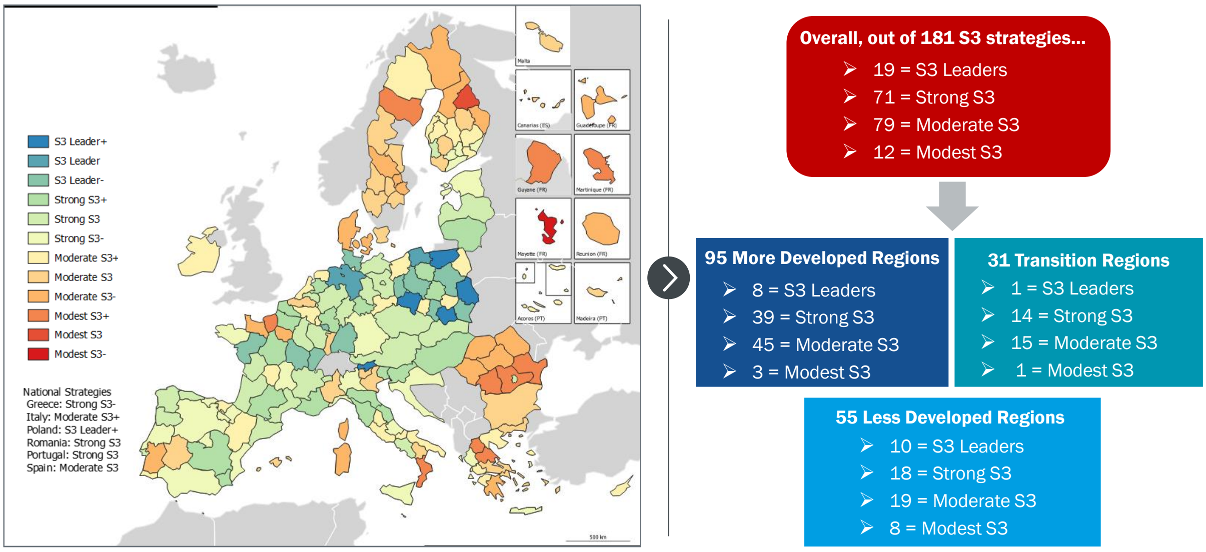
Das S3 Scoreboard - Bewertung der Qualität von Strategien und ihrer Umsetzungsaussichten

Das **S3 Scorebcoard spielt eine einzigartige Rolle in der Landschaft der Scoreboards und noch mehr im Kontext der S3-Politik**. Durch die vergleichende Bewertung aller Strategien zur intelligenten Spezialisierung in den EU-Mitgliedstaaten/Regionen und die Konzentration auf zentrale Aspekte des S3 Ansatzes ermöglicht das S3 Scoreboard zu untersuchen, wie die europäischen Mitgliedstaaten/Regionen die Ex-ante-Konditionalitäten für den kohäsionspolitischen Zeitraum 2014-2020 erfüllt haben. Das S3 Scoreboard erlaubt es jedoch nicht, Schlussfolgerungen hinsichtlich der Wirksamkeit und der Auswirkungen der Umsetzung der Strategien zu ziehen.

Das S3 Scoreboard 2021 wurde in der Vorgängerstudie von Prognos und CSIL als Bewertungsinstrument für S3 entwickelt. Diese Vorgängerversion des Scoreboards bewertete jedoch die 185 S3 der Kohäsionsgruppe. Durch die Entwicklung einer integrierten Methodik wird eine einzige vergleichende Karte für das S3 Scoreboard erstellt, die alle S3 der jeweiligen Mitgliedstaaten und Regionen umfasst. Im Mittelpunkt der Verfeinerung des S3 Scoreboards stehen die Einführung von **drei verschiedenen Kontextkriterien** (Reife des Innovationsökosystems, Intensität der Kohäsionsfinanzierung, Qualität der Governance) und die Einbeziehung der anderen Ergebnisse dieser Studie. Dies betrifft insbesondere die Ergebnisse hinsichtlich der angemessenen S3-Bandbreite und der Relatedness. Diese Aktualisierungen berücksichtigen sowohl unterschiedliche Entwicklungsniveaus der Mitgliedstaaten/Regionen als auch kontextuelle Faktoren, die potenziell einen Einfluss auf die S3 ausüben können.

Es zeigt sich **eine recht heterogene Leistung der Mitgliedstaaten/Regionen im S3 Scoreboard**, und ein klares regionales Muster ist kaum zu erkennen. Ähnlich wie in der Vorgängerstudie über die Prioritätensetzung bei Strategien der intelligenten Spezialisierung in der EU bestätigen wir auch im aktualisierten S3 Scoreboard, dass Mitgliedstaaten/Regionen mit geringen Innovationskapazitäten und geringen institutionellen Kapazitäten relativ gut abschneiden. Diese Mitgliedstaaten/Regionen scheinen den vorgeschlagenen Ansatz, wie er in der Ex-ante-Konditionalität 1.1 dargelegt ist, sehr umfassend umgesetzt zu haben. Im Gegensatz dazu schneiden viele Regionen, die normalerweise in Bezug auf ihre Innovationskapazitäten und die Qualität ihrer Regierung gut abschneiden, im S3 Scoreboard nicht so gut ab, was früher als "nordisches Paradoxon" bezeichnet wurde, da es auf viele skandinavische Regionen zutraf. Dies gilt insbesondere für die Prozesskriterien im S3 Scoreboard, nämlich die (angegebene) "Kontinuität des EDP" und die "S3-Auswahlkriterien bei Projektauswahl", sowie für das Ergebniskriterium "Anteil des gematchten Budgets". Eine mögliche Interpretation dieses Ergebnisses ist, dass diese Regionen eine starke Tradition und Erfahrung in der Nutzung ihrer eigenen regionalen Innovationsfonds zur Verfolgung ihrer Strategie der intelligenten Spezialisierung haben.

Karte 1 (Zusammenfassung): Aktualisiertes S3 Scoreboard



Quelle: Prognos / CSIL (2022). n = 181 Regionen. Anmerkung: Wenn eine Region sowohl von einer nationalen Strategie als auch von einer subnationalen Strategie abgedeckt wird, bezieht sich die farbige Fläche der subnationalen Region auf die subnationale Strategie. Die Informationen zu den nationalen Strategien sind im Text auf der linken Seite zu finden. Bei diesen Mitgliedstaaten handelt es sich um Italien, Griechenland, Spanien, Polen und Portugal. Das Vereinigte Königreich ist in dem aktualisierten S3 Scoreboard nicht enthalten.

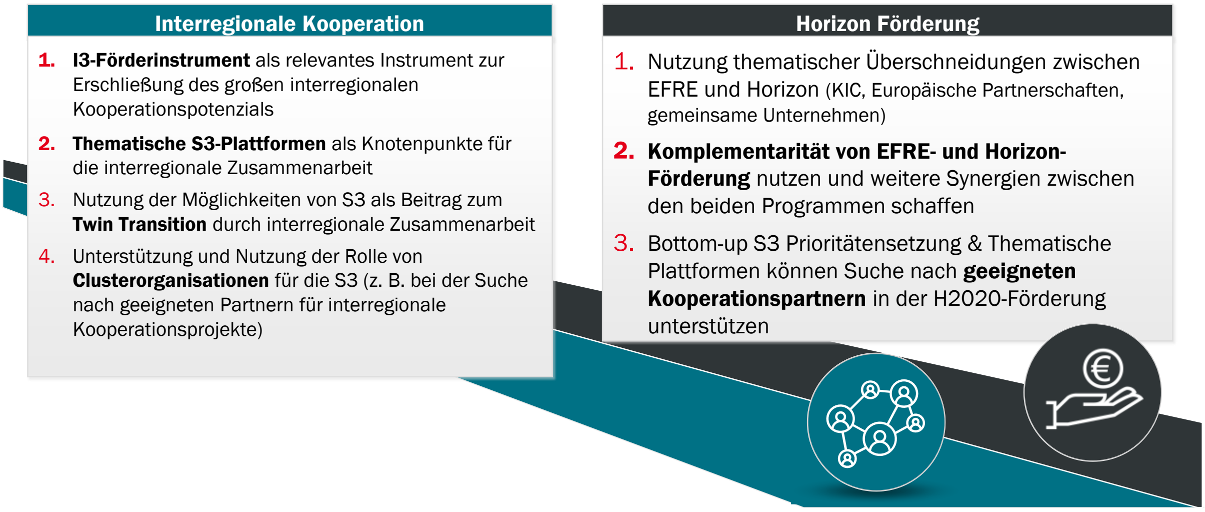
Es wird erwartet, dass das **S3 Scoreboard eine wichtige Rolle für die Zukunft der regionalen Innovationspolitik in der EU spielen wird**. Es zeichnen sich drei verschiedene Dimensionen für Verbesserungen und neue Anwendungen des Scoreboards ab. Dazu gehören die Untersuchung der Validität der Indikatoren zur Verbesserung der Qualität des Scoreboards, die Standardisierung von Konzepten für den Umgang mit subjektiven Daten und die Anwendung des S3 Scoreboards zur Unterstützung eines kontinuierlichen S3-Monitorings.

Ausblick

In dieser Studie wurden mehrere **Erkenntnisse** gewonnen, die das Verständnis von S3 weiter verfeinern und vertiefen. Aus diesen Erkenntnissen werden mehrere Empfehlungen abgeleitet, die Leitlinien für die weitere Entwicklung des S3-Konzepts bieten. Wie bereits erwähnt, sind die Erkenntnisse, die sich auf die Schwerpunktbereiche der Förderperiode 2014-2020 beziehen, auch für die Periode 2021-2027 relevant, da sich die meisten Schwerpunktbereiche voraussichtlich nicht in größerem Umfang ändern werden. Darüber hinaus beweist diese Studie, dass das Konzept der S3 ein tiefgreifendes Potenzial hat, um zu anderen wichtigen Zielen der Kommission beizutragen.

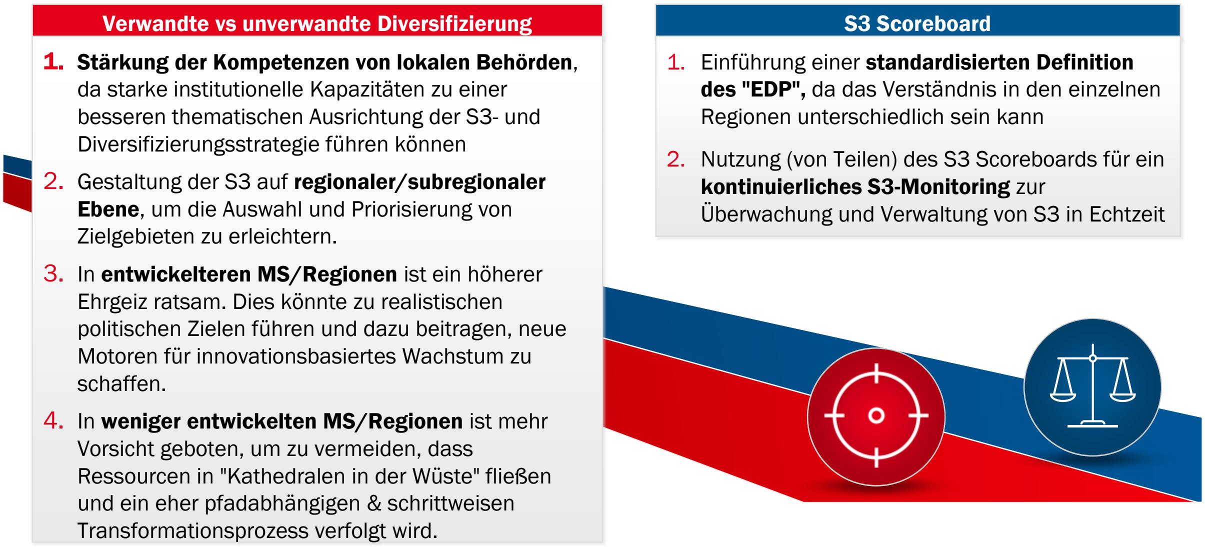
Im Folgenden werden **Empfehlungen** ausgesprochen:

Abbildung 1 (Zusammenfassung): Empfehlungen zur interregionalen Zusammenarbeit und zur Nutzung von Synergien mit der Horizont-Finanzierung



Quelle: Prognos/CSIL (2022).

Abbildung 2: Empfehlungen zur Diversifizierung und dem S3 Scoreboard



Quelle: Prognos/CSIL (2022).

SYNTHESE

Contexte et objectifs

Ce résumé concerne **l'analyse des paramètres clés des stratégies de spécialisation intelligente (S3)**, entreprise en 2022 par une équipe dirigée par Prognos AG et des experts du Centre d'études industrielles (CSIL). L'étude s'appuie sur l'étude précédente sur la "hiérarchisation des stratégies de spécialisation intelligente dans l'UE" par Prognos et le CSIL. Elle permet d'affiner et d'approfondir les analyses et la compréhension des stratégies de spécialisation intelligente dans l'UE. Les cinq questions centrales suivantes sont abordées dans cette étude:

1. **Potentiel de coopération interrégionale**: Quel est le potentiel de coopération interrégionale concernant les stratégies et les priorités de la S3 choisies par les États membres et les régions et dans quels domaines?
2. **Transition écologique et numérique**: Comment les stratégies S3 contribuent-elles aux priorités clés de la Commission, en particulier la double transition (verte et numérique) ? Quelles sont les opportunités de la S3 pour contribuer au Green Deal dans les régions rurales, moins développées et périphériques?
3. **Liens avec le financement communautaire de la recherche**: Quel est le lien entre les priorités de la S3 et les projets Horizon 2020? Quelles sont les complémentarités possibles avec les instruments clés d'Horizon Europe?
4. **Diversification connexe ou non connexe**: Qu'est-ce qui détermine une "bonne largeur de bande" des stratégies S3 et dans quelles conditions une stratégie de diversification liée ou non liée est-elle une "bonne" option pour un EM/une région?
5. **Tableau de bord S3:** Que faut-il pour une méthodologie intégrée menant à une carte comparative unique du tableau de bord S3?

Principales conclusions

L'analyse de cette étude s'appuie sur les 185 stratégies S3 des différents États membres/régions de l'UE pour la période de financement 2014-2020, pour lesquelles une base de données complète a été établie dans l'étude précédente intitulée Study on Prioritisation in Smart Specialisation Strategies in the EU par Prognos et CSIL. Bien que cette évaluation soit basée sur les données de la période 2014-2020, les résultats sont également pertinents pour la période de financement 2021-2027 puisque, dans l'ensemble, la définition des priorités dans les régions n'a pas considérablement changé.

Potential of S3 for interregional cooperation

Les 185 stratégies **S3 et les domaines prioritaires correspondants de la période de financement 2014-2020 offrent un potentiel important pour la coopération interrégionale**. Ce potentiel est évalué dans le présent rapport sous différents angles. Premièrement, sur la base des différents secteurs économiques sous-jacents des domaines prioritaires, une multitude de connexions avec les 14 écosystèmes industriels de l'UE peuvent être établies. La plus grande correspondance entre les écosystèmes industriels et les domaines prioritaires de la S3 se trouve dans les écosystèmes industriels "numérique", "industries à forte intensité énergétique" et "industries culturelles et créatives", suivis par les écosystèmes "agroalimentaire" et "santé" - en d'autres termes, les orientations stratégiques et les priorités se correspondent. Il convient toutefois de noter que les différences globales entre les écosystèmes industriels sont plutôt faibles, ce qui peut s'expliquer par l'étendue générale de la classification des écosystèmes industriels. Globalement, on peut conclure que les priorités de la S3 correspondent profondément aux différents écosystèmes industriels et que les activités de financement des États membres/régions dans leurs stratégies S3 contribuent également à l'ensemble des 14 écosystèmes industriels de l'UE.

En outre, les priorités abordées par les États membres/régions dans les **185 stratégies S3 correspondent souvent à des stocks de connaissances complémentaires**. Une base de données a été créée pour fournir des informations sur les connaissances complémentaires dans les domaines prioritaires (sur la base des données relatives aux brevets). Avec les informations sur la similitude entre les domaines prioritaires respectifs et les liens de coopération existants (basés sur les brevets) entre les régions, des recommandations détaillées pour la coopération interrégionale pour une région respective peuvent être dérivées. Cette base de données sert de point de départ pour identifier les régions pertinentes pour les projets de collaboration interrégionale, par exemple dans le cadre du défi I3 de la DG REGIO.

L'analyse des connaissances complémentaires dans les domaines prioritaires montre que le plus grand potentiel de coopération se trouve avant tout parmi les priorités qui traitent du même thème principal. Cela n'est pas surprenant, car certains des thèmes primordiaux peuvent être considérés comme transversaux. En outre, l'analyse détaillée du potentiel de collaboration interrégionale sur la base de connaissances complémentaires montre que le potentiel de coopération varie en fonction du degré de similitude entre les domaines prioritaires et du nombre de liens de coopération existants. Étant donné que pour de nombreuses régions, nos données ne font état d'aucun lien de coopération existant, ou seulement d'un faible nombre, on peut en conclure qu'il existe encore de **vastes potentiels de coopération interrégionale dans le contexte des stratégies S3 dans les régions européennes**. Dans l'ensemble, les résultats suggèrent que la collaboration interrégionale devrait être davantage soutenue et étayée.

Opportunités liées à la transition écologique et numérique

Dans **l'ensemble, les domaines prioritaires des 185 S3 de la période 2014-2020 présentent des liens significatifs avec les thèmes de la double transition**. D'une manière générale, plus de 700 des 1018 (69%) domaines prioritaires ont un lien avec les thèmes de la transition verte et numérique. Ces références varient en qualité puisque certains domaines prioritaires peuvent aborder complètement un certain sujet de la transition jumelle alors que d'autres n'abordent que certains aspects d'un certain sujet. D'une manière générale, **davantage de priorités présentent un lien (fort) avec les thèmes de la transition écologique**. Le lien le plus important entre les priorités de la S3 et les thèmes de la transition jumelle se trouve dans des domaines généraux plutôt généraux tels que les TIC, la bioéconomie ou les énergies renouvelables. Des sujets spécifiques tels que "Blockchain", "Super & Quantum Computing" ou "Clean Tech" sont des sous-thèmes qui sont abordés par les domaines prioritaires de la S3. En outre, certains sujets comme les "TIC" sont souvent soit spécifiquement traités par les domaines prioritaires, soit simplement mentionnés dans la description des domaines prioritaires. Par exemple, certaines régions concentrent leurs domaines prioritaires sur les TIC (par exemple, l'Estrémadure a un domaine prioritaire intitulé "TIC"), tandis que dans de nombreux autres domaines prioritaires, seuls des termes liés aux TIC sont mentionnés (par exemple, le domaine prioritaire "Énergie" de la stratégie nationale portugaise mentionne les "TIC" dans sa description).

L'étude a également évalué les projets FEDER relevant de l'objectif thématique 1 qui ont été liés aux 185 S3 et à leurs domaines prioritaires. **Les projets de R&I du FEDER mis en œuvre au cours de la période 2014-2020 ont considérablement contribué à la Transition Jumelée** puisqu'environ 35 160 des 49 750 projets (71%) qui étaient liés aux domaines prioritaires de l'étude précédente sont généralement liés aux sujets de la transition verte et numérique. En conséquence, environ 14,9 milliards d'euros (75 %) du budget des projets qui ont été canalisés dans les domaines prioritaires peuvent être généralement liés à des thèmes de la double transition. En ce qui concerne les domaines prioritaires qui présentent une grande pertinence pour les thèmes de la transition écologique et numérique, 17 860 des 49 750 projets (36 %) peuvent être liés à ces domaines prioritaires. Un plus grand nombre de projets peuvent être liés à des domaines prioritaires présentant un grand intérêt pour la transition écologique que pour la transition numérique.

Les différences régionales globales dans la contribution de la S3 à la transition verte et numérique sont plutôt faibles. Il n'y a qu'une faible variation de la pertinence des liens entre les priorités de la S3 et les thèmes de la transition jumelle entre les différentes régions. Néanmoins, quelques différences régionales sur certains sujets (par exemple, "Bioéconomie" ou "Système alimentaire équitable, sain et respectueux de l'environnement") ont été détectées. En ce qui concerne les projets liés aux domaines prioritaires dans les États membres/régions de l'UE13, en moyenne, davantage de projets et de budgets sont liés aux domaines prioritaires relatifs à la transition verte. Parmi les États membres/régions de l'UE15, davantage de projets et de budgets ont été liés à des priorités très pertinentes pour la transition numérique.

Correspondance entre S3 et le financement Horizon

L'analyse entre la S3 et le financement d'Horizon démontre un degré élevé de correspondance thématique, tant en ce qui concerne la correspondance entre la S3 et les projets Horizon 2020 que la correspondance potentielle avec les domaines de financement clés d'Horizon Europe.

Globalement, **64% des projets H2020 analysés peuvent être reliés aux domaines prioritaires de la S3 respective**. La part des projets qui peuvent être connectés aux domaines prioritaires est plus élevée que la part du budget lié. Une analyse plus granulaire de la part des projets H2020 liés aux domaines prioritaires de la S3 montre qu'au niveau général, un peu plus de projets H2020 sont jumelés dans les États membres/régions de l'UE13 (66%) par rapport aux États membres/régions de l'UE15 (64%). D'un point de vue plus régional, certaines variations dans les parts de projets et de budgets liés apparaissent. Les régions d'Europe occidentale (par exemple, l'Allemagne et la France) ont tendance à avoir une part plus importante de projets liés aux domaines prioritaires respectifs.

Une **distribution régionale relativement hétérogène des organisations financées par le FEDER et H2020 est identifiée**. Dans l'ensemble, au moins 3 417 organisations (7% des 51 674 organisations identifiées dans la base de données des projets FEDER) ont également mené des projets financés par Horizon 2020 au cours de la période 2014 à 2020. La part des organisations qui ont été financées à la fois par le FEDER et par Horizon 2020 est d'environ 80 % dans les États membres/régions de l'UE15, ce qui est nettement supérieur à la part des organisations dans les États membres/régions de l'UE13.

Presque tous les domaines prioritaires (924 sur 1018) peuvent être liés aux domaines de financement clés d'Horizon Europe. Cela signifie que les sujets abordés par les domaines de financement clés d'Horizon Europe se retrouvent également dans de nombreuses priorités de la S3, ce qui souligne le potentiel fondamental de création de synergies entre les deux. Dans l'ensemble, les résultats indiquent un grand potentiel de synergies entre la S3 et les instruments clés d'Horizon Europe tels que les partenariats, les entreprises communes, les missions et les CCI.

Diversification connexe ou non connexe

Malgré une littérature académique prolifique et la disponibilité de lignes directrices de la Commission européenne sur la manière de concevoir une S3, **il n'existe aucune théorie sur ce qui constitue une bonne S3 pour différents types de territoires**. Plus précisément, aucune indication n'est donnée sur le degré de sélectivité conseillé pour différents types d'États membres/régions, ni sur la question de savoir si l'orientation thématique de la S3 pour un type particulier d'États membres/régions peut viser une diversification non liée ou doit plutôt s'en tenir à une diversification liée. Certaines recherches antérieures ont montré que les priorités sélectionnées dans la plupart des États membres/régions de l'UE n'étaient pas liées à leurs domaines de spécialisation (Deegan et al., 2022 ; Di Cataldo et al., 2020 ; Marrocu et al., 2022 ; Prognos et CSIL, 2021). Pourtant, aucune étude ne s'est penchée sur la question de savoir si le degré de parenté de ces stratégies était adapté aux caractéristiques de l'État membre/de la région, et si un choix plus ou moins ambitieux aurait été plus approprié.

Cette analyse contribue à la littérature en développant une "**théorie pour une bonne S3**", avec une référence spécifique à sa concentration thématique (appelée "largeur de bande S3") et à son objectif de diversification connexe ou non connexe. Après avoir développé un cadre théorique qui spécifie les niveaux les plus appropriés de largeur de bande et de connexité qui seraient recommandés pour différents types d'États membres/régions, nous avons analysé le niveau réel de largeur de bande et de connexité choisi par les S3 publiées jusqu'en 2020. En comparant le degré de largeur de bande et les approches de diversification attendus de la théorie avec ceux réellement adoptés dans les S3, il est possible d'identifier quelles S3 ont fait de bons choix, c'est-à-dire conformes aux postulats de la théorie, ou se sont écartées des attentes théoriques et de quelle manière.

Nous constatons que 61% des 162 S3 analysées ont atteint un niveau approprié de concentration thématique. En général, les petits États membres/régions à forte intensité de R&D sont plus à même d'établir des priorités. La qualité inférieure des institutions est associée à une meilleure définition des priorités, c'est-à-dire à une concentration sur les priorités sélectionnées, ce qui pourrait indiquer que les États membres/régions moins avancés sont davantage incités à se conformer pleinement à l'approche S3.

52% des priorités sélectionnées par la S3 correspondent bien aux capacités endogènes régionales et visent un degré raisonnable de diversification. Des capacités institutionnelles plus fortes permettent d'atteindre un degré approprié de connexité et de maîtriser les ambitions. Les capacités institutionnelles plus faibles sont au contraire associées à des stratégies trop liées, c'est-à-dire trop proches des capacités et des forces existantes et avec un potentiel limité de diversification et de création de nouveaux moteurs de croissance basés sur l'innovation.

Une ambition excessive se cache derrière les stratégies trop peu liées. Ces S3 ont tendance à être plus fréquents lorsque les États membres/régions sont peu diversifiés (ils n'ont donc pas beaucoup d'options en termes de domaines de force) et lorsqu'ils n'investissent pas fortement dans la R&D (c'est-à-dire que leurs efforts et capacités d'innovation sont limités). Dans les États membres/régions moins développés, il est donc conseillé de faire preuve de plus de prudence (c'est-à-dire d'adopter une stratégie de diversification plus connexe) afin d'éviter de canaliser les ressources vers de nouvelles "cathédrales dans le désert" et de poursuivre un processus de transformation plus dépendant de la voie suivie et plus progressif.

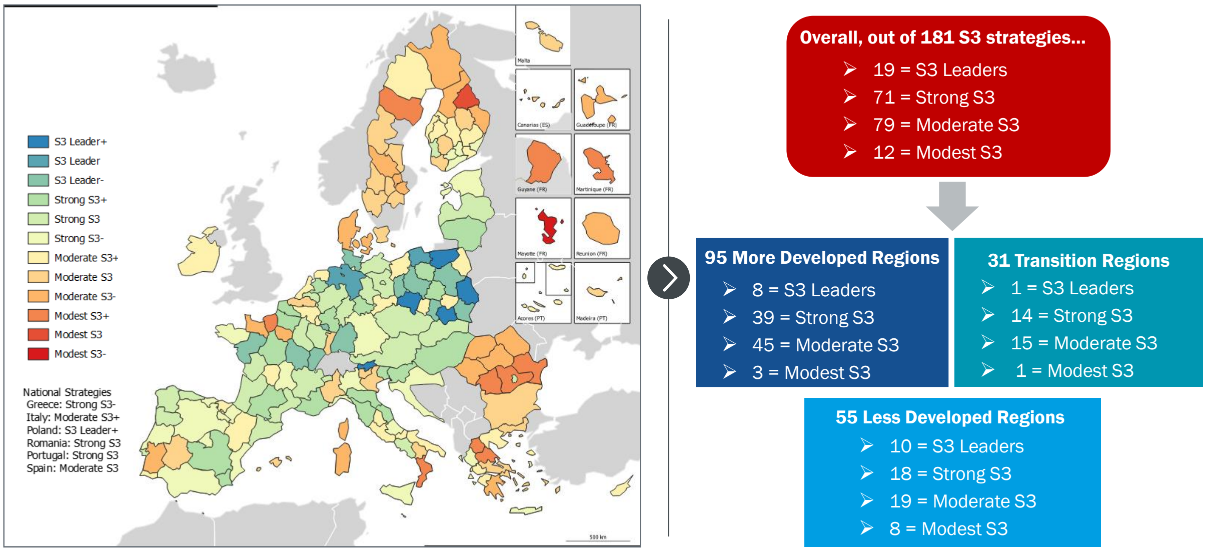
Le tableau de bord de la stratégie S3 - évaluer la qualité des stratégies et leurs perspectives de mise en œuvre

Le tableau de bord S3 joue un rôle unique dans le paysage des tableaux de bord et encore plus dans le contexte des politiques S3. En fournissant une évaluation comparative de toutes les stratégies de spécialisation intelligente dans les États membres/régions de l'UE et en se concentrant ainsi sur les aspects centraux de l'approche S3, **le tableau de bord S3 permet d'examiner comment les États membres/régions européens ont respecté les conditionnalités ex ante pour la période 2014-2020 de la politique de cohésion**.

Toutefois, le tableau de bord S3 ne permet pas de tirer des conclusions sur l'efficacité et l'impact de la mise en œuvre des stratégies.

Le tableau de bord S3 2021 a été développé dans l'étude précédente par Prognos et CSIL comme un outil d'évaluation pour la S3. Toutefois, cette version précédente du tableau de bord évaluait les 185 S3 du groupe Cohésion. Le développement d'une méthodologie intégrée permet de fournir une carte comparative unique pour le tableau de bord de la S3 qui inclut toutes les S3 des États membres et des régions respectifs. L'amélioration du tableau de bord S3 repose sur **l'introduction de trois critères contextuels différents** (maturité de l'écosystème d'innovation, intensité du financement de la cohésion, qualité du gouvernement) et sur l'inclusion des autres conclusions de cette étude. Cela concerne en particulier les résultats relatifs à la largeur de bande S3 appropriée et à la connexité. Ces mises à jour tiennent compte à la fois des différents niveaux de développement entre les États membres/régions et des facteurs contextuels qui peuvent potentiellement exercer une influence sur la S3.

Figure 4 (synthèse): Le tableau d'affichage S3 mis à jour



Source: Prognos / CSIL (2022). n = 181 régions. Note : Lorsqu'une région est couverte à la fois par une stratégie nationale et une stratégie infranationale, la zone colorée de la région infranationale fait référence à la stratégie infranationale. Les informations relatives aux stratégies nationales sont fournies par les chiffres de gauche. Ces États membres sont l'Italie, la Grèce, l'Espagne, la Pologne et le Portugal. Le Royaume-Uni n'est pas inclus dans la mise à jour du tableau de bord S3.

Les performances des États membres/régions dans le tableau de bord S3 sont plutôt hétérogènes et il est difficile de déceler un modèle régional clair. Globalement, à l'instar des résultats de l'étude précédente sur la hiérarchisation des priorités dans les stratégies de spécialisation intelligente dans l'UE, nous confirmons également dans le tableau de bord S3 mis à jour que les États membres/régions ayant de faibles capacités d'innovation et de faibles capacités institutionnelles obtiennent des résultats relativement bons. Ces États membres/régions semblent avoir appliqué l'approche suggérée, telle que décrite dans la conditionnalité ex ante 1.1, de manière très complète. Au contraire, de nombreuses régions qui obtiennent habituellement de bons résultats en termes de capacités d'innovation et de qualité de leur gouvernement n'obtiennent pas les mêmes résultats dans le tableau de bord S3, ce que l'on appelait autrefois le "paradoxe nordique", car il s'appliquait à de nombreuses régions scandinaves. Cela est particulièrement vrai pour les critères de processus du tableau de bord S3, à savoir la "continuité de la PDE" (signalée) et les "critères de sélection S3 dans les appels à propositions", ainsi que pour les critères de résultats "part du budget assorti".

Une interprétation possible de ce résultat est que ces régions ont une forte tradition et expérience dans l'utilisation de leurs propres fonds régionaux d'innovation pour poursuivre leur stratégie de spécialisation intelligente.

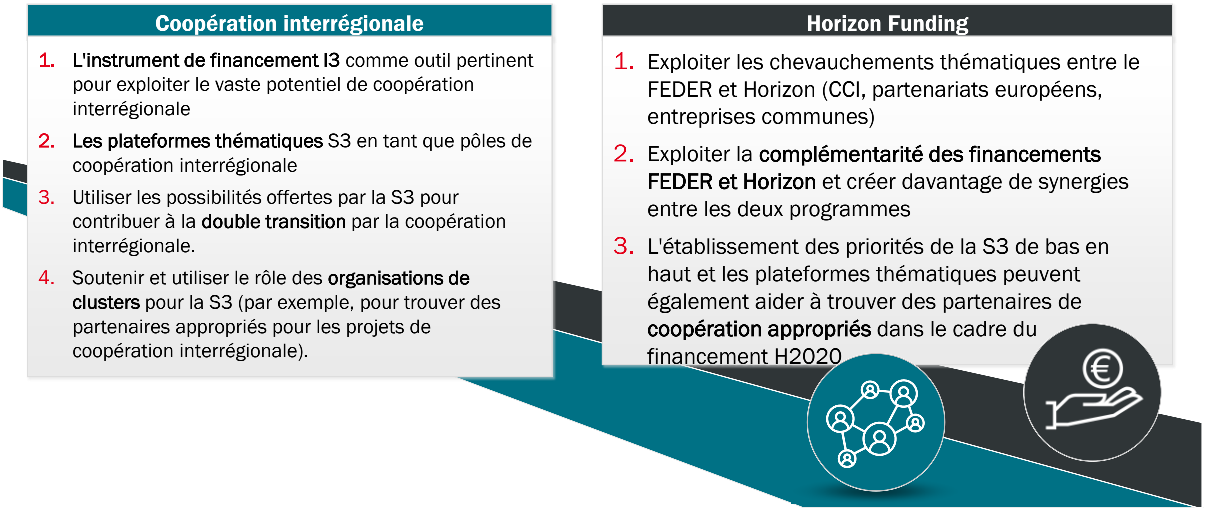
Le tableau de bord S3 est appelé à jouer un rôle important dans l'avenir des politiques régionales d'innovation dans l'UE. Trois dimensions différentes d'amélioration et de nouvelle application du tableau de bord se dégagent. Il s'agit de l'exploration de la validité des indicateurs pour améliorer la qualité du tableau de bord, de la normalisation des concepts pour traiter les données subjectives et de l'application du tableau de bord S3 pour soutenir le suivi continu de la S3.

Outlook

Cette étude a permis de dégager plusieurs conclusions qui affinent et approfondissent la compréhension de la S3. Sur la base de ces résultats, plusieurs **recommandations** ont été formulées afin de fournir des lignes directrices pour le développement futur du concept S3. Comme mentionné précédemment, les résultats basés sur les domaines prioritaires pour la période de financement 2014-2020 sont également pertinents pour la période 2021-2027, car la plupart des domaines prioritaires ne devraient pas changer dans une plus large mesure. En outre, cette étude prouve que le concept de la S3 a un profond potentiel pour contribuer à d'autres objectifs clés de la Commission.

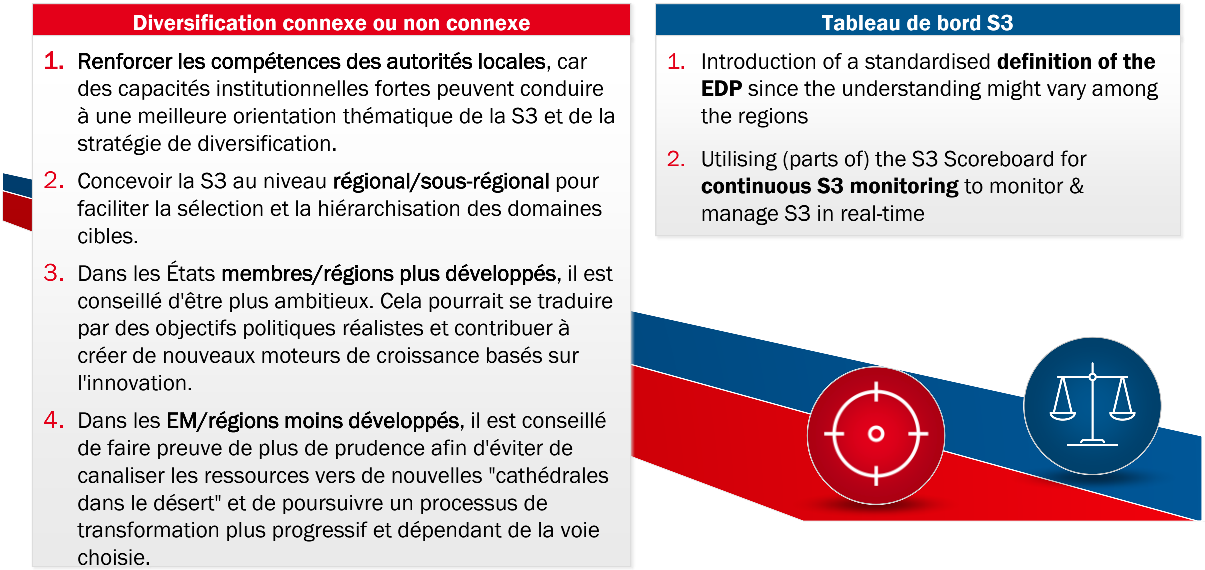
Les **recommandations** suivantes sont formulées:

Figure 5 (synthèse): Recommandations sur la coopération interrégionale et l'exploitation des synergies avec le financement Horizon



Source: Prognos/CSIL (2022).

Figure 6 (synthèse): Recommandations sur la diversification et le tableau de bord de la stratégie S3



Source: Prognos/CSIL (2022).

1. Introduction

1.1 Background and scope of the study

Smart specialisation strategies in the EU have gained increasing importance in the context of global competition, while the demands on companies and regions to be “innovative” are increasing. Only Member States/regions that succeed in creatively channelling the knowledge available worldwide and successfully transforming it, in connection with the endogenous potential of science and industry, can use the drivers of innovation for sustainable growth, employment and social cohesion. This requires strategic and coordinated support for innovation ecosystems at European, national, and regional levels. To foster a comprehensive innovation policy at a national and especially at the regional level, the EU set ex-ante conditionalities (ExAC) for the Cohesion Policy period 2014-2020. The development of a “national and regional research and innovation strategy for smart specialisation” (“S3”) constitutes such a conditionality (ExAC 1.1) and was a prerequisite for the approval of the Operational Programmes (OP) of the European Regional Development Fund (ERDF) that include investment into strengthening research, technological development, and innovation. The new ‘enabling conditions’ under the 2021-2027 regulation aim for a more consistent and continuous implementation of the S3, calling for more explicit governance of the strategy and stricter monitoring and evaluation.

In the **‘Study on prioritisation in smart specialisation strategies in the EU’** on the 2014-2020 programming period, Prognos and CSIL have assessed three core questions, namely if (1) prioritisation has been achieved in the S3, (2) to what extent the selected priorities reflect the regional profiles and (3) how S3 and the selected priorities have been implemented. This has been achieved by systematically screening and assessing all available S3 across the EU to discover the respective approaches to prioritisation, to analyse if priorities set within the strategies correspond to endogenous capacities and if these were translated into concrete projects.

The study was based on a very comprehensive set of data which was either collected directly from S3 and interviews (especially on prioritisation, EDP, etc.), other primary data sources such as projects and calls and complementary to this, other primary and secondary data on endogenous innovation capacities of regions and Member States. All this together created a unique database, which is illustrative in the following figure.

Figure 7: Empirical base of the 2021 Study on Prioritisation in Smart Specialisation

Collection of RIS3-strategies

- **185 S3-strategies** and accompanying documents collected
- **Creation of a custom-made online questionnaire** that was filled in for all 185 S3-strategies
- **181 interviews conducted**

Assessment of priorities

- **Prioritisation database** was developed (1006 priorities) (88 NACE 2-digit level sectors, 22 FOR 2-digit level dimensions, 35 Technology fields)
- **An automated text analysis was applied**

Analysis of correspondence

- **Dataset were created** (for economic, scientific, technological profiles and relatedness and complexity) on a NUTS 0,1,2 level for the relevant years
- **Correspondence and cluster analysis** completed
- **Ten case studies conducted**, each including 1-2 additional interviews

Assessment of implementation

- **186 ERDF project/beneficiary lists** collected and connected to the JRC dataset
- **2876 ERDF calls collected** and the relevant information transmitted into a framework

Source: Prognos AG/CSIL (2022).

As outlined above, 185 S3 from the programming period 2014-20 have been assessed as part of the baseline study, including basic quantitative analysis of key features of these strategies. This work has also resulted in an Excel database containing key parameters of each strategy. Each of the tasks of the predecessor study, especially tasks 3 and 4, have produced a wealth of information that can be utilised for further assessments. In particular, the data offers rich opportunities for additional quantitative analysis related to specific specialisation areas, their links to calls and related budgets.

1.2 Study objectives

Based on the tender specifications five core questions for further investigation can be derived:

Figure 8: Overview of the Study objectives

Interregional cooperation potential:
What is the potential for interregional cooperation regarding the S3 strategies and priorities chosen by Member States and regions and in which areas?

Green and digital transition:
- How do S3 strategies contribute to key Commission priorities, in particular the Twin Transition?
- What are the opportunities of S3 to contribute to the Green Deal in rural, less developed, and peripheral regions?

Links to EC research funding:
- What is the link between S3 priorities and Horizon 2020 projects?
- What are possible complementarities with the key Horizon Europe instruments?

Related vs. unrelated diversification:
- What determines a 'good bandwidth' of S3 strategies
- Under which conditions is a strategy of related or unrelated diversification a "good" option for a MS/region?

S3 Scoreboard:
What is needed for an integrated methodology leading towards a single comparative map of the S3 Scoreboard?

Source: Prognos/CSIL (2022).

1.3 Overall approach of the study

The study follows a quantitative, big-data analytics design to assess key parameters of smart specialisation strategies (S3). The baseline for this follow-up study is intricately linked to the findings and databases that were elaborated in the 'Study on prioritisation in Smart Specialisation Strategies in the EU' by Prognos/CSIL (2021) on behalf of DG REGIO. This study has analysed the 185 S3 of the programming period 2014-20 and assessed key parameters of each strategy using novel approaches. Against this background new quantitative analysis related to these strategies such as on specific specialisation areas, links to calls and related budgets are to be conducted that further develop the methodology that was applied in the previous study by Prognos and CSIL.

The following Figure 3 shows the central study areas of the study and briefly summarises the key working steps in each of the tasks as well as the underlying methodological approaches. The Working Papers mentioned in the figure below were prepared separately. However, the results of these Working Papers are used in this report.

Figure 9: Overview of the project approach

	Tasks	Outputs	Methods
1	**T1: Specific assessment as regards interregional cooperation potential**	Lists of regions with potential for interregional cooperation Detailed description of suggestions for future interregional cooperation and networking and the global positioning of S3 strategies	Data base construction, automated text mining, patent & publication analysis, descriptive & multivariate statistics,
2	**T2: Assessment of opportunities related to the green and digital transition**	List of existing S3 strategies, priorities & projects by Member State & their regions that are relevant for the green and digital transition Statistical analysis of these priorities and projects selected with a strong regional perspective	Data base construction, automated text mining, descriptive & multivariate statistics
3	**T3: Assessment of links to Horizon 2020**	Database with key Horizon Europe funding areas Databases with Horizon 2020 projects and key Horizon Europe funding areas matched to S3 priorities Analysis of projects and budget as well as potential of Horizon Europe funding areas matched to S3 priorities	Data base construction, automated text mining, descriptive & multivariate statistics
4	**T4: Analysis on related vs unrelated diversification**	Analysis of related vs. unrelated diversification in relation to characteristics of the MS/region (size, development level, etc.) List of strategies with optimal bandwidth & relatedness Recommendations on unrelated vs related diversification	Conceptualisation of an optimal S3 and theoretical framework, Data base construction, Descriptive & multivariate statistics (in collaboration with Tom Broekel)
5	**T5: Preparation of two Working Papers**	Working paper concerning the 'Nordic Paradox' Working paper on related vs. unrelated diversification	Desk research, Data base creation, automated text mining, descriptive & multivariate statistics
6	**T6: Assessment of the methodology for the scoreboard & Reporting**	Improved S3 scoreboard that takes account of different levels of devel-opment and intensity of funding. Single comparative map for all 185 strategies. Results-driven synthesis of study findings & conclusions.	Discussions with Dominique Foray, statistical analysis, triangulation, synthesis

Source: Prognos/CSIL (2022).

2. Methodological design of the study

2.1 Assessment of the potential for interregional cooperation

The potential for interregional cooperation can be assessed from different perspectives. Before delving into the different perspective of interregional cooperation it needs to be highlighted that according to a report[1] by the JRC several factors that enable interregional cooperation can be identified:

- **Geographical proximity**: this factor includes the sharing of tacit knowledge and face to face communication which enable joint learning and knowledge spill overs.
- **Functional proximity**: this factor can foster interregional collaboration since cooperation of similar innovation ecosystems with similar levels of capabilities have an increased likeliness of success.
- **Relational/institutional proximity**: factors such as similar norms, legislation but also similar cultures can increase the success of interregional cooperation.
- **Cognitive proximity**: similarities in the knowledge background (scientific discipline / technology) of different actors foster facilitate interregional collaboration.

A first perspective of assessing the potential for interregional cooperation can be found in the **14 EU Industrial Ecosystems.** This provides a framework for the assessment of priorities in pan-EU innovation ecosystems (see Figure 10 for an overview). Therefore, in a first step the priorities from the 185 S3 are matched with the EU industrial ecosystems. For this crucial step of the approach, the 14 industrial ecosystems related to the underlying NACE sectors of the S3 priorities.

In the predecessor study[2], the priorities of the 185 S3 were matched with the economic sectors of the NACE classification which led to a prioritisation database in which each priority area is related to several economic sectors. This information in the S3 prioritisation database is one key element of the matching of the priorities with the Industrial Ecosystems. The other elements are the underlying NACE sectors of the 14 Industrial Ecosystems. For the classification of the 14 Industrial Ecosystems, the NACE rev.2 classification that was developed in the Annual Single Market Report 2021[3] was used. Moreover, to further qualify these connections between the S3 and the ecosystems the shares of the NACE sectors connected to a respective S3 priority area as well as the weight which informs about the relevance of a NACE sector to an Industrial Ecosystem were included in the analysis.

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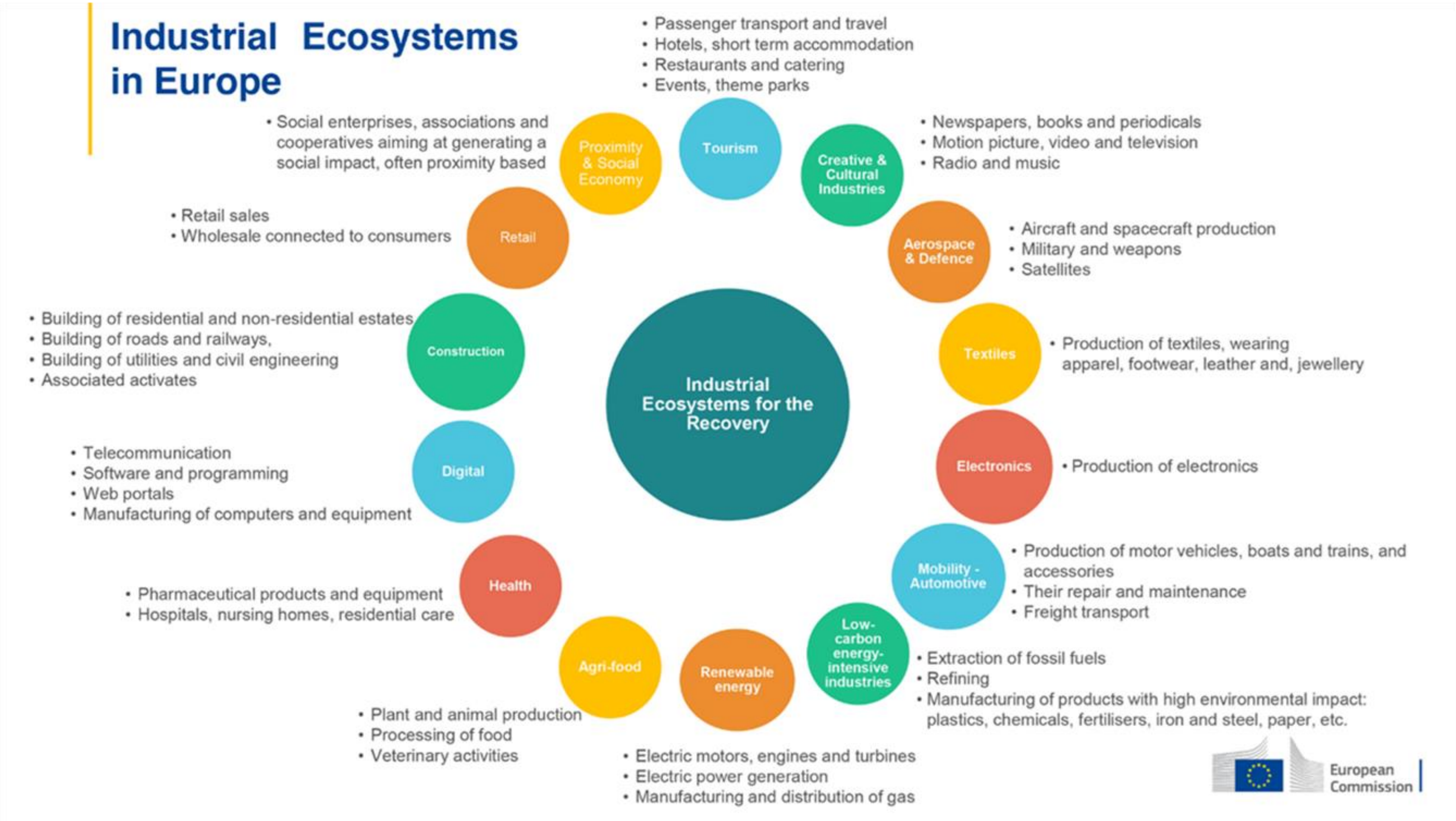
[1] JRC (2021): Interregional Cooperation and Smart Specialisation: a Lagging Regions Perspective. Available online: https://publications.jrc.ec.europa.eu/repository/handle/JRC124118 (last accessed on 13.04.2022)

[2] Prognos & CSIL (2021): Study on prioritisation in Smart Specialisation Strategies in the EU. Study on behalf of the European Commission. Available under: https://ec.europa.eu/regional_policy/en/information/publications/studies/2021/study-on-prioritisation-in-smart-specialisation-strategies-in-the-eu (last access 31.01.2022)

[3] European Commission (2021): Annual Single Market Report 2021. Commission Staff Working Document accompanying the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions.

Figure 10: Overview of the 14 EU Industrial Ecosystems in Europe



Source: https://euclidnetwork.eu/2020/07/social-and-proximity-economy-recognised-as-key-industrial-ecosystem-in-europe/industrial-ecosystems-in-europe

In a second step the potential for interregional cooperation is assessed from the perspective of **complementarity of the priority areas**. Since it is important to account for complementarity by bringing together complementary actors with complementary skills[4] and the issue of complementarity also plays a key role in the Interregional Innovation Investments (I3) initiative it is in the focus of the analysis.

For identifying the potential for interregional cooperation from the perspective of complementarity patent citations are utilised. Thereby, a focus does not lie on the status quo of patent citations between the 185 regions but rather on **detecting complimentary knowledge in the priority areas**. Figure 11 shows an overview of this approach. In a first step, patent citation patterns on the EU level are assessed to gain insights into which topics are cited and which patent citations are combined. Here, PATSTAT[5] as the well-established patent database of the European Patent Office has been utilised and patent citations since 2012 have been assessed. In the next step, these overarching citation patterns are used to connect the priority areas of the 185 regions for which S3 were collected in the predecessor study. This way regions can be matched based on complimentary knowledge in their priorities. A challenge that had to be met is found in the varying quality of the priority area descriptions (see also Section 2.2 for a detailed discussion). Overall, the number of keywords can vary to a larger extent between the different priority areas. This is relevant since a higher number of keywords increases the chance of a match. In other words, a more extensive priority area description means that more information can be used. An approach has been applied that accounts for these variations in the priority area description and at the same time does not "punish" more extensive and hence qualitative better priority area descriptions. This approach consists of two steps. In the first one, it was examined for each priority area which terms can be matched and only the most precise matches have been selected. In addition to this, three terms per possible connection had to match in order to trigger a successful match. In the next step, the analysis of complimentary knowledge in the priority area has been complemented by an analysis of the existing number of cooperation linkages between the regions based on patents linked to priority areas of a certain region as well as the similarity between the different priority areas. For the prior existing patents have been examined to see whether researchers from different regions have worked on a patent. For assessing the similarity between the different priority areas, a word embedding approach (see Section 2.2) has been applied that informs about the total similarity between the different priority areas.

Overall, the assessment of cooperation through patent citations is a well-tested procedure.[6] It is also important to highlight that this analysis goes one step further than comparable studies[7] since the analysis does not look at the status-quo of patent citations between regions but at the potential for cooperation. On the one hand, do patent citations allow to track knowledge and at the same time also to detect the impact of an invention. On the other hand, do these patent citations allow to examine the connections between technologies as well as industries and regions. Another advantage of patents is that they represent quality assured and verified knowledge since patents must be filed with (national) patent offices which assess the

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[4] Ciampi Stancova, K (2018): Interregional cooperation in agri-food smart specialisation. Available online: https://regions.regionalstudies.org/ezine/article/interregional-cooperation-in-agri-food-smart-specialisation/?doi=10.1080/13673882.2018.00001021 (last accessed on 04.02.2022)

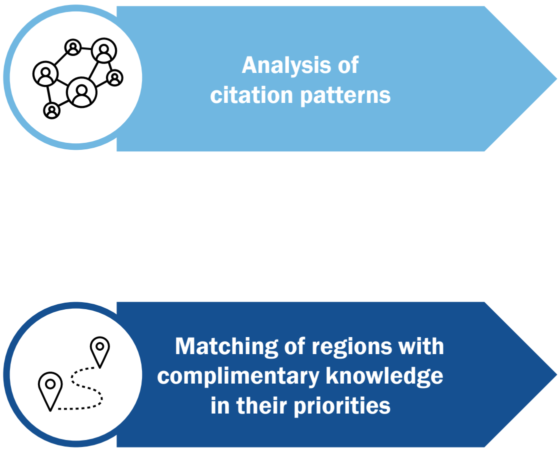
[5] https://www.epo.org/searching-for-patents/business/patstat.html (last access 11.04.2022)

[6] OECD (2009): The Use and Analysis of Citations in Patents. Available under https://www.oecd-ilibrary.org/docserver/9789264056442-7-en.pdf?expires=1649232262&id=id&accname=guest&checksum=5CC44BEAFCAEFD78DB8E1C0F571908DE (last access 06.04.2022)

[7] European Commission (2019): Smart Specialisation: Beyond Patents. Available under https://ec.europa.eu/regional_policy/sources/docgener/brochure/smartspec_beyond_patents_en.pdf (last access 06.04.2022)

applications regarding their patentability. Despite these advantages, some limitations of patent analysis need to be considered. For instance, not all inventions are patented meaning that not all knowledge is captured in patents. Moreover, there can be systematic differences in who patents and in the inventions that get patented.[8] Due to this nature of patents, some other studies suggest including additional indicators to avoid bias when assessing regional capabilities.[9]

Figure 11: Overview of detecting the potential for interregional cooperation based on patents analysis



- Analysis of citation patterns worldwide/in the EU
- For each priority it will be checked if these priorities are addressed in patent citations
- **Result**: Insights on which topics are cited and the combination of patent citations (e.g., life science patents cite patents from bioeconomy)

- Based on the prior step it can be assessed which citation patterns can be connected to the different regions & their respective priorities
- **Result**: Matched regions based on patent citations (e.g., Romanian with its priority 'Bioeconomy' can collaborate with Abruzzo and its priority 'Life sciences')

Source: Prognos/CSIL (2022).

Based on this detection of potential for interregional cooperation enriched by the number of existing cooperation linkages (based on patents) and the respective similarity of the priority areas for which interregional cooperation potential was identified matrices can be developed for each region. These matrices help to draw recommendations with which regions cooperation should be strengthened. In the following the different quadrants are briefly described (see also Figure 12):

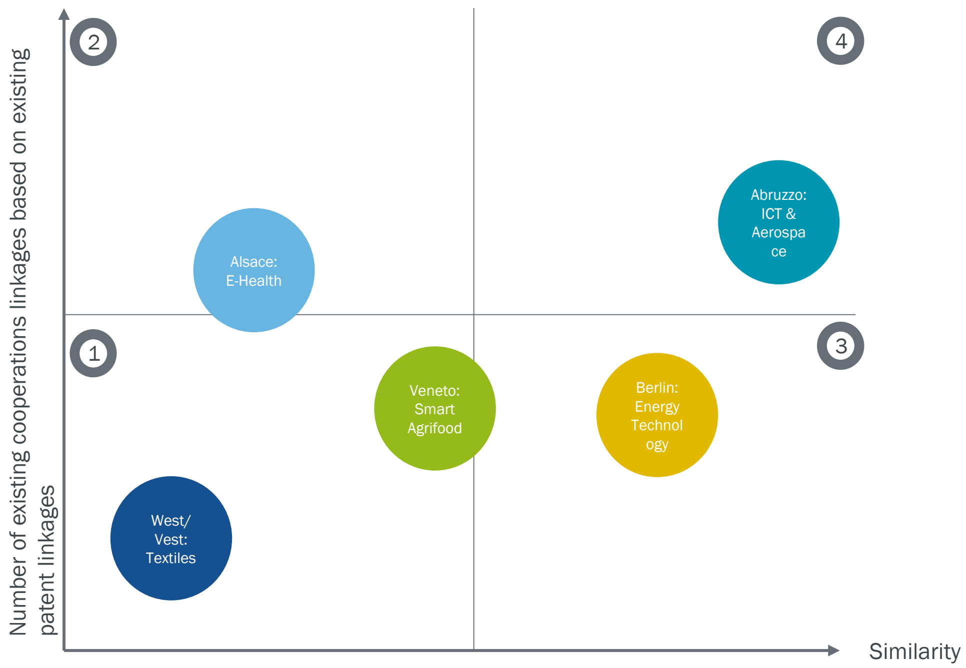
1. **Low similarity and low existing number of cooperation linkages**: in this case the two regions with identified potential for cooperation based on patents do not already engage in patent collaborations. Due to the low similarity of the identified cooperation potential interregional cooperation between the two regions in the respective priority areas shows a rather low potential.
2. **Low similarity and high existing number of cooperation linkages**: this case is similar to the previous one. Due to the low similarity of the identified cooperation potential interregional cooperation between the two regions in the respective priority areas shows a rather low potential. Based on this the two regions should not strengthen the cooperation linkages in the priority field at hand.

[8] Brouwer, E. & Kleinknecht, A. (1997): Innovative output, and a firm's propensity to patent. An exploration of CIS micro data. In Research Policy 28, p.615-624

[9] European Commission (2019): Smart Specialisation: Beyond Patents. Available under https://ec.europa.eu/regional_policy/sources/docgener/brochure/smartspec_beyond_patents_en.pdf (last access 06.04.2022)

3. **High similarity and low existing number of cooperation linkages:** in this case the degree of similarity between the identified potential for interregional cooperation provides a promising opportunity for collaboration. Based on the patent collaborations the number of existing cooperation linkages between the respective regions are low / non-existing and should be further developed.
4. **High similarity and high existing number of cooperation linkages:** in this case the degree of similarity between the identified potential for interregional cooperation is high and several cooperation linkages between the respective regions exist. The collaboration between the regions should be maintained and further strengthened.

Figure 12: Conceptual overview matrix for interregional cooperation assessment based on existing cooperation linkages and similarity of priority areas (illustrative)



Source: Prognos/CSIL (2022).

2.2 Assessment of opportunities related to the Twin Transition

To assess the opportunities related to the green and digital transition, the S3 prioritisation database first needed to be screened and the priorities need to be examined regarding their relevance to the green[10] and digital[11] transition. Thereby, the **understanding of the green and digital transition follows the descriptions laid out by the European Commission** in central documents. At the centre of the green transition is the European Green Deal which aims at overcoming the challenges of climate change and environmental degradation by making Europe climate neutral by 2050, fostering green technologies, reducing pollution, and creating sustainable industries and transport. The digital transition on the other hand follows the objectives of exploiting digital growth potentials and using innovative solutions for businesses and citizens as well as improving the accessibility and efficiency of public services.

[10] https://ec.europa.eu/reform-support/what-we-do/green-transition_en (last access 28.03.2022)

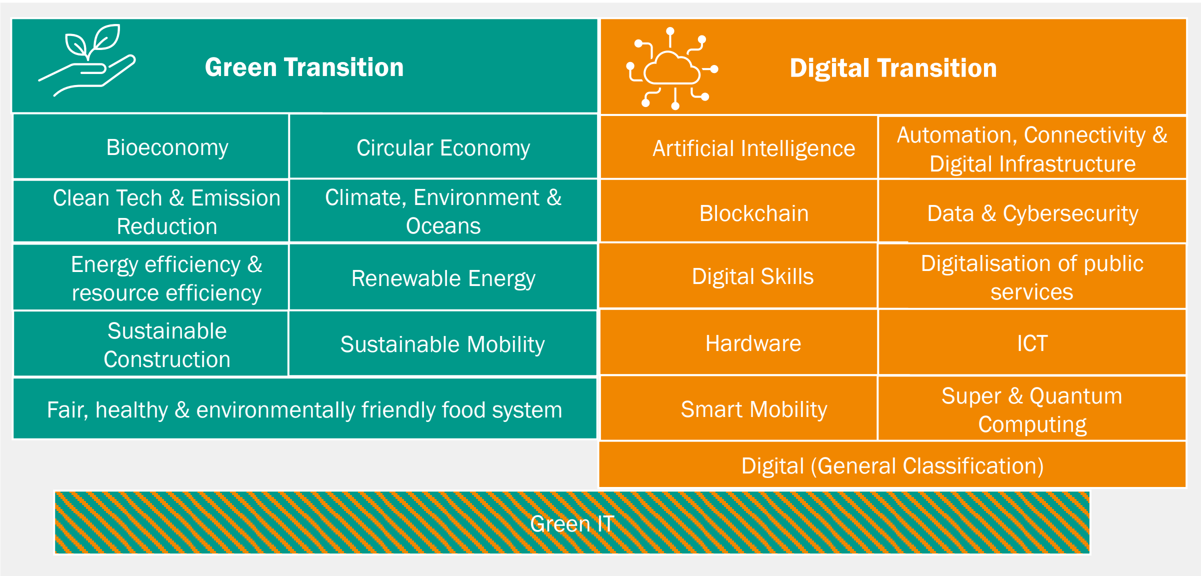
[11] https://ec.europa.eu/reform-support/what-we-do/digital-transition_en (last access 28.03.2022)

In order to assess the S3 priorities regarding their relevance to the Twin Transition first an ontology of this concept needed to be constructed. Besides the information provided by the European Commission on their webpages the following strategic documents for the green and digital transition were in the focus of the analysis:

- European Commission (2021): 2030 Digital Compass: the European way for the Digital Decade.
- European Commission (2020): Shaping Europe's digital future
- European Commission (2021): Digital Europe - Work Programme 2021 – 2022
- European Commission (2019): The European Green Deal
- European Commission (2020): Technical support for implementing the European Green Deal
- European Commission (2021): For a resilient, innovative, sustainable, and digital energy-intensive industries ecosystem: Scenarios for a transition pathway

The webpages and beforementioned documents were screened also utilising an **automatic keyword extraction algorithm.** The keywords that were extracted this way were thematically grouped to identify overarching topics. Figure 13 shows the identified topics and Table 17 in the Annex shows the full ontology of the topics related to the green and digital transition. These topics cover, for instance, bioeconomy and renewable energy for the green transition and artificial intelligence and smart mobility for the digital transition. One topic (Green IT) is related to both concepts.

Figure 13:Overview of topics of the green and digital transition



Source: Prognos/CSIL (2022).

These ontologies for topics relevant to the green and digital transition were matched with the S3 priority database that was constructed in the predecessor study.[12] Thereby, the

[12] Prognos & CSIL (2021): Study on prioritisation in Smart Specialisation Strategies in the EU. Study on behalf of the European Commission. Available under: https://ec.europa.eu/regional_policy/en/information/publications/studies/2021/study-on-prioritisation-in-smart-specialisation-strategies-in-the-eu (last access 31.01.2022)

descriptions of the 1240 priority areas of the 185 S3 of the different Member States and regions were matched following a word embedding approach (for more information see the following infobox).

i

Word embedding

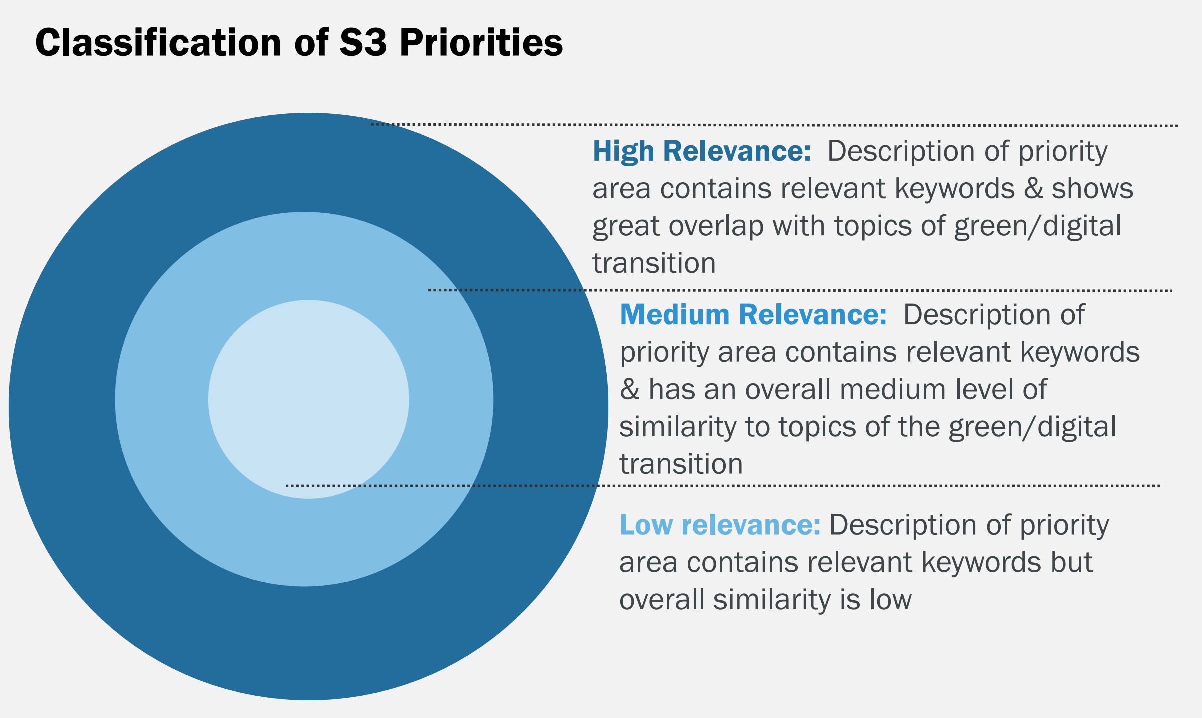
Word embeddings are a class of techniques in the field of natural language processing, where terms get transformed into a vector representation, which encodes the meaning of the word. Terms that are close to each other in vector spaces are expected to have a similar meaning. To calculate the distance between vectors there are different metrics. In the distance calculation for this study, the cosine similarity has been used. Pre-trained neural networks were used to implement the transformation process. These are provided as a package in Python and allow the use of the method without the need to train such a network.

The results of the matching process were then **classified into three distinct categories** to allow for a more nuanced analysis. This follows the logic of accounting for various levels of correspondence and connections between a priority area and a topic of the green and digital transition. For instance, the keywords for ICT can trigger a match with the priority "Educational digital and cultural industry" of Poitou-Charentes. However, the degree of correspondence between ICT and this priority area is lower compared to, for instance, the priority field "ICT" of Sardinia. Hence, various indicators were utilised to account for this issue which are shortly described in the following:

- **Maximum similarity:** This measure informs about the extent to which a word is found in the priority description as well as in the ontology for the Twin Transition. The value of this measure can range between 0 and 1 where a value of 1 means that an identical word (e.g., bioeconomy) was found in both the priority description and the ontology for the twin transition. A value of 0 means that no identical word was found. In the qualification process only matches with a value of 0.95 or higher were used. This way it was ensured that, for instance, priorities containing the keyword "smart grids" were still matched with "smart grid." Lower values for the maximum similarity led to a lower quality of the matches. For instance, the keyword "IT system" is then matched to "Biometric system"
- **Average similarity**: This measure shows the average maximum similarity of all the keywords of a relevant topic to the description of a priority field.
- **Total similarity:** This measure informs about the degree to which all keywords of a respective topic of the Twin Transition are similar to the whole description of a S3 priority field.

These indicators were used to **qualify and group the matching results**. An overview of this classification process is shown in Figure 14. In this process only matches with a maximum similarity value of 0.95 or higher were used. Next to that for each match the average of the three measures described before was calculated. Matches with an average of 0.9 or higher and a total similarity of at least 0.8 were classified into the group of matches with a high relevance to topics of the Twin Transition. Matches with an overall average of 0.9 or higher and a total similarity of 0.7 were classified into the group of matches with a medium relevance. All other matches that did not fall into any of the prior classifications are grouped into the category with a low relevance. Table 1 shows a snapshot of the matching results and classifications between the prioritisation database and topics of the Twin Transition.

Figure 14: Overview of classification of S3 priorities regarding their relevance to matched topics



Source: Prognos/CSIL (2022).

Once the S3 priorities were matched with the topics of the green and digital transition and classified regarding their relevance the **ERDF TO1 project database** that was constructed in the predecessor study was prepared. This project list bases on the Dataset of projects co-funded by the ERDF during the multi-annual financial framework 2014-2020[13]. Since this dataset did not contain information for all relevant regions, the dataset was merged with project/beneficiary lists that were collected in the predecessor study.[14] Overall, this project database contains 86,487 projects out of which 49,749 (57%) were connected to the priority areas of the 185 strategies. To examine the number of projects and the budget that is connected to the Twin Transition the previously as relevant classified priority areas were identified in this project database.

Although the applied matching approach was successful in identifying and classifying the S3 priorities regarding their relevance to the Twin Transition some factors that influence the results must be kept in mind. Some of those factors were also encountered in the predecessor study.[15] Here, especially the **varying quality of the descriptions** of priority areas plays a role. To have qualitatively good matchings, the input in terms of keywords by the priority areas' descriptions is particularly important. Whereas for most fields a very detailed description was

[13] Bachtrögler-Unger, J., Doussineau, M. and Reschenhofer, P. (2020): Dataset of projects co-funded by the ERDF during the multi-annual financial framework 2014-2020. Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-18860-5, doi:10.2760/491487, JRC120637; available under https://publications.jrc.ec.europa.eu/repository/handle/JRC120637 (last access 06.04.2022)

[14] Prognos & CSIL (2021): Study on prioritisation in Smart Specialisation Strategies in the EU. Study on behalf of the European Commission. Available under: https://ec.europa.eu/regional_policy/en/information/publications/studies/2021/study-on-prioritisation-in-smart-specialisation-strategies-in-the-eu (last access 31.01.2022)

[15] Prognos & CSIL (2021): Study on prioritisation in Smart Specialisation Strategies in the EU. Study on behalf of the European Commission. Available under: https://ec.europa.eu/regional_policy/en/information/publications/studies/2021/study-on-prioritisation-in-smart-specialisation-strategies-in-the-eu (last access 31.01.2022)

provided for the priority areas (on average 63 keywords), there are some regions and priority areas where five or fewer keywords were provided. On the other hand, there are also regions with a significantly higher number of keywords. This is relevant since a higher number of keywords increases the chance of a match. Moreover, the content of the priority areas can range from specific keywords that are thematically related to priority descriptions that cover a broad range of topics and keywords (e.g., ICT, energy efficiency, and bioeconomy). The broadness, cross-cutting and overlapping nature of some topics of the Twin Transition are also the reason why, for instance, the national Romanian priority “Bioeconomy” does not show a high relevance for the topic “Bioeconomy.” Instead, this priority shows a medium level of relevance for both “Bioeconomy” and “Fair, healthy & environmentally-friendly food system” since the description not only contains keywords related to Bioeconomy but also to food and the pharmaceutical industry. Moreover, some descriptions include keywords on a rather general level such as Health or E-Health whereas other priorities include specific and underlying topics and technologies. Varying levels can also be found when assessing the topics and keywords relevant to the Twin Transition that were extracted from key European Commission documents. For instance, in these documents the relevance of connectivity as well as blockchain technology for the digital transition are highlighted. While the prior is a rather broader topic with a relatively high number of different use cases and technologies attached to it blockchain refers to a specific technology.

Table 1: Snapshot of the matching results between the prioritization database and topics of the Twin Transition

Region	NUTS level	NUTS co	Cohesion Group	Innovation Scoreboard	EU15 / EU13	S3_Priority_area	Description	Twin Transition	Topic	Term	max. Similarity	average Similarity	total Similarity	Average	Cluster: High / Medium / Low Relevance
Central Macedonia	NUTS 2	EL52	Less developed	Moderate	EU15	Information and Communication Technologies (ICT)	information and communication technologies; digital tools; ict research;	Digital	ICT	digital communication; communications systems; radio spectrum; computing sciences; ict specialists; ict; new digital communications; holographic media; cloud computing; intelligent edge computing; it services; it systems; ict devices; apis; cloud service; digital service; digital tool; internet; it industry; online platform; software;	0.98	0.78	0.82	0.86	High Relevance
País Vasco	NUTS 2	ES21	More developed	Strong	EU15	Energy	electric power; oil, gas; alternative energy ; wind ; wave power ; solar thermoelectric ; energy storage ; smart grids ; transport electrification ; energy services	Green	Renewable Energy	renewable energy; solar panels; wind turbines; renewable energy sources; renewable power; industrial waste heat; replacement of fossil fuels; renewable hydrogen; offshore wind	0.88	0.79	0.90	0.86	High Relevance
Comunidad Foral de Navarra	NUTS 2	ES22	More developed	Moderate	EU15	renewable energies and resources	renewable energies; renewable resources; reduction of fossile energies; eolic sector; circular economy; generation systems; distributed generation; wind generation; photovoltaic solar generation; energy storage systems; energy efficient building ; urban planning	Green	Renewable Energy	renewable energy; solar panels; wind turbines; renewable energy sources; renewable power; industrial waste heat; replacement of fossil fuels; renewable hydrogen; offshore wind	0.98	0.87	0.88	0.91	High Relevance
Central Finland	NUTS 3	FI193	More developed	Leader	EU15	Bioeconomy	bioeconomy; forest-based industries; circular economy; food production; utilization of by-products; bio-based side streams; low-carbon economy; renewable energy sources; agriculture; blue economy; energy saving; blue economy; bioeconomy	Green	Fair, healthy & environmentally-friendly food system	food; safe food; healthy food; nutrition; nutritious food; food waste; obesity; diets; food chain; forest ecosystems ; sustainable food; farmers ; fishermen; agricultural; agriculture; fisheries; precision agriculture; organic farming; agro-ecology; agro-forestry ; animal welfare ; sustainable seafood; low-carbon food; chemical pesticides; pesticides; food waste; food fraud; seafood; reforestation ; afforestation; resilience of	1.00	0.73	0.81	0.85	Medium Relevance
Central Ostrobothnia	NUTS 3	FI1D5	More developed	Strong	EU15	Smart and sustainable wood products and constructing	smart wood products; smart constructing; sustainable construction; energy efficient pre-fabricated wooden constructions; wood houses; other wood products; smart living solutions; ict	Green	Sustainable construction	sustainable construction; good insulation; novel building materials; energy performance of buildings	1.00	0.75	0.79	0.85	Medium Relevance
Rhône-Alpes	NUTS 2	FR71	More developed	Leader	EU15	Industrial processes and eco-efficient factory	industrial processes ; eco-efficient factory; reprocessing ; bio-based ; low carbon processes ; metrology ; environmental instrumentation ; recycling ; waste management ; waste processing ; bio-based chemistry ; resources use ; energy efficiency ; water ; fluids ; raw materials ; close circuit ; toxic ; pollution ; emissions ; co2 ; carbon capture ; biomass ; cellulose ; biomaterials ; bioproducts ; bioenergy ; biotechnologies ; reuse ; circular economy ; waste water ; urban water ; sensors ; software ; health ; environment ; operating costs ; resource scarcity ; social responsibility ; plastics ; sustainable chemistry ; eco design ; physics ; engineering ; microelectronics ; clean processes ; intelligent	Green	Climate; Environment & Oceans	climate-neutral; environmental footprint; climate neutrality; environmentally sustainable; biodiversity; depollution; air pollution; climate change mitigation; environmental-related challenges; pollution; biodiversity; toxic-free environment; air pollution; water pollution; soil pollution; loss of biodiversity; climate change; biological diversity; blue economy; biodiversity in lakes; biodiversity in rivers; pollutants.; blue economy; oceans; aquatic resources; marine resources; maritime area	1.00	0.76	0.78	0.85	Medium Relevance
Central Finland	NUTS 3	FI193	More developed	Leader	EU15	Digital economy	cyber security; digital services; e-government; robotics; intelligence networks; communications networks; intelligent networks; automation; data analytics; gamification; artificial intelligence; big data	Digital	Automation, Connectivity & Digital Infrastructure	automation; automated mobility; automated transport systems; autonomous vehicle; robotics; robots; autonomous robots	1.00	0.87	0.68	0.85	Low Relevance
Comunidad Foral de Navarra	NUTS 2	ES22	More developed	Moderate	EU15	Automotive and mechatronics	automotive; mechatronics; electric vehicles; industry 4.0; intelligent transport; autonomous transport; electromobility vehicle; sustainable vehicle; robotics; materials genomics; alloys; composites; polymers; coatings;	Digital	Automation, Connectivity & Digital Infrastructure	automation; automated mobility; automated transport systems; autonomous vehicle; robotics; robots; autonomous robots	1.00	0.84	0.71	0.85	Low Relevance

Source: Prognos/CSIL (2022).

2.3 Assessment of links to H2020 and Horizon Europe

H2020

A starting point for the assessment of links between S3 priorities and H2020 funding is the construction of a project database for H2020. Here, the most up to date H2020 project databases provided by CORDIS[16] were used. This data covers projects and related organisations that were funded by the EU under the Horizon 2020 programme for research and innovation from 2014 to 2020. For the matching procedure and the later analyses, the two CORDIS databases on projects and organisations were merged. In the next step, the data was adapted to the needed regional level. This means that the regional information for the organisations funded under this programme was on the NUTS3 level. However, the majority of the 185 S3 are on the NUTS 2 and NUTS1 level, and some strategies are on the country level (NUTS 0). In other words, this means that the regional information provided for a project conducted in Aachen, Germany (DEA2D) was adapted to the level of the corresponding S3 which in this case is North Rhine-Westphalia (DEA). One specificity of the H2020 funding structure in comparison to the ERDF project database of the predecessor study needs to be highlighted. Projects funded by H2020 can include several project partners and these project partners in turn can be located in different regions. Moreover, whereas in the ERDF project database projects are related to a regional innovation strategy this is not the case for the H2020 projects. This is relevant for the six Member States (Greece, Italy, Poland, Portugal, Romania, Spain) that have both a national and regional S3. In these six countries the H2020 projects were matched on a regional level to the respective strategies. Moreover, all H2020 projects in those Member States were matched with the respective national strategy and analysed separately.

First, the H2020 database was prepared. For this purpose, keywords from the descriptions of the H2020 projects were extracted using the so-called Rapid Automatic Keyword Extraction (RAKE) method. Based on the extracted keywords the projects were matched with the S3 priorities of the prioritisation database constructed in the predecessor study. Here, similar to the assessment of opportunities related to the Twin Transition a **word embedding approach** was followed and the total similarity is used as the decisive instrument for determining a link between a H2020 project and a region's priority area. In the case of the linkages between the H2020 projects and the priority areas the total similarity ranges from 0 (no correspondence) to 1 (exact match). The analysis of the distribution of the total similarity at hand showed a distribution close to a normal distribution around the value of 0.5. Therefore, only linkages between a H2020 project and a priority area with a total similarity of 0.6 or larger were regarded as a match. Further scrutiny of the results of this approach underlined the quality of the approach. Correspondingly, linkages between H2020 projects and the priority areas with a lower total similarity led to a significantly decreasing thematical correspondence. For instance, the H2020 project “Tumor targeting through a TME-specific regulatory code and programmable CART cells” in Austria is then linked to the Austrian priority area “Mobility”.

Of course, in this matching approach of H2020 projects with the S3 priorities the individual characteristics of the priority descriptions that were outlined in Section 2.2 need also to be considered. In addition to that, it needs to be highlighted that the descriptions of the H2020 projects are in general quite extensive and include a relatively high number of keywords. As mentioned before, a higher number of keywords further increases the chances of a match.

Additionally, it is examined which **organisations** have been funded by both H2020 and the ERDF in the period 2014-2020. For this analysis, the organisations from the H2020 database

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[16] see https://data.europa.eu/data/datasets/cordish2020projects?locale=en (last access 01.04.2022)

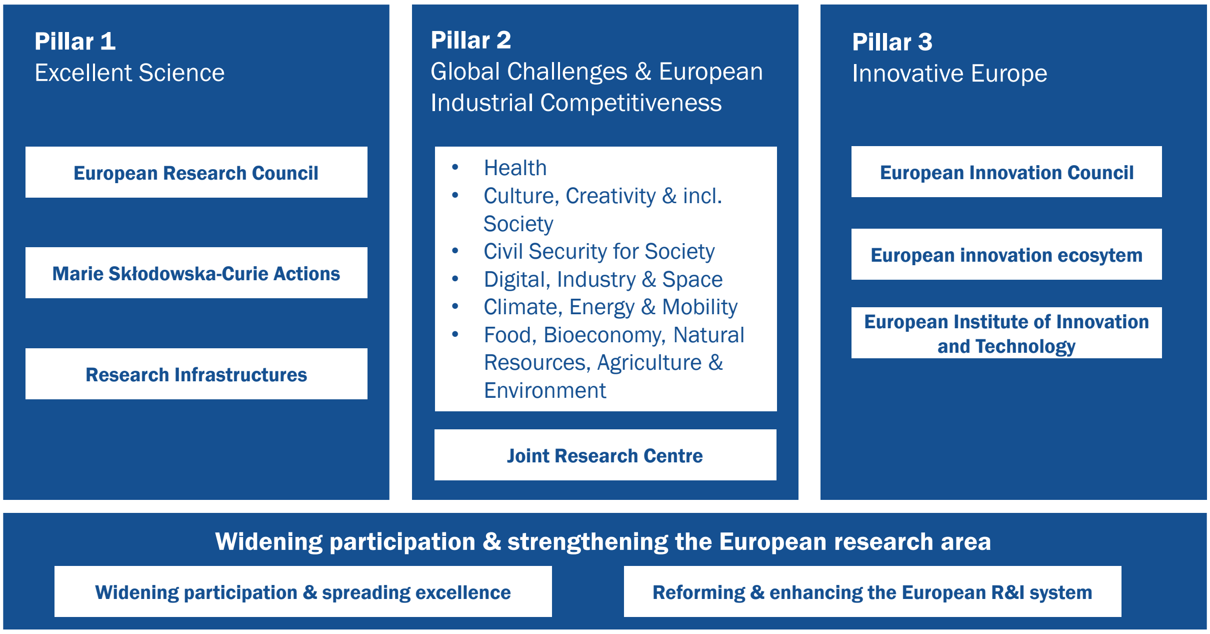
were matched with the organisations included in the ERDF project database that was constructed in the predecessor study (see also Section 2.2 for a description of this database). In this matching approach both the organisation name and if available also the organisation ID were utilised. A match was triggered when the ID or the name of the ERDF project list was found in the H2020 list. It needs to be highlighted that by this analysis not all organisations that were funded under the ERDF in the 185 regions are captured since the project database only covers 167 Member States/ regions. The difference between the number of S3 (185) and the total number of Member States/regions that are used for this section exists because some regions did not record any projects (Thessaly, several Finnish and Swedish regions, Mayotte, Martinique) or there were no projects on the NUTS level of the S3 (regions in Romania, OP only on a national level).

Horizon Europe

The first step of this sub-task includes the construction of Horizon Europe key funding areas. Since no projects of this funding programme have started yet ontologies for the key funding areas are constructed. These key funding areas that are considered are within the second pillar of Horizon Europe (see Figure 15 for a schematic overview of Horizon Europe) which includes different **thematic clusters** such as ‘Health’, ‘Digital, Industry & Space’ or ‘Climate, Energy & Mobility’. Besides these clusters, the five mission areas of the Horizon Europe programme have been taken into consideration. These mission areas include the following:

- Adaptation to climate change including societal transformation
- Cancer
- Climate-neutral and smart cities
- Healthy oceans, seas, coastal and inland waters
- Soil health and food

Figure 15: Schematic overview of Horizon Europe programme structure



Source: Prognos/CSIL (2022), based on https://ec.europa.eu/info/research-and-innovation/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en (last access 28.03.2022)

For the construction of ontologies for the Horizon Europe key funding areas presented above an automatic keyword extraction algorithm that determines keywords in documents by analysing the frequency of words and their co-occurrence was applied. The documents that were used in this step include the different work programmes[17] of the thematic clusters and mission areas. Table 19 in the Annex shows the complete ontology for the Horizon Europe key funding areas that were used in the matching approach with the S3 priorities.

In the next step, these ontologies were matched with the description of the priorities from the S3 priority database that was constructed in the predecessor study. The matching approach as well as the qualification process that were applied here follow the same steps that were presented in Section 2.2. Moreover, the same research limitations regarding the S3 priority database that were explained in Section 2.2 do also apply here. However, some specificities of the ontology for the key Horizon Europe funding areas need to be kept in mind. For instance, some of the key funding areas (like Digital, Industry and Space) encompass a broad range of topics and include a high number of keywords which increases the chances of a match. Other key funding areas (like Health or the mission areas) are less complex and more specific to certain topics.

[17] see https://ec.europa.eu/info/research-and-innovation/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en (last access 28.03.2022) and https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/wp-call/2021-2022/wp-12-missions_horizon-2021-2022_en.pdf (last access 28.03.2022)

3. Specific assessment of the potential of S3 for interregional cooperation

Overview of key findings
• **The 185 Smart Specialisation Strategies and corresponding priority areas of the 2014-2020 funding period provide significant potential for interregional cooperation.** Based on the various underlying economic sectors of the priority areas a multitude of connections to the 14 EU Industrial Ecosystems as a framework for priorities in pan-EU innovation ecosystems can be established. The largest correspondence of the Industrial Ecosystems and the S3 priority areas can be found in the Industrial Ecosystems “Digital”, “Energy Intensive Industries” and “Cultural and Creative Industries” followed by “Agri-Food” and “Health” – that means, here strategic directions and prioritisation correspond to each other. It is noteworthy though, that the overall differences between Industrial Ecosystems are rather small which can be explained by the overall broadness of the Industrial Ecosystem classification. • **The priorities addressed by Member States/regions in the 185 S3 frequently correspond to complementary knowledge stocks.** Based on the analysis of complementary knowledge in the priority areas it is found that the largest potential for cooperation is first and foremost found among priorities that address the same overarching topic. This is not surprising, as some of the overarching topics can be regarded as cross-cutting. In addition, the detailed analysis of the potential for interregional collaboration based on complimentary knowledge shows that depending on the degree of similarity between the priority areas and the number of existing cooperation linkages there are varying levels in the potential for cooperation. Since for many regions no or only low numbers of existing cooperation linkages are found in our data, it can be concluded that there are still vast potentials for interregional cooperation in the context of S3 across European regions. • **Overall, the findings suggest that interregional collaboration should further be supported and substantiated**. Due to the similarity in their concepts, the role of cluster organisations for smart specialisation strategies and thereby especially for interregional cooperation can further be promoted. Cluster organisations but also networks, business associations and other intermediaries could help to identify and provide suitable partners with complimentary skills for interregional cooperation projects.

Interregional cooperation facilitates interregional learning as well as accessing complementary partners and skills.[18] Moreover, interregional cooperation is essential for the concept of smart specialisation since exchanges and spill overs are important requisites for innovation.[19] Against this background, this Chapter follows the objective of assessing the potential for interregional cooperation regarding S3 and priorities chosen by Member States and regions. As described in Section 2.1 different approaches are followed to assess the potential for interregional cooperation in the 185 smart specialisation strategies of the different Member States/regions. In the following, the results of the analysis of connecting the S3 priorities to the EU Industrial Ecosystems as well as the detection of complementarities in the S3 priorities will be presented.

[18] see https://ec.europa.eu/growth/industry/strategy/interregional-partnerships_en (last accessed on 04.02.2022)

[19] JRC (2021): Interregional Cooperation and Smart Specialisation: a Lagging Regions Perspective. Available online: https://publications.jrc.ec.europa.eu/repository/handle/JRC124118 (last accessed on 04.02.2022)

3.1 On the connection between S3 priorities and the 14 EU Industrial Ecosystems

Overall, the results indicate a **broad potential for interregional cooperation** from the 185 S3. In the prioritisation database of the predecessor study[20] the S3 priorities were connected to around 6,500 NACE sectors.[21] Since a priority area can be linked to several NACE sectors (e.g., the priority area "ICT & Aerospace in Abruzzo is linked both to the sectors "Manufacture of computer, electronic and optical products" and" Telecommunications") this priority area can in turn also be connected to a multitude of Industrial Ecosystems. For instance, the previously illustrated example of the priority area "ICT & Aerospace in Abruzzo is linked through the underlying NACE sectors to the ecosystems "Aerospace & Defence", "Digital", and "Electronics".

Overall, numerous linkages between the underlying NACE sectors of the 185 strategies and the Industrial Ecosystems can be established. Based on these created links between the underlying NACE sectors of the 185 S3 and the 14 EU Industrial Ecosystems it can be stated that **almost all of the 185 S3 have links to all of the 14 different Industrial Ecosystems**. The following Figure 16 shows the shares of all the established (weighted) links between the S3 and the respective Industrial Ecosystems. This figure also underlines the fact that the S3 priorities are designed in relatively broad ways and are connected to various economic sectors. The figure also illustrates that the shares of the different ecosystems are rather homogenous which means that the links between the S3 and the Industrial Ecosystems are not solely concentrated on certain ecosystems. Overall, these shares range between 3% ("Textile", "Retail") and 11% ("Digital", "Energy Intensive Industries"). The highest shares of the Industrial Ecosystems addressed by the priority areas can be found in the ecosystems "Digital", "Energy Intensive Industries" and "Cultural and Creative Industries" followed by "Agri-Food" and "Health". Based on this it can concluded that the S3 priorities have profound linkages to the different Industrial Ecosystems and that the priorities can also contribute to all of the 14 EU Industrial Ecosystems.

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[20] Prognos & CSIL (2021): Study on prioritisation in Smart Specialisation Strategies in the EU. Study on behalf of the European Commission. Available under: https://ec.europa.eu/regional_policy/en/information/publications/studies/2021/study-on-prioritisation-in-smart-specialisation-strategies-in-the-eu (last access 31.01.2022)

[21] Not accounting for non-NACE descriptions. If a region had updated its strategy during the period 2014-2020, only the updated strategy is included in the analysis

Figure 16: Established links between the S3 and Industrial Ecosystems by addressed ecosystem (by share of all established links)

Source: Prognos/CSIL (2022). Note: n=9715 weighted links between the priority areas and the 14 Industrial Ecosystems. Link between priority areas and Industrial Ecosystems generated through NACE sectors that have been matched to the priority areas in the predecessor study. One priority area can be linked to several NACE sectors and one NACE sector can be linked to several Industrial Ecosystems

3.2 On complementarity of the S3 priority areas

The literature does not only highlight the importance of interregional learning but does also suggest that interregional cooperation has a positive impact on the diversification of regions. Moreover, it is underlined that what matters for cooperation are linkages to regions with complementary skills.[22] Against this background, the 185 S3 were assessed regarding complimentary knowledge in their priority areas (see also Section 2.1).

[22] Balland, P., Boschma, R. (2021): Complementary interregional linkages and Smart Specialisation: an empirical study on European regions. In Regional Studies, vol. 55 (6). Available online https://www.tandfonline.com/doi/full/10.1080/00343404.2020.1861240?scroll=top&needAccess=true (last access 07.04.2022)

Based on this approach a database has been created that contains a total of around **159,000 possible linkages** between the 185 S3 and their respective priority areas. This large number of possible linkages between the S3 based on complimentary knowledge in the priorities further substantiates the vast potential for interregional cooperation of the S3. This is also supported by an analysis of the status quo of patent cooperations in the EU which indicates that some regions do cooperate with a variety of different actors from different regions. However, what also emerges from this status quo analysis is that for many of these patent cooperations proximity plays an essential role. In other words, many of these cooperations occur within the same country (e.g., many different French regions cooperate with each other) or with regions that show some degree of regional/cultural proximity (e.g., (southern) German regions and Austria). The importance of (regional) proximity is also underlined by other research.[23] However, other research also points out detrimental effects of proximity on innovation due to lock-in problems which further substantiates the importance of interregional cooperation across the EU.[24]

In order to get a better thematical overview of this database of possible linkages between the S3 based on complimentary knowledge in the priorities the linked priorities have been assessed based on the addressed overarching topics by the priorities. These overarching topics addressed by the S3 priority areas have been established in the predecessor study.[25]

Table 2 displays an overview of the potential for cooperation through the overarching topics addressed by S3 priority area. Two central findings can be deducted from this overview. First, not surprisingly the **largest potential for cooperation is often found among priorities that address the same overarching topic**. For instance, the share of potential for cooperation of priority areas that address the overarching topic “Health & Life Sciences” is the highest for other priority areas of this same overarching topic. Second, **some of those overarching topics can be regarded as cross-cutting** since they show a high relevance for almost all other overarching topics. These overarching topics are “Agrofood & Bioeconomy”, “Health & Life Sciences”, “ICT & Industry 4.0”, “Materials & Advanced Manufacturing” and to a smaller extent also “Energy & Energy Storage” and “Mobility & Logistics”. Other priority areas that address overarching topics such as “Fashion, Media & Creative Industries” or “Social Innovation & Welfare” show less complimentary knowledge that is relevant for other priorities that address different overarching topics.

On a more regional level, the analysis shows that the number of priorities that have been linked to priorities of other regions can vary to a larger extent and that more potential cooperation links have been identified for regions and priority areas with qualitative good description. These findings are linked to limitations of the prioritisation database in terms of the **varying quality of the priority descriptions** which has also been discussed in Chapter 2. Here, especially the varying length of priority descriptions can lead to more links with regions that have more keywords in their descriptions since a higher number of keywords increases the chance for a match. For instance, the priority area “Advanced technologies for industrial applications” of the French region Bretagne contains 119 keywords compared to eight

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[23] Bell, G., Zaheer, A. (2007): Geography, Networks, and Knowledge Flow. In Organization Science, vol. 18 (6), pp-955-972

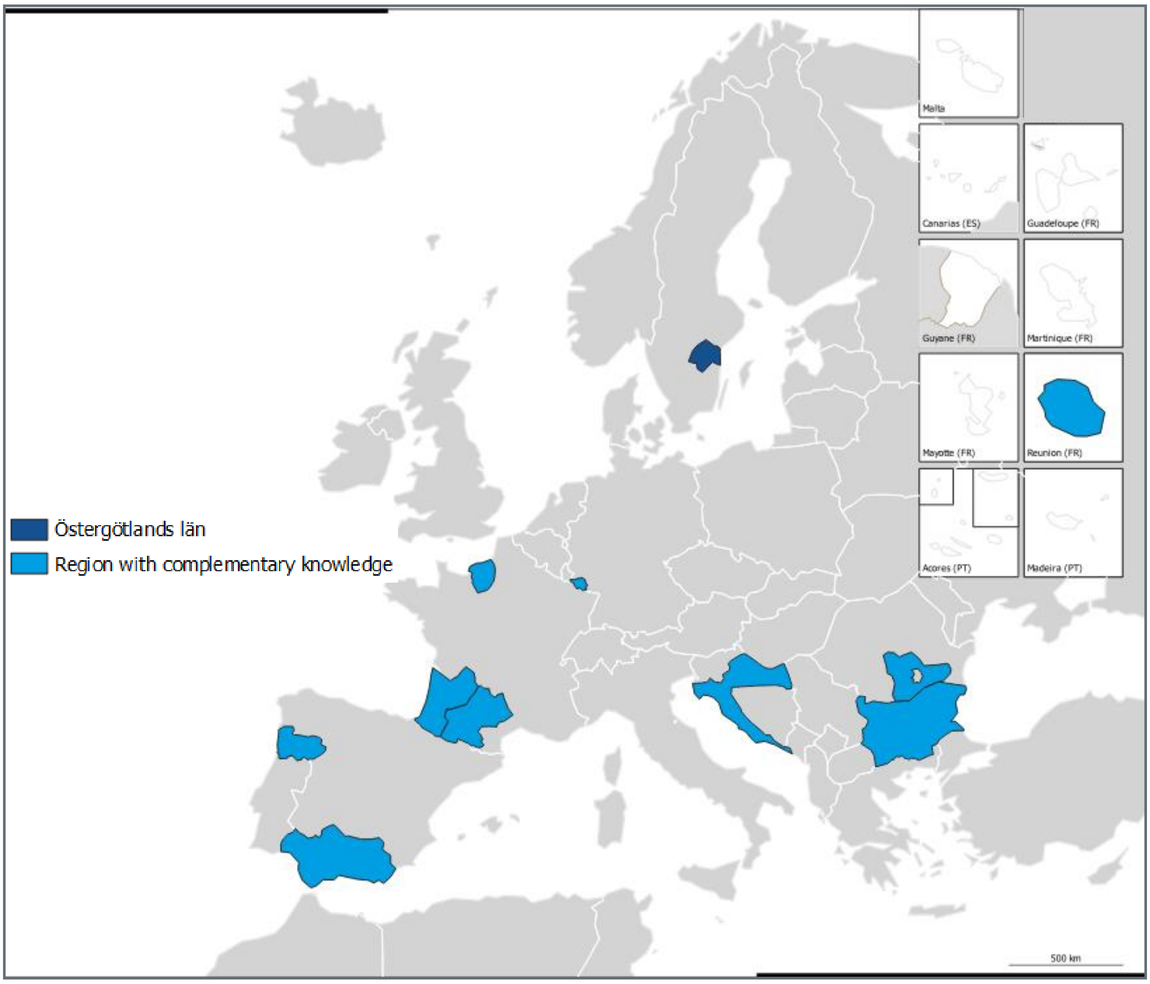
[24] Boschma, R. (2005): Proximity and Innovation : A Critial Assessment. In Regional Studies, vol.39 (1)

[25] Prognos & CSIL (2021): Study on prioritisation in Smart Specialisation Strategies in the EU. Study on behalf of the European Commission. Available under: https://ec.europa.eu/regional_policy/en/information/publications/studies/2021/study-on-prioritisation-in-smart-specialisation-strategies-in-the-eu (last access 31.01.2022)

keywords of the priority area “Advanced manufacturing processes” of the Spanish Region Communidad Valenciana.

Based on this database on complimentary knowledge in the priorities for each of the 185 S3 other Member States/regions for cooperation can be derived. As an exemplary overview the map below shows other regions with complementary knowledge in their priorities for the Swedish region Östergötlands län and its priority area “Smart, secure and robust connected products and systems”. In this specific case of Östergötlands län, 10 different priority areas from different regions have been identified. Table 16 in the Annex provides specific information about the respective regions and their priority areas.

Map 1: Illustrative overview of interregional cooperation potential for Östergötlands län and its priority are “Smart, secure and robust connected products and systems”

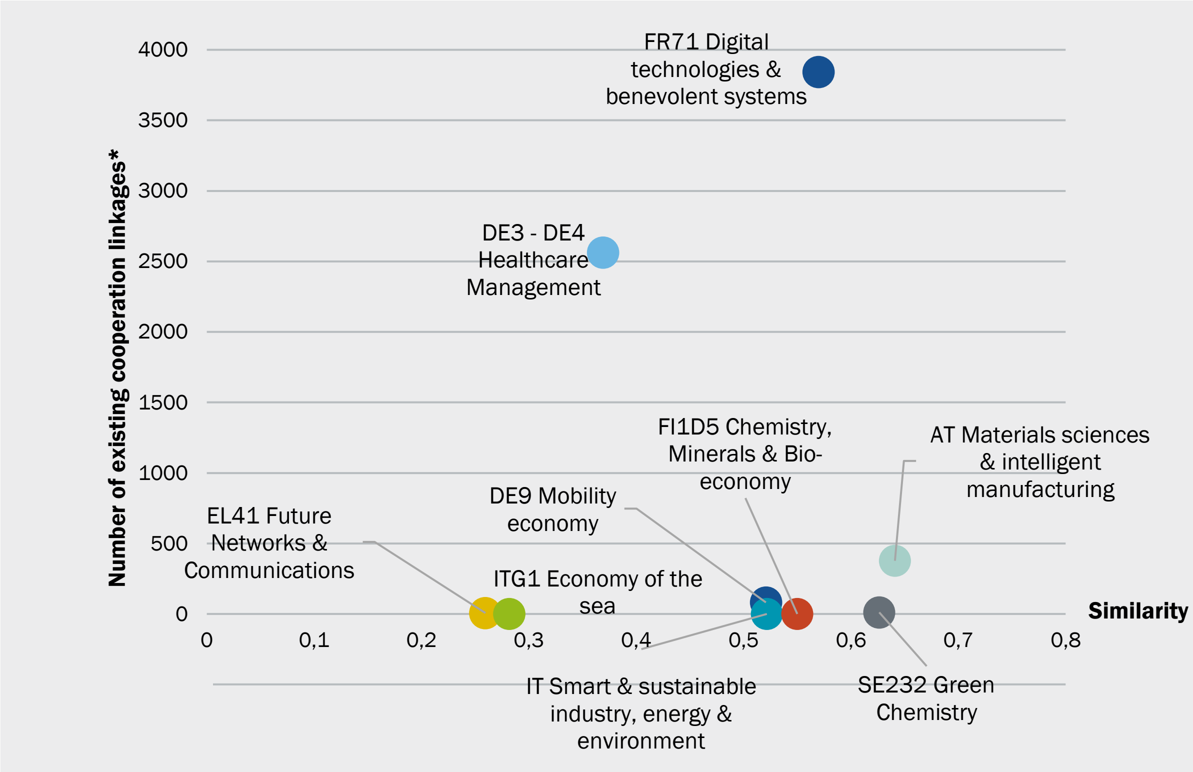


Source: Prognos/CSIL (2022). n = 11 regions.

Moreover, the identified potential linkages between the 185 S3 and their respective priority areas can further be examined from their **degree of similarity as well as the number of existing cooperation linkages** (based on patents) between the regions. The reasoning for this is that for instance for the Spanish region Communidad Foral de Navarra and its priority area “Health” the priority area “Information and Communication Technologies (ICT), Green IT and Smart Products” of the German region Baden-Württemberg provides some complimentary knowledge. However, thematically these two priority areas do not share a high thematic similarity. Hence, Slovakia and its priority area “Population health and medical technologies” might provide a better starting point for interregional cooperation since these are thematically closer priorities. This is also related to the discussion on proximity as a factor for interregional cooperation as presented in Section 2.1. By accounting for the number of existing cooperation linkages (based on patents) between the regions more fine-tuned information for the respective interregional cooperation potential can be derived. Based on these four different combinations of potential for interregional cooperation emerge which will be presented in the following. Overall, around 52% of the identified possible cooperation linkages in the priority areas show a low similarity and 48% show a high similarity. For more than 95% of these potential cooperation linkages a low or non-existing number of existing cooperation linkages have been found. Correspondingly, for less than 5% of these potential cooperation linkages a high number (more than 20) of existing cooperation linkages in patents have been found (see also Section 2.1).

The following Figure 17 provides an illustrative overview of selected regions with potential for interregional cooperation for the German region North Rhine-Westphalia and its priority area "Energy & Environmental Economics" thereby accounting for different levels of similarity and existing cooperation linkages. This figure underlines that for the majority of the identified potential for cooperation the number of existing cooperation linkages is low or non-existing. This also holds true for the majority of the identified potential cooperation linkages in the developed database which further substantiates the need and untapped potential for interregional cooperation in the context of S3. In the illustrative example of North Rhine-Westphalia and its priority area "Energy & Environmental Economics" it can be seen that several identified potential interregional cooperation linkages are characterised by a small degree of similarity and low numbers of existing cooperation linkages (e.g., with North Aegean and its Future Networks and Communications). With the German region of Berlin / Brandenburg a number of cooperation linkages based on patents do already exist but the degree of similarity between the two priority areas at hand is rather low. A relatively high degree of similarity can be identified between North Rhine-Westphalia and its priority area "Energy & Environmental Economics" and "Digital technologies and benevolent systems" of the French region Rhône-Alpes. At the same time, there is a high number of existing cooperation linkages between the two regions. For other regions like Västra Götalands län, Central Ostrobothnia and the national Italian strategy a low number of existing cooperation linkages emerges. At the same time the respective priority areas ("Green Chemistry", "Chemistry, Minerals and Bio-economy" and "Smart and sustainable industry, energy and environment") show a high degree of similarity to the priority area of North Rhine-Westphalia. Based on this it can be deducted that there is untapped potential for interregional cooperation with the aforementioned regions and their priority areas. However, it should be noted that a low or non-existing number of cooperation linkages in patents does not mean that no collaboration is happening between the regions since not all inventions are patented and collaboration can also occur in science (see also Section 2.1).

Figure 17: Overview of selected regions with potential for interregional cooperation with the S3 North Rhine-Westphalia and its priority area “Green Economy”, by similarity and number of existing cooperation linkages*



Source: Prognos/CSIL (2022). * based on patents. Note: Degree of similarity is shown on the abscissa and the number of cooperation linkages on the ordinate. AT: Austria; DE3–DE4: Berlin/Brandenburg; DE9: Lower Saxony; EL41: North Aegean; FI1D5: Central Ostrobothnia; FR71: Rhône-Alpes; IT: Italy (national strategy); ITG1: Sicily; SE232: Västra Götalands län.

Overall, these analyses have demonstrated that the 185 Member States/regions and their **S3 show profound potential for interregional cooperation**. In a first step, it is demonstrated that the general nature of this interregional cooperation potential is rather broad. However, cooperation projects are usually conducted on a specific issue. This can be exemplified when looking at the previous case of Östergötlands län and its priority area “Smart, secure and robust connected products and systems”. This priority area, like many others, is rather broad and includes a variety of overarching topics ranging from smart products, over sensors to electronics. In this regard, the developed list of possible linkages between the 185 S3 based on complimentary knowledge in their priorities provides rather a first orientation for finding suitable partners for interregional cooperation. Moreover, the further examination of the potential for interregional cooperation shows that for the majority of the regions no or only low numbers of cooperation linkages based on patents can be identified. In case there are interregional cooperation linkages the relevance of proximity emerges meaning that regions often collaborate only with regions nearby or within the same country. Based on this it can be concluded that there is a vast potential for interregional cooperation that is largely untapped.

The findings of this chapter can be complemented by findings from the JRC which finds that (especially for lagging regions) the potential for participating in interregional cooperation is not fully exploited and that less-developed regions are rather underrepresented in interregional collaboration activities.[26] Moreover, it is also found that key challenges for interregional collaboration are found in varying levels of socio-economic development, innovative capacities, and administration.

[26] JRC (2021): Interregional Cooperation and Smart Specialisation: a Lagging Regions Perspective. Available online: https://publications.jrc.ec.europa.eu/repository/handle/JRC124118 (last accessed on 09.11.2022) and JRC (2014): Interregional Collaboration in Research and Innovation Strategies for Smart Specialisation (RIS3)

Table 2: Overview of cooperation potential by S3 priority area, by linked overarching topics

Overarching Topics	Aerospace & Defense	Agrofood & Bioeconomy	Blue Growth	CleanTech & Circular Economy	Construction	Energy & Energy Storage	Fashion, Media & Creative Industries	Health & Life Sciences	ICT & Industry 4.0	Materials & Advanced Manufacturing	Mobility & Logistics	Other	Social Innovation & Welfare	Tourism, Cultural & Creative Industries
Aerospace & Defense	3%	1%	1%	1%	1%	1%	1%	0%	2%	1%	2%	1%	1%	1%
Agrofood & Bioeconomy	14%	25%	19%	21%	18%	20%	12%	15%	12%	19%	16%	19%	21%	19%
Blue Growth	4%	4%	6%	4%	4%	4%	3%	3%	3%	4%	4%	3%	4%	4%
CleanTech & Circular Economy	7%	7%	7%	8%	8%	8%	5%	4%	5%	7%	6%	6%	6%	6%
Construction	3%	2%	2%	3%	3%	3%	1%	1%	2%	2%	2%	2%	1%	1%
Energy & Energy Storage	12%	10%	11%	12%	13%	15%	4%	3%	8%	9%	10%	9%	6%	6%
Fashion, Media & Creative Industries	1%	1%	1%	1%	1%	1%	4%	2%	3%	2%	2%	2%	2%	2%
Health & Life Sciences	4%	11%	10%	9%	5%	5%	17%	34%	14%	11%	8%	13%	18%	17%
ICT & Industry 4.0	17%	9%	13%	11%	13%	12%	25%	14%	25%	11%	15%	13%	13%	15%

Materials & Advanced Manufacturing	15%	15%	13%	15%	17%	15%	12%	12%	10%	19%	16%	15%	13%	13%
Mobility & Logistics	16%	8%	11%	10%	11%	11%	9%	6%	11%	10%	14%	10%	9%	10%
Other	2%	2%	1%	2%	2%	2%	1%	1%	2%	2%	2%	1%	2%	1%
Social Innovation & Welfare	1%	1%	1%	1%	0%	0%	1%	1%	1%	1%	1%	1%	0%	1%
Tourism, Cultural & Creative Industries	2%	3%	3%	3%	3%	3%	5%	4%	3%	3%	3%	3%	4%	4%
Total number of links	**1736**	**29698**	**5918**	**10192**	**3452**	**16375**	**2569**	**20062**	**21957**	**23072**	**15628**	**2401**	**1112**	**5216**

Source: Prognos/CSIL (2022). Note: overarching topics addressed by the S3 priority areas have been established in the predecessor study[27]. The shares show the number of potential linkages for cooperation from a given overarching topic to a respective overarching topic divided by all the potential linkages to that respective overarching topic.

[27] Prognos & CSIL (2021): Study on prioritisation in Smart Specialisation Strategies in the EU. Study on behalf of the European Commission. Available under: https://ec.europa.eu/regional_policy/en/information/publications/studies/2021/study-on-prioritisation-in-smart-specialisation-strategies-in-the-eu (last access 16.05.2022)

4. Assessment of opportunities related to the green and digital transition

Overview of key findings

- **Overall, the priority areas of the 185 S3 of the 2014-2020 period show significant connections to topics of the Twin Transition**. On a general level, more than 700 out of 1018 (69%) priority areas have a connection to topics of the green and digital transition. These connections vary in their quality since some priority areas can completely address a certain topic while others only address certain aspects of a certain topic. Out of all identified linkages between priority areas and the topics of the green and digital transition 20% are classified as having a high relevance. The majority of these identified links with a high relevance concern topics of the green transition (63%) compared to topics of the digital transition (34%). The largest connections between the S3 priorities and topics of the Twin Transition can be found in rather general overarching domains such as ICT, Bioeconomy, or Renewable Energy.

- **The ERDF R&I projects implemented during the 2014-2020 period considerably contributed to the Twin Transition:** 35,157 out of the 49,749 projects (71%) that were connected to the priority areas in the predecessor study are generally linked to topics of the green and digital transition. Correspondingly, around €14.9 billion (75%) of the project budget that has been channelled into the priority areas can be generally linked to topics of the Twin Transition. With regards to priority areas that show a high relevance to the topics of the green and digital transition 17,861 of the 49,749 projects (36%) can be connected to such priority areas. More projects can be linked to priority areas with a high relevance to the green compared to the digital transition.

- **The overall regional differences in the contribution of S3 to the green and digital transition are rather small.** There is only a small variation in the relevance of the linkages between the S3 priorities and the topics of the Twin transition among the different regions. Nonetheless, some regional differences on certain topics (e.g., “Bioeconomy” or “Fair, healthy & environmentally-friendly food system”) have been detected. Regarding the projects linked to priority areas among the EU13 Member States/regions on average more projects and budget is linked to priority areas with a high relevance to the green Transition. Among the EU15 Member States/regions more projects and budget have been linked to priorities with a high relevance to the digital transition.

This Chapter has the objective of providing relevant insights regarding the potential of smart specialisation strategies in the context of the green and digital transition. Thereby, one focus lies on examining how S3 can contribute to key Commission priorities, in particular the Twin Transition. Moreover, this Chapter aims at exploring the opportunities of S3 to contribute to the Green Deal in rural, less developed, and peripheral regions. In the following first the identified priorities relevant to the green and digital transition are analysed followed by the projects relevant to the Twin Transition. Next to that the identified priorities and projects are analysed from a granular regional perspective.

4.1 S3 priorities relevant to the green and digital transition

The green and digital transition are both connected to profound challenges of the economy, society, and administration since, for instance, climate change and environmental degradation are posing existential threats to the world.[28] However, the Twin Transition should not only be perceived as a challenge since the transformative activities can boost competitiveness and modernise the European economy.[29] Moreover, both concepts are also deeply intertwined since digital solutions can also contribute to the green transition.[30] Against this background, it is crucial to assess how regional smart specialisation strategies and the priority areas set out therein can contribute to the Twin Transition.

The analysis shows that **with more than 700 out of 1018 (69%) priority areas[31] of the 185 S3 in the EU a majority of the priority areas have a connection to topics of the green and digital transition.** This demonstrates the potential of S3 to contribute to the Twin Transition. As described in Section 2.2 these connections between the S3 priorities and the topics of the green and digital transition were further classified regarding their relevance. As illustrated in Figure 35 in the Annex 20% of the identified linkages between S3 priorities and topics of the Twin Transition are classified as having a high relevance. 14% of the identified linkages are classified as having a medium relevance and with 66% most of the linkages show a low relevance to the topics of the Twin Transition. These linkages are scrutinised in more detail in the following thereby examining the correspondence of the priorities to the specific topics of the Twin Transition.

Figure 18 displays the shares of identified references with a high relevance between S3 priorities and topics of the Twin Transition. Overall, **275 priorities show a high relevance** to the topics of the green and digital transition. The majority of the identified links with a high relevance concern topics of the green transition (63%) compared to topics of the digital transition (34%). It is important to highlight that one priority area can have references to several topics of the Twin Transition. For instance, the priority area “Intelligent systems and digital data value chain” of the French region Midi-Pyrénées has strong references to both “ICT” and “Automation, Connectivity & Digital Infrastructure”. Many of the strong references between the S3 priorities are found in the topics “ICT” (18%), “Bioeconomy” (15%), “Renewable Energy” (15%), “Fair, healthy & environmentally-friendly food system” (11%), “Energy efficiency & resource efficiency” (11%) and “Automation, Connectivity & Digital Infrastructure”. These results are in line with the shares of overarching topics addressed by priority areas that were elaborated on in the predecessor study.[32] There the most addressed topics are “Agrofood & Bioeconomy” and “ICT & Industry 4.0.”

[28] https://ec.europa.eu/reform-support/what-we-do/green-transition_en (last access 04.04.2022)

[29] https://ec.europa.eu/reform-support/what-we-do/green-transition_en (last access 04.04.2022)

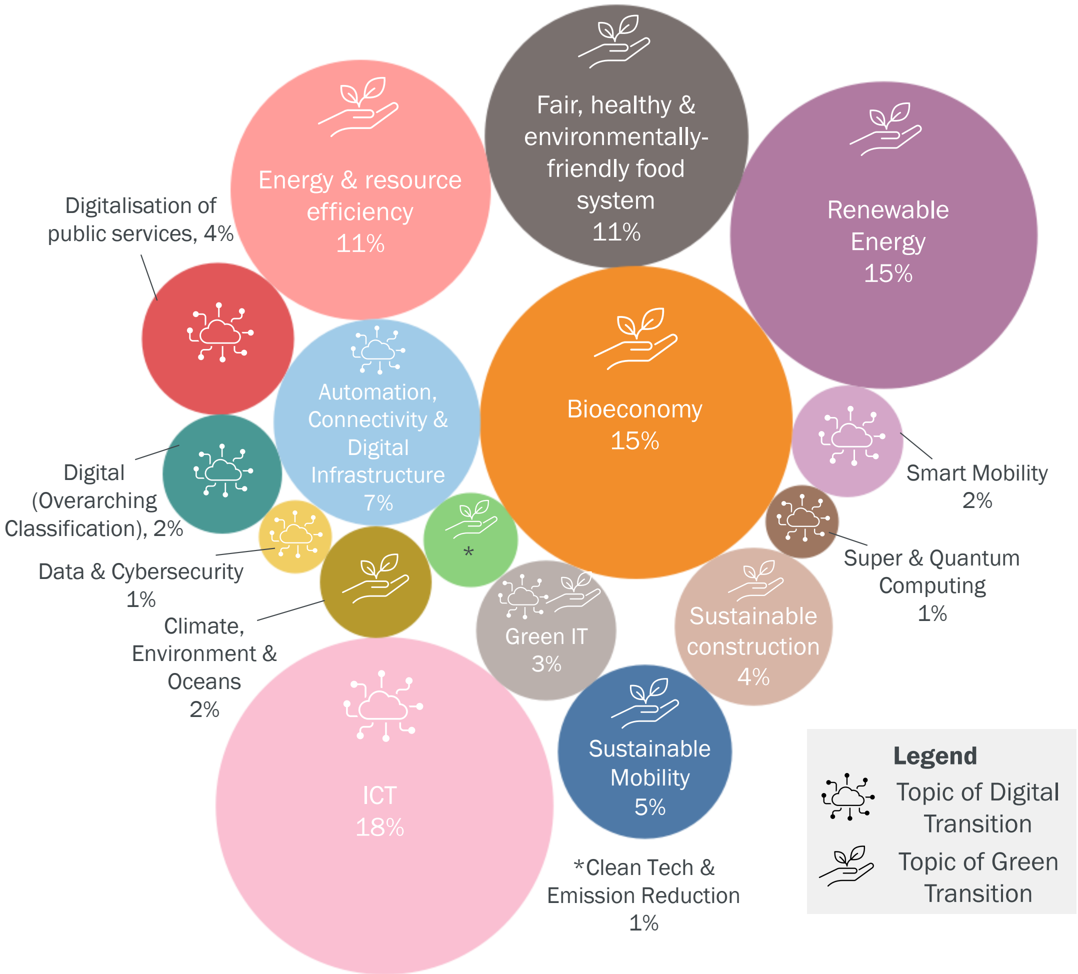
[30] https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/shaping-europe-digital-future_en (last access 04.04.2022)

[31] If a region had updated its strategy during the period 2014-2020, only the updated strategy is included in the analysis

[32] Prognos & CSIL (2021): Study on prioritisation in Smart Specialisation Strategies in the EU. Study on behalf of the European Commission. Available under: https://ec.europa.eu/regional_policy/en/information/publications/studies/2021/study-on-prioritisation-in-smart-specialisation-strategies-in-the-eu (last access 31.01.2022)

Other topics of the green and digital transition such as “Sustainable Mobility,” “Data & Cybersecurity” or “Climate, Environment & Oceans” show less frequently a high relevance for the S3 priorities. Some topics (e.g., Artificial Intelligence, Blockchain, Circular Economy) do not show a high relevance in the 185 S3 at all.

Figure 18: Topics of the Twin Transition addressed by S3 priorities, by share of identified references with high relevance



Source: Prognos/CSIL (2022), n=361 matches with a high relevance from 275 priority areas. One priority area can have multiple references to topics of the Twin Transition. If a region had updated its strategy during the period 2014-2020, only the updated strategy is included in the analysis. Note: no matches with a high relevance for Artificial intelligence, Blockchain, Circular Economy, Digital Skills, and Hardware

This changes when examining the S3 priorities that show a medium (see Figure 36 in the Annex) and a low (see Figure 37 in the Annex) relevance to topics of the Twin Transition.

Regarding the priorities with a **medium relevance to the Twin Transition 214 priority areas** are characterised by a medium correspondence to these topics (see Figure 36 in the Annex). Similar to the priorities with a high relevance here topics of the green transition (64%) are more frequently addressed compared to digital topics (31%). Regarding the specific address topics of the Twin Transition are more mixed picture emerges with the topics “Fair, healthy & environmentally-friendly food system” (20%) and “Energy efficiency & resource efficiency” being most frequently addressed. The other identified references with a medium relevance are distributed relatively homogenous among the diverse topics of the green and digital transition with shares between 0.4 and 8%.

570 priority areas have links with a low relevance to the topics of the green and digital transition (see Figure 37 in the Annex). Here, links to the digital transition (53%) play a larger role than links to the green transition (42%). This can be explained by the relatively high number of links between the S3 priorities and the topics “Automation, Connectivity & Digital Infrastructure” (17%) and ICT (13%). The shares for all the other topics vary between 0.3 and 7%. Topics like “Clean Tech & Emission Reduction” (3%), “Circular Economy” (6%), or “Data & Cybersecurity” (8%) are more prevalent among the links with a low relevance compared to the other classifications.

4.2 Regional perspective on opportunities of S3 priorities to contribute to the green and digital transition

In this section, the results that have been discussed before are analysed from a more regional perspective. Thereby, a focus lies on the potential of smart specialisation strategies in rural, less developed, peripheral regions in contributing to the European Green Deal. This analysis is of special interest as other research points out that rural regions have lower levels of innovation cooperation (based on co-patenting) compared to urban regions.[33]

Figure 19 shows an overview of the shares of matches to the topics of the green transition by their relevance and by different regional classifications. Likewise, Figure 20 shows the respective shares of the matches to the topics of the digital transition. The classifications that have been applied here is the classification by Cohesion Regions[34] and the urban-rural typology.[35] While the prior solely takes economic factors (GDP per capita) into account the urban-rural typology considers population. By assessing the regions from different regional typologies, a more holistic analysis can be carried out. Overall, there is only **small variation in the relevance of the linkages between the S3 priorities and the topics of the Twin transition among the different regions.**

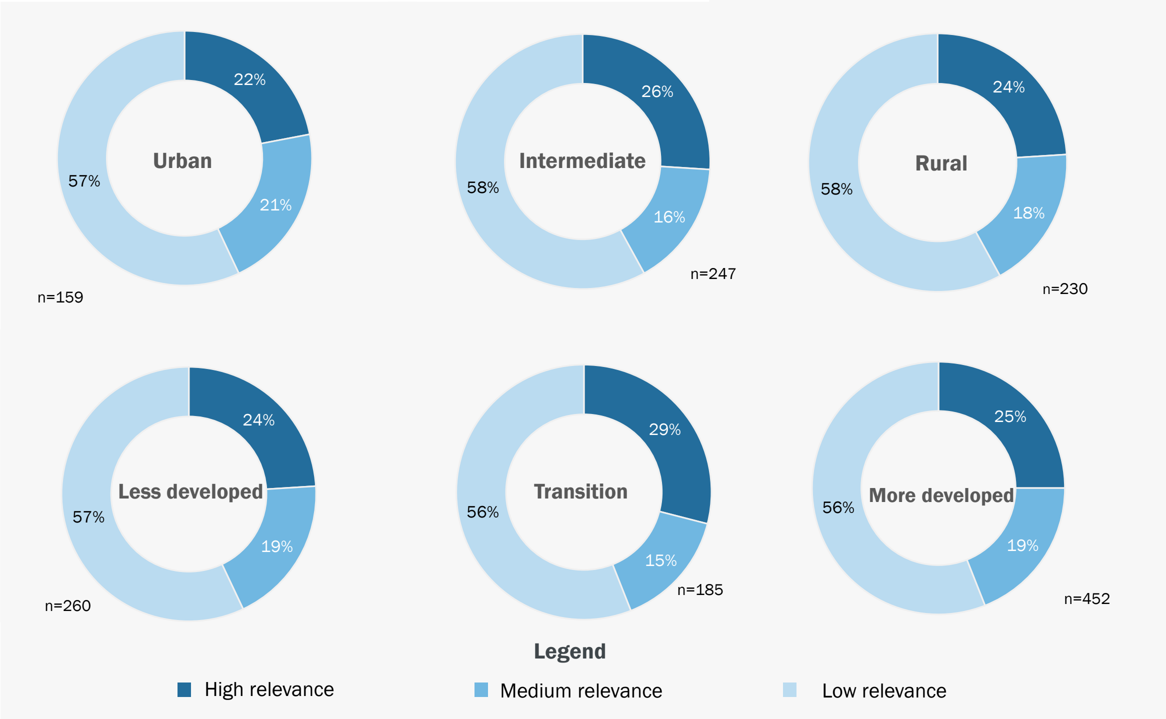
This overarching analysis is complemented by the shares of addressed topics by Cohesion Regions (Table 3) and Urban, Intermediate and Rural regions (Table 18 in the Annex). Here, some differences between the addressed topics by the different regions become visible. Regarding the **Cohesion Regions**, it can be stated that the topic “Automation, Connectivity & Digital Infrastructure” of the digital transition is more often linked with a high relevance to priority areas of More Developed Regions. In contrast to that are the topics” Energy efficiency & resource efficiency,” “Renewable Energy” and “Fair, healthy & environmentally-friendly food system” of the green transition more commonly addressed by Less Developed Regions by a high relevance. The prevalence of links with a medium relevance to the topic “Fair, healthy & environmentally-friendly food system” is significantly higher among the Less Developed compared to the More Developed Regions.

[33] Hjaltadóttir et al. (2020): Inter-regional innovation cooperation and structural heterogeneity: Does being a rural, or border region, or both, make a difference? In Journal of Rural Studies vol.74. Available online https://www.sciencedirect.com/science/article/abs/pii/S0743016718309100# (last access 12.04.2022)

[34] https://ec.europa.eu/eurostat/web/cohesion-policy-indicators/context/cohesion-regions (last access 05.04.2022)

[35] https://ec.europa.eu/eurostat/web/rural-development/background (last access 05.04.2022)

Figure 19: Matches to the topics of the green transition by urban-rural typology and Cohesion Regions

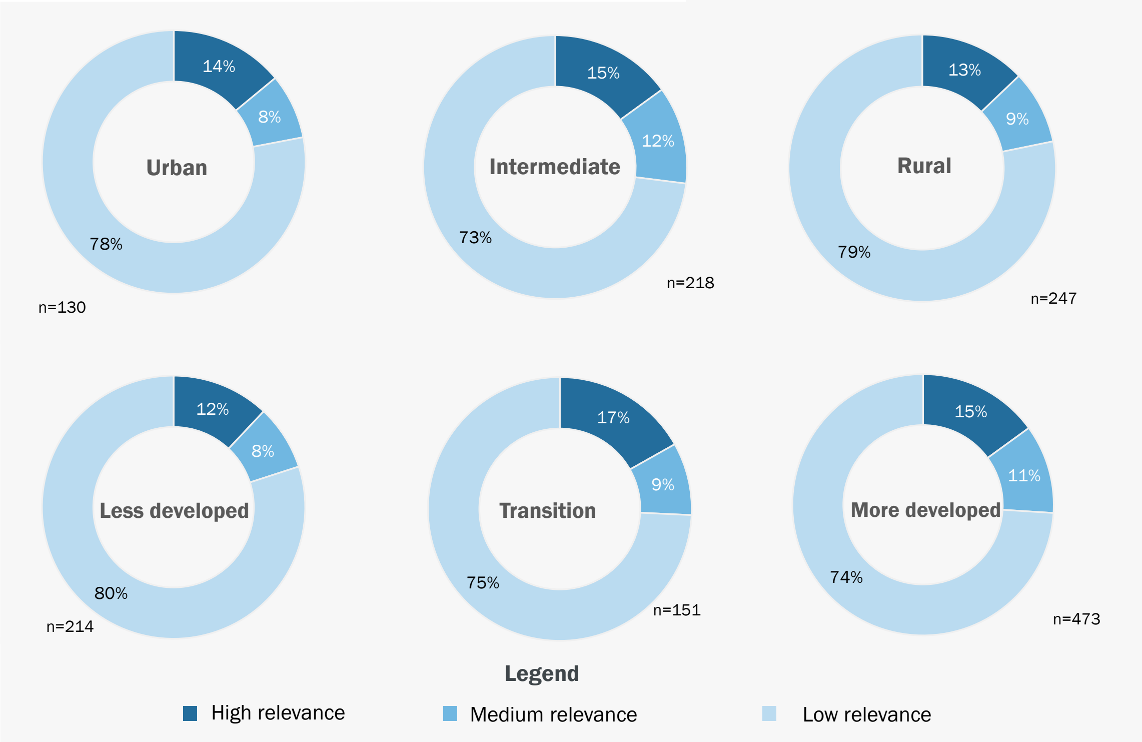


Source: Prognos/CSIL (2022). Note: if a region had updated its strategy during the period 2014-2020, only the updated strategy is included in the analysis. Note: The "n" varies from pie chart to pie chart as it only considers the S3 from the respective category. Urban-rural typology only for strategies on the NUTS2 and NUTS3 level

Considering the **Urban, Intermediate, and Rural regions** (Table 18 in the Annex) a slightly different picture of the relevance of the different topics in the respective regions emerges. The green transition topics of "Bioeconomy" and "Fair, healthy & environmentally-friendly food system" are more frequently linked with a high and medium relevance to priority areas in rural regions. In addition to the regional differences of the topic "Energy efficiency & resource efficiency" discussed among the Cohesion Regions (see above) this topic shows a higher relevance in the priorities of urban regions. The same holds true for the topic "Renewable Energy" and to a smaller extent also for "Sustainable Mobility."

Overall, this regional analysis of opportunities of S3 priorities to contribute to the green and digital transition show that for some topics (like Bioeconomy" or "Fair, healthy & environmentally-friendly food system") some regional differences exist. However, on a general level are the differences in the opportunities of S3 priorities to contribute to the green and digital transition rather small.

Figure 20: Matches to the topics of the digital transition by urban-rural typology and Cohesion Regions



Source: Prognos/CSIL (2022). Note: if a region had updated its strategy during the period 2014-2020, only the updated strategy is included in the analysis. Note: The “n” varies from pie chart to pie chart as it only takes into account the S3 from the respective category. Urban-rural typology only for strategies on the NUTS2 and NUTS3 level

Table 3: Shares of addressed topics by Cohesion Regions

Topics	Share of links with high relevance			Share of links with medium relevance			Share of links with low relevance		
	More developed	**Transition**	**Less developed**	**More developed**	**Transition**	**Less developed**	**More developed**	**Transition**	**Less developed**
Artificial Intelligence	0%	0%	0%	2%	0%	0%	2%	1%	2%
Automation, Connectivity & Digital Infrastructure	9%	6%	2%	8%	7%	6%	18%	13%	17%
Bioeconomy	16%	16%	12%	5%	5%	7%	2%	1%	3%
Blockchain	0%	0%	0%	0%	0%	1%	0%	0%	0%
Circular Economy	0%	0%	0%	1%	5%	0%	6%	7%	5%
Clean Tech & Emission Reduction	1%	2%	1%	1%	2%	3%	2%	1%	5%
Climate; Environment & Oceans	3%	2%	0%	3%	5%	7%	6%	8%	9%
Data & Cybersecurity	1%	0%	1%	0%	5%	3%	9%	8%	6%
Digital Skills	0%	0%	0%	0%	5%	1%	1%	1%	1%
Digitalisation of public services	4%	4%	3%	5%	2%	3%	6%	7%	7%
Energy efficiency & resource efficiency	8%	10%	16%	22%	22%	16%	7%	7%	6%
Fair, healthy & environmentally friendly food system	8%	13%	13%	16%	15%	31%	6%	7%	7%
Green IT	4%	4%	1%	4%	2%	6%	4%	5%	5%

Hardware	0%	0%	0%	0%	0%	0%	2%	1%	1%
ICT	17%	16%	20%	9%	10%	6%	12%	13%	13%
Renewable Energy	12%	17%	19%	3%	5%	0%	4%	3%	5%
Smart Mobility	3%	2%	0%	1%	0%	1%	1%	1%	1%
Super & Quantum Computing	2%	0%	0%	1%	0%	0%	0%	0%	0%
Sustainable construction	5%	2%	3%	2%	2%	1%	4%	6%	3%
Sustainable Mobility	5%	2%	6%	7%	5%	4%	3%	6%	2%
Digital (Overarching Classification)	3%	2%	1%	9%	2%	3%	4%	4%	3%

Source: Prognos/CSIL (2022).

4.3 ERDF-TO1 projects relevant to the green and digital transition

Based on the identification of priorities relevant to the green and digital transition the projects relevant to the Twin Transition can be assessed and further examined from a granular regional perspective. The basis for this is found in the project database that was constructed in the predecessor study (see Section 2.2 for an overview of the methodological approach).

Overall, the analysis shows that **35,157 out of the 49,749 (71%)** that were connected to the priority areas in the predecessor study are generally linked to topics of the green and digital transition. More projects (25,700, 52%) are linked to priorities that are relevant to the green transition compared to projects linked to priorities with relevance for the digital transition (18,350, 37%). These figures underline the **contribution of the S3 and the respective ERDF-TO1 projects implemented during the 2014 – 2020 period to the Twin Transition**. When only considering the priority areas that show a high relevance to the topics of the green and digital transition. 17,861 of the 49,749 projects (36%) can be connected to such priority areas. A closer examination of these projects reveals that also more projects can be linked to priority areas with a high relevance to the green compared to the digital transition. Thereby, 13,348 out of the 49,749 projects (27%) that have been linked to the priority areas are connected to priorities with a high relevance to the green transition. The number of projects that have been linked to priorities with a high relevance for the digital transition is comparably lower. Here, around 4,300 projects (9%) have been linked to the respective priority areas.

On a general level, **slightly more projects from EU13 Member States/regions are corresponding to S3 priorities that are relevant to the green transition** (78%) compared to 70% in EU15 Member States/regions. Considering the regional classification in Cohesion regions this picture is more mixed. On average Transition Regions (80%) and Less Developed Region (76%) have more projects connected to priorities with a relevance to the green transition than More Developed Regions (62%). The opposite picture emerges for projects linked to priorities that are relevant to the digital transition. Here, Member States/regions in the EU15 have on average more connected projects (54%) than Member States/regions in the EU13 (50%). In line with this More Developed Regions (68%) have on average more projects linked to priorities that are relevant to the digital transition compared to Transition Regions (32%) and Less Developed Regions (53%). Regarding the urban-rural regional typology, it can be stated that in urban regions more projects (74%) are linked to priority areas with a relevance to the green transition compared to rural regions (57%). However, it needs to be highlighted that due to the granular approach of this regional classification it is only applied to the NUTS2 and NUTS3 regions. Other strategies on the NUTS0 level (e.g., Lithuania) and NUTS1 level (e.g., Bavaria) are not included in this analysis.

A closer examination of the regional differences by looking at the shares of linked projects by region (Map 2) shows that **the number of projects linked to priority areas that are relevant for the Twin Transition varies to a greater extent**. For instance, in Śląskie 75% of all 465 projects that have been connected to the respective priority areas are linked to priority areas with a relevance to the green transition. In Umbria on the contrary, only four out of all 107 to the priority areas connected projects are linked to priority areas that are relevant to the green transition. Considering the projects linked to priorities that are relevant to the digital transition a similar heterogeneity among the regions is found. The maps below also underline the higher average of projects linked to priority areas that are relevant to the green transition (panel a) compared to the digital transition (panel b). Map 6 in the Annex informs about the share of projects that are linked to priorities with a high relevance to topics of the Twin Transition.

Overall, around **€14.9 billion (75%) of the project budget that has been channelled into the priority areas can be generally linked to topics of the Twin Transition**. Similar to the number of projects most of the project budget is related to the green transition. Thereby, €11.2 billion out of the 19,8 billion (65%) project budget that has been channelled into the priority areas can generally be connected to priorities that are relevant to the green transition. Correspondingly, €8.9 billion (51%) can be linked to priorities that are relevant to the digital transition. Regarding the projects linked to priority areas with a high relevance for topics of the Twin Transition the linked budget amounts to €6.5 billion out of the 19,8 billion (33%).

Similar to the distribution of the connected projects on average the **budget share that is linked to priority areas that are relevant to the green transition is higher among EU13 Member States/regions** (59%) compared to the EU15 (55%). The share for the Cohesion Regions follows the shares of the linked projects. The share of budget linked to priority areas with a relevance to the digital transition is lower in the EU15 (39%) compared to the EU13 (49%). However, when only regarding priorities with a high relevance to the digital transition more of the project budget of EU15 Member States/regions (8%) is connected to such priority areas as opposed to EU13 Member States/regions (2%). The distribution of these budget shares among the different regions with relevant priorities to the Twin Transition is mostly a reflection of the share of the projects with a linkage to priority areas as discussed before (see Map 3). Map 7 in the Annex informs about the share of budget that are linked to priorities with a high relevance to topics of the Twin Transition

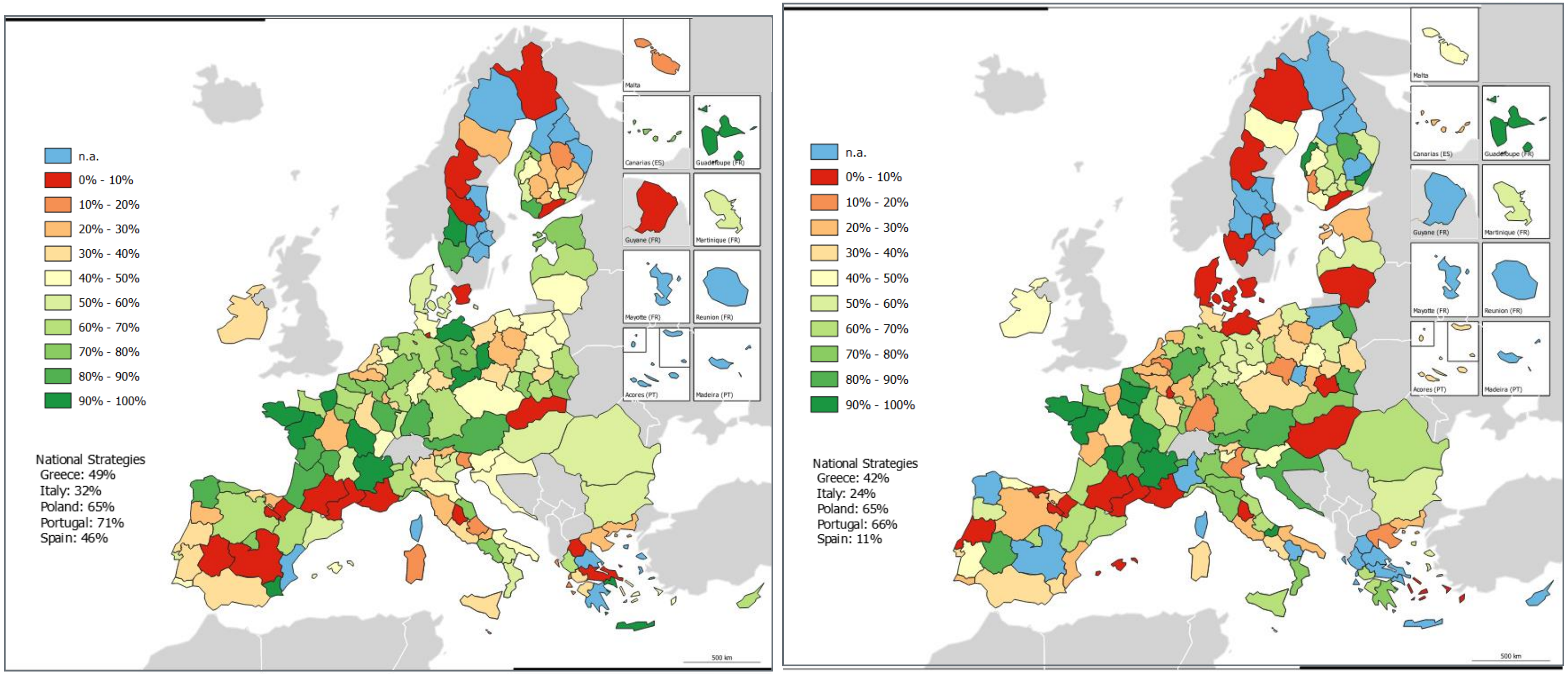
In conclusion, the analysis has shown that on a general basis there is a **great connection between the 185 S3 and the topics of the green and digital transition**. These references do however vary in their quality since some priority areas can completely address a certain topic of the Twin Transition while others only address certain aspects of a certain topic. On a general level, more priorities show a (strong) connection to topics of the green transition compared to topics of the digital transition. The regional analysis of the correspondence between S3 priorities and the Twin Transition has shown that on a general level the differences in the opportunities of S3 priorities to contribute to the green and digital transition are rather small. Nonetheless, some regional differences on certain topics (e.g., “Fair, healthy & environmentally-friendly food system”) have been detected. Regarding the implementation of the S3 around two third of the projects and project budget have been linked to priorities that are relevant to the Twin Transition. Thereby, more projects and budget has been connected to priorities relevant to the green transition. These findings are also in line with findings by the JRC that states “[…] even though the original S3s were not always initially designed with a strong green focus in mind, many regions have successfully used the S3 approach to promote innovation for green transformation”.[36] However, regarding the S3 process besides the identification of S3 priority areas and the implementation of projects the phase of S3 development (and especially the Entrepreneurial Discovery Process (EDP)) can also play a crucial role in contributing to the green transition.[37]

[36] JRC (2021): Fostering the green transition through Smart Specialisation Strategies. Available online https://publications.jrc.ec.europa.eu/repository/handle/JRC123169 (last accessed on 04.02.2022), p.2

[37] JRC (2021): Fostering the green transition through Smart Specialisation Strategies. Available online https://publications.jrc.ec.europa.eu/repository/handle/JRC123169 (last accessed on 04.02.2022)

Map 2: Share of projects that are linked to priorities areas that are relevant to topics of the Twin Transition

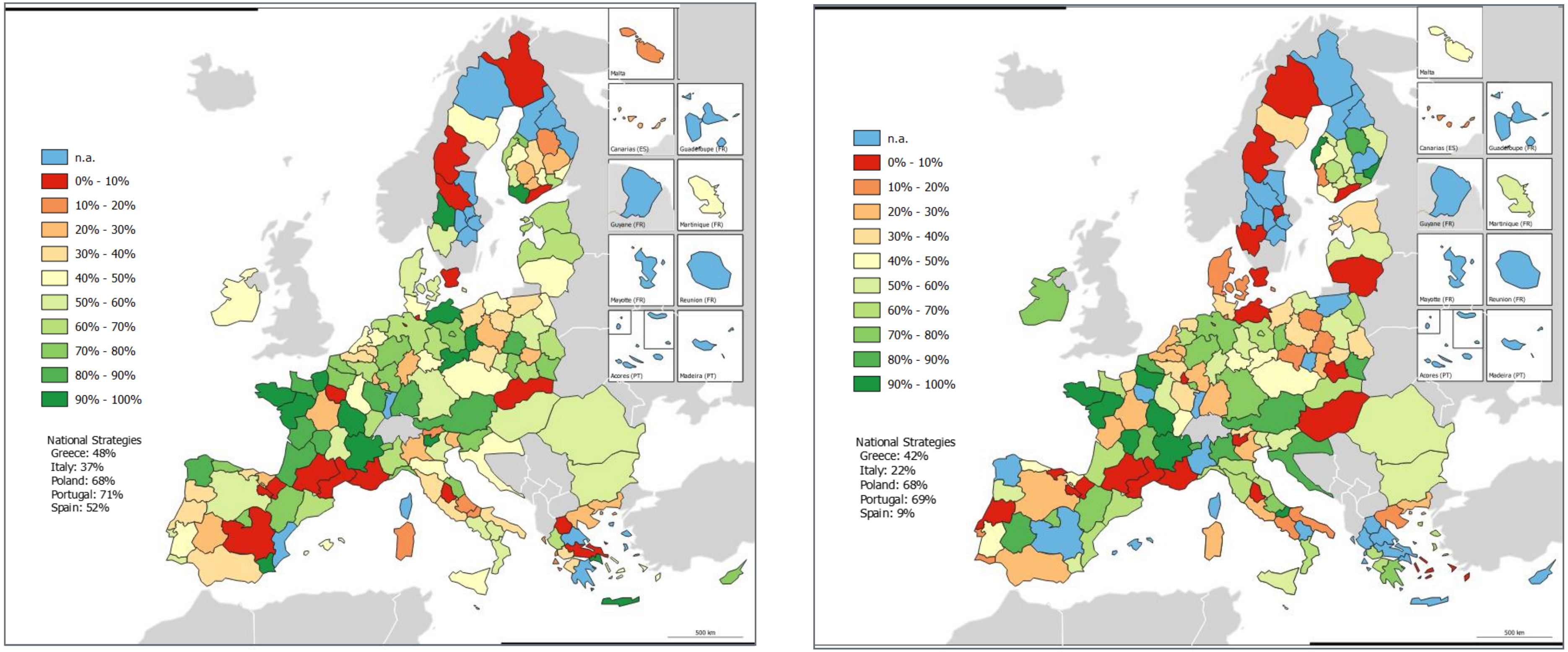
Panel a: Share of projects linked to green transition (left); Panel b: Share of projects linked to digital transition (right)



Source: Prognos/CSIL (2022). n = 181 regions. Note: The number show the share of project budget connected to priority areas that are relevant to topics of the green/digital transition relative to all successfully connected projects. Blue regions without available projects and/or priority areas that have been linked to topics of the green / digital transition. Data for Romanian regions is aggregated at the NUTS0 level. When a region is covered by both a national strategy and a sub-national strategy, the coloured area of the sub-national region refers to the correspondence of the sub-national strategy. The values for the national strategies are given by the figures next to the respective regions. These Member States are Italy, Greece, Spain, Poland, and Portugal.

Map 3: Share of budget linked to priorities areas that are relevant to topics of the Twin Transition

Panel a: Share of budget linked to green transition (left); Panel b: Share of budget linked to digital transition (right)



Source: Prognos/CSIL (2022). n = 181 regions. Note: The number show the share of project budget connected to priority areas that are relevant to topics of the green/digital transition relative to all successfully connected projects. Blue regions without available budgets and/or priority areas that have been linked to topics of the green / digital transition. Data for Romanian regions is aggregated at the NUTS0 level. When a region is covered by both a national strategy and a sub-national strategy, the coloured area of the sub-national region refers to the correspondence of the sub-national strategy. The values for the national strategies are given by the figures next to the respective regions. These Member States are Italy, Greece, Spain, Poland, and Portugal.

5. Assessment of links to Horizon 2020 & Horizon Europe

Overview of key findings

- **Overall, 64% of the analysed H2020 projects can be connected to priority areas of the respective S3.** The share of projects that can be connected to the priority areas is higher than the share of the linked budget. A more granular analysis of the share of H2020 projects linked to S3 priority areas shows that on a general level slightly more H2020 projects are matched in EU13 Member States/regions (66%) compared to EU15 Member States/regions (64%). From a more regional perspective, some variations in the shares of linked projects and budgets emerge. Western European regions (e.g., Germany, France) tend to have higher shares of projects linked to the respective priority areas.

- **At least 3,417 organisations (7% out of the 51,674 organisations identified in the ERDF project database) have also conducted projects funded by Horizon 2020 in the 2014 to 2020 period.** A relatively stark heterogenous regional distribution of organisations funded by both the ERDF and H2020 is identified. The share of organisations that have been funded by both the ERDF and Horizon 2020 is with around 80% among the EU15 Member States/regions significantly higher compared to the share of organisations in EU13 Member States/regions.

- **Topics that are addressed by Horizon Europe key funding areas are also found in many of the S3 priorities. For almost all priority areas linkages to Horizon Europe key funding areas are found.** This underlines the fundamental potential for creating synergies between S3 and the Horizon Europe funding programme in the future**.** Overall, the findings indicate great potential for synergies between the S3 and key Horizon Europe instruments such as the Partnerships, Joint Undertakings, Missions and KICs.

- **It is important to exploit the complementarity and to further create synergies between ERDF & Horizon funding.** The findings show a great overlap from topics addressed in the priority areas of the 2014-2020 period to Horizon funding. Moreover, the priority areas of the regions across the EU are not expected to change dramatically for the 2021-2027 period.

In this Chapter the 185 S3 are assessed regarding the links of their respective priority areas to Horizon funding. Two approaches are followed: on the one hand, the projects of Horizon 2020 are matched with the priorities of the 185 strategies that were collected by Prognos and CSIL in the previous study (Section 5.1). Here, the analyses aim at informing where the two concepts (S3 and H2020) converged in the past. On the other hand, key funding areas of the new Horizon Europe programme are matched to the priorities of the 185 strategies thereby assessing the correspondence as well as the possibility of creating synergies between S3 and the new Horizon Europe programme. Thereby, the aim is to see where the potential for the two concepts (S3 & Horizon Europe) can be found in the future (Section 5.2. Moreover, this Chapter addresses possible complementarities between the S3 and key Horizon Europe instruments such as the Partnerships, Joint Undertakings, Missions, and KICs.

5.1 Assessment of links to Horizon 2020

Horizon 2020 was the most important EU funding programme for research and innovation in the period 2014-2020 and had an overall budget of almost €80 billion.[38] Overall, more than 35,347 funded projects have been conducted covering project partners from Europe and

[38] https://ec.europa.eu/info/research-and-innovation/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-2020_en (last access 20.06.2022)

beyond.[39] Out of those 35,347 funded projects around 32,500 projects have been identified that have been conducted in at least one of the 185 regions for which S3 have been collected. At this point, it needs to be highlighted that in contrast to the ERDF project database one H2020-funded project can be conducted by several project partners that are located in different regions. For instance, the project "PAPILLONS" on plastic in agricultural production includes project partners from Belgium, Czechia, Germany, Greece, Spain, Finland, and Italy. This is important to keep in mind since in the matching process the projects have been matched on the level of the respective regions, i.e., one project can be connected to several regions. Hence the number of projects that is assessed in the following is higher than the 32,500 single-counted projects mentioned before (see also Section 2.3).

Overall, around 69,540 out of around 108,300 H2020 projects (64%) could be linked on a regional level to the priority areas of 183[40] S3. A more granular analysis of the share of H2020 projects linked to S3 priority areas shows that on a general level slightly more H2020 projects are matched in EU13 Member States/regions (66%) compared to EU15 Member States/regions (64%). Regarding the Cohesion Regions, the share of matched H2020 projects amounts to 63% in More Developed Regions, 72% in Transition Regions, and 66% in Less Developed Regions. This difference can at least partially be explained by the low shares of matched project and budget in multiple Swedish regions (see Map 4). This result can be linked to the small number of keywords in the descriptions of these priority areas. As mentioned before, a higher number of keywords increases the chance for a match (see also Section 2.2).

48% (€28.6 billion out of €60 billion) of the H2020 budget could be linked to the priority areas of the 183 S3. Similar to the analysis of the linked projects the linked H2020 budget is slightly higher in EU13 (51%) Member States/regions compared to EU15 (47%) Member States/regions. Correspondingly the share of linked H2020 budget in More Developed Regions amounts to 46%, to 59% in Transition Regions and to 52% in Less Developed Region. The smaller share of budget that could be linked to the S3 priority areas compared to the share of the linked projects can partially be explained by the wide span of the H2020 project budget. Whereas the budget of some H2020 projects totals around €1,100 other budgets amount to more than €30 million.

Map 4 displays both the share and the budget of H2020 projects that have been linked to S3 priority areas by Member State/region. This map shows that in general a relatively high share of H2020 projects was linked to the S3 priority areas across the different Member States/regions. However, it is noticeable that in many western European regions (such as Germany, France, Portugal) the shares of H2020 projects linked to the respective priority areas are comparably higher. Moreover, in some Eastern European regions (e.g., Poland, Greece) varying shares of linked projects and budgets are found. For instance, in the Polish region Wielkopolskie 80% of the H2020 projects could be linked to the respective S3. In Podlaskie on the other hand this share amounts to 17%. In addition, the share of linked projects and budgets in many Swedish regions is below the average. This can largely be explained by the quality of the priority area descriptions of those regions which often only contain a small number of keywords. As explained in Chapter 2 a higher number of keywords increases the chances of a match. However, it also needs to be noted that in some cases the shares between the different regions are exaggerated by varying numbers of H2020 projects.

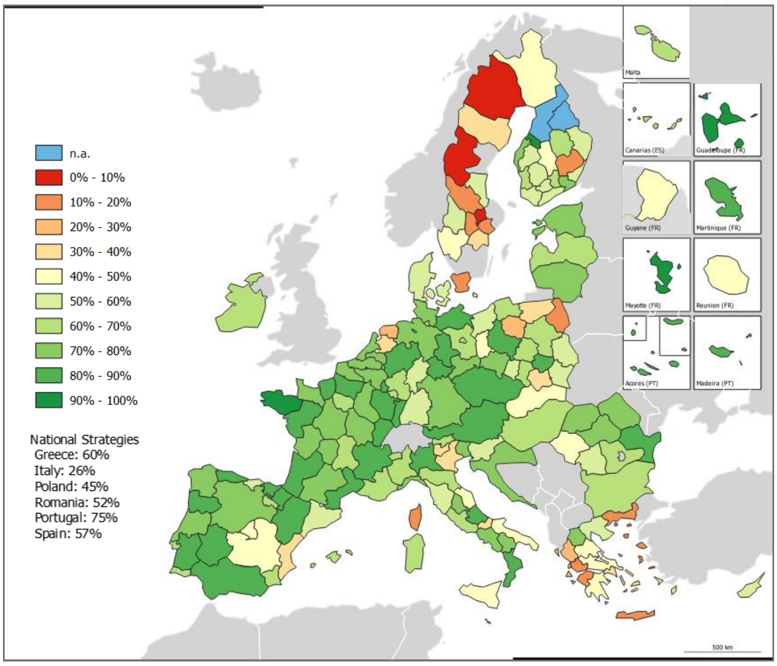
[39] see also https://webgate.ec.europa.eu/dashboard/sense/app/93297a69-09fd-4ef5-889f-b83c4e21d33e/sheet/erUXRa/state/analysis (last access 13.04.2022)

[40] The difference between the number of S3 (185) and the total number of Member States/regions that are used for this analysis exists because for some regions no H2020 projects were available (Northern Ostrobothnia and Kainuu)

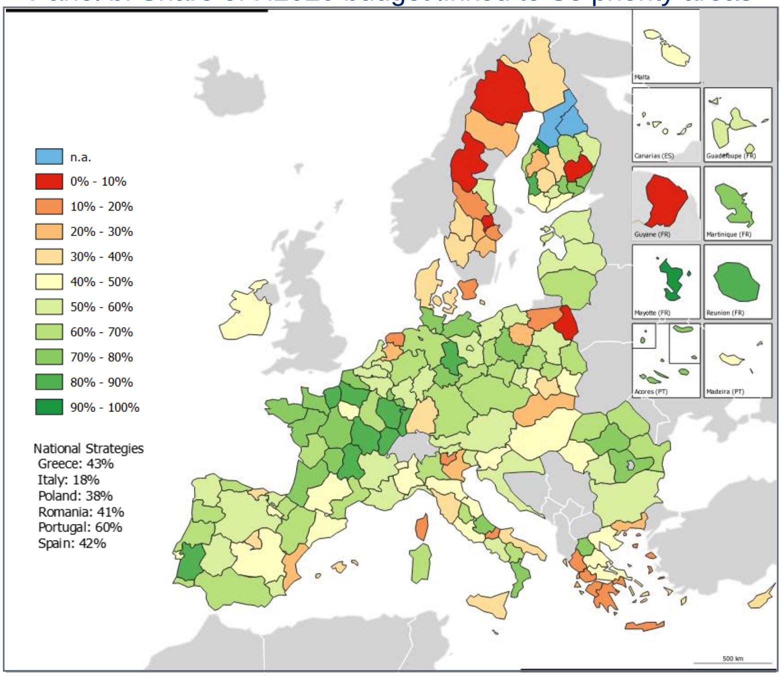
For instance, in Guyane only two H2020 projects were identified, which exacerbates the likelihood of either a very high or very low share of H2020 projects linked to priority areas.

Map 4: Share of H2020 projects and budget that have been linked to S3 priority areas

Panel a: Share of H2020 projects linked to S3 priority areas



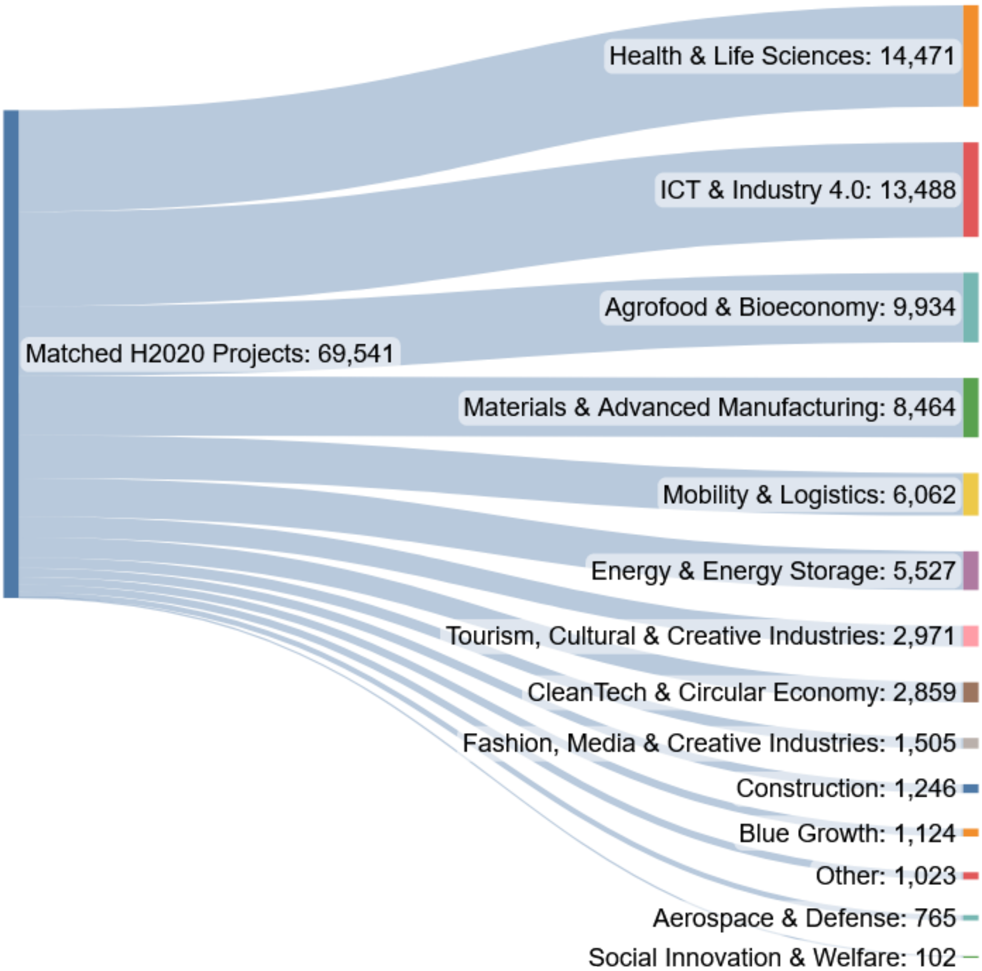
Panel b: Share of H2020 budget linked to S3 priority areas



Source: Prognos/CSIL (2022). n= 179 regions. Note: When a region is covered by both a national strategy and a sub-national strategy, the coloured area of the sub-national region refers to the correspondence of the sub-national strategy. The values for the national strategies are given by the figures next to the respective regions. These Member States are Italy, Greece, Spain, Poland, and Portugal No H2020 projects in Northern Ostrobothnia and Kainuu.

Additionally, the overarching topics addressed by the S3 priority areas that were identified in the predecessor study[41] are used to detect a potential focus in the H2020 projects that are linked to the S3 priority areas. Figure 21 shows the number of H2020 projects that have been linked to the S3 priority areas and grouped into the overarching topics addressed by these S3 priority areas. As outlined before, altogether around 69,500 projects were connected on a regional level to the S3 priority areas. The majority of these projects are assigned to the overarching topics **"Health "Life Sciences" (21%), "ICT & Industry 4.0" (19%), and "Agrofood & Bioeconomy" (14%)**. Compared to the relative importance of these overarching topics in the ERDF projects that have been elaborated on in the predecessor study the importance of "Health & Life Sciences" in the linked H2020 projects stands out. Moreover, the overarching topics "Materials & Advanced Manufacturing" as well as "Mobility & Logistics" demonstrate a relatively higher relevance for the linked H2020 projects.

Figure 21: Number of matched H2020 projects by overarching topics of S3 priorities



Source: Prognos/CSIL (2022). Note: The numbers are based on the projects that were successfully connected with the priority areas of 177 regions, meaning that projects that potentially fell into a certain overarching thematic area, were however not connected with a priority field, are not included here. When a region is covered by both a national strategy and a sub-national strategy, only the projects of the sub-national region are included.

[41] Prognos & CSIL (2021): Study on prioritisation in Smart Specialisation Strategies in the EU. Study on behalf of the European Commission. Available under: https://ec.europa.eu/regional_policy/en/information/publications/studies/2021/study-on-prioritisation-in-smart-specialisation-strategies-in-the-eu (last access 31.01.2022)

Overall, these findings indicate that at least from an overarching thematic perspective there is a connection between the projects funded under H2020 and the S3 priority areas chosen by the respective Member States/regions. In addition to the analysis of the correspondence between H2020 projects and the S3 priority areas in the following section, the focus lies on organisations that have conducted projects under both the ERDF and H2020.

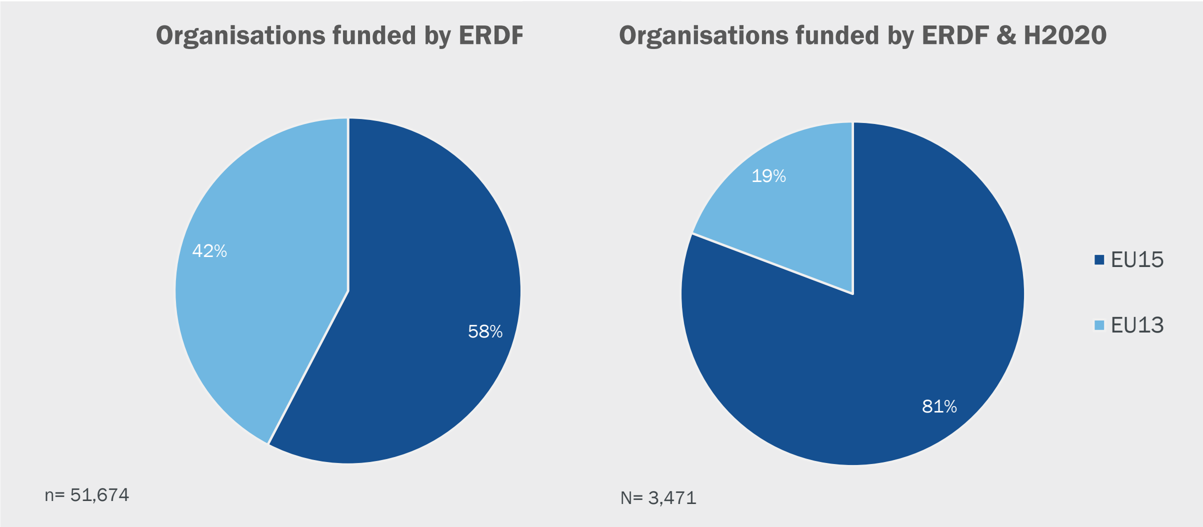
On organisations funded by the ERDF and H2020

Complimentary to the previous analysis of links between the S3 and H2020 projects in the following the organisations who participated in both funding programmes are scrutinised.

Overall, the analysis shows that out of the 51,674 organisations identified in the ERDF project database at least **3,417 (7%) organisations are also conducting projects funded by Horizon 2020** from 2014 to 2020. A closer examination of these organisations by region sheds light on a rather heterogenous distribution among the different regions.

Figure 22 provides an overview of the organisations funded by ERDF and organisations that participated in both the ERDF and H2020 by EU15 Member States/regions and EU13 Member States/regions. On a general level around 60% of the ERDF funded organisations are located in EU15 Member States/regions and around 40% of the ERDF funded organisations are situated in EU13 Member States/regions. However, when examining the organisations that have participated in both funding programmes a different picture emerges. The **share of organisations funded by both ERDF and Horizon 2020 with around 80% among the EU15 Member States/regions is significantly higher** compared to the share of organisations in EU13 Member States/regions.

Figure 22: Overview of organisations funded by ERDF (left) and organisations funded by ERDF & H2020 (right) by EU15 / EU13



Source: Prognos/CSIL (2022). Note: all organisations that are included as beneficiaries in the ERDF TO1 project database as well as the H2020 project database are included in this assessment. See also Section 2.3 for a description of the methodology.

This observation is also in line with the classification of regions into **Cohesion regions**. Here, around 30% of the organisations funded by the ERDF are located in More Developed Region, 15% in Transition regions, and 55% in Less Developed Regions. When considering the location of organisations funded by both the ERDF and Horizon 2020 51% of the organisations are located in More Developed Region, 22% in Transition Regions, and 27% in Less Developed Region. A similar picture also emerges for the classification of regions by their

Regional Innovation Scoreboard performance. In regions that are classified as Innovation Leaders and Strong Innovators the share of organisations funded by both the ERDF and Horizon 2020 is higher compared to the overall share of organisations funded by the ERDF in these regions. These findings are in line with other research that indicates a positive correlation between the development level of regions and their capacity to attract EU funding.[42]

5.2 Assessment of links to Horizon Europe

Equipped with a budget of 95.5 billion euros until 2027 Horizon Europe is the most important EU funding programme for research and innovation.[43] As illustrated in Section 2.3 Horizon Europe is structured in three different pillars: Excellent Science, Global Challenges and European Industrial Competitiveness, and Innovative Europe. In the focus of the assessment of links between S3 priorities and Horizon Europe are the six thematic clusters of the pillar Global Challenges and European Industrial Competitiveness and the five mission areas. Against this background and the backward-looking analysis of the correspondence of S3 and H2020 in the previous Section the following analysis tries to outline possibilities of creating synergies between the concepts (S3 and Horizon Europe) in the future.

The analysis shows that for **almost all priority areas linkages between the priorities of the 185 S3 and the Horizon Europe key funding areas have been identified since for 924 out of 1018 (91%) of the priority areas** such linkages have been found. Figure 38 in the Annex provides an overview of these identified linkages by their relevance. For these linkages it is found that only a minority is characterised by a high relevance meaning that those priorities show great connections to the Horizon Europe key funding areas. 10% of those linkages are characterised by a medium relevance. The vast majority (85%) of the linkages are characterised by a low relevance. This can partially be explained by the varying levels of the Horizon Europe key funding areas. For instance, the broad and extensive thematic cluster “Digital, Industry, Space” has a lower likeliness of having a strong connections with a priority area compared to smaller and more concise clusters like “Health.” In the following, the identified linkages are be examined by the Horizon Europe key funding areas.

Figure 23 displays the number of identified references with a high relevance between S3 priorities and Horizon Europe key funding areas. Overall, in **130 priority areas with high relevant links** to the Horizon Europe key funding areas have been identified. The majority of those priority areas have been linked to the funding areas “Health,” “Soil health and food,” and “Food, Bioeconomy, Natural Resources, Agriculture & Environment”. Considering the high relevance of identified linkages in Section 4.1 to “Bioeconomy” and “Fair, healthy & environmentally-friendly food system” these results are not surprising. Other relevant key funding areas of Horizon Europe with a high relevance to S3 priorities are “Climate-neutral & smart cities”, “Digital, Industry & Space” and “Climate, Energy & Mobility”. Funding areas like “Cancer” or “Healthy oceans, seas, coastal and inland waters” are less frequently linked with a high relevance which can be explained since the S3 priority areas are rarely focused on such specific areas.

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[42] Varela-Vázquez, P. et al. (2019): The uneven regional distribution of projects funded by the EU Framework Programmes. In Journal of Entrepreneurship, Management and Innovation, vol. 15 (3). Available online https://jemi.edu.pl/vol-15-issue-3-2019/the-uneven-regional-distribution-of-projects-funded-by-the-eu-framework-programmes (last access 07.04.2022)

[43] https://ec.europa.eu/info/research-and-innovation/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en (last access 05.04.2022)

Figure 23: Overview of the number of identified references with a high relevance between S3 priorities and Horizon Europe key funding areas

Source: Prognos/CSIL (2022). n=130 priority areas. One priority area can have multiple references to topics of the Twin Transition. No links with high relevance were identified for the topic “Civil Security for Society”.

Considering the number of identified references with a **medium relevance** the most important key funding areas are “Soil health and food,” “Climate-neutral and smart cities” and “Food, Bioeconomy, Natural Resources, Agriculture & Environment” followed closely by “Health,” “Climate, Energy & Mobility” and “Digital, Industry & Space” (see Figure 39 in the Annex). For several other key funding areas like “Culture, Creativity & inclusive Society” and “Adaptation to climate change including societal transformation” are less frequently linked to the S3 priority areas.

892 priority areas that have low relevance to the Horizon Europe key funding areas have been identified (see Figure 40 in the Annex). Here, a different picture compared to the identified linkages with a low relevance emerges. Among the key funding areas that have been linked with low relevance to the S3 priorities the majority of funding areas are rather broad and general. This especially concerns the three funding areas with the highest number of identified links: “Digital, Industry & Space”, “Climate, Energy & Mobility,” and “Food, Bioeconomy, Natural Resources, Agriculture & Environment”. As described before this means that many of the priority areas contain keywords relevant to key Horizon Europe funding areas but the overall similarity of the priority and funding areas is low.

Overall, it can be concluded that on a general level **topics addressed by Horizon Europe key funding areas are also found in many of the S3 priorities**. Nonetheless, rather a few priority areas show strong connections to key horizon funding areas. Based on these findings it can be deducted that generally there is fundamental potential for creating synergies between S3 and the Horizon Europe funding programme in the future. However, a higher specificity between the different thematic clusters and mission areas of Horizon Europe is found in a relatively smaller number of priority areas of the 185 Member States/regions. Moreover, these findings indicate great potential for synergies between S3 and the Knowledge and Innovation Communities (KIC).[44] These KICs are partnerships that bring together different actors with goals such as developing innovative products and services in different areas. Against the backgrounds of the findings especially high potential for synergies can be found in the KIC on Health (EIT Health[45]), Food (EIT Food[46]), Climate (EIT Climate-KIC[47]) as well as Digital (EIT Digital[48]). In addition to the KICs the correspondence between the S3 and the Horizon Europe key funding areas also indicated a high relevance for the five areas of the European Partnerships.[49] Correspondingly, potential for synergies between the S3 and joint undertakings of the Horizon Europe programme can be identified. Out of the nine institutionalised partnerships[50] that have been established especially the ones on "Circular Bio-based Europe," "Global Health EDCTP3", "Innovative Health Initiative", "Key Digital Technologies" as well as "Smart Networks and Services" can be deemed relevant.

[44] see https://eit.europa.eu/our-communities/eit-innovation-communities (last access 12.04.2022)

[45] https://eithealth.eu/ (last access 12.04.2022)

[46] https://www.eitfood.eu/ (last access 12.04.2022)

[47] https://www.climate-kic.org/ (last access 12.04.2022)

[48] https://www.eitdigital.eu/ (last access 12.04.2022)

[49] The five areas are "Health", "digital, industry and space", "climate, energy and mobility", "food, bioeconomy, natural resources, agriculture and environment" and partnerships across these themes. See https://ec.europa.eu/info/research-and-innovation/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/european-partnerships-horizon-europe_en (last access 12.04.2022)

[50] https://www.consilium.europa.eu/en/press/press-releases/2021/11/19/council-commits-to-nine-institutionalised-european-partnerships/ (last access 12.04.2022)

6. Analysis of related vs unrelated diversification

Overview of key findings

- S3 requests Member States/regions to focus on investing in a limited number of priorities that could potentially create new sources of competitive advantage. However, **neither the academic literature nor policy documents prescribe how many priority areas** should be identified by an S3, or **to what extent these priorities should be similar (or "related") to existing technological assets**, or different to them to promote more diversification. The S3 approach requires Member States/regions to strike a **balance between the risks and the benefits of investment concentration and diversification**, by considering their existing capabilities and technological opportunities.

- **61% of the 162 S3 analysed achieved an appropriate level of thematic focus** (referred to as "S3 bandwidth"). In general, small Member States/regions with high R&D intensity are better able to prioritise. Lower quality of institutions is associated with better prioritising, i.e. focus on selected priorities, possibly indicating the stronger incentives of less advanced Member States/regions to comply with the S3 approach fully.

- **52% of the strategies selected priorities that fit well to the regional endogenous capacities and aim for a reasonable degree of diversification**. Stronger institutional capacities help achieve an appropriate degree of relatedness and keep ambition under control. Lower institutional capacities are instead associated with too related strategies, i.e. too close to the existing capabilities and strengths and with limited potential for diversification and creation of new engines of innovation-based growth.

- **Excessive ambition is behind the overly unrelated strategies**. These S3 tend to be more frequent when Member States/regions are poorly diversified (hence, do not have many options in terms of areas of strength) and when they do not invest strongly in R&D (i.e., their innovation efforts are limited). **In less developed Member States/regions, more prudence** (i.e., a strategy of more related diversification) **is** therefore **advisable** to avoid channelling resources into new "cathedrals in the desert" and pursue a more path-dependent and gradual transformation process.

6.1 Objectives and methodological design

This Chapter aims to answer this overall question: have regional and national authorities selected S3 priority areas that can be regarded as a good fit with respect to their profile, capabilities, and other fundamental socio-economic features? A good prioritisation approach can be defined on the basis of the bandwidth of the S3 (i.e., their degree of selectivity) and the degree of related or unrelated diversification pursued through the S3. Accordingly, this overarching question can be spelled out in two specific research questions:

1. **What determines an appropriate level of thematic focus (bandwidth) of S3?** Are the size of an economy/ the degree of economic diversification/ the level of development of the Member State/region, the resources available from EU funds, the characteristics of the EDP process, and institutional capacity good predictors of a good bandwidth of the S3 of EU Member States and regions?
2. **Under which conditions is a strategy of related or unrelated diversification a good option for a Member State/region?** How does this relate to the size, development level,

and diversification of an economy, the thematic focus of the S3 (i.e., bandwidth indicator), the characteristics of the EDP process, and institutional capacity of the Member State/region?

By answering these questions, this Chapter produces recommendations about what it is likely to be the most appropriate strategy in terms of thematic focus (bandwidth) and correspondence (relatedness) with the regional profile. This work builds on new data analysis and econometric estimations and on a refinement of the academic insights and concepts considered in the previous Study on Prioritisation in Smart Specialisation (Prognos and CSIL, 2021).The methodology applied consists of three phases:

- **Theory development**. Previous literature and policy documents by the European Commission identified a number of key principles and concepts that should drive the design of S3 across Member States/regions of the EU. Based on this literature, we formulate hypotheses about the *expected* thematic focus and degree of relatedness of S3, taking into account different features of Member States/regions in terms of technological opportunities and socio-economic characteristics.
- **Theory testing**. As previous studies show, the principles underpinning the S3 design were translated into different prioritisation approaches by EU Member States/regions, in terms of thematic focus and degree of relatedness to their specialisation profiles. In this second step, we compare the *degree of* bandwidth and diversification approaches expected from the theory with the *actual* ones adopted in the S3 published between 2011 and 2022. This assessment enables us to identify which S3 deviated from the theoretical expectations and in which way. An econometric analysis supports the understanding of the factors that determined the bandwidth and diversification approaches of S3 as well as the deviation from the theory.
- **Conclusions and policy recommendations**. Building on the two previous analytical steps, we provide conclusions as to which Member States/regions designed good or less good strategies and what determinant factors explained it. These conclusions enable us to draw recommendations to guide future policy action (discussed more extensively in Chapter 8).

The analysis and results obtained from the three phases above are provided in what follows.

6.2 Theory development

6.2.1 The principles of S3 investment concentration and diversification and four potential strategies

The concept of smart specialisation was developed in the context of the increasing attention to place-based approaches offering an alternative to centralised, top-down approaches to industrial and innovation policy. Smart specialisation offers itself as a policy approach that guides EU Member States and regions to create new capabilities and sources of competitive advantage (Foray, 2019, 2015; Foray et al., 2009). The S3 should be developed by involving national or regional managing authorities and stakeholders and ensuring a match between a **top-down process of identification of industrial/innovation policy objectives, and a bottom-up process** of emergence of candidate niches for smart specialisation, areas of experimentation, and future development, stemming from the discovery activity of entrepreneurial actors.

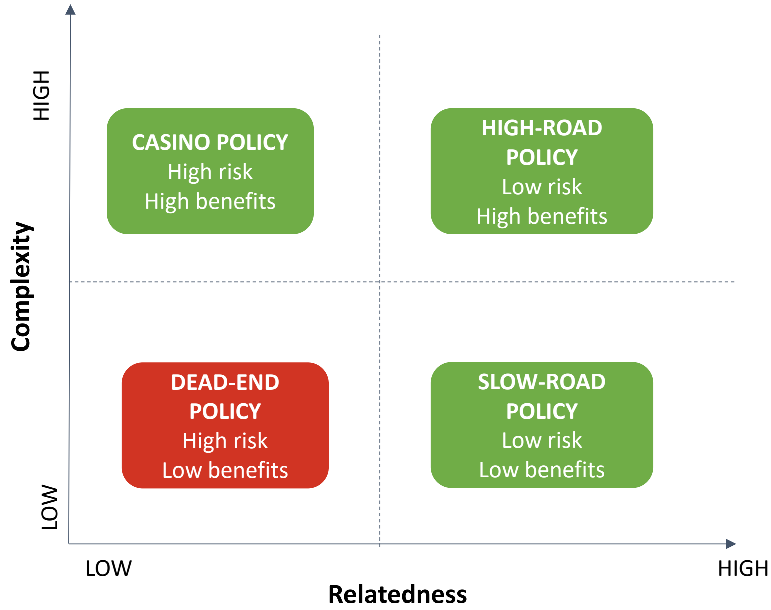
The S3 prioritisation approach requests Member States/regions to focus investments in a limited number of priorities. Concentration of resources is necessary to guarantee an impact and achieve critical mass (i.e., avoid spreading investments too thinly across too many areas) and ensure more effective budgetary management (European Commission, 2012). Concentrating resources around the same priority area would also allow Member States and regions to benefit from synergies, complementarities, and agglomeration effects which are essential for innovation (Foray, 2019). At the same time, S3 aim to enable Member States/regions to **diversify and create new sources of competitive advantage by building on their existing capabilities and strengths** (Foray, 2019, 2015; Foray et al., 2009; European Commission, 2014). As the European Commission (2012: p. 51) explains, "Priorities in RIS3 need to: Define concrete and achievable objectives. These objectives should be based on present and future competitive advantage." In designing their S3, Member States/regions are advised to avoid globally defined megatrends (Foray et al., 2018) and the establishment of "another biotech cluster" (Foray et al., 2011).

While the overall guiding principles of the S3 approach are well acknowledged, neither the academic literature nor policy documents prescribe how many priority areas should be identified by an S3, or to what extent these priorities should be similar (or "related") to existing technological assets, or different to them so as to promote more diversification.

Academic researchers developed a framework to **identify potentially beneficial smart specialisation strategies, based on the technological opportunities of the Member States/regions** (Balland et al., 2019; Crespo et al., 2017; Balland and Boschma, 2019a, 2019b). To do so, they intersected the concepts of relatedness density – i.e. the degree to which the technologies produced in the region are related to each other and to the existing capabilities and allow to diversify into new technologies easily – and knowledge complexity – i.e. the degree of sophistication of the technologies produced. Theoretically, Member States/regions would profit the most from reducing their reliance on low-value-adding activities and uncomplex technologies, by upgrading towards more complex activities. Diversification towards more complex technologies is relatively easier or less risky when it builds on related inputs (e.g. similar and complementary skills and knowledge) to those already present in the economy (Pinheiro et al., 2021). Hence, Member States/regions with higher technological relatedness are in an advantageous position. Because they already have competencies and knowledge in several fields, diversification into related fields is expected to be more accessible. Based on this framework, it is possible to define **four potential smart specialisation strategies** (see Figure 24):

1. Some regions face technological opportunities closely connected to their production structure (high relatedness) that simultaneously allow for upgrading (high complexity). These technological opportunities are in the top right quadrant of Figure 24. Balland et al. (2019) define the strategy that targets these technologies "**high road policy**". A strategy focused on these technological areas would be both beneficial and a safe bet. Not all regions have the luxury of opting for this strategy because this strategy is available only when regions possess capabilities in a good number of high-value-added areas.
2. Another scenario that yields high benefits in terms of sophistication of the production structure (high complexity) would require Member States/regions to accept higher risks. In such a scenario, diversification would be towards technological areas which are distant from the technological specialisation of the region (low relatedness). Due to the high risks involved with this strategy, this policy is referred to as "**casino policy**."
3. The region can also diversify into areas with strong linkages with its technological profile (high relatedness) but low benefits in terms of upgrading (low complexity). Balland et al. (2019) named this a "**slow road policy**".
4. Finally, the fourth and last scenario would lead regions to focus on technological opportunities that share few commonalities with existing production assets (low relatedness) and, at the same time, do not allow for upgrading into more promising technological areas (low complexity). Such a "**dead-end policy**" is not what regions should be after.

Figure 24: Potential S3 based on levels of regional technological relatedness and complexity



Source: Prognos/CSIL elaboration based on Balland et al. (2019).

S3 should be designed to allow Member States/regions to progressively increase their technological relatedness and sophistication by avoiding dead-end policies. These are unlikely to bring profound structural transformation in the medium-long rum.

However, policy documents and empirical studies provided **no clear indications about which policy approach specific types of Member States/regions should adopt**, whether a high-road, a slow road, or a casino policy. In practice, these general principles of S3 were translated into different prioritisation approaches by Member States/regions. Member States/regions need to strike a balance between the risks and benefits of investment concentration and diversification, by taking into account their existing capabilities and technological opportunities. In other terms, whether the pendulum shall swing more towards related or unrelated diversification and more or less complex technologies, and towards more or fewer priority areas strongly depends upon the territory's underlying characteristics.

The following sections briefly review the existing literature about which S3 approach promises to be more successful for particular Member States and regions, by its thematic focus (or bandwidth) and the degree of relatedness of the priorities to the existing skills, capabilities, and activities.

6.2.2 On S3 bandwidth: selectivity to concentrate resources

As put forth in Section 6.2.1, an S3 should prioritise, i.e. concentrate on a limited number of priority areas. Indeed, one of the 4 Cs of smart specialisation is: "(Tough) Choices and Critical mass: limited number of priorities on the basis of own strengths and international specialisation – avoid duplication and fragmentation in the European Research Area – concentrate funding sources ensuring more effective budgetary management" (EC, 2012).

Despite the original ideas on how S3 should look like, a clear indication of, or benchmark for, the **"right" number of priorities is not present in the literature**. A recurrent finding in the literature points to a lack of concentration of resources and the selection of many priorities (Gianelle et al., 2019, 2018; Iacobucci, 2014; Kroll, 2015; Pellegrini and Stefano, 2017). Some authors have noted that the number of selected priorities seems to be higher precisely in those regions where one would think the number of areas of strength is somewhat limited (Iacobucci, 2014; Kroll, 2015). Moreover, no univocal assessments seem to emerge from different studies on the same regions. For example, several studies find that Italian regions tend to select a high number of priorities (Gianelle et al., 2019; Iacobucci, 2014). Still, other studies argue that prioritisation was achieved because regions selected only a sub-set of the technological domains in which they are currently specialised (D'Adda et al., 2019).

Although the number of priorities remains a straightforward indicator of the selectivity of the S3, it is often argued that reasoning in terms of the absolute number of priorities is not (Prognos and CSIL, 2021). An element that complicates assessments on whether the concentration of resources has been achieved through prioritisation has to do with the **multi-level (tree-shaped) structure of priorities**. This implies that the assessment is mainly dependent on the level of priority chosen for the analysis, and if one considers the lowest-level priorities as the real level of prioritisation, some strategies identify hundreds of priorities (Gianelle et al., 2019).

Moreover, **priorities should be also related to each other**. This is a further element that complicates the assessment of the bandwidth of S3. As put forth by Foray (2019: p. 2067): "a certain density of actors and projects that are 'related' as they are dedicated to the same priority – an imperative condition to benefit from the resulting synergies, complementarities, and agglomerations, which are essential determinants of innovation, creativity, and R&D productivity". This implies that when the number of priorities is high, the degree of bandwidth of the strategy might still be considered acceptable if these priorities are interrelated and point in the same direction.

Finally, **whether a number is too high for any specific region ultimately depends on its socio-economic conditions**, such as the size, productive structure, innovation capabilities of the economy, the size of the policy programme, and the specific technological characteristics of the selected priority areas (e.g., Gianelle et al., 2018). For example, larger and richer regions would find prioritising and concentrating resources less suited to their productive, scientific, and technological profile (Foray, 2019; Hassink and Gong, 2019). However, less advanced regions would have difficulties implementing this approach due to their limited capacities (Foray, 2019).

6.2.3 On S3 relatedness: the pros and cons of more and less related diversification strategies

In the S3 approach, diversification is intended primarily as "related diversification", i.e., diversification towards activities that require similar or complementary inputs (e.g., skills and knowledge) to those already present in the economy (Pinheiro et al., 2021). This entails an incremental process by which a country (region or city) moves from one activity to another similar activity (Balland et al., 2019; Coniglio et al., 2018; Hidalgo et al., 2007; Neffke et al., 2011; Petralia et al., 2017). The opposite of related diversification is unrelated diversification. This strategy is less path dependent as it entails the development of entirely new competencies in areas in which the country has no prior knowledge. Unrelated diversification might take advantage of the windows of opportunity that disruptive technologies create. These windows of opportunities displace established players and facilitate new entries in a technology (Asheim, 2019; Grillitsch et al., 2018; Perez and Soete, 1988). On the one hand, it might trigger a more profound structural transformation (Coniglio et al., 2021). On the other hand, it is a "less travelled road" because the territory cannot build on its knowledge, competence, or input to move to the new activity (Pinheiro et al., 2021).

Smart-specialisation strategies face a difficult choice of supporting either related or unrelated (or both) processes. Answering this question is extremely difficult because several factors play a role therein.

Previous studies established that **advanced countries and regions are best positioned to reap the benefits of related diversification**. Their economic and technological development and stronger capabilities make diversification easier as they can build on many differentiated inputs, knowledge, and skills to upgrade into more complex activities and technologies (Balland et al., 2019; Boschma, 2021; Xiao et al., 2018). These regions are so technologically advanced that paths of more unrelated and still value-adding diversification are difficult to find (Pintar and Scherngell, 2021). Related diversification also pays off economically for these economies as it fosters GDP and employment growth (Rigby et al., 2022).

In the context of the S3, qualitative evidence showed how various advanced economies chose a related diversification approach. For example, the Danish S3 promoted diversification and upgrading along the value chains of traditional sectors of strength (e.g., food processing and tourism). This was to be achieved by integrating digital and green content in products, services, and processes and moving into new niches and export-oriented segments (Prognos and CSIL, 2021). Similarly, the S3 of Berlin and Brandenburg was conceived as a strategy for "strengthening strengths": its high degree of relatedness, therefore, does not surprise (Prognos and CSIL, 2021).

In these contexts, few possibilities for unrelated (and still value-adding) diversification are available: more developed economies already master a variety of complex technologies, and there might not be new unrelated technologies that can be profitably added (Balland et al., 2019). Still, if some avenues remain for unrelated diversification, their innovation capacities make unrelated diversification beneficial (if directed towards complex technologies) and not excessively risky (Balland et al., 2019; Pinheiro et al., 2021; Xiao et al., 2018).

Despite having reached high levels of economic development, **certain EU countries and regions are not very diversified, and their areas of specialisation are still centred around traditional (non-complex) technologies** (Boschma, 2021; Pintar and Scherngell, 2021; Pinheiro et al., 2021). By favouring path dependencies, related diversification might lock these economies into sub-optimal specialisations and constrain their development (Asheim, 2019; Boschma, 2017; Boschma and Gianelle, 2014; Boschma et al., 2019; Coniglio et al., 2021; Frenken, 2017; Grillitsch et al., 2018; Hassink and Gong, 2019; Janssen and Frenken, 2019). Unrelated diversification might spur profound structural transformation in these countries and regions and create higher diversity, making them more resilient over time (Boschma, 2015, 2021). Indeed, unrelated diversification is a viable option at medium and medium-high levels of development (Alshamsi et al., 2018).

While advanced countries and regions have access to many differentiated inputs, knowledge, as well as skills, and hence are able to diversify and upgrade into more complex activities and technologies, **less advanced territories can be caught in a "diversification dilemma"** (Balland et al., 2019; Pinheiro et al., 2021). Theoretically, these Member States/regions would profit the most from reducing their reliance on low-value-adding activities and uncomplex technologies and upgrading towards more complex activities. However, such strategies are very risky, as these regions lack related skills and knowledge, as well as the necessary abilities and institutions to acquire and manage complex activities (Balland et al., 2019; Boschma, 2021; Pinheiro et al., 2021; Cortinovis et al., 2017; Xiao et al., 2018). Indeed, even at this level of development, related variety remains the most profitable route to diversification (Alshamsi et al., 2018; Balland et al., 2019; Petralia et al., 2017; Xiao et al., 2018; Pinheiro et al., 2021).

6.2.4 On the factors behind the appropriate S3 bandwidth and relatedness

The literature suggests that two types of factors can influence the design and implementation of S3. On the one hand, the socio-economic characteristics of the region determine their specialisation profile and endogenous capabilities, and their possibilities of achieving critical mass. These factors, in turn, can explain the degree of selectivity and relatedness pursued with their S3. On the other, the choices made in the S3 can be driven by "soft" variables, such as the institutional capacities of the national and regional authorities, or the strategic preferences and vision of the policy-maker.

The quality of institutions is consistently found to influence the quality of the S3 prioritisation approach in the EU (Boschma, 2021; Di Cataldo et al., 2020; Karo and Kattel, 2015; Marrocu et al., 2022; McCann and Ortega-Argilés, 2015; Rodríguez-Pose et al., 2014; Rodríguez-Pose and Wilkie, 2015). The S3 is by no means an easy approach and process for national and regional governments as they require strong leadership, an enabling public administration, vision, and the institutional and administrative capacity to promote an Entrepreneurial Discovery Process (EDP) (European Commission, 2017). Some authors have argued that weak institutional capacity might undermine the potentially positive impact of S3, leading to deepening economic disparities among EU regions (Hassink and Gong, 2019). The quality of institutions is partly correlated with the level of development of EU regions (e.g. Rodriguez-Pose, 2013; Farole et al., 2011). In backward regions, governments may simply lack the knowledge and capabilities to design a S3 and set-up and keep alive a proper EDP (Blažek and Morgan, 2018; Kroll et al., 2014; Marques and Morgan, 2018; McCann and Ortega-Argilés, 2016, 2015; Morgan, 2017, 2016; Rodríguez-Pose et al., 2014). In Greece, for example, "the smart specialisation concept has heroic demands of public authorities, presupposing that they will become 'smarter,' more flexible and creative, at a time of economic austerity; a phenomenon that may be a paradox, especially in the context of peripheral regions, where lack of entrepreneurial capacities and weak administrative capabilities increase the risks for smart specialisation implementation" (Chrysomallidis and Tsakanikas, 2017, p. 195). In Lithuania, the literature noticed that: "With no vision, no overall intensive collaboration between research and business in any of the given fields and no substantial analysis to justify the decisions, it is easy to get lost in the wish list and influence of lobbying" (Reimeris, 2016, p. 1567).

To the best of our knowledge**, the literature does not systematically discuss how the Member State/region's socio-economic characteristics affect the degree of selectivity (i.e. thematic bandwidth) of an S3.** For example, in terms of the regions' size and diversification level, some authors point out that some regions might lack critical mass in any technological domain (Iacobucci and Guzzini, 2016; Kroll et al., 2014; McCann and Ortega-Argilés, 2016). Therefore, any technology chosen by these regions would not guarantee an adequate concentration of resources. Following the same reasoning, due to the limited technological competencies of these regions, identifying areas of technological strength to target as S3 priority areas would be challenging. Ultimately, and almost by definition, this would leave the region with an S3 with a low relatedness profile.

By contrast, a rich region is likely to be more diversified, making it relatively easier to identify areas of strength and build linkages between existing activities (Balland et al., 2019). Other studies have noted that achieving selectivity and concentration of resources might be particularly difficult when the region is very diversified. This was the case in Lower Saxony (Germany), for example, where the seven areas of prioritisation reflect existing economic structures but create a risk that critical mass will not be achieved (Kroll et al., 2016). Conversely, when production structures are highly concentrated in low-value-added activities, concentration of resources has been seen with distrust, while diversification has been hampered by a lack of critical mass in potentially related industries. For example, the region of Algarve (Portugal) became over-specialised in 'sun and beach' tourism. Its prioritisation first aimed at searching for areas of 'related variety,' for example, through developing linkages between tourism and ICTs, renewable energy, marine biotechnology, and creative industries. It then restricted its focus to a smaller number and more cautious priorities due to a lack of critical mass (Cooke, 2016).

Choosing priorities can also prove to be politically challenging, as left-out actors might engage in lobbying activities, to be included in the strategy. In Lithuania, for example, representatives from most of the sectors involved had an interest in emphasising the excellence of their activities to secure a priority status (Reimeris, 2016). This is corroborated by other empirical evidence which suggests that: "There are tangible signs that regions and countries tend to by-pass the very rationale of Smart Specialisation (i.e. selectivity)" (p. 2) and "This could be the result of lobbying activities, higher political return from widespread public support measures, risk-averse attitude of policy makers, and lack of adequate institutional and administrative capacity that can be observed at national and regional level." (Gianelle et al., 2019, p. 3). In a recent contribution, Di Cataldo et al. (2020) analysed a large sample of S3 and showed that: "the proliferation of investment targets in S3 is a sub-optimal policy choice often conducted by regions with weaker governance structures. Regions with better institutional capacity tend to be much more selective when it comes to identifying the areas in which to invest." (p. 17).

As discussed in Section 6.2.3, **economic factors, particularly related to the structure of the economic and technological profile of the MS/region, critically influence the opportunities of Member States/regions in terms of the degree of relatedness of their S3**. Although the literature is clear on the idea that diverse types of economies face different opportunities and risks from related (or unrelated) diversification it found enormous heterogeneity in the prioritisation approaches of EU Member States/regions (Marrocu et al., 2022; Prognos and CSIL, 2021). This heterogeneity is so marked that the literature could not reach firm conclusions on whether more or less advanced Member States/regions, new or old Member States applied a consistent diversification approach. In particular, the variables capturing the level of economic and technological development (e.g., GDP per capita, number of patents, or human capital) are never found as significant determinants of S3 choices (Marrocu et al., 2022; Deegan et al., 2021). Instead, other factors (often country-specific and hidden in country fixed effects) may have played a key role in the S3 prioritisation process (Marrocu et al., 2022; Deegan et al., 2021; Di Cataldo et al., 2020; Prognos and CSIL, 2021).

Moving to the "soft factors," Marrocu et al. (2022) tested a measure of "S3 coherence", reflecting the degree to which a Member State/region selected a priority coherent with its specialisation areas. They showed that "**policy decisions on S3 target sectors are robustly associated only with the quality of local governments**" (p. 14). Low institutional capacities impact S3 policy choices in various ways. Low-quality governments might face additional difficulties accessing and processing the data and information needed to produce an S3 document (Blažek and Morgan, 2018; Foray et al., 2018; Kroll et al., 2014; Marques and Morgan, 2018; McCann and Ortega-Argilés, 2016, 2015; Morgan, 2017). They might also face lobbying forces and political capture (Foray, 2019; McCann and Ortega-Argilés, 2015), especially in countries lacking experience with innovation policymaking or participatory policymaking.

The diversification dilemma explained in Section 6.2.3 might also lead regions towards excessively unrelated policy priorities driven by the ambition to upgrade to complex technologies (Balland et al., 2019). This strategy is particularly risky in less developed contexts where the "strong pull from relatedness" would leave complex technologies out of their range of possibilities (Pinheiro et al., 2021). Ultimately, their ambition to move away from low-value-added specialisation might lead them to create "cathedrals in the desert", or "another biotech cluster" (Balland et al., 2019; Foray et al., 2011, 2018; Foray, 2019).

In this regard, Deegan et al. (2021) found that EU regions picked the most complex activities, regardless of whether they had prior knowledge in those activities. Prognos and CSIL (2021) found that 25% of the strategies did not achieve any significant correspondence with the economic, scientific, and technological profile of the MS/region, possibly because they denoted a high degree of ambition (defined as the degree to which a strategy selected priority areas that are overly complex as compared to the mix of technologies already mastered by the MS/region). These insights indicate that S3 aiming for a too unrelated diversification are likely to be strongly influenced by the degree of ambition of the national and regional authorities, i.e. the desire to move into very complex technological areas.

6.2.5 Theory of a 'good' S3

In this section, we build on the insights from the literature about bandwidth and relatedness to formulate an overall theory for an S3 that adequately matches the aims of selectivity and diversification towards more or less related capabilities.

Table 4 summarises the main theoretical and empirical foundations for an appropriate S3 thematic bandwidth. Based on these insights, several (context-specific) indications for a good S3 bandwidth are derived. Table 5 uses the same logic of Table 4 and reports the insights from the literature on the diversification approach for different types of regions, and the translation of what they mean for an appropriate S3 relatedness.

Table 4: Indications for an appropriate S3 bandwidth

Theoretical and empirical foundations	Indications for an appropriate S3 bandwidth
One of the 4 Cs of smart specialisation is: "(Tough) Choices and Critical mass: limited number of priorities on the basis of own strengths and international specialisation – avoid duplication and fragmentation in the European Research Area – concentrate funding sources ensuring more effective budgetary management" (EC, 2012).	1. Member States/regions should prioritise (i.e., make tough choices).
Regions with high-quality institutions are better able to achieve prioritisation (e.g., Di Cataldo et al., 2020; Gianelle et al., 2019). Achieving selectivity and concentration of resources might be particularly difficult when the region is very diversified (Kroll et al., 2016; Balland et al., 2019; Foray, 2019; Hassink and Gong, 2019).	2. At higher levels of development: • High-quality institutions are better able to prioritise. • At the same time, prioritisation might be difficult to achieve (due to the many alternatives available) or undesirable (because new specialisation paths are needed to replace traditional sectors).
At lower levels of development, some regions might lack critical mass in any technological domain (Iacobucci and Guzzini, 2016; Kroll et al., 2014; McCann and Ortega-Argilés, 2016; Cooke, 2016; D'Adda et al., 2019). Institutional quality impacts on the S3 policy process, and in particular on the selectivity of the S3 (e.g., Di Cataldo et al., 2020; Gianelle et al., 2019)	3. At lower levels of development, higher selectivity (i.e. lower thematic bandwidth) is advisable, due to the limited technological and institutional capacities.

Source: Prognos/CSIL (2022).

Table 5: Indications for an appropriate S3 relatedness

Theoretical and empirical foundations	Indications for an appropriate S3 relatedness
"Priorities in RIS3 need to: Define concrete and achievable objectives. These objectives should be based on present and future competitive advantage and potential for excellence, as derived from the analysis of regional potential for innovation-driven differentiation" (EC, 2012).	1. S3 should build on related variety but shall also look at future sources of (potential) competitive advantage. Therefore, a too high relatedness of the strategy with the MS/regional profile is not advisable.
Advanced countries and regions are best positioned to reap the benefits of related diversification (e.g., Balland et al., 2019; Boschma, 2021; Pintar and Schenrgell, 2021; Rigby et al., 2022; Xiao et al., 2018). By favouring path dependencies, related diversification might lock these economies into sub-optimal specialisations, especially when they are specialised in traditional sectors (e.g., Asheim, 2019; Boschma, 2021; Boschma and Gianelle, 2014; Coniglio et al., 2021; Grillitsch et al., 2018¸ Pintar and Scherngell, 2021; Pinheiro et al., 2021).	2. At higher levels of development, regional relatedness values are high, so few possibilities for (value-adding unrelated) diversification exist. a. If the MS/region already specializes in complex technologies, a related strategy and an unrelated diversification are both viable. b. If the MS/region has a dense knowledge space but is specialised in traditional technologies, unrelated diversification might allow moving towards higher-value-added activities. Their consolidated technological and institutional capacities also facilitate more unrelated diversification.
"Regions benefit from building comparative advantage in complex technologies. (…) However, complex technologies are relatively scarce and it is therefore difficult (…) to develop competencies in these fields. These two tendencies give rise to a 'diversification dilemma.' On the one hand, the search for technological rents pushes regional actors to seek out complex knowledge possibilities. On the other hand, complex technologies remain out of reach for most because they lack the diversity of capabilities out of which complex technologies are derived. The general solution (…) is for regional economies to develop their existing knowledge cores and to expand their technological repertoires along related trajectories that lead toward more complex technologies" (Balland et al., 2019). The quality of institutions is consistently found to influence the quality of the S3 prioritisation approach in the EU, by affecting their ability to choose priorities in line with their specialisation areas and potential (Marrocu et al., 2020) and to move into new and more complex technologies (Balland et al., 2019). Ambition might drive Member States/regions towards excessively unrelated (and excessively complex) technological targets (Balland et al., 2019; Deegan et al., 2021; Prognos and CSIL, 2021).	3. At lower levels of development, a relatively more related strategy is advisable as unrelated diversification would be too risky (from a technological and an institutional point of view). 4. At the same time, exploring a few unrelated (but potentially beneficial) targets might help avoid lock-ins, especially when the region can count on (newly emerging) competencies in a few complex technologies.

Source: Prognos/CSIL (2022).

Figure 25 depicts the theoretical framework adopted in the study to assess the S3 prepared in the 2014-2020 period. This framework builds on the representation of the different typologies of S3 that Member States/regions might design, depending on their technological relatedness density and complexity (see Figure 24Figure 24). In particular, by plotting the technological relatedness and complexity values of the Member States/regions in a graph like the one in Figure 25, four categories of Member States/regions can be identified (each type corresponds to one of the four quadrants of the figure). Each quadrant hosts similar Member States/regions regarding the average degree of relatedness and complexity. Therefore, for each of these typologies of Member States/regions, it is possible to define advisable levels of bandwidth and relatedness based on the insights of the literature summarised in Sections 6.2.2, 6.2.3, and 6.2.4.

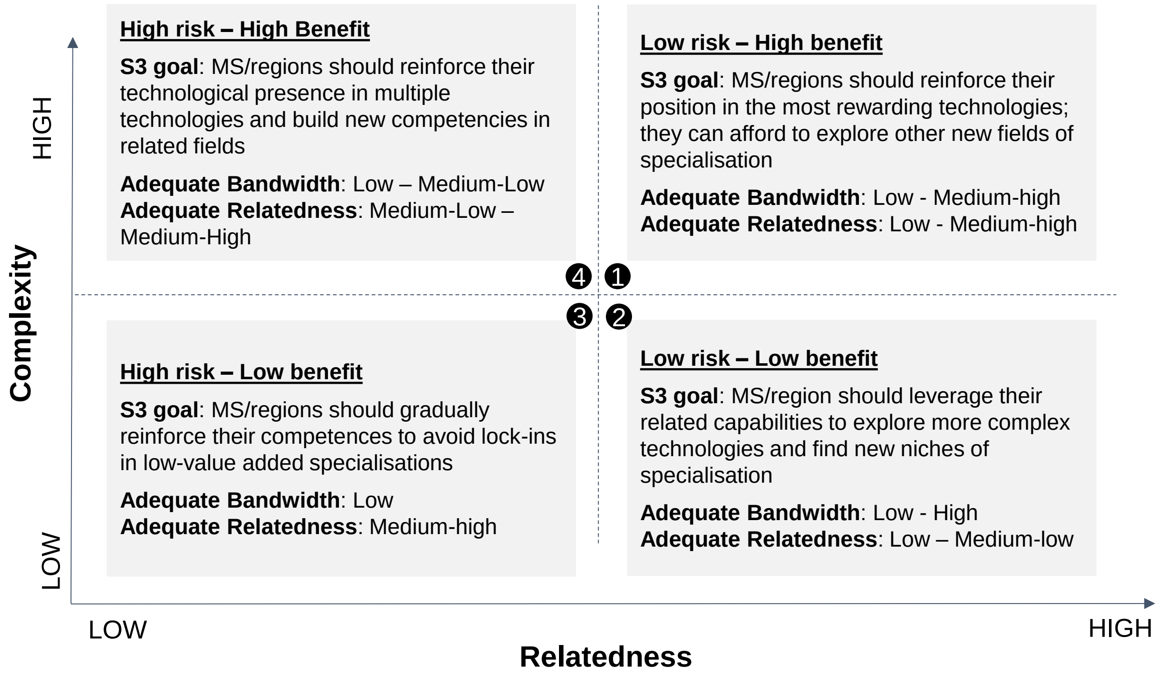
In **Quadrant 1** "**Low risk – high benefits strategy"**, Member States/regions are characterised by high levels of relatedness and complexity. Their knowledge space is densely populated, suggesting that they master a wide range of technologies, among which many complex technologies. As the literature shows, the Member States/regions with high levels of relatedness and complexity tend to be advanced in socio-economic terms (Balland et al., 2019). Consequently, and as widely acknowledged in the literature (e.g. Rodriguez-Pose, 2013; Farole et al., 2011), they are likely to benefit from strong institutional capacities. Their S3 shall focus on strengthening their position in the most complex technologies while continuously exploring new areas of technological upgrading. They might afford a higher bandwidth which might allow for more experimentation. Moreover, their profile and positioning in terms of relatedness and complexity suggest that these Member States/regions have the knowledge and skills to diversify into new (complex) technologies easily. Because they have a consolidated positioning in many complex technologies, their opportunities in terms of (unrelated) technological upgrading are few. Hence, related diversification is their easiest, safest, and often most rewarding option. At the same time, lower levels of relatedness allow for more exploration and might strengthen their competencies in new and more advanced areas of specialisation.

In **Quadrant 2** "**Low risk – low benefits strategy**", we find the Member States/regions with high relatedness and low complexity. These Member States/regions have good innovation capacities but are specialised in more traditional (less complex) technological fields (e.g., mechanical engineering or transport). Despite the low degree of complexity of the technologies they master, their high levels of relatedness suggest that they have some competencies that can allow them to diversify into more complex technologies. This, indeed, shall be their aim. Given the need to transform their economic structures, these Member States/regions might opt for more selective (when their alternatives are already evident) or less selective strategies (when they need to explore the technology space to find new areas of strength). Strong innovation capacity would also allow these Member States/regions to venture into relatively more unrelated diversification.

The Member States/regions in **Quadrant 3** "**High risk – low benefits strategy**" (low relatedness and complexity), have limited technological capacities. Their knowledge spaces are sparsely populated (i.e., they do not master any technological field), and their few patents mainly focus on non-complex technologies. Given this profile, less developed Member States/regions are expected in this quadrant. Because of their low level of development, a relatively selective strategy would be considered preferable. In terms of relatedness, avoiding lock-ins in low-value-added specialisations should be their target. Still, upgrading to more promising technological areas can be difficult for them. Therefore, while some unrelated targets are justifiable, a too high level of unrelatedness is not advisable.

Finally, in **Quadrant 4** "**High risk – high benefits strategy**", i.e. Member States/regions with low relatedness and high complexity, we find Member States/regions with limited technological capacity but with a few niches of specialisation in complex technologies. These are generally less developed territories with limited innovation capacities. The objective of their S3 should be fostering these specialisations and "thickening" their knowledge space (i.e., reinforcing their technological presence in multiple technologies). For this reason, medium levels of relatedness are recommended. As far as their S3 bandwidth is concerned, their limited innovation capacity can be expected to be matched by low institutional capacities. Therefore, a high level of selectivity (i.e. low bandwidth) is more appropriate.

Figure 25: Theoretical framework to assess the S3 bandwidth and relatedness



Source: Prognos/CSIL (2022).

6.3 Theory testing

6.3.1 Operationalisation of the theory

The policy documents and the conceptual and empirical literature on the S3 bring to light some key principles and requirements for an appropriate S3 in different contexts. Indeed, how a 'good' S3 should look like crucially depends on the technological profile of the Member States/regions (in terms of its relatedness and complexity). The features of the S3 also depend on other key socio-economic factors, such as the level of economic development, diversification, institutional capacity, and human capital of the Member State/region. That the smart specialisation approach was not a "one size fit all" approach was clear from the outset (Foray et al., 2009). Consequently, territorial features must be taken into account when designing and assessing an S3.

This section builds on these notions and tests the theory of a good S3 outlined in Section 6.2.5. In doing so, it identifies the S3 that conformed or deviated from the theory. To accomplish these objectives, the section:

1. Classifies EU Member States/regions according to their levels of relatedness and complexity and identifies their technological opportunity positioning at the time when the S3 was designed (Step 1). This step is necessary to define the type of S3 that the theory would recommend them;
2. Measure the S3 bandwidth and S3 relatedness of 162 strategies in scope (Step 2). These are the strategies drafted and used in the 2014-2020 programming period. If any revision over this timespan occurred, the latest version of the strategies was taken into account for

the analysis. The analysis covers 27 Member States.[51] The sample includes 27 S3 defined at NUTS 0 level, 23 S3 at NUTS 1 level, and 118 S3 at NUTS 2 level.

3. Compares the actual levels of the bandwidth and relatedness observed in the S3 in scope with those expected from the theory to identify the most appropriate levels of bandwidth and relatedness depending on the Member States/regions characteristics S3 (Step 3);
4. Analyses the determinants that led Member States/regions to select an appropriate versus non-appropriate S3, i.e. conforming or not to the theory (Step 4).

6.3.2 Detecting the Member States/regions' technological opportunities

The first step entails classifying the Member States/regions according to their technological opportunities. As shown in Figure 25, territories with different levels of technological relatedness – i.e. the degree to which the technologies produced in the region are related to each other and to the existing capabilities and allow to diversify into new technologies easily – and knowledge complexity – i.e. the degree of sophistication of the technologies produced – face different potential risks and benefits from the S3 approach. These risks and benefits should ultimately be considered to decide on the most appropriate S3 thematic focus and diversification strategy. We have computed the regional technological relatedness density and the knowledge complexity index for all Member States and regions in the scope of the analysis (see the following Infobox for the definition of the two indicators used).

i

Indicators to measure the Member States/regions technological opportunities

The indicator of **technological relatedness density** measures how much of the technology produced in the Member State/region tends to cluster around individual technological fields. This determines how easy it is for the Member State/region to use the knowledge, skills, and capabilities it has to diversify. Following the relevant literature, we measured regional relatedness with the technological relatedness density index, computed with patent data, and technological classes' co-occurrence within the same patents. The index, ranging from 0 to 100, measures the extent to which a technological domain is linked to other domains in the technological portfolio of the Member State/region. The higher the score on this measure, the denser the knowledge space of the Member State/region and the easier it is to diversify into new technological fields. Following the same reasoning, lower scores indicate that the knowledge space of the Member State/region is sparsely populated. Therefore, new technologies are more difficult to master, and related diversification is more difficult to achieve. The regional relatedness index in the 162 Member States/regions under scrutiny ranges from 0.2 to 51.1, with an average of 27.5.

The **knowledge complexity** index measured at the Member State/region level captures the average complexity of the technologies that the Member State/region can produce. Our preferred indicator of knowledge complexity is the index of structural diversity developed by Broekel (2019) and Mewes and Broekel (2022).

[51] Strategies from the UK were excluded from the analysis. Strategies that have been defined at NUTS 3 level (from Finland and Sweden) were aggregated at NUTS 2 level, to enable their matching with available statistical indicators.

This index uses network theory and network-related indicators to identify the most complex technologies based on patent data. Based on this indicator, a complex technology combines different types of knowledge in a complex way, i.e., in a more difficult way to imitate. A region with a higher (or lower) complexity index has more (or less) complex technologies. In principle, this complexity index ranges from 0 to 100. In our sample, it ranges from 60 to 98.9, with an average of 74.

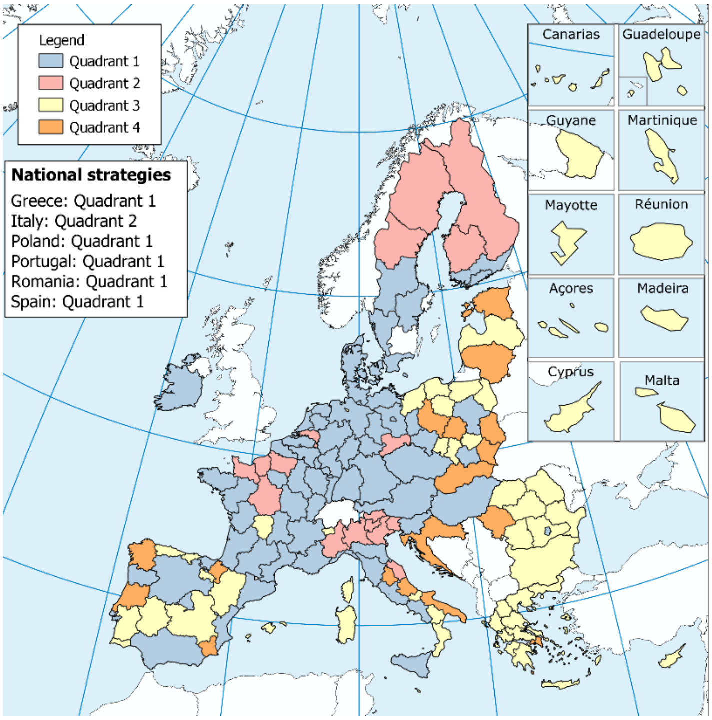
By intersecting these two indicators as in Figure 25Figure 24, we can classify the Member States/regions as follows:

- **Quadrant 1 (Low risk – High benefits)**: A total of 72 Member States/regions fall in this quadrant (see Table 20 in the Annex for the complete list). They are characterised by regional relatedness and complexity above the EU average values, meaning that they can master several technologies which are overly sophisticated than for the EU average. Results of an econometric analysis[52] indicate that these Member States/regions are generally large (in terms of population) and with a high level of development (as measured by GDP per capita). Their economies are diversified and innovative (categorised as Leader and Strong Innovators on the Innovation Scoreboard). As expected from the literature and the theoretical framework (see Section 6.2.5), they can count on strong institutional capacities and high-quality human capital. As illustrated in the map below, most regions in Germany and France and parts of Italy, Spain, the Netherlands, Sweden, and Finland fall in the first quadrant (high relatedness and complexity). Denmark and Ireland also belong to this group.
- **Quadrant 2 (Low risk – Low benefits)**: 18 Member States/regions are in this quadrant, characterised by regional relatedness above the average and complexity below the average. These Member States/regions rely on a good set of technologies, which, however, are not particularly complex with respect to the EU average. As compared to other EU territories, they have a relatively low share of employment in high-tech manufacturing and knowledge-intensive services, even though they are the richest Member States/regions in the sample. They are Leader, Strong, or Moderate Innovators, but their R&D intensity is lower than Member States/regions in Quadrant 1. This might be justified in light of their specialisation, which is less focused on complex technologies. While they do not excel in terms of the quality of their human capital, their institutional capacities are well-developed. Northern Italy, parts of France, Sweden, and Finland feature in this type of regions, disguising a specialisation in more traditional (less complex) technologies. This is consistent with other empirical findings (Pintar and Scherngell, 2021; Deegan et al., 2021).

[52] We employed multivariate econometric analysis to study the relationships between the structural features of the Member States/regions (e.g., the size of the economy, its economic diversification, innovation capability, institutional quality, and human capital) and the probability of belonging to a specific quadrant. When we were interested in a specific quadrant (e.g., to test the structural features that drive the probability of belonging to quadrant 2 “Low risk – Low benefits”), binary logistic models were estimated. In these models, all the Member States/regions in the quadrant of interest (e.g., quadrant 2) were assigned the value of 1, while the value of zero was assigned to all the other Member States/regions. In this set up, each quadrant is analysed separately, and the model predicts the probability of observing the value of 1, given the features of the Member States/regions. A multinomial logistic model was then applied to further confirm (or deny) the evidence from the binary logistic models. In this model, all the quadrants were analysed simultaneously, and the Member States/regions were assigned the value of 1 if belonging to the quadrant 1, 2 if belonging to the quadrant 2 and so on up to quadrant 4. With this procedure, the model predicts the probability of observing the value 1, 2, 3, 4 for each Member State/region based on its structural features.

- **Quadrant 3 (High risk – Low benefits)**: 55 Member States/regions belong to this quadrant, where both regional relatedness and complexity are below the average. 55 Member States/regions belong to this quadrant. The Member States/regions of this kind tend to feature low levels of development and economic diversification, and limited innovation and institutional capacities. Consistently with this profile, these Member States/regions also show low levels of tertiary education attainments (low quality of human capital) and low employment in high-tech manufacturing and knowledge-intensive services. This category includes most Greek and Romanian, together with parts of Poland, Spain, Bulgaria, and Latvia.
- **Quadrant 4 (High risk – High benefits)**: 17 Member States/regions are placed in this quadrant, with regional relatedness below the average and complexity above the average. These territories, which include Croatia, Lithuania, Estonia, and parts of Portugal, Spain, Italy, and Poland, are specialised in relatively few technologies, which are however quite sophisticated and more difficult to imitate by other regions. In this group, we find small Member States/regions, with limited innovation and institutional capacity, but economically diversified.

Figure 26: Distribution of the EU Member States/regions in the four quadrants



Note: We recall that Quadrant 1 Member States/regions are characterized by high technological relatedness and high complexity; Quadrant 2 by high technological relatedness and low complexity; Quadrant 3 by low technological relatedness and low complexity; Quadrant 4 by low technological relatedness and high complexity
Source: Prognos/CSIL (2022).

Table 6: Characteristics of the Member States/regions in the four quadrants – results from an econometric analysis

Dimension	Variable	Quadrant 1 : High relatedness & high complexity N = 72	Quadrant 2 : High relatedness & low complexity N = 18	Quadrant 3 : Low relatedness & low complexity N = 55	Quadrant 4 : Low relatedness & high complexity N = 17
Size of the economy	Population	+ +	n.s.	n.s.	- -
Level of economic development	GDP per capita	-	++	n.s.	n.s.
Economic diversification	1-HHI on NACE sectors	++	n.s.	- -	++
Innovation capabilities	RIS Scoreboard	Leader, Strong	Leader, Strong, Moderate	Modest	n.s.
	R&D/GDP intensity	++	n.s.	- -	-
Institutional quality	EQGI	++	++	n.s	- -
Human capital	Tertiary education attainment	++	-	n.s.	n.s.
	High Knowledge & Technology Employment	n.s.	-	- -	n.s.

Notes: ++ and - - indicate a strong statistically significant positive or negative association between the variable and the probability to enter a specific quadrant; + and – indicate a positive or negative association, that is statistically significant only in some specifications of the econometric models. When no statistically significant associations emerged, this is indicated with “n.s.” in the respective cell of the table. Results are primarily from logit models. Results were cross-validated by performing a multinomial logit model with different specifications.
Source: Prognos/CSIL (2022).

6.3.3 Measuring the S3 bandwidth and S3 relatedness

The second step of the theory testing exercise consists of computing indicators to measure the level of bandwidth and relatedness in the S3 in the scope of analysis.

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Indicators to measure the S3 bandwidth and S3 relatedness

We defined and computed a "**thematic bandwidth index**" as a measure of the degree of the broadness of the strategy. It goes from 0 to 1, with low (high) values indicating low (high) bandwidth. It is computed by accounting for how many NACE sectors, technological fields, and scientific domains were selected as the share of the total number of NACE sectors, technological fields, and scientific domains. The index is then adjusted to take into account the interlinkages between different priority areas. Indeed, some strategies might have selected many priority areas, but these might be strongly interrelated with each other (i.e., might reinforce each other) (Foray, 2019). In these cases, these priorities can be considered part of a common target, and therefore the strategy's bandwidth can be reduced.

The indicator of **technological relatedness of the S3** proxies the extent to which the priorities of the S3 reflect technological fields closer to the areas of specialisation of the Member State/region.[53] However, the degree of S3 relatedness cannot be used alone to assess the degree to which a strategy is related to the areas of specialisation of a Member States/regions. By construction, this indicator will be low (high) for all Member States/regions with low (high) relatedness density indexes. Therefore, a relative indicator that considers the initial degree of density of the knowledge space of the Member States/regions is needed. To consider this issue, we compute the **ratio between the S3 relatedness and the regional relatedness density.** This measure compares how much the strategy is related to how much it could be related. It can range from 0 (low relatedness of the S3 with the technological profile of the Member State/region) to an index higher than 100% (high relatedness with the technological profile of the Member State/region).

The figures below show the distribution of the S3 bandwidth and relatedness indicators for the 192 S3 analysed. The following main points can be highlighted:

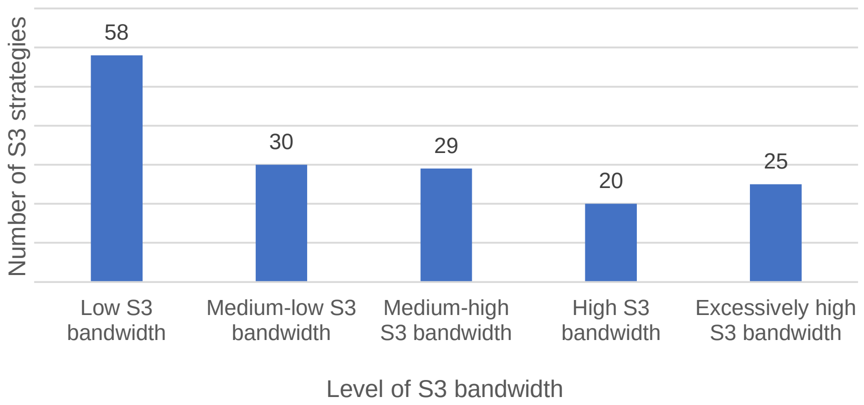
- The average bandwidth indicator is 0.32. The index can vary, in principle, between 0 and 1, so this average denotes that the **S3 analysed overall adopted a medium-low S3 bandwidth, i.e. they designed a quite focused and selective strategy**. The most selective regions were some Greek ones (South Aegean, Epirus, Peloponnese), having few priority areas (from 2 to 4), all linked to the tourism economy and similar technological fields (mainly digital technologies). The Swedish region of Mellersta Norrland, the French Guyane and the Italian Molise are other examples of very selective S3. The highest value of S3 bandwidth (i.e. least selective S3) observed in the sample of strategies amounts to 0.78, and it refers to the French region of Bretagne. It selected seven priority areas, which

[53] The technological relatedness measure of the S3 also takes into account the shares (weights) of each technological field in the strategy. These shares assign a weight to each of the matched sectors and indicate their relevance. The higher this share, the higher the correspondence between the priority area description and the matched sector. So, if the value for one sector is 100%, only one sector is relevant for the priority area.

are associated with several and quite different sectors and technological fields. Other less focused strategies are Pays de la Loire, Limousin and Acquitaine in France, as well as the national strategies of Portugal and Czech Republic.

- The average S3 relatedness indicators is equal to 76% in the sample of S3 analysed, which denotes that **Member States/region generally selected priority areas that are quite related to their capabilities**. For some Member States/regions, the relatedness indicator is close to 0, meaning that the S3 targeted technological fields where there are no existing competencies. These include the outermost regions of Guyane, Madeira and Azore, as well as some Greek regions which have no or very few patents overall, none of which are in the technological fields associated with the selected priorities. The Italian region Basilicata, the Ioinian Islands (Greece), the Comunidad de Madrid and North Netherlands have the highest degree of relatedness with their technological profile (the indicator is equal to 164%). Their strategies selected fields where the regional technological relatedness was high and attributed them a great relevance in the strategy.

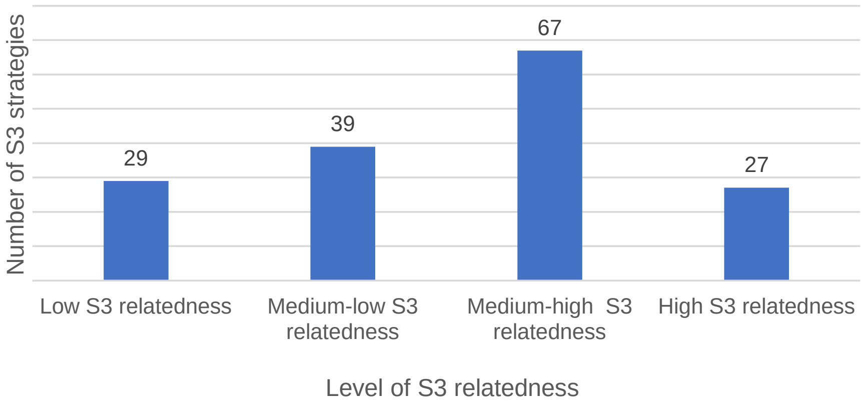
Figure 27: Number of S3 by level of S3 bandwidth[54]



Source: Prognos/CSIL (2022).

[54] The thresholds used to determine the five levels of the S3 bandwidth are based on key parameters of the overall S3 bandwidth distribution (i.e. the mean and the standard deviations). In particular, the upper bound of the low bandwidth range is defined as the mean minus one standard deviation. The medium levels of bandwidth range from the mean minus one standard deviation and the mean plus one standard deviation. In particular, the medium-low bandwidth ranges from the upper bound of the low bandwidth range to the mean and the medium-high bandwidth ranges from the mean to the mean plus one standard deviation. The high bandwidth ranges from the mean plus one standard deviation to the mean plus two standard deviations. The excessive bandwidth covers all values below the mean plus two standard deviations. The ranges of the S3 bandwidth were defined as follows: Low bandwidth: below 0.23; Medium-low bandwidth: between 0.24 and 0.31; Medium-high bandwidth: between 0.32 and 0.4; High bandwidth: between 0.41 and 0.5; Excessive bandwidth: above 0.5.

Figure 28: Distribution of the S3/regional relatedness ratio[55]



Source: Prognos/CSIL (2022).

These indicators measure the actual degree of thematic focus and relatedness of the S3, but they do not provide any information about whether the strategic choices made by the national and regional authorities can be considered adequate or not with respect to the technological opportunities faced by each Member State/region. To answer this question, the next analytical step is necessary.

6.3.4 Testing the theoretical framework: which S3 have the appropriate level of bandwidth and relatedness?

This section compares the *expected* bandwidth and diversification approach as defined in Section 6.2.5 with the *actual* values of the bandwidth and relatedness in the S3. Table 7 shows that **99 (61%) of the 162 S3 analysed here achieved a level of bandwidth** that is regarded as appropriate according to the theory. Most of the strategies that opted for a too high bandwidth belong to French regions.

In Quadrant 1 (i.e., Member States/regions with high relatedness and complexity), 46 of the 72 S3 (64%) chose a good level of bandwidth, in line with the theoretical expectations for this category of territories. In Quadrant 2 (Member States/regions with high technological relatedness but in less complex technologies), 14 of 18 strategies (78%) show bandwidth ranges that are deemed adequate for these S3. The majority (9) of the S3 in this quadrant opted for a low level of bandwidth. According to the theory, this is acceptable for this type of Member States/regions. Their level of development, diversification, institutional and innovation capacity, and high level of relatedness would have made a broader strategy still manageable and not risky. Their need to explore new areas of potential competitive advantage might have justified an even higher bandwidth. This notwithstanding, these Member States/regions preferred to focus more.

In Quadrant 3 (regions with low technological relatedness and low complexity), 26 out of 55 S3 (47%) display an appropriate level of bandwidth. In this quadrant, we also observe the most significant deviations from the S3 bandwidth levels expected from the theory. Looking at these strategies, 12 out of the 26 S3 that had a good bandwidth are Greek. As discussed in the literature, **limited diversification offers limited options in terms of priority areas that can be selected**. Finally, in Quadrant 4 (the group of regions with less related technologies

[55] The ranges of the S3 relatedness indicator were defined like for the bandwidth indicator (see previous footnote). The ranges of the relatedness in an S3 are defined as follows: Low relatedness (i.e., unrelated diversification strategy): below 57; Medium-low relatedness: between 58 and 76; Medium-high relatedness: between 77 and 95; High relatedness: between 96 and 164.

but in very complex fields), 13 out of the 17 S3 (76%) achieved low and medium-low bandwidth, in line with the theory.

Table 7: Expected vs actual S3 bandwidth: number of S3 which achieved the most appropriate bandwidth level

			Actual S3 bandwidth						
			1 - Low	2 - Medium-low	3 - Medium-high	4 - High	5 - Too high	**Total**	**Share of S3 matching the theory**
Expected S3 bandwidth by	Q1	From Low to Medium-high	15	14	17	9	17	**72**	**64%**
	Q2	From Low to High	9	1	1	3	4	**18**	**78%**
	Q3	Low	26	10	8	7	4	**55**	**47%**
	Q4	From Low to Medium-low	8	5	3	1	0	**17**	**76%**
		Total	**58**	**30**	**29**	**20**	**25**	**162**	

Note: Cells in green indicate the number of S3 with an appropriate level of bandwidth (i.e. conforming to the theory)

Source: Prognos/CSIL (2022).

Table 8 reports the number of S3 that reached an appropriate level of relatedness, i.e. conforming to the levels expected in theory. In total, **85 S3 (52% of the sample) achieved a good level of relatedness**, while 36 are too related to accomplish any degree of smart diversification. The latter strategies include cases where the region is so technologically advanced that paths of more unrelated (and still value-adding) diversification were challenging to find (e.g., Communidad de Madrid). They also include strategies that could be considered particularly conservative. An example is the Danish S3: its approach promoted diversification and upgrading along the value chains of established sectors (e.g., food processing and tourism).[56] Beyond the Danish case, some of these too related strategies could have been more ambitious by exploring or giving more emphasis to relatively less consolidated areas of specialisation.

Among the S3 of Quadrant 1 (Member States/regions with high technological relatedness and complexity), the vast majority achieved an appropriate level of relatedness (56 out of 72 strategies, 78%). For these strategies, it was hypothesized that low, medium-low, and medium-high levels of bandwidth were all desirable. This broad criterion might explain why so many strategies succeeded in complying with the theory. Most of these 'good' strategies present a medium-high level of relatedness, showing a preference for related diversification. In Quadrant 2 (Member States/regions with high technological relatedness and low complexity), 8 out of 18 strategies (44%) are considered to have an appropriate degree of relatedness. However, many strategies in this quadrant (9) opted for medium-high relatedness, confirming that related diversification remains the preferred approach at high levels of development.

In Quadrant 3 (Member States/regions with low technological relatedness and low complexity), only seven over 55 strategies (13%) show an appropriate level of relatedness. In this quadrant, a medium-high level of relatedness is considered preferable. However, 26 strategies opted for low relatedness (a risky endeavour given their characteristics), and another 28 chose medium-low levels of relatedness. Due to their characteristics, related diversification would have been more appropriate for these Member States/regions. In Quadrant 4 (Member States/regions with low technological relatedness and high complexity), all S3 except for 3 (82%) are appropriate in terms of relatedness. Indeed, while a medium

[56] Prognos and CSIL (2021).

level of relatedness (both medium-low and medium-high) is advisable for these strategies, three S3 achieved high relatedness. Differently from regions in Quadrant Q3, no regions in Q4 opted for a too low level of S3 relatedness.

Table 8: Expected vs actual S3 relatedness: number of S3 which achieved the most appropriate technological relatedness level

			Actual S3 relatedness					
			1 - Low	2 - Medium-low	3 - Medium-high	4 - High	**Total**	**Share of S3 matching the theory**
Expected S3 relatedness by quadrant	Q1	From Low to Medium-high	1	13	42	16	**72**	**19%**
	Q2	From Low to Medium-low	1	7	9	1	**18**	**44%**
	Q3	Medium-High	27	14	7	7	**55**	**13%**
	Q4	From Medium-low to Medium-high	0	5	9	3	**17**	**82%**
		Total	**29**	**39**	**67**	**27**	**162**	

Note: Cells in green indicate the number of S3 with an appropriate level of relatedness (i.e. conforming to the theory)

Source: Prognos/CSIL (2022).

By intersecting the results of an appropriate bandwidth and relatedness,

Table 9 and Figure 29 identify the 53 "optimal" S3 (for the list of optimal S3, see Table 21 in the Annex). Most of them are in Quadrant 1 (i.e., Member States/regions with strong technological capacities). One-third of these strategies belong to German regions (e.g., Baden-Württemberg, Bavaria, and Lower Saxony).

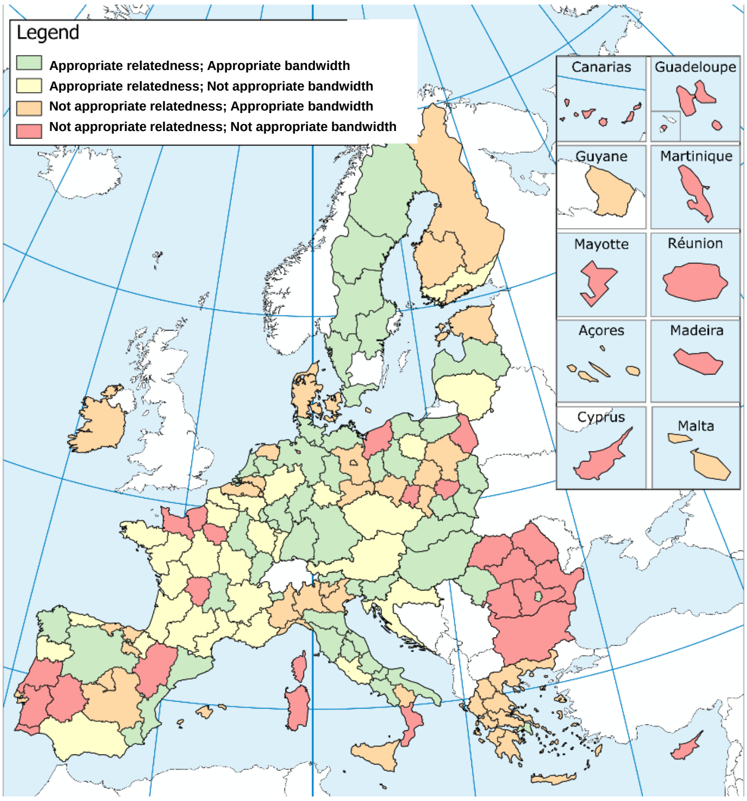
Table 9: Number of S3 with an appropriate or non-appropriate S3 bandwidth and relatedness (i.e. conforming or not to theory)

		S3 relatedness		Total
		Appropriate	Not appropriate	
S3 bandwidth	Appropriate	53 (33%)	46 (28%)	**99 (61%)**
	Not appropriate	32 (20%)	31 (19%)	**63 (39%)**
	Total	**85 (52%)**	**77 (48%)**	**162 (100%)**

Source: Prognos/CSIL (2022).

Beyond the German regions, various parts of Italy and Poland, as well as Sweden and some regions in Spain, designed a S3 with the most appropriate levels of bandwidth and relatedness. By contrast, various regions of Romania and Portugal display a non-appropriate S3. Most French regions could not meet the expected levels in terms of bandwidth but attained the expected level of relatedness. The opposite occurred in Greece, Finland, Ireland, Denmark, and Northern Italy, where the degree of selectivity (bandwidth) of the S3 is considered in line with theory, but the level of relatedness is not.

Figure 29: A map of the EU Member States/regions with appropriate and non-appropriate S3



Notes: The results of the national S3 (Italy, Greece, Poland, Portugal, Romania, Spain) are not displayed in the map. Italy and Romania have both an appropriate bandwidth and appropriate relatedness; Spain, Greece, Poland, and Portugal have an appropriate relatedness, but a sub-optimal bandwidth.

Source: Prognos/CSIL (2022).

6.3.5 On determinants of optimality in S3

This section investigates the factors that explain the deviations from the expected levels of S3 bandwidth and relatedness. Optimality (i.e. the probability for Member States/regions to opt for a level of S3 bandwidth and relatedness which are deemed appropriate to the underlying technological opportunities) can be explained by two sets of variables:

- Variables capturing the socio-economic conditions and other structural features of the Member States/regions. They include data on the Member State/region size (expressed in terms of population), level of development (GDP per capita), economic diversification, R&D intensity, and human capital (share of the population with tertiary education level).
- Variables capturing the institutional and policy features of the Member States/regions. They include the quality of government index (developed by Charron et al., 2019),[57] and the indicator of S3 ambition defined in the following Infobox.

[57] Developed and regularly updated by the University of Gothenburg, this aggregate indicator is based on a large citizen survey where respondents are asked about perceptions and experiences with public sector corruption, government effectiveness, rule of law and accountability. It is currently the only index providing standardised data on the quality of institutions for the EU up to a regional (NUTS 2) level. It is a relative measure with respect to the EU average, therefore negative values indicate worse institutional capacities compared to the EU average and positive values denote better institutional quality with respect to the EU average.

Defining the indicator of "S3 ambition"

To build our indicator of S3 ambition, we combined the indicator of regional complexity described above (Section 6.3.2) with an index of the *S3 complexity*. This is constructed as a weighted average of the complexity of the technologies selected in the S3, where the weights represent the relevance of each technology in the S3 document. This is a novel indicator in this literature. It ranges between 0 to 100, with a higher (lower) score indicating a higher (lower) degree of complexity of the chosen technologies. The *S3 ambition* was then defined as the difference between the S3 complexity and the regional complexity. The resulting variable ranges from -57 to +94. Negative values are associated with strategies where the indicator of S3 complexity is lower than the regional complexity indicator, i.e. the selected strategies are less ambitious and more risk averse. In contrast, the indicator takes on positive values when the S3 complexity is higher than the regional complexity, meaning that the policymakers are risk-takers and adopted a more ambitious strategy.

All explanatory variables are expressed at the time when the S3 was drafted. For this reason, the Quality of Government index and all socio-economic variables are taken as the average in the years t-1, t-2, t-3 before the S3 publication year (t). The S3 ambition indicator is also computed based on patent data that refer to the three years before the S3 publication.

Table 10: List of the variables used in the analysis

Variable	Definition	Data source
Structural variables		
Population	Total population in the territory covered by the S3 (expressed as natural logarithm)	Eurostat
GDP per capita	GDP per capita at current market prices (in PPS) in each region/MS (expressed as natural logarithm)	Eurostat[58]
Tertiary education attainment	Share of the population with tertiary education level	Eurostat
Economic diversification	1-HHI (Herfindahl-Hirschman Index) based on employment data. $1 - \sum_i s_i^2$ for each NACE sector i where si is the employment share in the NACE sector i for each region/MS at time t	Authors' estimation based on Eurostat data
R&D intensity	Intramural R&D expenditure (GERD) as a percentage share of GDP	Eurostat
Institutional and policy variables		
Quality of Government Index	Index based on the combination of four indicators: control of corruption, government effectiveness, rule of law, and voice and accountability. Data are collected through a citizen survey.	Charron et al. (2019)

[58] French NUTS2 regional data (2005-2015) was estimated from OECD (GDP per capita growth rate PPS) data, due to some missing data in Eurostat.

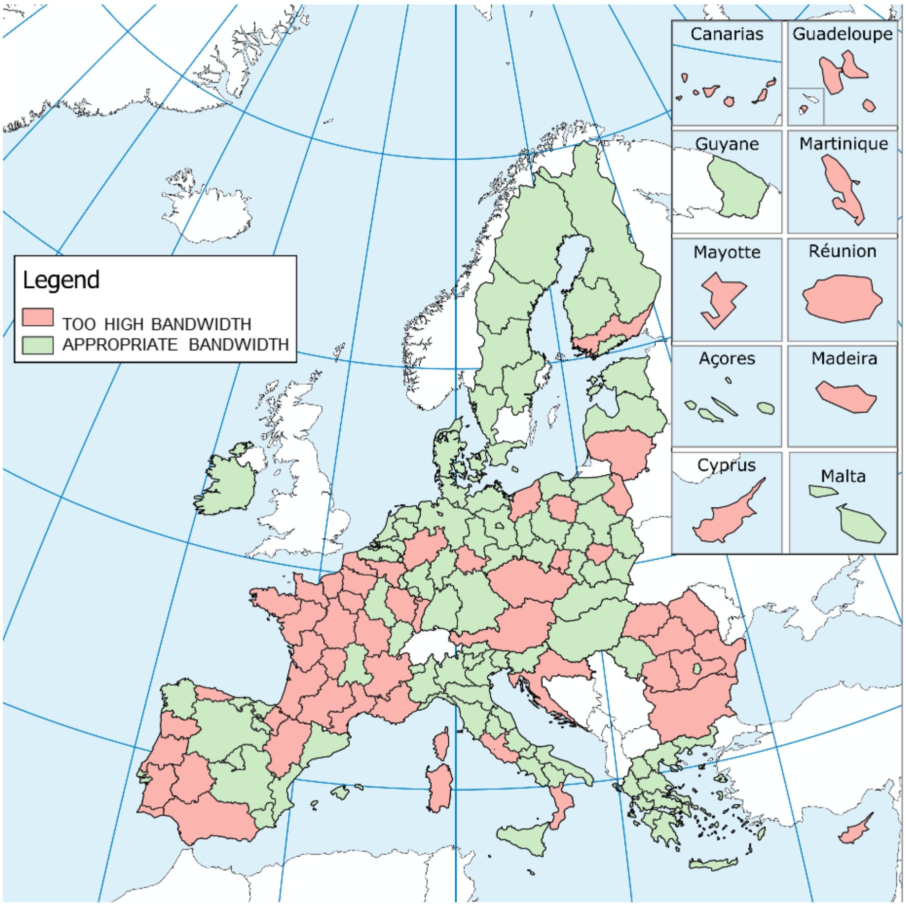
S3 Ambition	Difference between the S3 complexity (average technological complexity of the priorities of the S3) and the regional complexity (average technological complexity of the region/MS)	Authors' computation based on PATSTAT and data from Prognos/CSIL (2021)

Source: Prognos/CSIL (2022).

S3 Bandwidth

Figure 30 displays the Member States/regions with good or less good bandwidth. France, Portugal, and Romania stand out for their too high S3 bandwidth. Lithuania, Bulgaria, Croatia, Austria, as well as some parts of Germany, also reached a bandwidth level outside their expected range. By contrast, the map clearly shows that appropriate choices were made in Ireland, Denmark, Sweden, and Finland, as well as Greece, Hungary, and various regions in Italy and Spain.

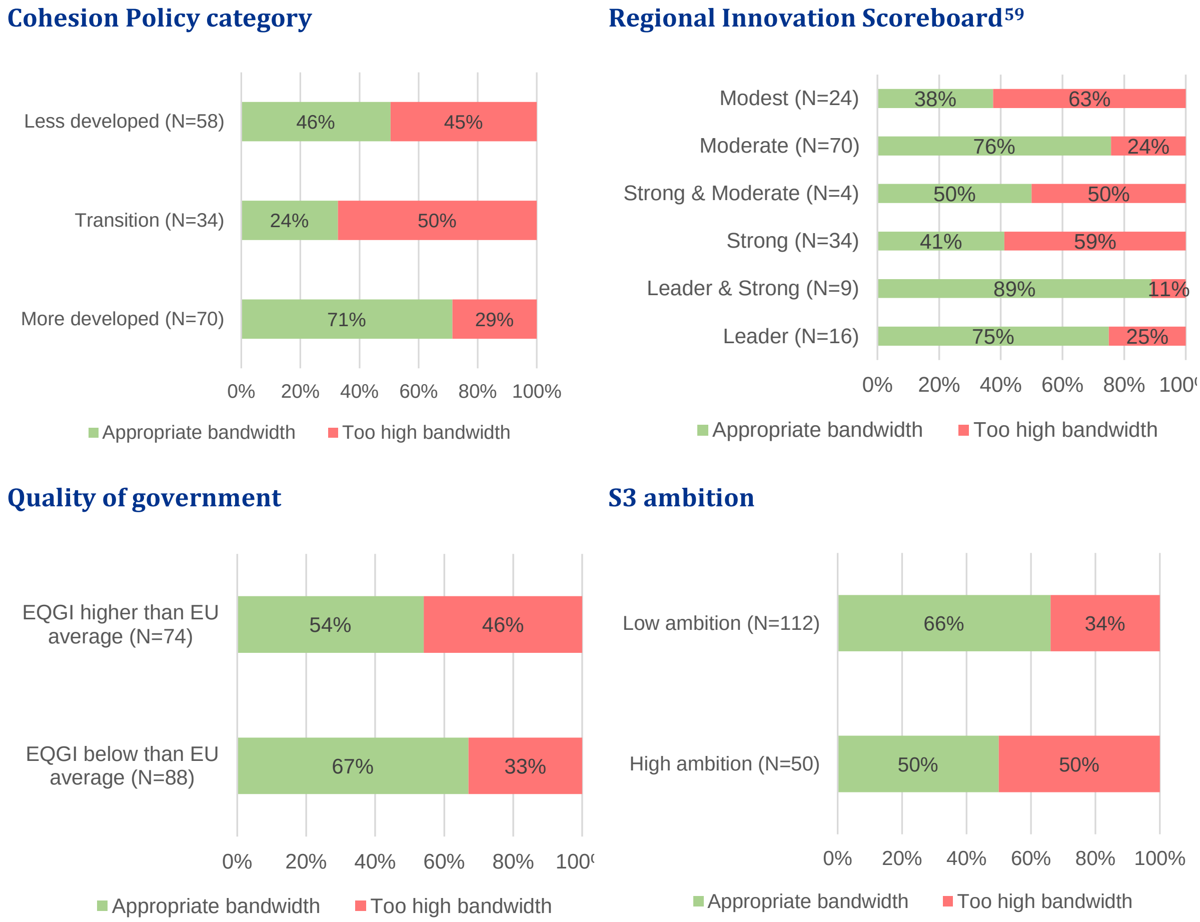
Figure 30: EU Member States/regions in scope with an appropriate or a too high S3 bandwidth



Note: The results of the national S3 (Italy, Greece, Poland, Portugal, Romania, Spain) are not displayed in the map. Italy and Romania have an appropriate bandwidth; Spain, Greece, Poland and Portugal have a too high bandwidth.
Source: Prognos/CSIl (2022).

The descriptive analysis reported below (Figure 31) shows the types of Member States/regions for which we observe an appropriate S3 bandwidth (or not). A high portion (70%) of the more developed territories achieved a good level of S3 bandwidth. Frequently, Leader, Strong, and Moderate innovators reached optimality in terms of bandwidth. Finally, 67% of the Member States/regions with a quality of institution index below the EU average display an appropriate S3 bandwidth, and the majority (66%) of the S3 that can be considered prudential (i.e., that show low ambition) were also better able to select an adequate number of priorities.

Figure 31: Descriptive statistics for S3 with an appropriate or too-high S3 bandwidth



Source: Prognos/CSIL (2022).

We now use econometric techniques to provide a solid assessment of the determinants of optimality in our sample of S3 (see the infobox below for the details of the methodology employed).

[59] The indicator is missing for five French outermost regions.

Methodology of the econometric analysis

We employed multivariate econometric analysis to study the relationships between the structural features of Member States/regions (presented in Section 6.3.2) and the S3 optimality. In this analysis, we also explored the role of the "S3 ambition" as a determinant of optimality.

The dependent variables to explain (predict) are:

- Optimal bandwidth, which takes on the value of 1 for Member States/regions with an appropriate bandwidth and 0 otherwise (a too high bandwidth);
- Optimal relatedness, which takes on the value of 1 for Member States/regions with an appropriate relatedness and 0 otherwise (with a too high or too low relatedness);
- Too high relatedness, taking on the value of 1 for Member States/regions with a too high relatedness and 0 otherwise;
- Too low relatedness, taking on the value of 1 for Member States/regions with a too low relatedness and 0 otherwise.

Logistic models allowed us to estimate the probability of observing optimality in S3 (dependent variable) given a set of potential driving factors, including Member States/regions' structural features and institutional/policy factors (namely, the degree of ambition of their S3, and the institutional quality). Positive and statistically significant coefficients[60] indicate that the corresponding variable positively influences the probability of observing optimality in the S3. In contrast, negative and statistically significant coefficients suggest that the corresponding variables negatively influence the probability of observing optimality. Coefficients that are not statistically significant can be interpreted as irrelevant; therefore, the corresponding feature is not a driving factor of optimality.

In Table 11, we explore the factors that explain the probability that an S3 achieves a good level of bandwidth. Differently from the descriptive statistical analysis shown above, the econometric models allow us to identify the determinants of an appropriate bandwidth, after taking into account the concurrent effect of other variables. Results indicate that **a good S2 bandwidth can be found especially in smaller Member States/regions (in terms of population)**. In other words, smaller Member States/regions tend to be more selective and better able to concentrate their resources. Conversely, the S3 covering larger territories in terms of population are generally associated with too high levels of bandwidth. These sub-optimal strategies include S3 defined at NUTS 0 level (e.g. Poland, Greece, Portugal, and the Czech Republic) and regional S3 in highly populated areas (e.g. Lombardy, Ile-de-France, Andalusia, and North Rhine-Westphalia). This might be because when the S3 is defined at more granular levels, it is easier to identify specialisations, or there are simply fewer options

[60] The signs *,**,*** indicate statistical significance at 10%, 5%, and 1% level respectively. This means that the variables for which one of these signs are present play a role in determining the optimality of the S3.

to choose from. Moreover, when the areas of specialisation are fewer, a smaller number of stakeholders are involved in the design of the S3, facilitating the prioritisation process. Finally, while there is a positive correlation between population and economic diversification,[61] the latter does not seem to be a strong predictor of the appropriate bandwidth.

The econometric results also indicate that **Member States/regions with higher R&D intensity and lower quality of government are more likely to display a good level of S3 bandwidth**. This result emerged from the descriptive statistics and is corroborated by the econometric analysis. It is in contrast with other studies which show that Member States/regions with higher institutional quality were better able to prioritise (e.g. Di Cataldo et al., 2020). While the extant literature relied on the count of economic sectors and scientific fields in the S3, in our contribution, we consider the share of available options chosen and the degree to which priorities are interrelated (see the bandwidth indicator definition in Section 0). We argue that this method leads to more accurate results. Furthermore, our result could be explained by the importance played by Cohesion Policy funds in less developed regions. In these contexts, the financial envelope of the S3 is considerable and often represents a sizable share of the funding available for innovation. Less developed regions characterised by a weaker quality of institutions could have achieved higher selectivity thanks to a more careful application of the EDP and the technical assistance received by DG REGIO and the JRC experts during the strategy design phase.

Finally, even if optimal bandwidth is observed generally in more developed regions (as shown in Figure 29), the econometric analysis indicates that the level of development does not play a decisive role in explaining the optimal bandwidth after controlling for all other variables.

Table 11: The determinants of the optimal S3 bandwidth (probit model)

VARIABLES	1	2	3	4	5
Structural determinants					
Population	**-0.189*****				**-0.281****
	(0.0704)				(0.115)
GDP per capita	0.252				0.489
	(0.248)				(0.307)
Economic Diversification	2.600				1.368
	(3.821)				(2.559)
Tertiary Education Attainment	-0.0106				0.000
	(0.0216)				(0.018)
R&D intensity	**0.245****				**0.300****
	(0.120)				(0.116)
Institutional and policy determinants					
S3 Ambition		-0.005		-0.005	-0.006
		(0.006)		(0.005)	(0.005)
Quality of government index			-0.012	-0.103	**-0.412***
			(0.227)	(0.211)	(0.218)
Constant	-1.988	0.267	0.290	0.258	-2.320
	(4.043)	(0.265)	(0.262)	(0.265)	(2.535)
Observations	161	162	161	161	161

Source: Prognos/CSIL (2021).
Notes: Robust standard errors in parentheses (Clustered by country); *** p<0.01, ** p<0.05, * p<0.1

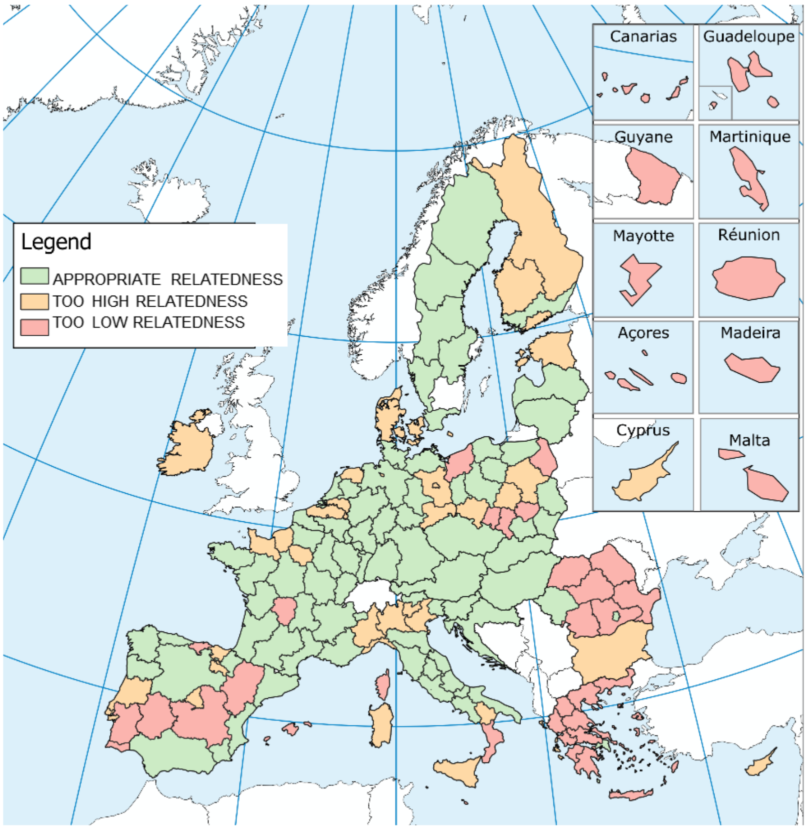
Relatedness

Figure 32 depicts the regions that attained an appropriate, too high, or too low S3 relatedness. Many Member States/regions targeted the right set of priorities, thereby showing optimality in the degree of S3 relatedness. Various parts of Central and Western Europe present an optimal relatedness, although some German, French, and Polish regions remained too anchored in

[61] In our sample, the correlation is nearly 30%.

their areas of strength. Sweden and parts of Italy and Spain, together with Lithuania and Latvia, are also characterised by an appropriate relatedness level. Finland, Denmark, Ireland, but also Bulgaria and some Italian regions show excessive closeness of their priorities with their areas of specialisation, indicating limited scope for exploration of new engines of competitiveness. These findings are consistent with the analysis in Prognos and CSIL (2021) for Denmark and the German region of Berlin and Brandenburg. In the case of Denmark, the case study evidenced that the S3 aimed at deepening certain specialisation. In the case of Berlin and Brandenburg, the S3 was explicitly referred to as a strategy to "strengthen strengths".

Figure 32: EU Member States/regions with appropriate, too high, or too low S3 relatedness

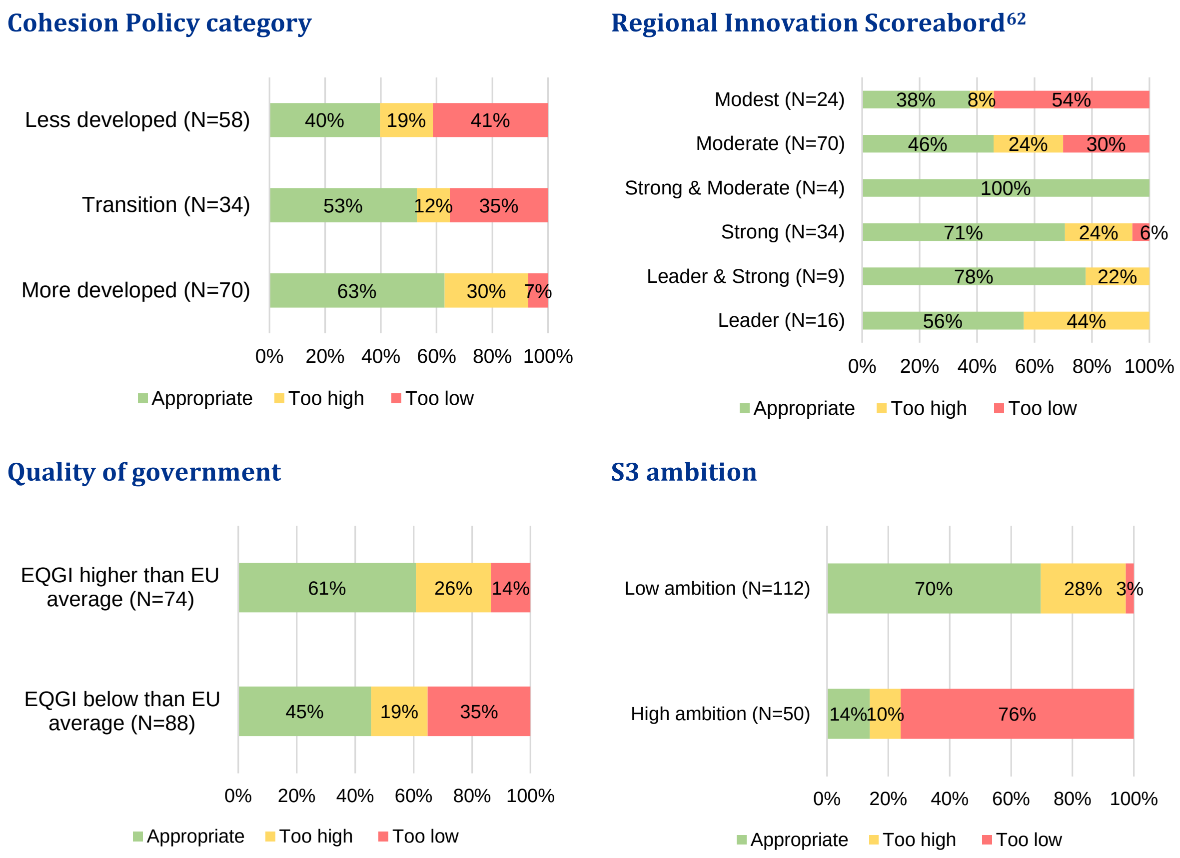


Source: Prognos/CSIL (2021).
Note: The results of the national S3 (Italy, Greece, Poland, Portugal, Romania, Spain) are not displayed in the map. They all have an appropriate level of relatedness.

Some descriptive statistics (Figure 33) are used to highlight the types of Member States/regions where we observe an appropriate S3 relatedness (or not), and, by doing so, to identify possible determinants of optimality.

Optimal relatedness is more likely to be found in more developed regions (63%), regions with a higher institutional capacity index (61%), and regions with a medium-high level of innovation capacities (measured by the Regional Innovation Scoreboard). Modest innovators are characterized instead by a higher share of S3 with too low relatedness levels. **The indicator of S3 ambition seems to differentiate very well between appropriate and less appropriate relatedness.** Most Member States/regions (70%) with low S3 ambition achieved an appropriate relatedness. In contrast, 86% of the highly ambitious strategies are associated with sub-optimal related diversification. More specifically, the vast majority of the strategies with high ambition show too low relatedness. The econometric analysis below is used to validate and enrich the preliminary insights drawn from this descriptive analysis.

Figure 33: Descriptive statistics for S3 with an appropriate, too high, or too low S3 relatedness



Source: Prognos/CSIL (2022).

The test of the determinants of optimality in terms of the S3 relatedness is structured in three analyses: i) the test of the factors that determine whether EU Member States/regions have designed an appropriate S3 relatedness; ii) the test of the factors behind a too high relatedness; and iii) the test of the determinants of too low relatedness.

The results of the first test are displayed in Table 12. Results show that it is more likely to observe an appropriate relatedness in large Member States/regions, highly diversified and with high R&D intensities. The quality of institutions is also positively related to optimality, indicating that strong institutional capacities help territories design better S3. Finally, as the descriptive analysis suggests, an indicator that is relevant when assessing the relatedness of S3 is the S3 ambition. This measures the jump in complexity that Member States/regions aim to make. In other words, the higher the ambition, the higher the difference between the complexity of the Member State/region and complexity sought in the S3. This index is negatively correlated with the probability of achieving an appropriate degree of relatedness, indicating that ambition pushes territories into sun-optimal areas.

[62] The indicator is missing for five French outermost regions.

Table 12: Determinants of the optimal relatedness (probit model)

VARIABLES	1	2	3	4	5
Structural determinants					
Population	**0.127***				**0.104***
	(0.0772)				(0.055)
GDP per capita	0.115				0.008
	(0.206)				(0.145)
Economic Diversification	**8.485****				3.288
	(3.470)				(2.958)
Tertiary Education Attainment	-0.0217				**-0.033****
	(0.0143)				(0.016)
R&D intensity	**0.323****				-0.070
	(0.164)				(0.156)
Institutional and policy determinants					
S3 Ambition		**-0.021*****		**-0.021*****	**-0.020*****
		(0.004)		(0.004)	(0.004)
Quality of government index			**0.306***	0.019	**0.210***
			(0.166)	(0.119)	(0.122)
Constant	-10.74***	-0.071	0.118	-0.063	-3.734
	(4.117)	(0.106)	(0.124)	(0.119)	(2.803)
Observations	161	162	161	161	161

Source: Prognos/CSIL (2021).
Notes: Robust standard errors in parentheses (Clustered by country); *** p<0.01, ** p<0.05, * p<0.1

The second test aims at identifying the factors behind an overly related S3. In contrast with the previous findings, this more prudential approach seems more frequent in smaller Member States/regions. other socio-economic factors do not explain excessive relatedness. When we look at the “soft factors”, instead, the index of institutional quality is negatively associated with the probability of observing a too highly related strategy. Therefore, institutional capacities help Member States/regions avoid sub-optimal strategies. The level of ambition emerges as a relevant factor only in a few specifications and becomes unimportant when all factors are considered. Hence, the ambition of the S3 is not a determinant of excessive relatedness.

Table 13: Determinants of too high relatedness (probit model)

VARIABLES	1	2	3	4	5
Structural determinants					
Population	**-0.135****				**-0.158*****
	(0.0527)				(0.047)
GDP per capita	0.0549				0.163
	(0.168)				(0.174)
Economic Diversification	7.088				5.997
	(5.578)				(5.880)
Tertiary Education Attainment	0.0225				0.032
	(0.0268)				(0.023)
R&D intensity	0.194				0.254
	(0.150)				(0.168)
Institutional and policy determinants					
S3 Ambition		**-0.007****		**-0.007****	-0.003
		(0.003)		(0.003)	(0.004)
Quality of government index			0.146	0.050	**-0.278****
			(0.161)	(0.151)	(0.137)
Constant	-6.946	-0.825***	-0.745***	-0.812***	-7.072
	(4.520)	(0.148)	(0.141)	(0.154)	(5.057)
Observations	161	162	161	161	161

Source: Prognos/CSIL (2021).
Notes: Robust standard errors in parentheses (Clustered by country); *** p<0.01, ** p<0.05, * p<0.1

Our third test explores the factors behind an excessively unrelated strategy (Table 14). This is a key test for less developed regions and more generally, to understand how the first experience of the S3 has worked in the EU. The key findings of this test can be summarised as follows:

- First, less diversified Member States/regions were more tempted to go for an unrelated strategy. This is possibly due to the challenges in finding some (related) technological fields within their technological portfolios that the S3 could target.
- Second, the probability of observing a too unrelated strategy is higher for Member States/regions with low R&D intensities, possibly indicating a desire to revamp structural transformation towards new (more innovative) directions.
- Third, the S3 ambition emerges as a crucial determinant of unrelatedness: the higher the ambition, the higher the chances that the region chose an unrelated S3. By contrast, the indicator of the quality of institution does not emerge as a critical factor to explain the probability of designing a too unrelated S3.

Table 14: Determinants of too low relatedness (probit model)

VARIABLES	1	2	3	4	5
Structural determinants					
Population	0.0280				0.120
	(0.0946)				(0.113)
GDP per capita	-0.262				-0.463
	(0.222)				(0.382)
Economic Diversification	**-17.04*** **				**-12.614*** **
	(5.013)				(3.598)
Tertiary Education Attainment	0.0309				0.013
	(0.0263)				(0.036)
R&D intensity	**-2.282*** **				**-1.349** **
	(0.555)				(0.612)
Institutional and policy determinants					
S3 Ambition		**0.036*** **		**0.034*** **	**0.024*** **
		(0.005)		(0.004)	(0.005)
Quality of government index			**-0.577** **	-0.150	0.286
			(0.254)	(0.226)	(0.322)
Constant	18.66***	-1.045***	-0.864***	-1.090***	14.700***
	(5.015)	(0.169)	(0.185)	(0.162)	(5.185)
Observations	161	162	161	161	161

Source: Prognos/CSIL (2021).
Notes: Robust standard errors in parentheses (Clustered by country); *** p<0.01, ** p<0.05, * p<0.1.

The results of all our econometric exercises are summarised in Table 15. We can recapitulate them as follows:

1. Overall, socio-economic characteristics hardly matter to explain the choice of an appropriate bandwidth and relatedness in S3. Member States/regional features related to institutions and the nature of the policy process play a more decisive role.
2. In terms of bandwidth, small Member States/regions with high R&D intensity can better prioritise. Lower quality of institutions is associated with better prioritising, possibly indicating the stronger incentives of less advanced Member States/regions to comply with the S3 approach fully.
3. In terms of relatedness, stronger institutional capacities help achieve appropriate levels of relatedness by keeping ambition under control. Lower institutional capacities are instead associated with too related strategies. Excessive ambition, in turn, is behind the overly unrelated strategies. These S3 tend to be more frequent when Member States/regions are poorly diversified (hence, they do not have many options in terms of areas of strength) and when they do not invest strongly in R&D (i.e., their innovation efforts are limited).

Table 15: Synthesis of the main determinants of optimal and sub-optimal S3

Variable	Appropriate bandwidth	Appropriate relatedness	Too high relatedness	Too low relatedness
Size (population)	Small	Not relevant	Small	Not relevant
Economic development (GDP per capita)	Not relevant	Not relevant	Not relevant	Not relevant
Economic diversification	Not relevant	Not relevant	Not relevant	Small
R&D intensity (R&D/GDP)	High	Not relevant	Not relevant	Low
Tertiary education	Not relevant	Low	Not relevant	Not relevant
Quality of government index	Low	High	Low	Not relevant
S3 Ambition	Not relevant	Low	Not relevant	High

Source: Prognos/CSIL (2022).

6.4 Conclusions

Few EU Member States and regions followed the S3 principles *in toto*, particularly regarding the number and choice of thematic areas selected. These too often chose an excessive number of priority areas, misaligned with the Member State/regional areas of specialisation or areas of strongest potential. This emerges as a clear message from the extant literature on the novel experience of EU Member States/regions with the S3 approach.

This Chapter aimed at answering two key questions:

1. What determines an appropriate thematic focus of S3?
2. Under which conditions is a strategy of related or unrelated diversification a good option for a Member State/region?

To answer these questions, this study developed a **theory of what constitutes an appropriate S3 (with a focus on its thematic focus and diversification approach) in different regional contexts**. While this effort was never formally undertaken in any previous academic or policy study or policy document, the development of a theory of a "good" S3 is a necessary step toward the assessment of the prioritisation approach adopted by MS/region and the formulation of recommendations for the new programming period.

This theory crucially builds on the conceptual and empirical literature and the policy documents by the EC, which outlined the key principles and concepts that should drive the design and development of S3 across Member States/regions of the EU, with particular reference to the need to balance two concurrent aims: thematic focus and resource concentration on the one hand, and diversification to exploit new sources of competitive advantage on the other hand. Based on this literature, we formulate the hypotheses about the *expected* thematic focus and degree of relatedness of S3, taking into account the features of Member States/regions in terms of their technological opportunities and socio-economic characteristics.

In a subsequent stage, this theory is tested by comparing the *expected* bandwidth and diversification approach expected from the theory with the *actual* ones adopted by the S3. This assessment enables the identification of the S3 that complied or deviated from the theory, in which way, and why. Clearly, this assessment and all our results depend on the definition of the desirable levels of bandwidth and relatedness. Overall, our thresholds can be considered as relatively conservative. However, different ranges and thresholds could be tested.

This study contributes to the extant literature in at least four important ways. First and foremost, it develops a theory of a good S3 with reference to its thematic focus and related vs unrelated diversification goal. Despite prolific academic literature and the availability of guidelines provided by the European Commission on how to design S3**, there is no theory on what constitutes a good S3 for different types of territories**. No indications are given on what degree of selectivity is advisable for different types of Member States/regions, or whether the thematic focus of the S3 for a particular type of MS/region can aim at unrelated diversification or should better stick to related diversification. Some evidence showed that the priorities selected in most of the EU Member States/regions were not related to their areas of specialisation (Deegan et al., 2022; Di Cataldo et al., 2020; Marrocu et al., 2022; Prognos and CSIL, 2021). Still, no study has discussed whether the degree of relatedness of these strategies was appropriate to the characteristics of the Member State/region, and whether more or less ambition would have been a more suitable choice.

Second, this study goes beyond the mere count of the priority areas listed in the S3 or associated with the strategy and devises a **measure of the degree of selectivity** (i.e., thematic bandwidth) of the S3. This new measure takes into account: i) the number of selected priorities in economic, scientific, and technological terms as a share of the number of possible economic, scientific, and technological fields; ii) the relevance (i.e., weight) of each priority in the S3; and iii) whether these fields are related to each other (i.e., reinforce each other).

Third, it adds a new dimension of the analysis to the bulk of available empirical evidence on the diversification processes triggered by the S3, i.e., the **technological dimension**. Previous literature could not investigate this dimension due to the lack of available data on S3 priorities in terms of technological classes. The S3 are fundamentally innovation strategies looking to establish innovation-based sources of economic growth. Therefore, assessing the relatedness of the technological objectives of these strategies is not only an interesting research topic but also unavoidable from a policy perspective.

Fourth, this paper goes beyond the usual explanation of policy failures centred around the concept of institutional capacities. Instead, it identifies policy orientations, particularly policy **ambition**, to be a key determinant of the degree of relatedness of the S3. The concept of ambition is hinted at in the debate on relatedness and complexity. The "diversification dilemma" (Balland et al., 2019) and the "complexity gain" (Pintar and Scherngell, 2021) are just two of the terms coined to imply the idea that when diversification options are accessed, policymakers operate a tough choice that requires balancing risks and rewards.

Our analysis provides **substantial empirical evidence** on these topics by analysing a sample of 162 S3 published until 2020. We find that:

- **61% of the 162 S3 under scrutiny achieved an appropriate bandwidth**. Most of these strategies belong to Member States/regions with strong innovation capacities.
- **52% of the 162 S3 achieved an appropriate level of relatedness**. Most of these S3 are found in Member States/regions with strong innovation capacities.
- **36 S3 are too related** to the areas of strength of the MS/region to achieve any degree of smart diversification.
- Most of the too unrelated strategies are found in Member States/regions with limited innovation capacities and few technological possibilities for upgrading.

In terms of the **determinants for choosing an appropriate level of bandwidth and relatedness in S3**, our analysis shows that:

- Appropriate bandwidth is generally found in small Member States/regions with high R&D intensity and lower quality of institutions. While the latter finding seems counterintuitive, it can be explained by the possibly stronger incentive of less advanced Member States/regions to fully comply with the S3 approach, given their larger financial envelope.
- Appropriate relatedness is generally associated with stronger institutional capacities and lower ambition.
- Lower institutional capacities are associated with too related strategies.
- High ambition is behind the design of too highly unrelated strategies. This diversification approach tends to be more frequent in poorly diversified Member States/regions with low R&D intensities.
- S3 relatedness critically depends on regional relatedness and complexity, which determines the technological opportunities available to the Member State/region. Therefore, more advanced economies find it relatively more straightforward to build on their existing strengths and follow a related diversification approach.
- The S3 ambition is a powerful predictor of the S3 relatedness. In particular, more ambitious Member States/regions tended to deviate more from relatedness, possibly venturing into excessively unrelated diversification.

7. The updated S3 Scoreboard

Overview of key findings

- **By developing an integrated methodology, a single comparative map for the S3 Scoreboard that includes all the S3 of the respective Member States and regions is provided**. At the heart of the refinement of the S3 Scoreboard is the introduction of three different context criteria and the inclusion of the other findings of this study. This concerns especially the new findings regarding the appropriateness of bandwidth and relatedness. These updates account for both different levels of development among the Member States/regions and contextual factors that can potentially exert an influence on the S3.

- **A rather heterogenous performance in the S3 Scoreboard of the different S3 emerges and a clear regional pattern can hardly be detected**. Overall, relatively similar findings from the updated S3 Scoreboard emerge compared to the 2021 version which includes that several Member States/regions with low innovation capacities and low institutional capacities perform relatively well in the S3 scoreboard. Moreover, many regions that usually perform well in terms of their innovative capacities and the quality of their government underperform in the updated version of the S3 Scoreboard. A possible interpretation for this 'Nordic Paradox' is that those regions have a strong tradition and experience in using their own regional innovation funds for pursuing their smart specialisation strategy and the priority areas

- **The S3 Scoreboard plays a unique role in the scoreboard landscape and even more in the context of S3 policies**. By providing a comparative assessment of all smart specialisation strategies in EU Member States/regions and focusing thereby on central aspects of the S3 approach the S3 Scoreboard allows examining how the European Member States/regions have followed the ex-ante conditionalities for the Cohesion Policy period 2014-2020. However, the S3 Scoreboard does not allow to draw conclusions regarding the effectiveness and the impact of the implementation of the strategies.

- **The S3 Scoreboard is expected to play an important role in the future of regional innovation policies in the EU.** Three different dimensions for improvement and new application of the Scoreboard are discussed. These include the exploration of indicators' validity to improve the quality of the Scoreboard, standardizing concepts to deal with subjective data, and the application of the S3 Scoreboard to support continuous S3 monitoring.

This Chapter presents the results of the critical assessment of the S3 Scoreboard 2021 that was developed and presented in the Study on prioritisation in Smart Specialisation Strategies in the EU by Prognos and CSIL.[63] Thereby, Section 7.1 discusses the methodological refinements and presents the updated version for the S3 Scoreboard. Section 7.2 elaborates on the role of the S3 Scoreboard and section 7.3 gives an outlook on the future of the Scoreboard.

[63] Prognos & CSIL (2021): Study on prioritisation in Smart Specialisation Strategies in the EU. Study on behalf of the European Commission. Available under: https://ec.europa.eu/regional_policy/en/information/publications/studies/2021/study-on-prioritisation-in-smart-specialisation-strategies-in-the-eu (last access 16.05.2022)

7.1 The updated S3 Scoreboard

Based on the comprehensive database that was developed and presented in the Study on prioritisation in Smart Specialisation Strategies in the EU by Prognos and CSIL[64] the S3 Scoreboard 2021 was developed in the predecessor study. This S3 Scoreboard was the result of iterative discussions with the EC to consolidate the comprehensive assessments of the study into one overarching assessment of the processes and outcomes of S3 in the 2014-2020 period. The Scoreboard provided a new comparative assessment of all smart specialisation strategies in EU Member States and regions based on a novel methodology, using six indicators grouped into outcome and process criteria. It was constructed following the **concept of an "ideal" S3 process**: from the development of S3 over the identification of priority areas and transformative activities & critical mass to the implementation of projects. The S3 Scoreboard provides a detailed breakdown of performance groups with contextual data, including the share of ERDF budget linked to S3 priority areas, the continuity of the EDP or the strictness of selection criteria for S3 related calls under ERDF 2014-2020. Moreover, with this S3 Scoreboard an interesting finding emerged which states that some Member States/regions that perform strongly in the Regional Innovation Scoreboard and European Quality of Government Index underperform in the S3 Scoreboard. This finding which is especially visible in the case of the Scandinavian regions was labelled as the 'Nordic Paradox'.

Although the S3 Scoreboard 2021 was developed in close cooperation with DG REGIO there is still potential for further improvements, especially by considering the findings that have emerged throughout the follow-up study "Analysis of key parameters of Smart Specialisation Strategies (S3)". The aim of this refinement of the S3 Scoreboard is to design an integrated methodology to provide a **single comparative map** that includes the 185 S3 of the respective Member States and regions.

The starting point for this refinement of the S3 Scoreboard were discussions and close interactions with Dominique Foray as a senior academic advisor. Central elements of the S3 Scoreboard that were discussed include, for instance, the used variables, the applied weighting of the criteria and the overall methodological validity.

Based on the critical assessment and discussions with Dominique Foray on the variables and criteria of the S3 Scoreboard the following adapted methodological approach emerged (see Figure 31 for an illustrative overview). Like the S3 Scoreboard 2021, the updated version is based on three outcome and three process criteria. However, it needs to be highlighted that the findings regarding the analysis of related vs unrelated diversification are included in the refinement of the S3 Scoreboard. This concerns especially the analyses that address the issue of appropriateness of bandwidth and relatedness of the 185 S3. As these analyses cover among others the economic diversification of regions this data in the refined S3 Scoreboard further accounts for different levels of development. The indicator used in this regard accounts for the fact whether a strategy has achieved an appropriate level of bandwidth and/or relatedness (see also Table 22 and Table 23 in the Annex for an overview and ranking of the indicators that have been applied in the refinement of the S3 Scoreboard).

In order to account for different levels of development, differences in the intensity of funding and different capacities of the innovation ecosystems among the regions three **context criteria** are introduced. These context criteria are presented and discussed in detail in the following. For each region, an average of these nine indicators is constructed and in the next step, each region is then compared to the average EU S3. Thereby, a similar approach as in

[64] Prognos & CSIL (2021): Study on prioritisation in Smart Specialisation Strategies in the EU. Study on behalf of the European Commission. Available under: https://ec.europa.eu/regional_policy/en/information/publications/studies/2021/study-on-prioritisation-in-smart-specialisation-strategies-in-the-eu (last access 16.05.2022)

the Regional Innovation Scoreboard[65] was applied and the relative performances were categorised into four groups:

- **S3 Leader**: all strategies with a relative performance more than 25% above the average;
- **Strong S3**: all regions with a relative performance between 100% - 125% of the average;
- **Moderate S3**: all regions with a relative performance 70% - 100% of the average;
- **Modest S3**: all regions with a relative performance below 70% of the average.

Similar to the 2021 version of the S3 Scoreboard a more detailed breakdown of these performance groups is introduced by splitting each group into thirds. For instance, the performance group "Moderate S3" is divided into three subgroups: "Moderate S3+" for strategies between 90% and 100% of the average, "Moderate S3" for strategies between 80% and 90% of the average and "Moderate S3-" for strategies between 70% and 80% of the average.

In the following the three context criteria that have been introduced for the updated S3 Scoreboard are presented and their causal link to the S3 concept discussed:

- **Maturity of the Innovation Ecosystem**: This indicator captures the capacity of a region's innovation ecosystem and is based on the Regional Innovation Scoreboard. This Scoreboard provides a comparative assessment of the performance of innovation systems across the different regions and EU countries. For the S3 Scoreboard the 2017 Regional Innovation Scoreboard Groups[66] (Innovation Leader, Strong Innovator, Moderate Innovator & Modest Innovator) have been applied. This time frame has been applied to be closer to the time when the S3 were developed. Figure 41 in the Annex provides a comparison of the development of the Regional Innovation Scoreboard between 2017-2021. Overall, small variations can be identified. However, this comparison is limited by changes in the NUTS regions (especially in Poland).
- **Intensity of Cohesion Policy Funding**: This indicator informs about the share of Cohesion Policy Funding per Member State to public investment 2015-2017. This data[67] compares the allocations of Cohesion Policy per Member State (available on the Cohesion Policy open data platform) to public investment (Gross fixed capital formation by general government). This is usually referred to as total public investment.
- **Quality of Government**: This indicator is based on the European Quality of Government Index (EQI)[68] which is the result of novel survey data regional (e.g., sub-national) level governance within the EU. The data was first gathered and published in 2010 and then repeated in 2013, 2017, and 2021. For the Scoreboard, the 2017 data is used. In other words, this indicator captures average citizens' perceptions and experiences with corruption, quality, and impartiality in various public sectors in their region.

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[65] European Commission (2021): Regional Innovation Scoreboard 2021 – Methodology Report. Available under: https://ec.europa.eu/docsroom/documents/45972 (last access 16.05.2022)

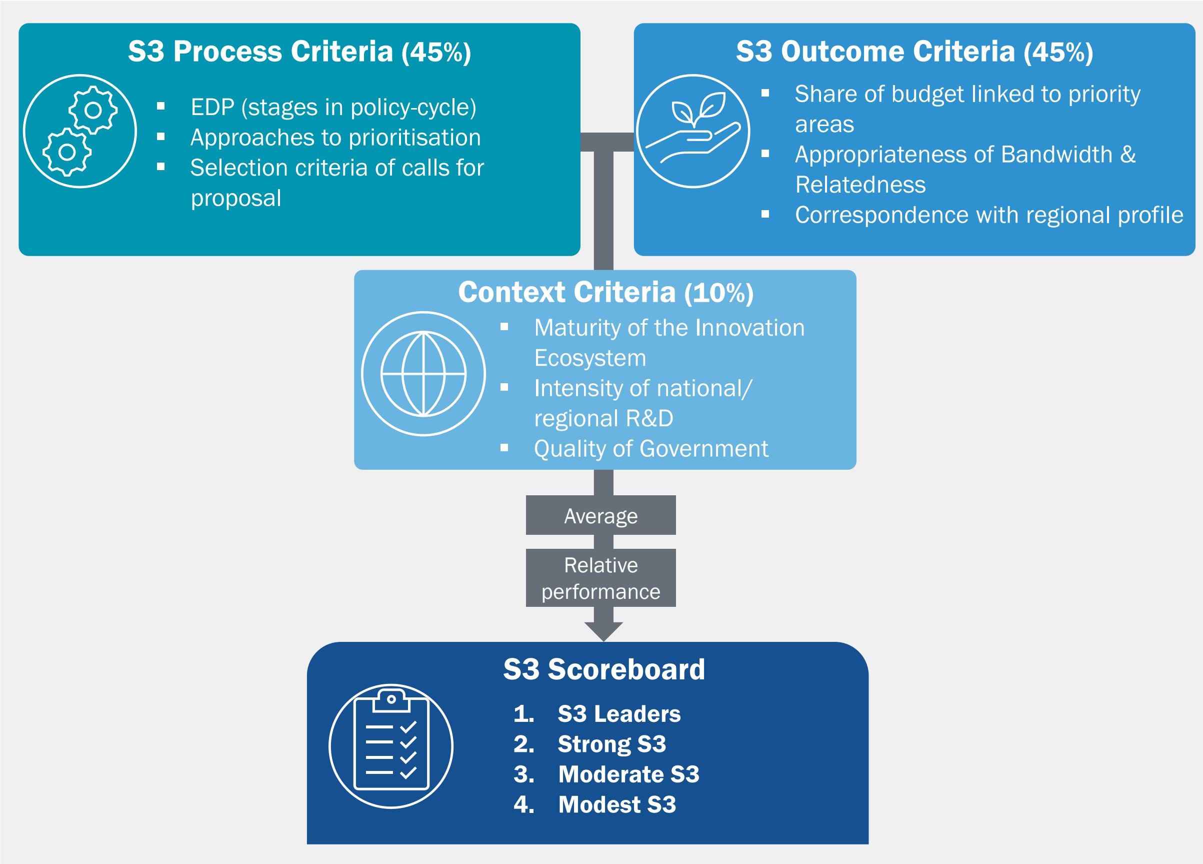
[66] European Commission (2017): Regional Innovation Scoreboard 2017. Available under https://op.europa.eu/en/publication-detail/-/publication/ce38bc9d-5562-11e7-a5ca-01aa75ed71a1/language-en (last access 16.05.2022

[67] see https://cohesiondata.ec.europa.eu/Other-Eurostat/Share-of-Cohesion-Policy-per-Member-State-to-publi/drqq-sbh7/data (last access 16.05.2022)

[68] https://www.gu.se/en/quality-government/qog-data/data-downloads/european-quality-of-government-index (last access 16.05.2022)

The rationale for including these criteria is that these **context criteria are relevant factors for smart specialisation strategies**. The causal link is, however, the clearest for the Quality of Government since better governance should lead to better S3 (e.g., through the implementation of a better Entrepreneurial Discovery Process). A causal link between the intensity of cohesion funding policy and the quality of S3 can also be suspected. The logical argument – supported by anecdotal evidence – is that a high intensity of Cohesion Policy funding, regions are eager to comply with the ex-ante conditionality and therefore show engagement and commitment which are rather positive factors to produce a good strategy. On the opposite, regions with a low level of cohesion policy funding have smaller incentives to care for the S3 conditionality (see also Section 6.4). For the Maturity of the Innovation Ecosystem, two opposing hypotheses can be brought forward. On the one hand, it can be argued that a mature innovation ecosystem can enable regions to develop and implement good smart specialisation strategies. On the other hand, it is also possible that the more mature an innovation ecosystem the less the S3 are developed and/or the region is relying on it. Based on these reflections different options for refining the S3 Scoreboard have been assessed and discussed with the Academic Experts and DG REGIO. As a result, the methodological approach as illustrated in the following figure has been developed. Thereby, the Outcome and Process Criteria both account for 45% of the weighted average. The Context Criteria take up 10% of the weighting.

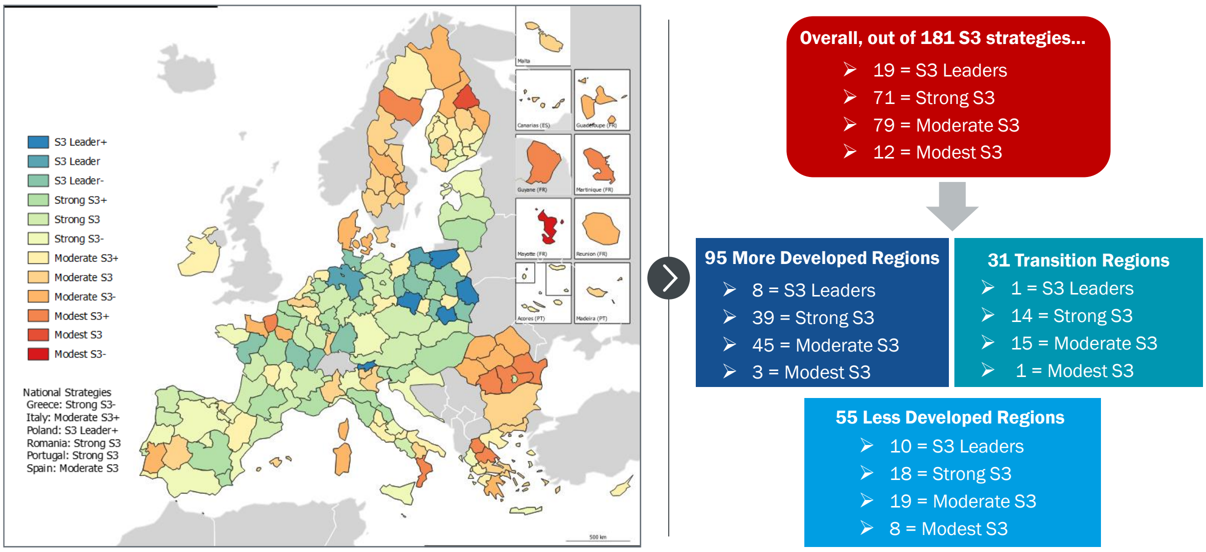
Figure 34: Overview of the methodological approach for the refined S3 Scoreboard



Source: Prognos / CSIL (2022).

Map 5 shows the performance of the assessed S3 of the 2014 – 2020 period in the updated S3 Scoreboard. Overall, out of the 181[69] S3 that are considered in the Scoreboard 19 are classified as S3 Leaders and 71 as Strong S3. These strategies perform above the EU average. 79 S3 are regarded as Moderate S3 and 12 regions as Modest S3. These regions perform below the EU average. Regarding the regional classification by Cohesion Regions, the relatively high share of S3 Leaders in Less Developed Regions stands out. From a more granular **regional perspective**, an overall mixed picture emerges meaning that no clear regional patterns can be found. However, it can be highlighted that the good performance of many Polish regions stands out. This was also found in the S3 Scoreboard 2021[70] albeit to a smaller extent. The good performance of these regions can often be explained by a relatively high share of budget that is linked to the priority areas, strict selection criteria and the application of the EDP in all stages. In addition, many Polish regions have reached appropriate levels in both the bandwidth and relatedness in their strategies. Many regions in Southeast Europe (such as Romanian and Greek regions, Bulgaria etc.) perform below the EU average. Overall, similar findings as in the 2021 version of the S3 emerge.[71] This includes for instance that several Member States/regions with low innovation capacities and low institutional capacities perform relatively well in the S3 scoreboard. Moreover, many regions that usually perform well in terms of their innovative capacities and the quality of their government[72] underperform also in the updated version of the S3 Scoreboard. This especially concerns the Scandinavian countries but also for instance some German and French regions.

Map 5: Single comparative map for the updated S3 Scoreboard



Source: Prognos / CSIL (2022). n = 181 regions. Note: When a region is covered by both a national strategy and a sub-national strategy, the coloured area of the sub-national region refers to the sub-national strategy. The information for the national strategies is provided by the figures on the left. These Member States are Italy, Greece, Spain, Poland, and Portugal. The United Kingdom is not included in the updated S3 Scoreboard.

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[69] The four strategies of the United Kingdom are not included in the updated version of the S3 Scoreboard

[70] Prognos & CSIL (2021): Study on prioritisation in Smart Specialisation Strategies in the EU. Study on behalf of the European Commission. Available under: https://ec.europa.eu/regional_policy/en/information/publications/studies/2021/study-on-prioritisation-in-smart-specialisation-strategies-in-the-eu (last access 16.05.2022)

[71] as per the Regional Innovation Scoreboard: https://ec.europa.eu/info/research-and-innovation/statistics/performance-indicators/regional-innovation-scoreboard_en (last access 16.05.2022)

[72] as per the European Quality of Government Index: https://www.gu.se/en/quality-government/qog-data/data-downloads/european-quality-of-government-index (last access 16.05.2022)

Regarding the Scandinavian regions, the overall ranking in the Scoreboard is influenced by a below-average performance in the Process rather than Outcome Criteria. Especially for many of the Swedish regions an explanation for this performance can be found in the fact that often the EDP was only applied in one stage and/or no selection criteria for the calls of proposal were applied. For many Finnish regions, it also needs to be highlighted that no EDP was used. Although especially the Swedish regions have reached appropriate levels in their bandwidth and relatedness a low share of budget linked to the priority areas or the non-availability of projects[73] further contribute to the performance in the S3 Scoreboard. A possible interpretation for this mismatch between the innovation strength and innovation opportunities stimulated by S3 is that some regions have a strong tradition and experience in using their own regional innovation funds for pursuing their smart specialisation strategy and the priority areas.

7.2 Role of the S3 Scoreboard

By assessing and comparing strategies the S3 Scoreboard plays a unique role in the scoreboard landscape and even more in the context of S3 policies. **It allows for a comparative assessment of all 185 smart specialisation strategies** in EU Member States and regions and focuses thereby on central aspects of the S3 approach. Moreover, it provides a detailed breakdown of performance groups with contextual data, including the share of ERDF budget linked to S3 priority areas, the continuity of the EDP or the strictness of selection criteria for S3-related calls under ERDF 2014-2020, which can all be used to analyse and compare the sophistication of S3 across the EU.

In other words, the S3 Scoreboard allows to examine how the European Member States/regions have followed the **ex-ante conditionalities** (ExAC) for the Cohesion Policy period 2014-2020 set by the EU. The development of a "national and regional research and innovation strategy for smart specialisation" constituted such a conditionality (ExAC 1.1) and was a prerequisite for the approval of the Operational Programmes (OP) of the European Regional Development Fund (ERDF) that include investment into strengthening research, technological development, and innovation. By setting this ex-ante conditionality a general framework was applied to all regions that wanted to participate in the ERDF. This approach entailed that Member States/regions with previous experience in designing smart specialisation strategies have received new obligations to establish overarching strategy processes. It can be questioned whether this approach in some cases was too prescriptive and might not have been suitable for all the 185 regions. Especially for regions with previous experience with smart specialisation strategies a pre-defined process might not be ideal. Such a focus on the absolute number of priority areas is misleading especially for regions that have developed a multi-level (tree-shaped) structure of priorities meaning that such strategies have an additional thematic focus below the (few) defined main priorities.[74] Due to the inclusion of an improved indicator that accounts for the appropriateness of a strategies bandwidth and relatedness this factor has been accounted for in the proposed refinement of the S3 Scoreboard.

In conclusion, the S3 Scoreboard allows for a comparative assessment of the 185 S3 of the period 2014-2020 and includes various aspects of the S3 approach. However, this S3

[73] Some Finnish and Swedish regions did not record any ERDF TO1 projects

[74] Gianelle et al. (2019): 'Smart Specialisation from Concept to Practice: A Preliminary Assessment'. JRC Policy Insight JRC116297, May. Smart Specialisation. https://www.tandfonline.com/doi/full/10.1080/00343404.2019.1607970 (last access 23.05.2022) and Prognos & CSIL (2021): Study on prioritisation in Smart Specialisation Strategies in the EU. Study on behalf of the European Commission. Available under: https://ec.europa.eu/regional_policy/en/information/publications/studies/2021/study-on-prioritisation-in-smart-specialisation-strategies-in-the-eu (last access 16.05.2022)

Scoreboard does not allow to draw conclusions regarding the effectiveness and the impact of the implementation of the strategies. This entails that a poor positioning in the S3 Scoreboard does not automatically imply a non-functioning innovation ecosystem and vice versa.

7.3 Outlook for the S3 Scoreboard

The S3 Scoreboard is expected to play a key role in the future regional innovation policies in the EU since the building blocks of S3 – prioritisation and entrepreneurial discovery – will remain since they are now mainstream and will be applied to the next generation of regional innovation policy. And precisely, the Scoreboard is about measuring these components as process and as outcome. It is therefore important to think of potential improvements and specific use of the instrument since the Commission could consider applying it at a larger scale to monitor and evaluate future regional policies. Improvements are certainly needed as the 'Nordic Paradox' can show, but these should be marginal improvements – meaning that the core of the metrics – based on solid and sound databases – will remain as it is now.

We can envision three distinct levels of discussions and works which could suggest some room for improving the Scoreboard and deploying it for new applications. The first level deals with the validity of the indicators which need further exploration, the second level address the issue of subjective data and the need to move towards more standardized and stable categories of activities (for example in the case of EDP), and the third level deals with the possibility of using a sub-set of the Scoreboard (process criteria) as a tool for continuous monitoring.

Exploring indicators' validity

On the indicator side, we identify below various criteria which make an indicator a valid one. Since an indicator, by definition, is an imprecise measure of the underlying concept (here the quality of the strategy), its validity must be evaluated. The following criteria are important:

A) an indicator should be as precise as possible, that is, it should bear a tight relationship with the underlying concept or have a high "signal-to-noise" ratio.

B) the indicator should be unbiased, meaning that the relationship between the indicator and the underlying concept does not vary systematically with particular characteristics

C) the relationship between the indicator and the underlying concept should be stable over time

D) an indicator should be comparable across different environments

E) indicators should not be susceptible to manipulation

F) indicators should be subject to aggregation

Of course, no indicator satisfies all criteria and there are often trade-offs between criteria. We find that, in general, all indicators of the Scoreboard meet these criteria in a satisfactory way and are therefore fully valid. However, there are a few issues. We just mention two as illustrations: The indicator "Maturity of the Innovation Ecosystem" does not meet criteria A (the relationship between the indicator and the underlying concept of interest (quality of the S3) is unclear). One might suspect that the indicator "degree of continuity of EDP" does not fully meet criteria E since the definition of EDP remains vague and S3 managing authorities have large leeway to respond (their responses are not based on hard facts) – see below, our discussion on subjective data. It will, thus, be interesting to further explore the validity of each indicator within this criteria framework to improve the quality of the Scoreboard. For the moment, it is proposed that the best option for refining the S3 Scoreboard is the involvement of equally weighted Process and Outcome criteria as well as the inclusion of the three Context Criteria (as shown in Map 5) mentioned before since the Quality of Government, Cohesion

Policy Funding and the Maturity of the Innovation Ecosystem are relevant context factors for the S3.

Standardizing concepts to deal with subjective data – the case of EDP

While the S3 Scoreboard is using a great deal of hard data, it has also to rely on subjective data – i.e. data that are largely based on the personal appreciation and judgment of the respondents. Obviously, the quality of subjective answers to questions posed in S3 surveys can be very different depending on the judgement and knowledge of the respondents. The fact that the metrics are partially based on subjective data is not by itself a big problem and economists and econometricians know how to deal with such issues (for instance by treating some variables as categorical and not making too much out of continuous variations). However, at least personal appreciation and judgement should be supported by clear and unambiguous definitions of the considered variable. An obvious example is precisely the indicator “Continuity of the EDP process”. It is obvious that the definition of EDP needs to become much more standardized – based on a clear identification of the activity and a specification of the requirements which need to be met to comply with the definition. Historically, the indicator “R&D” was also very vague and unstable until governments and international organizations worked together to agree upon a standard definition which then was instrumental to create new policy instruments (such as the R&D tax credit). The same is true today for EDP. We are now at some kind of historical bifurcation – either the EDP remains essentially conceptual, the EDP provision is more a matter of rhetoric than substance and, therefore, it is not very much suited for measurement and policy - or the EDP concept is translated into a well-defined and stable category of innovation-related activity – which in turn will increase the validity of the indicator, the strength of the Scoreboard and the effectiveness of the policy. Going back to the ‘Nordic paradox, it is probably the case that Scandinavian regions have not highlighted something they are practicing usually and do not look to them as an extraordinary achievement. If the EDP became a standard category with a clear definition, they would have ticked the box.[75]

Using a particular module of the Scoreboard (process criteria) to support continuous S3 monitoring

The empirical work which has been done to evaluate the quality of S3 has been what we could call “after-the-fact” assessment, which refers to an assessment in which researchers come along sometimes after regional S3 were funded and attempt to assess the S3 quality using observational data collected at that time. However, the S3 Scoreboard is specific since it aims at assessing strategies, not impacts. Because of this specific nature, the Scoreboard has the potential to be used as the S3 process unfolds. Some indicators – not all but for sure the process criteria – can generate very useful information for some kind of mid-term review of the S3. Thus, one specific module of the Scoreboard could be applied as a barometer, which can provide up-to-the-minute monitoring of the process (EDP, prioritisation, calls). Such a barometer measuring how the process is evolving could provide a measurement of the degree to which there is progress in the right direction. It can also provide an indication that something warrants further and more detailed investigation. The potential of the Scoreboard will be fully realized if some of the criteria can be used to monitor and manage S3 not only ex-post but also in real-time. This is why it will be interesting to explore the possibility of producing more proactive monitoring by having the funding agencies anticipate the need for such a continuous evaluation process and build certain features into the funding process to facilitate it.

[75] The information in this regard was collected and assessed by regional experts in the Study on prioritisation in Smart Specialisation Strategies in the EU based on the S3, related documents as well as interviews with managing authorities/relevant public authorities.

8. Conclusion and outlook on the future of S3

Overall, this study has built upon the knowledge and data created in the predecessor study on prioritisation in Smart Specialisation Strategies in the EU.[76] In this regard, a number of analyses have been further refined and at the same time questions that have arisen in the context of the predecessor study have been answered. In the following, the key findings of this follow-up study are summarised and an outlook on the future of S3 is provided. Although this assessment is based on priority areas of the 2014-2020 funding period the results of this study are also relevant for the 2021-2027 funding periods since the priority areas of the different region across the EU are not expected to change to a greater extent. Moreover, not least due to the importance of smart specialisation strategies in the New European Innovation Agenda[77] by the European Commission S3 can be expected to be relevant in the future.

As a first step, the 185 S3 of the different Member States/regions have been assessed from a rather internal perspective by examining the potential for **interregional cooperation** in the different S3. Here, it is found that there is vast potential for interregional cooperation among the 185 S3. On the one hand, there is a multitude of connections between the priority areas of the 185 S3 and the 14 EU Industrial Ecosystems that can be established. Moreover, the 185 S3 and their priority areas offer a multitude of complimentary knowledge in their respective priority areas. However, it is also found that this interregional cooperation potential is largely untapped. Therefore, interregional cooperation among the different regions and their different capabilities should be strengthened to further foster and stimulate innovative activities which further substantiates the recommendation on supra-regional and international cooperation and networking of the predecessor study. [78] Together with the 'enabling conditions' under the 2021-2027 that also set a stronger focus on international cooperation the Interregional Innovation Investments (I3) funding instrument by DG REGIO which aims at fostering interregional cooperation and sustainable links between different regional innovation ecosystems plays an important role.[79] Especially in the implementation of S3 cluster organisations can play an important role since in both concepts the facilitation of economic growth and competitiveness through regional proximity are key elements.[80] A specific advantage of cluster organisations is that they represent a broad number of actors and can therefore potentially provide potential collaboration partners with complementary skills. In this regard, the list of priority areas/regions with complimentary knowledge that was developed in this study can support the process of finding partners for interregional cooperation. However, as it was discussed previously the detected potential for interregional cooperation is broad and on a rather general level. However, cooperation projects are usually conducted on specific issues. Cluster

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[76] Prognos & CSIL (2021): Study on prioritisation in Smart Specialisation Strategies in the EU. Study on behalf of the European Commission. Available under: https://ec.europa.eu/regional_policy/en/information/publications/studies/2021/study-on-prioritisation-in-smart-specialisation-strategies-in-the-eu (last access 16.05.2022)

[77] European Commission (2022): A New European Innovation Agenda. Communication from the Commission to the European Parliament, the Council, the European Economic & Social Committee & the Committee of the regions. Available under: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52022DC0332&from=EN (last access 09.11.2022)

[78] Prognos & CSIL (2021): Study on prioritisation in Smart Specialisation Strategies in the EU. Study on behalf of the European Commission. Available under: https://ec.europa.eu/regional_policy/en/information/publications/studies/2021/study-on-prioritisation-in-smart-specialisation-strategies-in-the-eu (last access 16.05.2022)

[79] See https://ec.europa.eu/regional_policy/en/policy/themes/research-innovation/i3/ (06.07.2022)

[80] European Commission (2013): The role of clusters in smart specialisation strategies. Available at: https://op.europa.eu/en/publication-detail/-/publication/2fe44194-e5a8-42b7-ac14-9c9b8e157de3 (last access on 06.07.2021); OECD (2016): OECD Science, Technology and Innovation Outlook 2016 – Cluster Policy and Smart Specialisation Available at: https://www.oecd-ilibrary.org/docserver/sti_in_outlook-2016-28-en.pdf?expires=1628167848&id=id&accname=guest&checksum=54667669BA762145CD40965A391C05BE (last access on 06.07.2021)

organisations, as well as networks, business associations and other intermediaries, could in the next step then help to identify and provide suitable partners with complimentary skills for such interregional cooperation projects. Moreover, the S3 Thematic Platforms[81] as joint initiatives between several DGs of the European Commission are an important tool for encouraging interregional partnerships across the different regions.

Moreover, by connecting the smart specialisation strategies with other concepts such as topics of the green and digital transition as well as different funding programmes (H2020 and Horizon Europe) the S3 have also been assessed from a rather external perspective. Overall, the priority areas of the 185 S3 of the 2014-2020 period show significant connections to topics of the **Twin Transition**. The largest connections between the S3 priorities and topics of the Twin Transition are thereby found in rather general and overarching domains such as ICT, Bioeconomy, or Renewable Energy. Topics related to the green transition do in general show a higher relevance in the 185 S3. Furthermore, a significant amount of project budget can be linked to priorities that are relevant to the green and digital transition. However, the overall regional differences in the opportunities of the S3 to contribute to the green and digital transition are rather small since there are only small variations in the relevance of the linkages between the S3 priorities and the topics of the Twin transition among the different regions. Nonetheless, some regional differences on certain topics (e.g., “Bioeconomy” or “Fair, healthy & environmentally-friendly food system”) can be detected. Based on this thematic assessment profound potential for 185 S3 to contribute to key Commission priorities such as the green and digital transition. In addition, this thematic assessment further demonstrates the potential for interregional cooperation among the different regions. Especially against the background of current geopolitical events, supply chain shortages, and resource scarcity interregional cooperation in the context of S3 can support in meeting current and future challenges. These findings underline the various opportunities provided by smart specialisation and based on these considerations it can be expected that S3 will continue to play a pivotal role in the future.

In addition, this study has shown that from an overarching thematic perspective a significant connection between the 185 S3 of the 2014-2020 period to both **H2020 and Horizon Europe funding** can be identified. For the new funding programme Horizon Europe, it can be stated that topics that are addressed by Horizon Europe key funding areas are also found in many of the S3 priorities. This underlines the fundamental potential for creating synergies between S3 and key Horizon Europe instruments such as the Partnerships, Joint Undertakings, Missions and KICs. With around 65% of H2020 projects being connected to priority areas of the respective S3 a similar thematic connection is also found for the S3 and H2020 as the predecessor of Horizon Europe. However, it is also found that only a small number of organisations that have been funded by H2020 have also conducted ERDF TO1 projects and that these organisations are rather located in EU15 Member States/regions. Based on these findings and the fact that Horizon funding is rather scientifically driven and targets lower technological readiness levels whereas ERDF TO1 funding is rather application-oriented and targets higher technological readiness levels it is important to exploit this complementarity and to further create synergies between the two programmes.

This study contributes to the literature and policymaking by determining the appropriate level of the **bandwidth and relatedness** of the S3 as well as by giving clear indications about which policy approach specific types of Member States/regions should adopt. It is found that the thematic focus of the S3 (bandwidth) and diversification approach (related vs unrelated diversification) depends on the technological opportunities faced by the different Member States/regions. Based on these considerations it is found that 61% of the 162 S3 analysed achieved an appropriate level of thematic focus (bandwidth) and 52% of the strategies chose

[81] see https://s3platform.jrc.ec.europa.eu/s3-thematic-platforms (last access 08.11.2022)

an appropriate diversification strategy, which fits to the regional capabilities and shows a good balance between diversification risks and benefits. This analysis yields a number of policy recommendations regarding the best strategy in terms of thematic focus (bandwidth) and relatedness with the regional profile and endogenous capabilities:

- **Strong institutional capacities are an imperative enabling condition of a good S3**. Therefore, reinforcing the competencies of local authorities, also through adequate technical assistance for the development of S3, is a priority for regional policy making in the EU. In the context of the S3, this process of institutional capacity building might lead Member States/regions to improve their policymaking, both in terms of the thematic focus of the S3 priority areas and related diversification strategy.
- It is **advisable to design S3 at the regional/sub-regional level to facilitate the selection and prioritisation of target areas**. In doing so, activating processes that ensure interregional coordination and collaboration will be pivotal to minimise overlaps and help regions find their “uniqueness”.
- **In more developed Member States/regions, higher ambition is advisable**. The ambition to deviate from technological relatedness might result in realistic policy targets and help create new engines of innovation-based growth.
- In **less developed Member States/regions, more prudence** (i.e., a strategy of more related diversification) **is advisable** to avoid channelling resources into new “cathedrals in the desert” and pursue a more path-dependent and gradual transformation process.

An updated methodology of the **S3 Scoreboard** as well as a single comparative map that includes all the S3 emerge from this follow-up study. An updated methodology of the **S3 Scoreboard** as well as a single comparative map that includes all the S3 emerge from this follow-up study. This is achieved especially by including the findings on the appropriate levels of bandwidth and relatedness and by accounting for different context factors that can exert an influence on the S3. As an overarching assessment tool, the S3 Scoreboard plays a unique role in the scoreboard landscape and even more in the context of S3 policies. While it also allows to examine how the European Member States/regions have followed the ex-ante conditionalities for the Cohesion Policy period 2014-2020 the S3 Scoreboard does not allow to draw conclusions regarding the effectiveness and the impact of the implementation of the S3. For the future, some further improvements and new application areas such as the introduction of a standardised definition of the EDP and the use of the S3 Scoreboard for continuous S3 monitoring are proposed. Based on this it is expected that the S3 Scoreboard plays an important role in the future of regional innovation policies in the EU. Especially against the background of the new 2021-2027 funding period where in contrast to the 2014-2020 funding period the focus is no longer solely on the identification of specialisation fields and the EDP, but also on the optimisation of existing priorities and the establishment or documentation of existing governance structures for the implementation of strategic innovation policy it will be interesting to see how the revised S3 perform in a future S3 Scoreboard.

Overall, this follow-up study has further refined and deepened the analyses and understanding of smart specialisation strategies across the EU. At the same time, the analyses do also underline the broad potential of the S3 such as contributing to key Commission priorities, and it can hence be expected that S3 will play a role in both policy making and policy implementation in the future.

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Annex

Chapter 3

Table 16: Overview of potential regions for cooperation for the priority area "Smart, secure and robust connected products and systems" of Östergötlands län

Region	NUTS Code	Priority Area	Description
Östergötlands län	SE123	Smart, secure and robust connected products and systems	Smart products ; smart systems ; secure systems ; robust systems ;Internet integrated communicating electronics; sensors; printed electronics.
Sud Muntenia/ South Muntenia	RO31	Construction of machinery, components and production equipment	electrical, electronic, engineering, electric, machinery,car,subassemblies,subsystems,mechanical,mechatronics,motors,automation
Norte	PT11	Advanced production system	electrical,electronics,automation,generators,plastic,ict,intelligent,materials,metal,metallurgy,metalworking,motors
Andalucía	ES61	Advanced Industry for transport	layers,mapping,materials,nanotechnology,naval,orbit,transport,transportation,sensor,signal,military,communications,connection,aeronautical,aerospace,aircraft,automation,autonomous,hybrid,plastics,powertrains,precision,rail,digitization,carbon,electronic,energy,fiber
Saarland	DEC	Automotive and Production	robust,sensor,space,networking,fibre,fluid,aluminium,assembly,automation,automotive,materials,metal,vehicle,virtual,steel,suppliers,surface,transmission,transport,hydraulics,intelligent,light,lightweight,logistics,manufacturers,material,engine,engineering,exhaust,expertise
Haute Normandie	FR23	Reliability of systems and components in embedded systems	vehicles,vibration,wind,aeronautics,aerospace,ageing,automotive,defence,diagnosis,digital,elastomers,security,software,electrical,electrification,electronic,electronics,energy,environmental,failure,mechanical,mechatronics,medical,metallurgy,modelling,lightweight,materials,subsystems,thermal,powder,power,reliability,reliable,functions,humidity,hyper,integration,component,computing,conductivity,multimedia,multiscale,offshore,performance
Midi-Pyrénées	FR62	Coupling between advanced materials and processes for aeronautics and diversification	medicine,metallic,metals,microstructure,mobility,molecular,nanomaterials,nanotechnology,organic,packaging,performance,space,biobased,building,diversification,eco,energy,engineering,ceramics,composite,computing,coupling,plastics,precision,printing,rail,recycled,recycling,intelligent,layer,lifecycle,lightweight,machining,maintenance,materials,sport,surface,thermal,thermoplastics,transport,transportation,3d,aeronautics,agri-food,assembly,automotive

Croatia	HR	Transport and mobility	noise,vehicles,wire,emissions,environmental,mobility,heating,boats,port,power,railroad,logistics,materials,automatization,automobile,automotive,decrease,eco,transport,robotic,security,co2
Wales	UKL	Life sciences and health	healing,health,biological,biotechnology,telehealth,records,medical,electronic,devices,discovery,drug,neuroscience,patient,social,wound
La Réunion	FR94	Experiential eco-tourism	landmarks,leisure,cultural,digital,digitalisation,ecology,experiential,biodiversity,photography,medicine,mobility,gastronomy,commerce,crafts,safety,sites,tropical,valorisation,visual,well-being,health,heritage,historical,sport,theatres,tourism,transportation,park,accommodation,ageing,agricultural,archaeological,art,arts,augmented
Aquitaine	FR61	Clean and intelligent mobility	traffic,train,transport,transportation,pollution,port,emissions,multimodal,noise,operators,passengers,mobility,satellite,security,speed,location,health,ict,intelligent,aerospace,automotive,fleet,gas,geolocation,gps,greenhouse,vehicles
Bulgaria	BG	Industry for a healthy life and biotechnology	river,sea,space,medical,medicine,food,biotechnology,dental,diagnostics,drink,healing,healthy,electricity,substances,therapy,tourism,water

Source: Prognos AG/CSIL (2022).

Chapter 4

Table 17: Ontology of topics related to the green and digital transition

Twin Transition	Topic	Sub-Topic	Keywords
Digital	Artificial Intelligence	-	artificial intelligence; deep tech; AI; ethical artificial intelligence; ethical artificial intelligence; ai application; ai system; ai tool; machine learning
		Automation	Automation; automated mobility; automated transport systems; autonomous vehicle; robotics; robots; autonomous robots
		Connectivity	connectivity; connected objects; Gigabit connectivity; interoperability; connectivity infrastructures; secure connectivity; satellite connectivity; high-capacity connectivity; internet of things; interoperability; connecting sensors
		Digital Infrastructure	digital infrastructure; 5G; 6G; secure fibre infrastructure; 5G corridors; connectivity infrastructures; performant digital infrastructures; sustainable digital infrastructures Very High-Capacity Networks; terabit connections; cloud infrastructures; data centers; cloud-based infrastructure; broadband infrastructure; cloud-based infrastructure

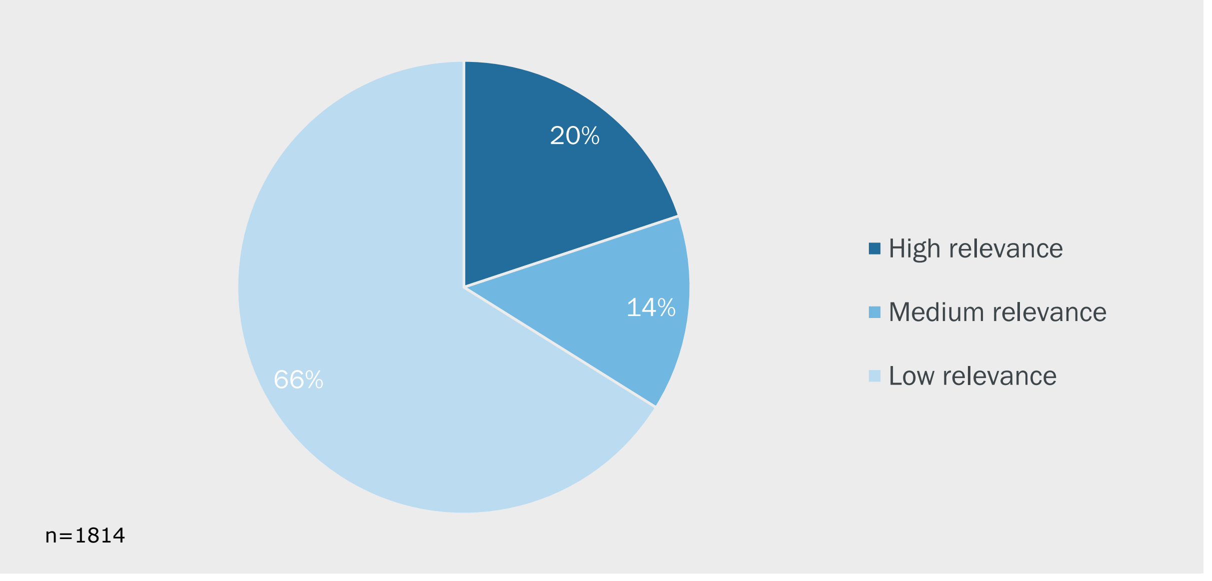
Digital	Automation, Connectivity & Digital Infrastructure		
Digital	Blockchain	-	Blockchain; blockchain technology; Blockchain Services Infrastructure
Digital	Data & Cybersecurity	Cybersecurity	cyberactivity; malicious cyberactivity; cyber resilience; Cybersecurity; cybercriminals; digital security; cyber resilience; secure digital identity; cyber theft; gigabit connectivity; privacy standards; digital crimes; cyberattack; data protection; secure cyberspace; online investigation; cyber threat; disinformation campaigns
		Data	data; personal data; data infrastructure; data access; data-agile; data flows; high-quality data; disinformation; Data Governance; data analysis; vast data; real-time data processing; data storage; Big data; algorithm; data sharing; non-personal data; private data; public data
Digital	Digital Skills	-	Digital Skills; digital competences; digital literacy; Digital Education; digital divide; digital education; Digital training
Digital	Digitalisation of public services	Digitalisation of healthcare	electronic health; ehealth; telemedicine; Digitalisation of healthcare; digitally enabled health solutions
Digital	Hardware	-	circular electronics; microelectronics; microprocessors; semiconductors; sustainable semiconductors; low-power processors
Digital	ICT	ICT	Digital communication; communications systems; Radio Spectrum; computing sciences; ICT specialists; ICT; new digital communications; holographic media; cloud computing; Intelligent edge computing; IT services; IT systems; ICT devices; APIs; cloud service; digital service; digital tool; internet; it industry; online platform; software; Telematic; telematics

		Simulation Technologies	Digital Twin; Augmented reality; virtual reality; simulation technologies
Digital	Smart Mobility	-	multi-modal intelligent transport systems; connected cars; automated mobility; automated transport systems; autonomous vehicle; Smart Mobility; smart systems for traffic management; Mobility as a Service; connected mobility
Digital	Super & Quantum Computing	-	quantum technologies; supercomputing; quantum communication; supercomputing; supercomputer; High performance computing; HPC; Quantum gravity sensors; quantum internet
Digital	Digital (General Classification)	-	digitalisation; Digital technologies; digital economy; digital sector; digital transformation; digital transition; digitisation; digitalization
Green	Bioeconomy	-	Bioeconomy; bio-based materials; sustainable biomass; sustainable bioenergy; bioenergy; biodegradable plastics; bio-based plastics ; bio-economy; bio-based plastic
Green	Circular Economy	-	recycling; circular economy; circularity; circular transition; circular products; reuse; circular production processes; circular industrial technologies; waste streams; circularity of energy; circularity of materials; Circular Plastics
Green	Clean Tech & Emission Reduction	-	carbon-neutral; carbon intensity; Zero-Pollution; greenhouse gases; emission reduction; GHG emissions; GHG; Greening of energy-intensive industries; deep decarbonisation; decarbonisation; CO2; zero pollution; net-zero emissions; carbon capture; clean hydrogen; low-carbon technologies; low-carbon production processes; Clean Steel; carbon capture technologies; carbon storage; carbon utilisation; CO2 emissions reductions; Clean Energy; low-CO2 installations; H2 production ; H2 storage; waste prevention; CCUS; net-negative emissions; no net emissions of greenhouse gases; greenhouse gas emissions reductions; clean air, clean technology
Green	Climate, Environment & Oceans	-	climate-neutral; environmental footprint; climate neutrality; environmentally sustainable; biodiversity; depollution; air pollution; climate change mitigation; environmental-related challenges; pollution; biodiversity; toxic-free environment; air pollution; water pollution; soil pollution; loss of biodiversity; climate change; Biological Diversity; blue economy; biodiversity in lakes; biodiversity in rivers; pollutants.; Blue Economy; oceans; aquatic resources; marine resources; maritime area
Green	Energy efficiency & resource efficiency	Energy efficiency	energy efficient; energy efficiency; energy storage; energy-efficient heating; energy-efficient cooling
		Resource Efficiency	resource efficiency; material efficiency; resource efficient building; resource efficient renovation

Green	Fair, healthy & environmentally friendly food system	-	food; safe food; healthy food; nutrition; nutritious food; food waste; obesity; diets; food chain; Forest ecosystems ; sustainable food; farmers ; fishermen; agricultural; agriculture; fisheries; precision agriculture; organic farming; agro-ecology; agro-forestry ; animal welfare ; sustainable seafood; low-carbon food; chemical pesticides; pesticides; food waste; food fraud; seafood; reforestation ; afforestation; resilience of forests; forest preservation; agricultural land
Green	Renewable Energy	-	renewable energy; solar panels; wind turbines; renewable energy sources; renewable Power; Industrial waste heat; replacement of fossil fuels; renewable hydrogen; offshore wind
Green	Sustainable Construction	-	Sustainable Construction; good insulation; novel building materials; energy performance of buildings
Green	Sustainable Mobility		Sustainable Mobility; electric vehicle ; electric vehicle motors; electric vehicle batteries; clean hydrogen; fuel cell; alternative fuels; multimodal freight operation; sustainable mobility services; sustainable alternative transport fuels; zero-emission vehicles; low-emission vehicles; zero-emission mobility; sustainable transport
Both	Green IT		green ICT; Smart Farming; Digital farming technologies; power grid; smart grid ; smart energy

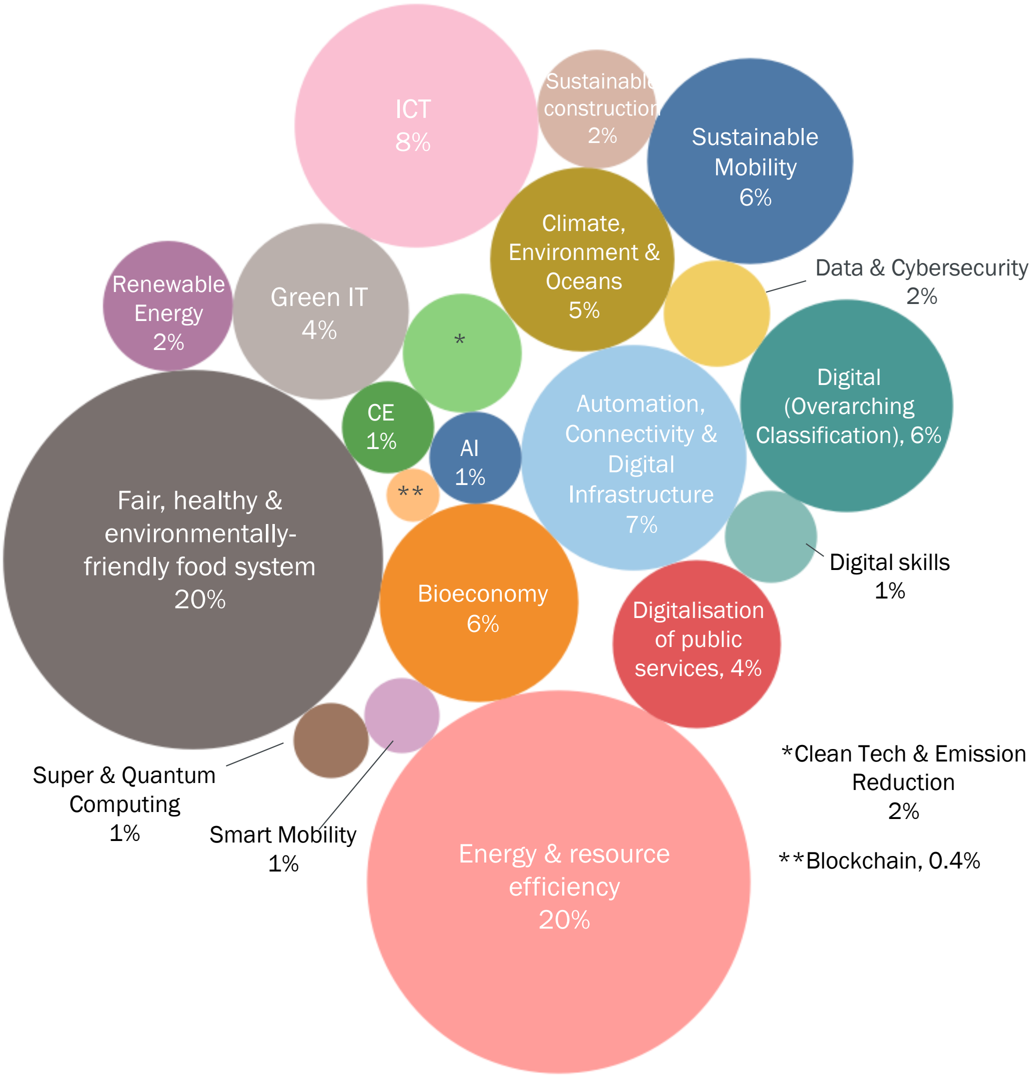
Source: Prognos AG/CSIL (2022).

Figure 35: Identified linkages between S3 priorities and topics of the Twin Transition, by their relevance



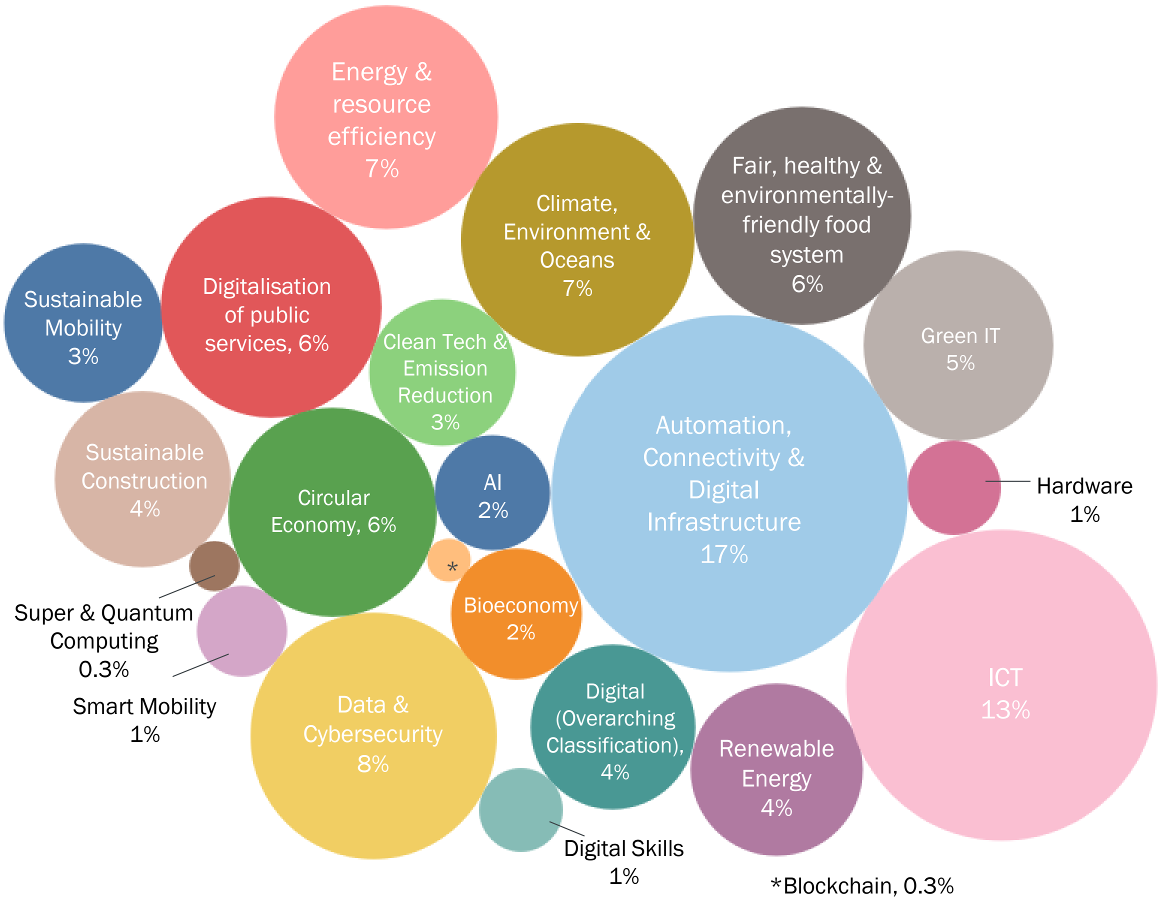
Source: Prognos/CSIL (2022), n=1814 matches from 702 priority areas. One priority area can have multiple references to topics of the Twin Transition. If a region had updated its strategy during the period 2014-2020, only the updated strategy is included in the analysis

Figure 36: Topics of the Twin Transition addressed by S3 priorities, by share of identified references with a medium relevance



Source: Prognos/CSIL (2022), n=254 matches with a medium relevance from 214 priority areas. One priority area can have multiple references to topics of the Twin Transition. Note: no matches with a medium relevance for Hardware

Figure 37: Topics of the Twin Transition addressed by S3 priorities, by share of identified references with a low relevance



Source: Prognos/CSIL (2022), n=1199 matches with a low relevance from 570 priority areas. One priority area can have multiple references to topics of the Twin Transition. Note: no matches with a medium relevance for Hardware

Table 18: Regional analysis of shares of addressed topics (Urban-Rural Classification)

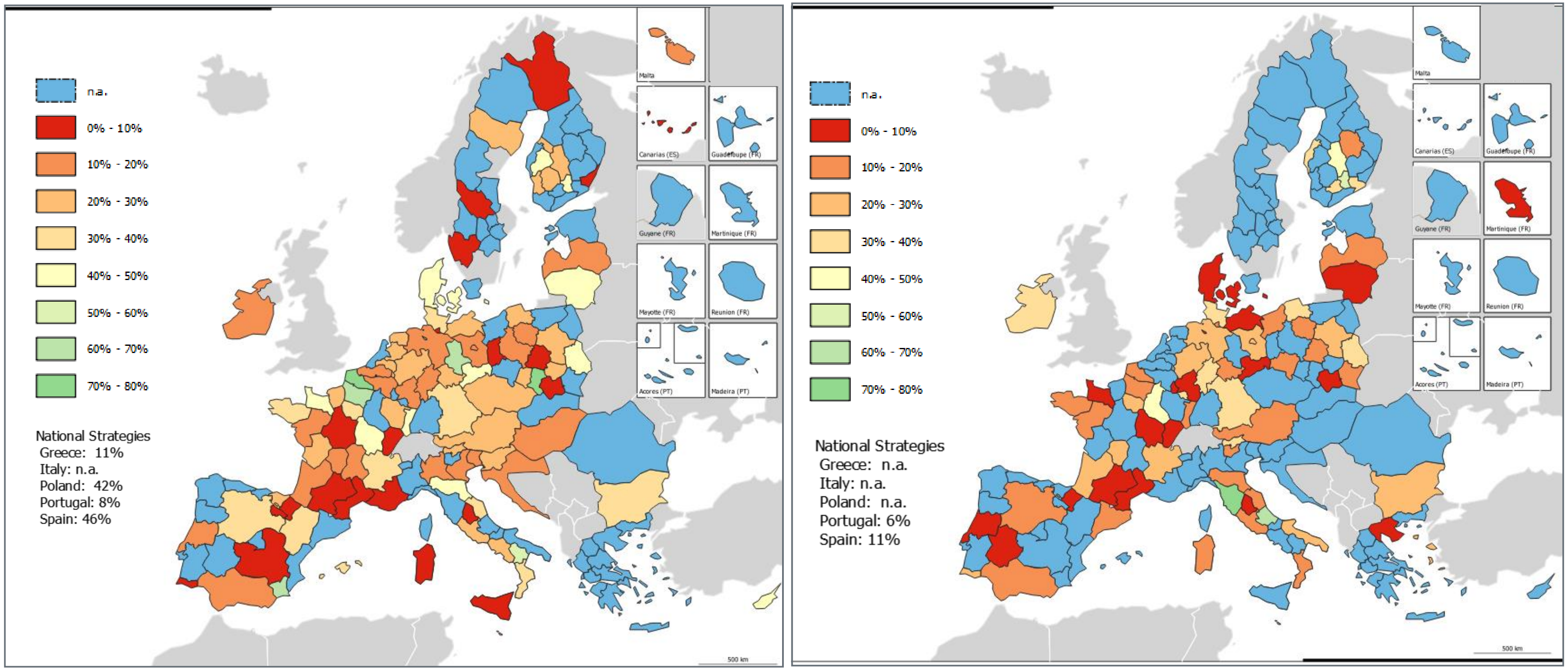
Topics	Share of links with high relevance			Share of links with medium relevance			Share of links with low relevance		
	Urban	Intermediate	Rural	Urban	Intermediate	Rural	Urban	Intermediate	Rural
Artificial Intelligence	0%	0%	0%	0%	3%	0%	2%	1%	2%
Automation, Connectivity & Digital Infrastructure	4%	10%	8%	4%	7%	8%	16%	18%	17%
Bioeconomy	13%	15%	20%	2%	1%	11%	3%	2%	2%
Blockchain	0%	0%	0%	0%	0%	2%	0%	0%	0%
Circular Economy	0%	0%	0%	2%	3%	0%	4%	7%	8%
Clean Tech & Emission Reduction	0%	2%	1%	4%	1%	2%	3%	4%	2%
Climate; Environment & Oceans	0%	1%	4%	13%	6%	3%	9%	9%	7%
Data & Cybersecurity	0%	0%	0%	0%	3%	2%	11%	7%	7%
Digital Skills	0%	0%	0%	4%	0%	2%	2%	1%	1%
Digitalisation of public services	4%	7%	2%	2%	3%	3%	6%	7%	5%
Energy efficiency & resource efficiency	9%	13%	4%	31%	16%	13%	8%	5%	4%
Fair, healthy & environmentally-friendly food system	9%	9%	13%	13%	20%	27%	10%	7%	6%
Green IT	4%	2%	4%	0%	6%	3%	5%	3%	4%
Hardware	0%	0%	0%	0%	0%	0%	0%	1%	2%

ICT	18%	12%	20%	7%	10%	9%	13%	10%	17%
Renewable Energy	20%	15%	11%	2%	3%	3%	3%	5%	3%
Smart Mobility	2%	2%	2%	0%	0%	2%	0%	1%	1%
Super & Quantum Computing	2%	0%	0%	0%	0%	0%	0%	0%	1%
Sustainable construction	4%	6%	2%	2%	1%	3%	3%	4%	4%
Sustainable Mobility	9%	3%	5%	4%	6%	3%	4%	3%	3%
Digital (Overarching Classification)	4%	2%	2%	7%	11%	6%	2%	5%	5%

Source: Prognos/CSIL (2022), Note: Urban-rural typology only for strategies on the NUTS2 and NUTS3 level

Map 6: Share of projects that are linked to priorities with a high relevance to topics of the Twin Transition

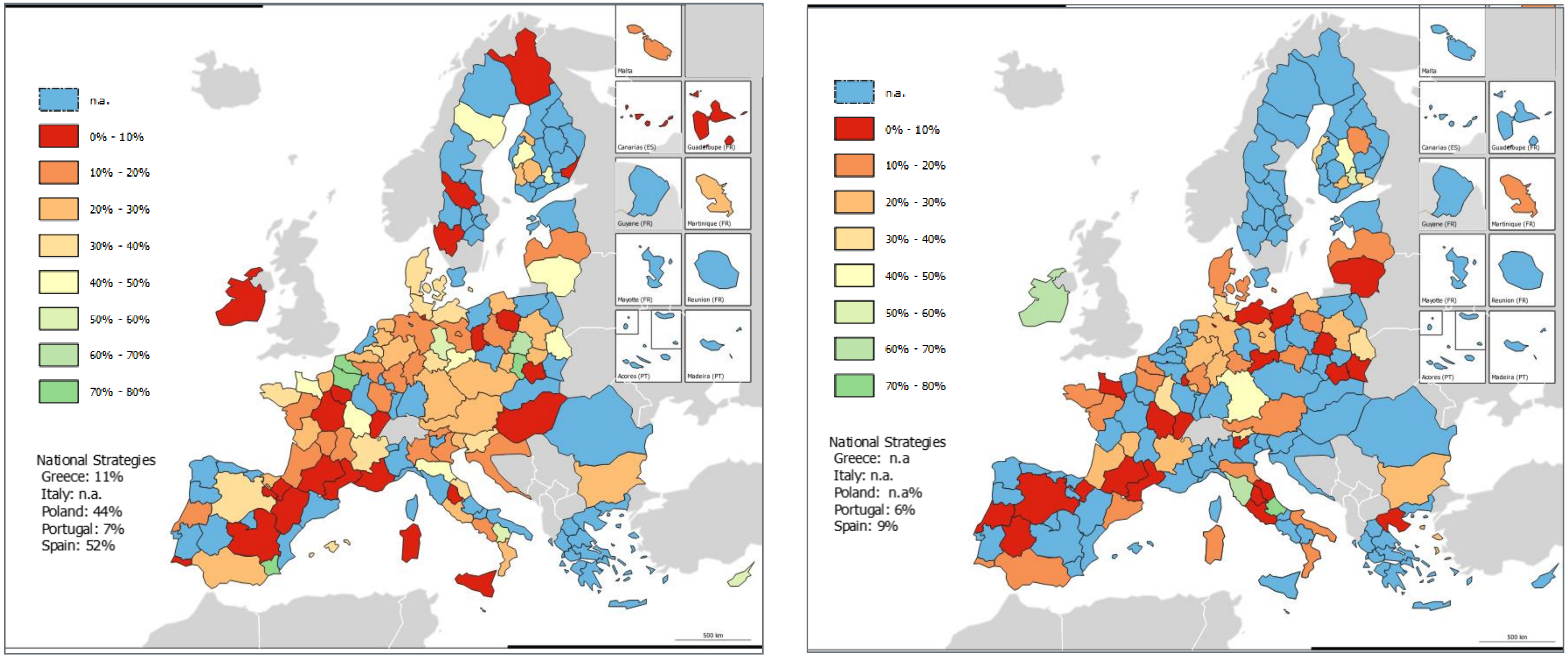
Panel a: Share of projects linked to green transition (left); Panel b: Share of projects linked to digital transition (right)



Source: Prognos/CSIL (2022). n = 163 regions. Note: The number show the share of project budget connected to priority areas with a high relevance to topics of the green/digital transition relative to all successfully connected projects. Blue regions without priority areas that have been linked with a high relevance to topics of the green / digital transition. Data for Romanian regions is aggregated at the NUTS0 level. When a region is covered by both a national strategy and a sub-national strategy, the coloured area of the sub-national region refers to the correspondence of the sub-national strategy. The values for the national strategies are given by the figures next to the respective regions. These Member States are Italy, Greece, Spain, Poland, and Portugal.

Map 7: Share of budget linked to priorities with a high relevance to topics of the Twin Transition

Panel a: Share of budget linked to green transition (left); Panel b: Share of budget linked to digital transition (right)



Source: Prognos/CSIL (2022). n = 163 regions. Note: The number show the share of project budget connected to priority areas with a high relevance to topics of the green/digital transition relative to all successfully connected projects. Blue regions without priority areas that have been linked with a high relevance to topics of the green / digital transition. Data for Romanian regions is aggregated at the NUTS0 level. When a region is covered by both a national strategy and a sub-national strategy, the coloured area of the sub-national region refers to the correspondence of the sub-national strategy. The values for the national strategies are given by the figures next to the respective regions. These Member States are Italy, Greece, Spain, Poland, and Portugal.

Chapter 5

Table 19: Ontology of Key Horizon Europe Funding Areas

Thematic Cluster / Mission Area	Type	Keywords
Civil Security for Society	Thematic Cluster	biometric; biometric data; biometric information; biometric technology; biometric trace; border; border authority; border check; border crime; CCTV; civil protection; civil security; coast guard; corruption; crime; crime prevention; crime scene; criminal; criminal activity; criminal network; criminal organisation; crisis; crisis management; crisis situation; critical infrastructur; critical infrastructure; custom authority; custom Authority; custom inspection; cyber threat; cyberattack; cybercrime; cybercriminal activity; cybersecurity; Cybersecurity; cybersecurity incident; cybersecurity threat; decontamination; deepfake; Disaster; security of information systems; disaster; disaster event; disaster-resilient society; disaster resilience; disaster risk; disasters; domestic abuse; domestic violence; drug trafficking; earthquake; emergency; emergency planning; emergency service; environmental crime; Environmental crime; epidemics; fake news; fighting crime; fire; fire brigade; firearm; Firearm; firearm trafficking; firefighter; firefighting; first responder; flood; flood rescue; forensic evidence; forensic expert; forensic institute; forest fire; fraud; geological disasters; geological hazard; hazard; hazardous agent; hybrid threat; hybrid threats; identity theft; illegal activity; illegal trade; illegal waste; illicit; illicit drug; illicit goods; illicit trade; infrastructure protection; infrastructure resilience; money launder; money laundering; natural disaster; natural hazard; pandemic; pandemic risk; Pandemics; pandemics; physical attack; physical security; Police; police; protective equipment; Resilient infrastructure; Resilient society; risk awareness; risk exposure; risk management; risk scenarios; risks; safety; safety risk; Security; security; security area; security authority; security check; security context; security perception; security problem; security technology; security threat; sensitive information; serious crime; sexual abuse; sexual violence; societal Resilience; societal resilience; terrorism; terrorist; terrorist attack; terrorist group; terrorist offence; violent extremist; violent radicalisation; volcanic eruption
Climate, Energy and Mobility	Thematic Cluster	advanced biofuel; advanced lithium; advanced material; aeronautic; agricultural waste; air pollutant; air pollution; air quality; air transport; airborne; aircraft; aircraft operation; aircraft technology; airport; alternative fuel; ambient heat; ambition; anode; anode material; artificial photosynthesis; atmosphere; atmospheric flow; atmospheric signal; atom; automate mobility; automate Mobility; automate vehicle; automated shipping; automated system; automated vehicle; automation; automatisation; automotive; automotive industry; autonomous; autonomous system; Aviation; aviation ecosystem; aviation environment; aviation industry; aviation market; aviation sectors; batterie; batteries; battery; battery cell; battery chemistry; battery design; battery electric; battery interface; battery management; battery material; battery materials; battery operation; battery partnership; battery system; battery technology; battery testing; battery utilisation; bike; biochemical; biodiversity; biodiversity conservation; biodiversity loss; biodiversity objective; bioenergy; biofuel; biofuel production; biogenic residue; biological; biological origin; biological pathway; biomass; biomethane; biomethane injection; biomethane production; carbon dioxide; carbon emission; carbon footprint; carbon neutrality; carbon sequestration; carbon sink; carbon value; cargo; cargo bike; cargo transport; cathode material; cell; cell component; cell level; cell manufacturing; pollutant; circular economy; circular use; circularity; circularity approach; circularity potential; clean transport; circularity principle; clean energy; clean hydrogen; climate; climate action; climate adaptation; climate change; climate crisis; climate impact; climate impacts; climate information; climate mitigation; climate model; climate neutral; climate neutrality; climate policy; climate predictions; climate projection; climate protection; climate replica; climate risk; climate science; climate system; climate target; climate transition; climate variability; co2; co2 capture; co2 emission; co2 transport; coal; cobalt; commercial aviation; commercial cargo; commercial shipping; commercial vessel; conversion efficiency; conversion process; conversion

		technology; decarbonisation; decarbonization; drone; ecological footprint; efficient building; electric grid; electric ship; electric system; electric vehicle; electric vessel; electrical grid; electrical power; electrical system; electricity consumption; electricity generation; electricity production; electrification; Electrification; electro mobility; electrochemical; electrochemical potential; electrochemical process; electrochemical stability; electrode; electrolysis; electrolyte; electromagnetic interference; electron; electronics; emission; emission reduction; emission technology; emission vehicle; e-mobility; energy carrier; energy communities; energy community; energy consumption; energy demand; energy density; energy efficiency; energy generation; energy independence; energy infrastructure; energy intensive; energy management; energy market; energy need; energy network; energy plant; energy poverty; energy research; energy savings; energy sector; energy sectors; energy service; energy storage; energy supplier; energy supply; energy system; energy systems; energy target; energy technology; energy transfer; energy transition; energy use; energy vector; energy yield; environment; environmental; environmental emission; environmental footprint; environmental impact; environmental performance; environmental sustainability; exhaust emission; ferry; forest bioeconomy; forest management; forestry; forests; fossil fuel; freight flow; freight forwarder; freight transport; fuel; fuel cell; fuel consumption; fuel technology; gas; gas grid; gas market; gas network; gas system; gasification system; geothermal energy; geothermal plant; geothermal reservoir; geothermal system; Ghg; Ghg emission; GHG emission; global warming; graphite; graphitisation; green transitions; greener; greener operation; greenhouse gas; grid; grid application; grid architecture; grid ready; heat source; heat storage; heat upgrade; heat use; Hvdc system; Hvdc systems; hybrid ship; hydrocarbon; hydrogen; Hydrogen; hydrogen fuel; hydropower; hydropower equipment; hydropower fleet; last mile; Li-ion battery; liquid fuel; lithium; lithium metal; logistic; logistic chain; logistic hubs; logistic network; logistic operation; logistic operators; logistic support; low carbon; marine environment; maritime transport; Mobility; mobility infrastructure; mobility sectors; mobility service; mobility system; mobility systems; modal shift; noise emission; noise pollution; offshore energy; offshore grid; carbon dioxide removal; carbon capture and conversion; offshore strategy; offshore wind; oil; oil recovery; personal mobility; photovoltaic; pollutant; pollutant emission; pollution; power conversion; power converters; power density; power electronics; power generation; power grid; power plant; power production; power sector; power system; power unit; powertrain; PV; PV cell; PV technology; rail; rail system; rail transport; recyclability; recycling; Recycling; renewable electricity; renewable energie; renewable energy; renewable fuel; renewable heating; renewable hydrogen; renewable integration; renewable source; road crash; road crashes; road death; road infrastructure; road safety; road traffic; road transport; road user; semiconductor; semiconductor such; shipbuilding; shipping; shipyard; smart grid; smart mobility; solar energy; solar fuel; solar power; solar thermal; sustainable batterie; sustainable biofuel; sustainable biomass; sustainable building; sustainable energy; sustainable fuel; sustainable material; sustainable mobility; sustainable renovation; sustainable transition; sustainable transport; synthetic graphite; thermal storage; thermochemical; traffic congestion; traffic disruption; traffic efficiency; traffic flow; traffic jam; traffic management; traffic system; traffic volume; transport; transport accident; transport emission; transport infrastructure; transport mode; transport modes; transport network; transport safety; transport sector; transport service; transport system; transport vehicle; turbine; urban freight; urban logistic; urban mobility; urban space; usable hydrogen; vessel; vessel battery; waste; waste management; water; water pollution; water quality; water use; waterborne; waterborne transport; wind energy; wind farm; wind technology; wind turbine; zero-emission mobility; zero-emission target; zero-emission vehicle; clean mobility
Culture, Creativity & inclusive Society	Thematic Cluster	active citizenship; archaeological site; artistic expression; arts; asylum; atypical worker; basic rights; basic service; citizen engagement; citizen participation; city; civic participation; craftspeople; Creative industries; creative industries; creative industry; creative sector; cultural artefact; cultural asset; cultural diversity; cultural empowerment; cultural goods; cultural heritage; cultural landscape; culture; decent work; democratic access; democratic debate; democratic governance; democratic legitimacy; democratic participation; democratic process; democratic society; demographic change; designer; digital divide; digital literacy; endanger languages; endangered language; european art; european culture; extremist discourse; extremist narrative; feminism; Feminism; filmmaking; filmmaking industry; filmmaking sector; fundamental rights; game industry; gender equality; gender inequality; gender issue; gender role; hate speech; heritage; heritage site; historical building; human dignity; human rights; inclusive citizenship; inclusive society; income inequality; linguistic diversity; media; migrant integration; migration policy; multilingualism; museum; Museums; music; music consumption; music participation; music sector; silver economy; social dialogue; social enterprisis; social entrepreneurship; social exclusion; social fairness; social inclusion; social

		innovation; societal cohesion; traditional artefact; traditional craft; underwater heritage; vulnerable population; welfare policy; welfare system
Digital, Industry and Space	Thematic Cluster	2d material; 2d materials; 6g technology; additive manufacturing; advanced electronic; advanced H4c; advanced manufacturing; advanced material; advanced processing; advanced robotic; Advanced spintronic; aeronautic; aerospace; agile manufacturing; airborne; airplane; airspace; algorithm; algorithmic decision; Artificial Intelligence; artificial intelligence; Artificial intelligence; automation; autonomous; autonomous robot; autonomous system; autonomous vehicle; aviation; avionic; big data; Big data; bio-intelligent manufacturing; biological component; biomaterial; Biomaterial database; blockchain; circular process; circular utilisation; circularity; Circularity; clean product; clean Steel; cloud; cloud application; cloud computing; cloud infrastructur; cloud server; cloud service; consumer goods; consumer product; cybersecurity; data; Data; data access; data analysis; data augmentation; data breach; data centre; data communication; data confidentiality; data documentation; data economy; data environment; data exchange; data fusion; data governance; data infrastructure; data interoperability; data management; data mining; data model; data platform; data privacy; data processing; data protection; data provenance; data security; data sharing; data sovereignty; data storage; data trading; data transfer; data visualisation; database; digital; digital application; digital autonomy; digital building; digital competence; digital identity; digital information; digital innovation; digital model; digital platform; digital platforms; digital sector; digital service; digital society; digital solution; digital sovereignty; digital Technologies; digital technology; digital tool; digital transformation; digital transition; digital Transition; digital twin; digital Twin; digitalisation; Digitalisation; digitalization; digitisation; Digitised Production; drone; edge application; edge cloud; edge computing; edge device; edge technology; energy efficiency; energy reduction; energy source; energy storage; energy supply; energy system; engineering; engineering integration; engineers; entrepreneurship; environmental footprint; environmental impact; green manufacturing; green technology; hybrid coating; hydrogen; hydrogen storage; Ict; Ict innovation; Ict standardisation; industrial application; industrial Biotechnology; industrial capability; industrial competitiveness; industrial data; industrial ecosystem; industrial environment; industrial innovation; industrial investment; industrial manufacturing; industrial modernisation; industrial network; industrial process; industrial production; industrial sector; industrial technology; industrial waste; industrialisation; industries; industry; industry sectors; industry sustainability; internet; interoperability; Interoperability; interoperable; lightweight material; machine collaboration; machine interaction; manufacturing; manufacturing capacity; manufacturing industry; manufacturing line; manufacturing process; manufacturing sector; material design; material industry; material modelling; material science; material stream; mechatronic; metal coating; metal fraction; metallurgy; modular avionic; modular manufacturing; modular technology; modularisation; modularity; nanocoating; Nanoelectronic; nanomaterial; Nanotechnology; nanotechnology; orbit; orbit demonstration; orbit operation; orbit servicing; orbit testing; polymer; polymer composite; production; production process; production system; production technology; programming; quantum communication; quantum computation; quantum computer; quantum computing; quantum network; quantum processor; quantum technology; Quantum technology; resource efficiency; reusability; robot; robot interaction; robotic; robotic system; robotic technology; Robotics; satellite; satellite communication; satellite constellation; satellite data; satellite navigation; satellite system; cybersecurity; semiconductor; smart manufacturing; smart mobility; smart monitoring; smart Networks; smart object; smart sensors; smartphone; soft robotic; software; Software; software technology; space; Space; space debris; space economy; space environment; space industry; space infrastructure; space operation; space programme; space science; space sector; space system; space technology; space transportation; spacecraft; spray coating; standard interface; Standardisation; standardisation; standardization; steel; steel making; steel production; steel sector; steelwork; supply chain; surface treatment; surveillance; sustainable product; sustainable production; sustainable supply; sustainable technology; telescope; teleworking; terrestrial weather; value chain; virtual environment; virtual reality; waste reduction; waste regulation
Food, Bioeconomy, Natural Resources,	Thematic Cluster	abiotic; abiotic stress; abiotic stressor; acidification; affordable diet; afforestation; agri; agricultural; agricultural area; agricultural data; agricultural equipment; agricultural feedstock; agricultural knowledge; agricultural land; agricultural landscape; agricultural loss; agricultural operators; agricultural policy; agricultural practice; agricultural product; agricultural production; Agricultural Productivity; agricultural productivity; Agricultural productivity; agricultural residue; agricultural sector; agricultural waste; agriculture; Agriculture; agri-

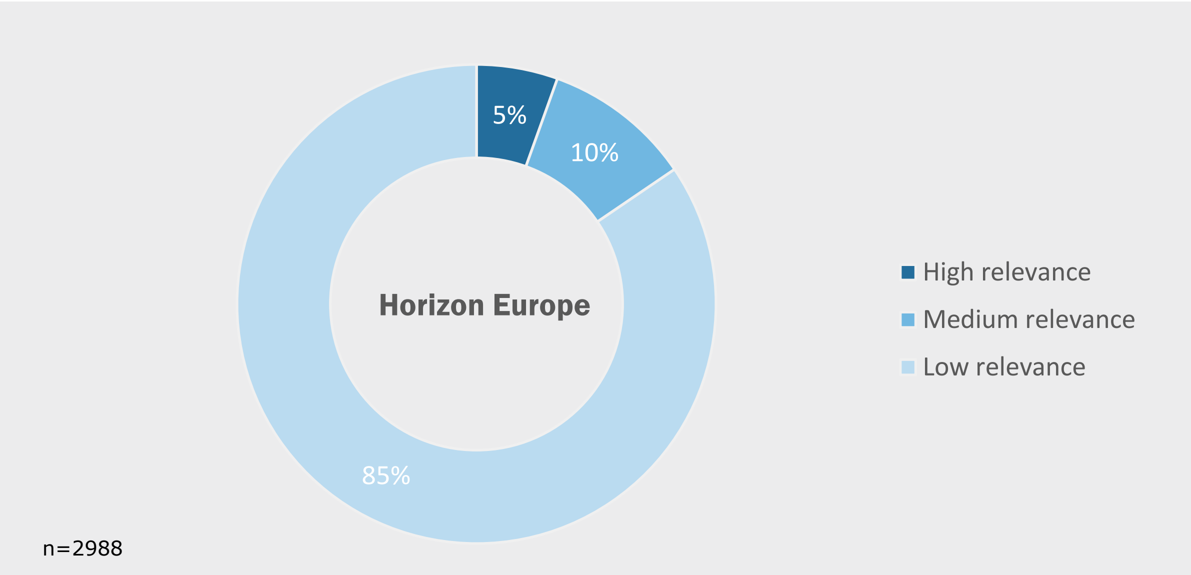
Agriculture & Environment		environmental condition; agro; agroecological; agro-ecological; agro-ecological agriculture; agroecological farming; agroecological practice; agro-ecological practice; agroecology; Agroecology; agroecosystem; agro-ecosystem; agroforestry; agroforestry system; agronomic practice; air pollution; allergenicity; allergy; alternative protein; animal disease; animal health; animal nutrition; animal origin; animal production; animal welfare; anthropogenic activity; antibiotic; antimicrobial; antimicrobial resistance; anti-microbial resistance; anti-microbial usage; aquaculture; aquaculture producer; aquaculture production; aquaculture proposal; aquaculture sectors; aquaculture system; aquatic; aquatic ecosystem; arable land; atmospheric deposition; beekeeper; beekeeping; beekeeping activity; bio; bioavailability; biobank; biochemical; biodegradability; biodegradable plastic; biodiversity; Biodiversity; biodiversity change; biodiversity commitment; biodiversity conservation; biodiversity decline; biodiversity loss; biodiversity monitoring; biodiversity protection; biodiversity recovery; biodiversity research; bioeconomy; Bioeconomy; bioeconomy innovation; bioenergy; bioenergy application; biofuel; biogeochemical cycle; biogeographical approach; biogeographical region; bioindicator; bioinformatic; biological; biological design; biological diversity; biological feedstock; biological pump; biological resource; biology; biomass; biomass production; biomass provision; biomass residue; biomass solutions; biome; biophysical; biorefinery; biorefining; bioremediation; bioresource; biosecurity; Biosecurity; biosensor; biotechnology; biotic; biotic stress; biotope; biotype; blue bioeconomy; blue biotechnology; blue economy; blue space; breed; breed activity; breeding; Breeding; breeding methods; breeding sector; carbon; carbon cycle; carbon cycling; carbon dioxide; carbon footprint; carbon removal; carbon sequestration; carbon sink; carbon storage; carbon-intensive; chemical pesticide; circular; circular bio; circular bioeconomy; circular City; circular city; circular design; circular economy; circular Economy; circular lifestyle; circular management; circular solution; circular transition; circular use; circularity; circularity potential; clean air; clean environment; clean soil; clean water; climate adaptation; climate change; climate crisis; climate footprint; climate friendly; climate mitigation; climate neutral; climate neutrality; co2; coastal; coastal aquifer; coastal area; coastal biodiversity; coastal community; coastal ecosystem; coastal environment; coastal pollution; coastal socio-economic; coastal water; contaminant; crop; crop condition; crop diversification; deep sea; deep uncertainty; deep water; deforestation; degradation; deoxygenation; desertification; diet; dietary; dietary advice; dietary behaviour; dietary guideline; dietary pattern; dietary shift; ecological; ecological corridor; ecological flow; ecological impact; ecological level; ecological process; ecological status; ecological transition; ecological transitions; ecological use; ecology; ecosystem; ecosystem barrier; ecosystem condition; ecosystem conservation; ecosystem degradation; ecosystem diversity; ecosystem function; ecosystem functioning; ecosystem health; ecosystem management; ecosystem protection; ecosystem restoration; ecosystems; ecotourism; environment; environmental; Environmental; environmental assessment; environmental authority; environmental change; environmental condition; environmental degradation; environmental effect; environmental externality; environmental factor; environmental footprint; environmental impact; Environmental impact; Environmental pollution; environmental protection; environmental sustainability; environmental threat; erosion; erosion control; farm; farm level; farm management; farm worker; farmer; farmer organisation; farmers; farming; Farming; farming sector; farmland; farms; feed chain; feed ingredient; feed production; feedstock; fertiliser; fish; fisher; fisherman; fishery; fishery product; flood; floods; food; food allergy; food business; food chain; food industry; food ingredient; food packaging; food processing; food product; food production; food quality; food safety; food sector; food security; food waste; forest; forest adaptation; forest community; forest ecosystem; forest fire; forest health; forest management; forest protection; forest restoration; forestry; forestry sector; forestry sectors; forestry system; forests; forests proposal; freshwater; freshwater aquaculture; freshwater biodiversity; freshwater ecosystem; freshwater resource; Freshwater resource; genetic; genetic diversity; genetic isolation; genetic resource; genome; genome sequencing; genomics; Ghg emission; GHGs; greenhouse gas; healthy air; healthy diet; healthy ecosystem; healthy environment; healthy food; healthy foodstuff; healthy nutrition; healthy ocean; healthy planet; healthy soil; industrial biotechnology; industrial environment; industrial sustainability; land; land area; land management; land resource; land use; landscape; legume; legume breeding; legume sector; livestock; livestock production; malnutrition; marine; marine biodiversity; marine domain; marine ecosystem; marine environment; marine mammal; marine water; maritime; microbe; Microbe; microbial biodiversity; microbial resistance; microbiome; Microbiome; microbiome science; Microbiomes; microbiota; microplastic; molecular biology; natural ecosystem; natural environment; natural resource; Natural resources; natural soil; nature; nature conservation; nature protection; nitrogen; nutrient; nutrient budget; nutrient loss; nutrition; nutrition security; nutritional; nutritional quality; nutritious; nutritious food; obesity; ocean acidification; organic agriculture; organic aquaculture; organic breeding; organic farming; organic food;

		organic sector; organic system; organic variety; organic waste; pesticide; pesticide reduction; pesticide use; phosphorus; phosphorus emission; pollination; pollination function; pollinator; pollutant; pollution; pollution prevention; protein; protein crop; protein source; resource efficiency; resource -efficient; resource independence; resource use; shellfish; soil; soil biodiversity; soil conservation; soil erosion; soil fertility; timber; vegetable; vegetation; wastewater; water; water pollution; water quality; water resource; water reuse; water scarcity; water supply; water system; water treatment; water use
Health	Thematic Cluster	vaccine; advanced therapy; adverse effect; affordable treatment; affordable vaccine; aids; ambulatory care; animal health; antibody; antimicrobial; antimicrobial resistance; anxiety; bacteria; biological; biology; biomarker; biomedical; biotechnology; borne disease; cancer; Cancer; cancer patient; cancer survivor; cancer treatment; cardiovascular disease; care agency; care delivery; care institution; care professional; care provider; care system; caregiver; cell; chronic condition; chronic disease; chronic inflammation; clinical pathway; clinical practice; clinical research; clinical setting; clinical study; clinical trial; clinical trials; Clinical validation; combinatorial treatment; co-morbidity; companion diagnostic; Covid; COVID; diabete; diagnosis; diagnostic; disability; disease; disease burden; disease prevention; disease progression; disease threats; disease transition; disorder; early detection; epidemic; epidemic outbreak; epidemic potential; epidemic preparedness; epidemics; epigenetic; epigenetic blueprint; good health; health; health app; health care; health issue; health literacy; health outcome; health outcomes; health practitioner; health R&d; health research; health risk; health sector; health system; health systems; health technology; healthcare; healthcare system; healthy; healthy behaviour; healthy citizen; healthy lifestyle; healthy society; heart; hospital; human health; infection; infections; infectious disease; Infectious disease; major disease; medical; medical countermeasure; medical device; medical equipment; medical imaging; medical intervention; medical professional; medicinal product; medicine; mental health; mental illness; microbiomics; morbidity; neurobiology; antimicrobial; nutrition; nutritional; obese; obesity; obesity prevention; occupational; occupational health; pandemic; pathogens; patient safety; pharmaceutical; pharmaceutical industry; pharmaceutical manufacturing; pharmacological; Pre-clinical development; premature death; prescription drug; rare disease; surgical intervention; tropical disease; tuberculosis; vaccination rate; vaccine; vaccine effectiveness; viral disease; virus
Adaptation to climate change including societal transformation	Mission Area	Climate change; climate change adaption; floods; forest fires; drought; hurricane; climate change effects; climate vulnerabilities; climate resilience; climate risks; land use; food systems; water management; health; well-being; resilient infrastructure; climate impacts; climate resilient; zero pollution; Climate targets
Cancer	Mission Area	Cancer; cancer diagnosis; cancer control; cancer monitoring; cancer treatment; cancer screening; cancer prevention; cancer drugs; cancer detection; early detection of cancer; tumour; tumour detection; tumour treatment; cancer cell; biomarker; mobile screening units
Climate-neutral and smart cities	Mission Area	smart city; climate-neutral city; emission reduction; clean air; safe transport; congestion; climate neutrality; urban planning; smart mobility; urban environmental footprint; noise pollution; urban greening; water management; carbon-free energy; energy storage; energy systems; climate neutrality; zero pollution; air pollution; Clean Energy; green ICT; sustainable digitisation; interoperability ; shared standards; Social inclusiveness ; carbon-free energy vectors; mobility systems; carbon neutral mobility; efficient mobility; alternative fuels; electric vehicle; vehicle-to-grid; sustainable transport; grids; resilience in cities; energy and resource efficiency; renewable energy; alternative mobility ; shared mobility; traffic congestion; (big) data;open source software; Smart Mobility; smart mobility; Urban Transitions; urban mobility
Healthy oceans, seas, coastal and inland waters	Mission Area	restoring marine eco-systems; marine ecosystems; reducing plastic litter at sea; reduction of chemical pesticides; blue economy; net-zero maritime emissions; digital ocean ; water knowledge system; Digital Twin Ocean; coastal water; inland water; marine ecosystem; freshwater ecosystem ; sustainable fisheries; Blue carbon; algae production; marine protected areas; pelagic ecosystem; benthic

		ecosystem; water quality; oastal areas; sea level rise; Floods; coastal resilience; beach litter; microplastic pollution; waste water treatment; port reception facilities; multi-purpose use of marine and water space; seafood ; aquatic organisms; aquaculture ; Blue Parks
Soil health and food	Mission Area	Soil; healthy soils; clean water; soil biodiversity; biodiversity; climate resilience; cultural heritage and landscapes; resilient soil; desertification; soil organic carbon stocks; soil sealing; urban soils; soil pollution; erosion; global footprint on soils; soil literacy; soil management; soil monitoring; nutrition; safe food; health; food; food and nutrition security; agriculture; forestry; land uses; Soil Health; agri-food; pesticides; food quality; land degradation

Source: Prognos/CSIL (2022).

Figure 38: Identified linkages between S3 priorities and Horizon Europe key funding areas, by their relevance



Source: Prognos/CSIL (2022). n=2988 matches from 924 priority areas. One priority area can have multiple references to key Horizon Europe funding areas. If a region had updated its strategy during the period 2014-2020, only the updated strategy is included in the analysis

Figure 39: Overview of the number of identified references with a medium relevance between S3 priorities and Horizon Europe key funding areas

Source: Prognos/CSIL (2022), n=261 priority areas. One priority area can have multiple references to topics of the Twin Transition

Figure 40: Overview of the number of identified references with a low relevance between S3 priorities and Horizon Europe key funding areas

Source: Prognos/CSIL (2022), n=892 priority areas. One priority area can have multiple references to topics of the Twin Transition

Table 20: The four typologies of Member States/regions based on relatedness and complexity

Quadrant 1: High relatedness and high complexity			Quadrant 2: High relatedness and low complexity	Quadrant 3: Low relatedness and low complexity		Quadrant 4: Low relatedness and high complexity
AT - Austria	ES41 - Castilla y León	ITC3 - Liguria	DED - Saxony	BG - Bulgaria	FR94 - La Réunion	EE - Estonia
BE1 - Brussels Region	ES51 - Cataluña	ITF3 - Campania	FI19 - Länsi-Suomi	CY - Cyprus	FR95 - Mayotte	EL30 - Attica
BE2 - Flanders	ES52 - Comunidad Valenciana	ITG1 - Sicily	FI1D - Pohjois- ja Itä-Suomi	DE5 - Bremen	ITC2 - Valle d'Aosta	ES11 - Galicia
BE3 - Walloon Region	ES61 - Andalucía	ITH5 - Emilia-Romagna	FR22 - Picardie	EL41 - North Aegean	ITF2 - Molise	ES22 - Comunidad Foral de Navarra
CZ - Czech Republic	FI1B - Helsinki-Uusimaa	ITI1 - Tuscany	FR23 - Haute Normandie	EL42 - South Aegean	ITF5 - Basilicata	ES62 - Región de Murcia
DE1 - Baden-Württemberg	FI1C - Etelä-Suomi	ITI4 - Lazio	FR24 - Centre	EL43 - Crete	ITF6 - Calabria	HR - Croatia
DE2 - Bavaria	FR10 - Ile-de-France	LU - Luxembourg	FR25 - Basse Normandie	EL51 - Eastern Macedonia and Thrace	ITG2 - Sardinia	ITF1 - Abruzzo
DE3 - Berlin	FR21 - Champagne-Ardenne	NL1 - North Netherlands	IT - Italy	EL52 - Central Macedonia	LV - Latvia	ITF4 - Apulia
DE4 - Brandenburg	FR26 - Bourgogne	NL2 - East Netherlands	ITC1 - Piedmont	EL53 - Western Macedonia	MT - Malta	ITI2 - Umbria
DE6 - Hamburg	FR30 - Nord-Pas-de-Calais	NL3 - West Netherlands	ITC4 - Lombardy	EL54 - Epirus	PL22 - Śląskie	LT - Lithuania
DE7 - Hessen	FR41 - Lorraine	PL - Poland	ITH1 – Aut.Prov. Bolzano	EL61 - Thessaly	PL33 - Świętokrzyskie	PL11 - Łódzkie
DE8 - Mecklenburg-Western Pomerania	FR42 - Alsace	PL12 - Mazowieckie	ITH2 - Autonomous Province of Trento	EL62 - Ionian Islands	PL34 - Podlaskie	PL31 - Lubelskie
DE9 - Lower Saxony	FR43 - Franche-Comté	PL21 - Małopolskie	ITH3 - Veneto	EL63 - Western Greece	PL42 - Zachodniopomorskie	PL32 - Podkarpackie
DEA - North Rhine-Westphalia	FR51 - Pays de la Loire	PL43 - Lubuskie	ITH4 - Friuli-Venezia Giulia	EL64 - Central Greece	PL52 - Opolskie	PL41 - Wielkopolskie
DEB - Rheinland-Pfalz	FR52 - Bretagne	PL51 - Dolnośląskie	ITI3 - Marche	EL65 - Peloponnese	PL61 - Kujawsko-Pomorskie	PT16 - Centro
DEC - Saarland	FR53 - Poitou-Charentes	PT - Portugal	NL4 - South Netherlands	ES12 - Principado de Asturias	PL62 - Warmińsko-Mazurskie	RO42 - West
DEE - Saxony-Anhalt	FR61 - Aquitaine	PT11 - Norte	SE32 - Mellersta Norrland	ES13 - Cantabria	PL63 - Pomorskie	SK - Slovakia
DEF - Schleswig-Holstein	FR62 - Midi-Pyrénées	PT17 - Lisbon	SE33 - Övre Norrland	ES23 - La Rioja	PT15 - Algarve	
DEG - Thuringia	FR71 - Rhône-Alpes	RO - Romania		ES24 - Aragón	PT18 - Alentejo	
DK - Denmark	FR72 - Auvergne	SE12 - Östra Mellansverige		ES42 - Castilla-La Mancha	PT20 - Azores	
EL - Greece	FR81 - Languedoc-Roussillon	SE22 - Sydsverige		ES43 - Extremadura	PT30 - Madeira	
ES - Spain	FR82 - Provence-Alpes-Côte d'Azur	SE23 - Västsverige		ES53 - Illes Balears	RO11 - NORTH-WEST	
ES21 - País Vasco	HU - Hungary	SE31 - Norra Mellansverige		ES70 - Canarias	RO12 - Centre	
ES30 - Comunidad de Madrid	IE - Ireland	SI - Slovenia		FR63 - Limousin	RO21 - North-East	
				FR83 - Corse	RO22 - South-East	
				FR91 - Guadeloupe	RO31 - South Muntenia	
				FR92 - Martinique	RO41 - Sud-Vest Oltenia	

Source: Prognos/CSIL (2022).

Table 21: Strategies with an appropriate or less appropriate S3 bandwidth and S3 relatedness (i.e. conforming to the levels expected by the theory)

NUTS	NUTS Label	S3 bandwidth - ranges	S3 Relatedness ratio - ranges	S3 bandwidth at the expected level	S3 relatedness at the expected level
Austria					
AT	Austria	5 - Excessively high	3 - Medium-high	NO	YES
Belgium					
BE1	Brussels Region	1 - Low	4 - High	YES	NO
BE2	Flanders	1 - Low	4 - High	YES	NO
BE3	Walloon Region	4 - High	2 - Medium-low	NO	YES
Bulgaria					
BG	Bulgaria	3 - Medium-high	4 - High	NO	NO
Cyprus					
CY	Cyprus	2 - Medium-low	4 - High	NO	NO
Czech Republic					
CZ	Czech Republic	5 - Excessively high	3 - Medium-high	NO	YES
Germany					
DE1	Baden-Württemberg	1 - Low	2 - Medium-low	YES	YES
DE2	Bavaria	2 - Medium-low	3 - Medium-high	YES	YES
DE3	Berlin	3 - Medium-high	4 - High	YES	NO
DE4	Brandenburg	3 - Medium-high	4 - High	YES	NO
DE5	Bremen	3 - Medium-high	4 - High	NO	NO
DE6	Hamburg	3 - Medium-high	3 - Medium-high	YES	YES
DE7	Hessen	3 - Medium-high	3 - Medium-high	YES	YES
DE8	Mecklenburg-Western Pomerania	3 - Medium-high	3 - Medium-high	YES	YES
DE9	Lower Saxony	3 - Medium-high	3 - Medium-high	YES	YES
DEA	North Rhine-Westphalia	5 - Excessively high	3 - Medium-high	NO	YES
DEB	Rheinland-Pfalz	3 - Medium-high	2 - Medium-low	YES	YES
DEC	Saarland	3 - Medium-high	3 - Medium-high	YES	YES
DED	Saxony	4 - High	3 - Medium-high	YES	NO
DEE	Saxony-Anhalt	3 - Medium-high	3 - Medium-high	YES	YES
DEF	Schleswig-Holstein	2 - Medium-low	2 - Medium-low	YES	YES
DEG	Thuringia	4 - High	3 - Medium-high	NO	YES
Denmark					
DK	Denmark	2 - Medium-low	4 - High	YES	NO
Estonia					
EE	Estonia	1 - Low	4 - High	YES	NO
Greece					
EL	Greece	5 - Excessively high	3 - Medium-high	NO	YES
EL30	Attica	1 - Low	3 - Medium-high	YES	YES
EL41	North Aegean	1 - Low	1 - Low	YES	NO
EL42	South Aegean	1 - Low	1 - Low	YES	NO
EL43	Crete	1 - Low	2 - Medium-low	YES	NO
EL51	Eastern Macedonia and Thrace	1 - Low	1 - Low	YES	NO
EL52	Central Macedonia	1 - Low	2 - Medium-low	YES	NO
EL53	Western Macedonia	1 - Low	1 - Low	YES	NO
EL54	Epirus	1 - Low	1 - Low	YES	NO
EL61	Thessaly	1 - Low	1 - Low	YES	NO
EL62	Ionian Islands	1 - Low	4 - High	YES	NO
EL63	Western Greece	1 - Low	2 - Medium-low	YES	NO
EL64	Central Greece	1 - Low	1 - Low	YES	NO
EL65	Peloponnese	1 - Low	1 - Low	YES	NO
Spain					
ES	Spain	4 - High	3 - Medium-high	NO	YES

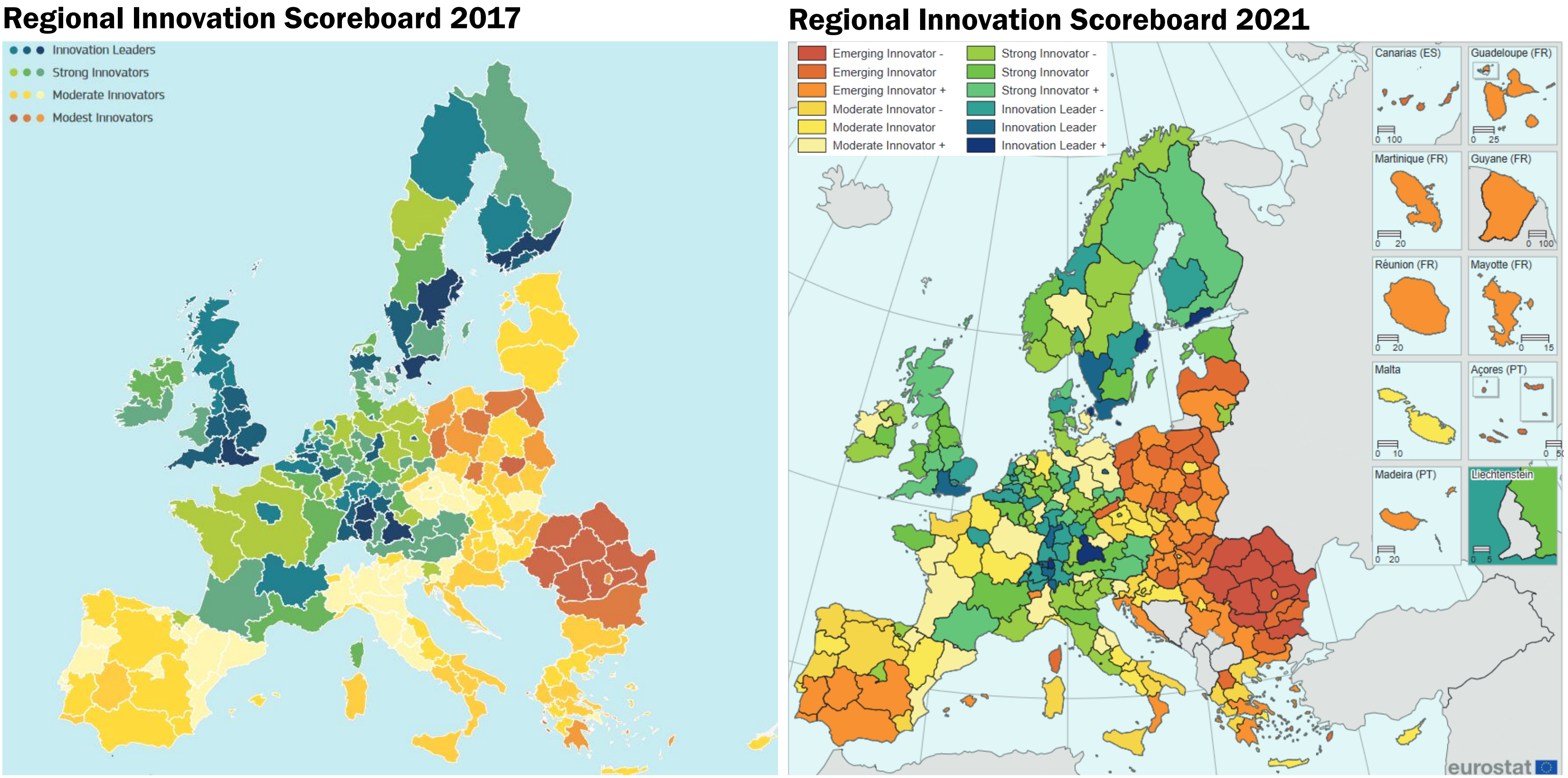
NUTS	NUTS Label	S3 bandwidth - ranges	S3 Relatedness ratio - ranges	S3 bandwidth at the expected level	S3 relatedness at the expected level
ES11	Galicia	1 - Low	3 - Medium-high	YES	YES
ES12	Principado de Asturias	3 - Medium-high	3 - Medium-high	NO	YES
ES13	Cantabria	1 - Low	1 - Low	YES	NO
ES21	País Vasco	2 - Medium-low	4 - High	YES	NO
ES22	Comunidad Foral de Navarra	3 - Medium-high	2 - Medium-low	NO	YES
ES23	La Rioja	1 - Low	4 - High	YES	NO
ES24	Aragón	2 - Medium-low	2 - Medium-low	NO	NO
ES30	Comunidad de Madrid	1 - Low	4 - High	YES	NO
ES41	Castilla y León	3 - Medium-high	3 - Medium-high	YES	YES
ES42	Castilla-La Mancha	1 - Low	2 - Medium-low	YES	NO
ES43	Extremadura	2 - Medium-low	1 - Low	NO	NO
ES51	Cataluña	3 - Medium-high	2 - Medium-low	YES	YES
ES52	Comunidad Valenciana	1 - Low	3 - Medium-high	YES	YES
ES53	Illes Balears	1 - Low	1 - Low	YES	NO
ES61	Andalucía	4 - High	3 - Medium-high	NO	YES
ES62	Región de Murcia	2 - Medium-low	3 - Medium-high	YES	YES
ES70	Canarias	2 - Medium-low	1 - Low	NO	NO
Finland					
FI19	Länsi-Suomi	3 - Medium-high	4 - High	YES	NO
FI1B	Helsinki-Uusimaa	1 - Low	4 - High	YES	NO
FI1C	Etelä-Suomi	4 - High	2 - Medium-low	NO	YES
FI1D	Pohjois- ja Itä-Suomi	4 - High	3 - Medium-high	YES	NO
France					
FR10	Ile-de-France	5 - Excessively high	4 - High	NO	NO
FR21	Champagne-Ardenne	2 - Medium-low	3 - Medium-high	YES	YES
FR22	Picardie	5 - Excessively high	2 - Medium-low	NO	YES
FR23	Haute Normandie	5 - Excessively high	3 - Medium-high	NO	NO
FR24	Centre	5 - Excessively high	2 - Medium-low	NO	YES
FR25	Basse Normandie	5 - Excessively high	3 - Medium-high	NO	NO
FR26	Bourgogne	5 - Excessively high	3 - Medium-high	NO	YES
FR30	Nord-Pas-de-Calais	5 - Excessively high	3 - Medium-high	NO	YES
FR41	Lorraine	5 - Excessively high	3 - Medium-high	NO	YES
FR42	Alsace	5 - Excessively high	3 - Medium-high	NO	YES
FR43	Franche-Comté	3 - Medium-high	3 - Medium-high	YES	YES
FR51	Pays de la Loire	5 - Excessively high	3 - Medium-high	NO	YES
FR52	Bretagne	5 - Excessively high	2 - Medium-low	NO	YES
FR53	Poitou-Charentes	4 - High	3 - Medium-high	NO	YES
FR61	Aquitaine	5 - Excessively high	3 - Medium-high	NO	YES
FR62	Midi-Pyrénées	5 - Excessively high	3 - Medium-high	NO	YES
FR63	Limousin	5 - Excessively high	2 - Medium-low	NO	NO
FR71	Rhône-Alpes	5 - Excessively high	3 - Medium-high	NO	YES
FR72	Auvergne	3 - Medium-high	1 - Low	YES	YES
FR81	Languedoc-Roussillon	5 - Excessively high	3 - Medium-high	NO	YES
FR82	Provence-Alpes-Côte d'Azur	5 - Excessively high	3 - Medium-high	NO	YES
FR83	Corse	4 - High	1 - Low	NO	NO
FR91	Guadeloupe	5 - Excessively high	1 - Low	NO	NO
FR92	Martinique	4 - High	1 - Low	NO	NO
FR93	Guyane	1 - Low	1 - Low	YES	NO
FR94	La Réunion	5 - Excessively high	1 - Low	NO	NO
FR95	Mayotte	5 - Excessively high	1 - Low	NO	NO
Croatia					
HR	Croatia	3 - Medium-high	3 - Medium-high	NO	YES
Hungary					

NUTS	NUTS Label	S3 bandwidth - ranges	S3 Relatedness ratio - ranges	S3 bandwidth at the expected level	S3 relatedness at the expected level
HU	Hungary	2 - Medium-low	3 - Medium-high	YES	YES
Ireland					
IE	Ireland	3 - Medium-high	4 - High	YES	NO
Italy					
IT	Italy	2 - Medium-low	2 - Medium-low	YES	YES
ITC1	Piedmont	1 - Low	3 - Medium-high	YES	NO
ITC2	Valle d'Aosta	1 - Low	3 - Medium-high	YES	YES
ITC3	Liguria	1 - Low	4 - High	YES	NO
ITC4	Lombardy	4 - High	3 - Medium-high	YES	NO
ITF1	Abruzzo	1 - Low	3 - Medium-high	YES	YES
ITF2	Molise	1 - Low	3 - Medium-high	YES	YES
ITF3	Campania	2 - Medium-low	3 - Medium-high	YES	YES
ITF4	Apulia	1 - Low	3 - Medium-high	YES	YES
ITF5	Basilicata	1 - Low	4 - High	YES	NO
ITF6	Calabria	3 - Medium-high	2 - Medium-low	NO	NO
ITG1	Sicily	2 - Medium-low	4 - High	YES	NO
ITG2	Sardinia	2 - Medium-low	4 - High	NO	NO
ITH1	Autonomous Province of Bolzano	1 - Low	1 - Low	YES	YES
ITH2	Autonomous Province of Trento	1 - Low	3 - Medium-high	YES	NO
ITH3	Veneto	1 - Low	3 - Medium-high	YES	NO
ITH4	Friuli-Venezia Giulia	1 - Low	2 - Medium-low	YES	YES
ITH5	Emilia-Romagna	2 - Medium-low	3 - Medium-high	YES	YES
ITI1	Tuscany	1 - Low	2 - Medium-low	YES	YES
ITI2	Umbria	1 - Low	2 - Medium-low	YES	YES
ITI3	Marche	1 - Low	2 - Medium-low	YES	YES
ITI4	Lazio	4 - High	3 - Medium-high	NO	YES
Lithuania					
LT	Lithuania	3 - Medium-high	3 - Medium-high	NO	YES
Luxembourg					
LU	Luxembourg	2 - Medium-low	3 - Medium-high	YES	YES
Latvia					
LV	Latvia	1 - Low	3 - Medium-high	YES	YES
Malta					
MT	Malta	1 - Low	1 - Low	YES	NO
The Netherlands					
NL1	North Netherlands	1 - Low	4 - High	YES	NO
NL2	East Netherlands	1 - Low	3 - Medium-high	YES	YES
NL3	West Netherlands	3 - Medium-high	3 - Medium-high	YES	YES
NL4	South Netherlands	1 - Low	3 - Medium-high	YES	NO
Poland					
PL	Poland	4 - High	3 - Medium-high	NO	YES
PL11	Łódzkie	2 - Medium-low	4 - High	YES	NO
PL12	Mazowieckie	3 - Medium-high	4 - High	YES	NO
PL21	Małopolskie	2 - Medium-low	3 - Medium-high	YES	YES
PL22	Śląskie	1 - Low	2 - Medium-low	YES	NO
PL31	Lubelskie	2 - Medium-low	2 - Medium-low	YES	YES
PL32	Podkarpackie	2 - Medium-low	3 - Medium-high	YES	YES
PL33	Świętokrzyskie	2 - Medium-low	1 - Low	NO	NO
PL34	Podlaskie	2 - Medium-low	2 - Medium-low	NO	NO
PL41	Wielkopolskie	2 - Medium-low	3 - Medium-high	YES	YES
PL42	Zachodniopomorskie	3 - Medium-high	2 - Medium-low	NO	NO
PL43	Lubuskie	1 - Low	2 - Medium-low	YES	YES
PL51	Dolnośląskie	3 - Medium-high	4 - High	YES	NO

NUTS	NUTS Label	S3 bandwidth - ranges	S3 Relatedness ratio - ranges	S3 bandwidth at the expected level	S3 relatedness at the expected level
PL52	Opolskie	2 - Medium-low	2 - Medium-low	NO	NO
PL61	Kujawsko-Pomorskie	3 - Medium-high	3 - Medium-high	NO	YES
PL62	Warmińsko-Mazurskie	1 - Low	3 - Medium-high	YES	YES
PL63	Pomorskie	1 - Low	3 - Medium-high	YES	YES
Portugal					
PT	Portugal	5 - Excessively high	3 - Medium-high	NO	YES
PT11	Norte	4 - High	3 - Medium-high	NO	YES
PT15	Algarve	3 - Medium-high	1 - Low	NO	NO
PT16	Centro	4 - High	4 - High	NO	NO
PT17	Lisbon	1 - Low	4 - High	YES	NO
PT18	Alentejo	4 - High	1 - Low	NO	NO
PT20	Azores	1 - Low	1 - Low	YES	NO
PT30	Madeira	4 - High	1 - Low	NO	NO
Romania					
RO	Romania	2 - Medium-low	3 - Medium-high	YES	YES
RO11	NORTH-WEST/NORD-VEST	2 - Medium-low	2 - Medium-low	NO	NO
RO12	Centre / Centru	4 - High	1 - Low	NO	NO
RO21	North-East / Nord-Est	4 - High	2 - Medium-low	NO	NO
RO22	Sud-Est/South-East	4 - High	2 - Medium-low	NO	NO
RO31	Sud Muntenia/South Muntenia	2 - Medium-low	1 - Low	NO	NO
RO41	Sud-Vest Oltenia	3 - Medium-high	1 - Low	NO	NO
RO42	West/Vest	1 - Low	2 - Medium-low	YES	YES
Sweden					
SE12	Östra Mellansverige	2 - Medium-low	2 - Medium-low	YES	YES
SE22	Sydsverige	1 - Low	3 - Medium-high	YES	YES
SE23	Västsverige	1 - Low	2 - Medium-low	YES	YES
SE31	Norra Mellansverige	2 - Medium-low	2 - Medium-low	YES	YES
SE32	Mellersta Norrland	1 - Low	2 - Medium-low	YES	YES
SE33	Övre Norrland	1 - Low	2 - Medium-low	YES	YES
Slovenia					
SI	Slovenia	1 - Low	2 - Medium-low	YES	YES
Slovak Republic					
SK	Slovakia	1 - Low	2 - Medium-low	YES	YES

Source: Prognos/CSIL (2022).

Figure 41: Development of the regional performance in the Regional Innovation Scoreboard 2017-2021



Source: European Commission (2017): Regional Innovation Scoreboard 2017. Available under https://op.europa.eu/en/publication-detail/-/publication/ce38bc9d-5562-11e7-a5ca-01aa75ed71a1/language-en (last access 16.05.2022) and European Commission (2021): Regional Innovation Scoreboard 2021. Available under https://op.europa.eu/en/publication-detail/-/publication/b76f4287-0b94-11ec-adb1-01aa75ed71a1/language-en/format-PDF/source-242412276 (last access 04.07.2022)

Table 22: Overview and description of variables used in the S3 Scoreboard

Dimension	Category	Variable	Description
Outcome Criteria	Implementation of the S3	Share of budget linked to priority areas	This indicator shows the correspondence between implemented projects and the regions' priority areas. It displays the shares of budget for each Member State or region that are linked to the priority areas.
Outcome Criteria	Thematic broadness	Appropriateness of bandwidth & relatedness	The indicator informs whether a region has achieved appropriate levels in its **bandwidth** and/or relatedness of their strategy. See also Chapter 6 for detailed information.
Outcome Criteria	Correspondence of S3	Correspondence with economic profile	These indicators show a Member States or regions Pearson correlation coefficient with the average employment / patent / publication share in the three years before the strategy implementation and the priority areas of the S3. A correlation coefficient higher than 0 indicates a positive correspondence between the S3 priority areas and the Member State/regional profile. Conversely, a correlation coefficient lower than 0 indicates a negative correspondence between the S3 priority areas and the Member State/regional profile. The higher the coefficient in absolute terms (i.e., the closer it is to 1 or -1), the stronger the positive or negative correspondence. Only positive correspondences were considered In the Scoreboard.
		Correspondence with technological profile	
		Correspondence with scientific profile	
Process Criteria	Development process of S3 (EDP)	Degree of continuity of EDP	This indicator informs about the number of stages in the policy-making cycle in which the S3 was used. The S3 policy-making cycle covers the three stages Policy formulation, Decision-making and implementation, and Monitoring, evaluation & updating. For the construction of this indicator, it was considered whether a strategy used the S3 in all, two or in one stage. In other words, the indicator shows the number of stages in which the EDP was used. The underlying data was collected by country experts in interviews with S3 managing authorities.
Process Criteria	Quality of the prioritisation approach	Economic approach to prioritisation	These indicators show the extent to which a Member States or regions priority areas are economically/technologically/scientifically driven. Share indicates the extent to which priority areas can be explained through NACE sectors / Technological fields /
		Technological approach to prioritisation	

		Scientific approach to prioritisation	Scientific fields. This has been based on a matching approach between priority fields and their description with NACE sectors /Technological fields / Scientific fields.
Process Criteria	Implementation of the S3	Quality of the selection process	This indicator is a measure of the strictness of calls for proposals. It is measured by the degree to which the priority areas had to be addressed. The indicator is constructed as a weighted average by assigning values to the four alignment criteria which were then multiplied with the Member States or regions share of calls of proposal with this alignment criteria. The assigned values are the following: 4 = S3 alignment as an eligibility condition – formal 3 = S3 alignment as an eligibility condition – substantial 2 = S3 alignment as a preferential criterion 1 = No specific alignment criteria
Context Criteria	Maturity of the Innovation Ecosystem	Regional Innovation Scoreboard Groups	This indicator captures the capacity of a region's innovation ecosystem. The Regional Innovation Scoreboard provides a comparative assessment of the performance of innovation systems across the different regions and EU countries. For the S3 Scoreboard the 2017 Regional Innovation Scoreboard Groups (Innovation Leader, Strong Innovator, Moderate Innovator & Modest Innovator) have been applied.
Context Criteria	Quality of Government	European Quality of Government Index	This indicator captures average citizens' perceptions and experiences with corruption, quality and impartiality various public sectors in their region. The European Quality of Government Index (EQI) is the result of novel survey data at the regional (e.g. sub-national) level governance within the EU. The data was first gathered and published in 2010 and then repeated in 2013, 2017, and 2021. For the Scoreboard the 2017 data is used. The data has been normalized to values between 0 and 1.
Context Criteria	Intensity of Cohesion Funding	Share of Cohesion Policy Funding	This indicator informs about the share of Cohesion Policy Funding per Member State to public investment 2015-2017. This data compares the allocations of Cohesion Policy per Member State (available on the Cohesion Policy open data platform) to public investment (Gross fixed capital formation by general government). This is usually referred as total public investment.

Source: Prognos / CSIL (2022).

Table 23: Overview of criteria to rank the variables used in the S3 Scoreboard

Variables	Rating
Share of budget linked to priority areas	Percentage ranging from 0% to 100%.
Appropriateness of bandwidth & relatedness	The scale that was used in the Scoreboard is the following: 1 = Appropriate level of bandwidth and optimal relatedness 0.5 = Appropriate level of bandwidth or optimal relatedness 0 = Neither appropriate levels of bandwidth nor relatedness achieved
Correspondence of S3	The variable is computed as the average correlation coefficient across the three profiles (economic, scientific, and technological), after removing negative correlation coefficients.
Degree of continuity of EDP	The number of stages in the policy-making cycle in which the S3 was used was normalised to values between 0 and 1. The scale that was used in the Scoreboard is the following: • 1/3 = one stage • 2/3 = two stages • 1 = all stages
Quality of the prioritisation approach	Percentage ranging from 0% to 100%. It is computed as the average prioritization approach across the three approaches (economic, scientific, and technological).
Quality of the selection process	The weighted average of the four possible alignment criteria in the calls of proposal was normalised to values between 0 and 1: • 1/3 = Averages between 1 and 2 (no alignment criteria) • 2/3 = Averages between 2 and 3 (moderate alignment criteria) • 1 = Averages above 3 (strict alignment criteria)
Regional Innovation Scoreboard Groups	The scale that was used in the Scoreboard is the following: • Rank 1 (best): Innovation Leader

	• Rank 0.75: Strong Innovator • Rank 0.5: Moderate Innovator • Rank 0.25: Modest Innovator
European Quality of Government Index	The Index ranges from -3 to +3. The values were normalized to values between 0 and 1 using a min-max procedure: $(Value - minimum\ value)/(maximum\ value - minimum\ value)$
Share of Cohesion Policy Funding	Percentage ranging from 0% to 100%. It compares the allocations of Cohesion Policy per Member State to public investment (Gross fixed capital formation by general government)

Source: Prognos / CSIL (2022).

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