CCDR NORTE

Comissão de Coordenação e Desenvolvimento Regional do Norte, I.P.

S3NORTE

2027

NORTE REGION SMART SPECIALISATION STRATEGY 2021-27

CCDR NORTE

Comissão de Coordenação e Desenvolvimento Regional do Norte, I.P.

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Opening remarks

After two deep recessions, resulting from the international financial crisis of 2008 and the national sovereign debt crisis that followed, Norte's economy entered a phase of recovery, during the 2014-20 programming period. Apart from 2015 (and 2020, for well-known reasons), economic growth in Norte surpassed the country and the European Union. This double convergence in so many consecutive years has no parallel in the current century. While it is true that there are several factors that contributed to this new trajectory, it is important to highlight the following: industrialisation, competitiveness of exports and valuation of specific assets of the territories.

Despite de-industrialisation, Norte is still, by far, the most industrialised region in the country, being the 11th most industrialised region among the 246 NUTS II regions of the EU27. On the other hand, Norte has been, notably, the most exporting region in the country and generates persistent surpluses in its external accounts: in 2021, exports of goods represented 36.6% of the national total and the coverage rate was 116.7%. However, reduced labour productivity is a structural problem that has been limiting economic growth and wages increased in Norte in the in this century, and is even the main cause for the low level of development in the national and European context.

According to the "Regional Innovation Scoreboard", Norte has been registering remarkable progress for almost a decade, having been classified, in 2019, as "Strong Innovator-". However, in 2021, Norte has obtained the previous classification of "Moderate Innovator". This more recent performance results from the degradation of indicators associated with non-R&D innovation, process innovation, marketing and organisational innovation and product innovation, to which is associated the systemic relationship between low qualifications and a productive structure with low levels of technology intensification, constituting the main structural weakness of the regional economy.

In this context, it is necessary to formalise and consolidate the Regional Innovation System (RIS), reinforcing the articulation between the Scientific and Technological System (STS) entities and the business and the alignment of the support for innovation with its regional strategy, based on the governance model of the regional smart specialisation strategy and on a better articulation with the European Structural Funds.

The network of RIS institutions is spatially unbalanced, with a clear division between the main urban centres, in particular AMPorto and the rest of the Region. It is therefore necessary to promote a more territorially distributed and balanced RIS, based on a network of institutions with different profiles, from fundamental research to support for business innovation, in close articulation with higher education institutions. Considering the strong correlation between the location of technological infrastructures and knowledge production centres and the business environment, this rebalancing is essential to support productive activities with greater potential for expanding the economic territory base of promotion of competitiveness.

Given the different technological bases in the several sectors of activity, and since it is a strategic objective of Norte to significantly increase labour productivity to correct its delay in terms of social well-being, the manufacturing industries will undoubtedly be instrumental in this real convergence process. The great challenge, therefore, consists of accelerating the industrialisation process by creating jobs and promoting technological innovation, making it possible to increase productivity in this sector.

In the Cohesion Policy regulations approved by the European Commission for the new programming period (2021-27), smart specialisation strategies and their governance model are of high relevance, constituting the only enabling condition for financing the Policy Objective 1 (PO1), which includes the support to the areas of innovation, digitalisation, economic transformation and incentives to SMEs. To fulfil this enabling condition, on the 23rd September of 2019, the Norte Regional Innovation Council (CRIN) approved the S3 NORTE 2027 Initiative, which planned the revision of RIS3 NORTE 2020 for the 2021-27 programming period, after being consulted the regional stakeholders within the framework work carried out in the Regional Platforms for Smart Specialisation (PREI) in each domain of RIS3.

The regional smart specialisation strategy review began with the involvement of regional stakeholders in the context of the monitoring exercise that took place in 2019. In accordance with approved methodology, new interactions were developed during 2020 with the stakeholders in the context of each PREI for reviewing the different priority areas, namely through surveys. Following these interactions, the final documents for the RIS3 NORTE 2020 review exercise were approved by written consultation with CRIN on 17th December of 2020. Norte Region Smart Specialisation Strategy 2021-27 (S3 NORTE 2027) was concluded with its presentation at the meeting of the Regional Council of the Norte Regional Coordination and Development

Commission (CCDR-Norte) on 16th December of 2020, and its subsequent approval through written consultation to this body concluded on 30th December of 2020, included in Chapter 2 of the Norte Development Strategy for the 2021-27 Programming Period of European Union Policies (NORTE 2030).

The analysis of results of the surveys to PREI members and the following prospective exercise for medium and long-term trends in each of the priority domains of smart specialisation allowed the identification of eight priority domains of S3 NORTE 2027 and the respective rationales of public policies for the 2021-27 programming period of European Union policies, namely: (i) Creativity, Fashion and Habitats; (ii) Industrialisation and Advanced Manufacturing Systems; (iii) Agro-environmental and Food Systems; (iv) Sustainable Mobility and Energy Transition; (v) Health and Life Sciences; (vi) Tourism Services and Territorial Assets; (vii) Sea Resources and Economy; and (viii) Technologies, State, Economy and Society.

Therefore, in a context of profound technological and geopolitical transformations, Norte region smart specialisation strategy presents the following vision: "Development and international affirmation of Norte commitment to knowledge and competitiveness of the economy, supporting a new path for strong economic growth, job creation and territorial cohesion". The implementation of regional strategy involves three strategic objectives: (SO1) technological intensification of productive base; (SO2) economic valuation of assets and resources of its territory; (SO3) improvement of competitive positioning on a global scale. To achieve these strategic objectives there were added three transversal objectives: (TO1) increase of qualifications of all segments of the population; (TO2) vertical and horizontal equity in access to quality public goods and services; (TO3) effectiveness and efficiency of the regional governance model.

This strategy finds a (partial) response from the point of view of public policies in the different priorities or priority axes of Norte Regional Program for 2021-27, in particular in PO1 - "A more competitive and smarter Europe" which includes support to innovation, digitisation, economic transformation and SMEs. Thus, the achievement of the strategic and transversal objectives also depends on the co-financing on thematic programs of PORTUGAL 2030 (Innovation and Digital Transition; Climate Action and Sustainability; Demography, Qualifications and Inclusion; Sea), on different components of the Recovery and Resilience Program (RRP) and, also, on Strategic Plan for the Common Agricultural Policy. In addition to referred funding programs, others can be mentioned, namely those related to European territorial cooperation programs and those directly managed by the European Commission, such as Horizon Europe, Digital Europe, Interregional Innovation Investments, among others.

Given the importance of S3 NORTE 2027 to promote to regional innovation system reinforcement and framing support, namely within the scope of PO1 for the period 2021-27, it is considered fundamental to prepare an autonomous publication that ensures greater visibility for the S3 NORTE 2027 and its appropriation by all the actors that constitute the Regional Innovation System, as well as for its governance model, involving, namely: (i) public administration entities with responsibilities in the development and financing of innovation public policies; (ii) non-business entities of the regional Scientific and Technological System responsible for R&D and knowledge transfer, such as higher education entities, R&D Institutions and Infrastructures, Technological Centres and Interfaces, among others; (iii) companies as responsible for transforming knowledge into products and services; and (iv) civil society as advanced users representing the demand side of innovation.

This document of S3 NORTE 2027 aims therefore to reproduce the strategy already approved on 30th December of 2020, namely all the subchapters included in chapter 2 of the NORTE 2030 strategy, including an updated diagnosis of Norte's Regional Innovation System, bearing in mind that a new edition of the Regional Innovation Scoreboard has been published. It is also intended to autonomize and detail the components associated with S3 NORTE 2027 that are stated in other chapters of the NORTE 2030 strategy, such has a socioeconomic diagnosis, the vision and the strategic and transversal objectives and the governance model. On the other hand, there is also a more detailed description of two fundamental components for the implementation of the S3 NORTE 2027 that are indicated in the Annex to the NORTE 2030 strategy, namely the monitoring system and the internationalisation measures of the smart specialisation strategy. Finally, it concludes with a description of compliance with the enabling condition criteria associated with the smart specialisation strategy and its governance model established in European Union regulations.

António M. Cunha
President of CCDR-Norte

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List of acronyms

AEFS - Agro-Environmental and Food Systems

AMPorto - Metropolitan Area of Porto

CAE - Statistic Classification of Economic Activities

CCDR-Norte - Norte Regional Coordination and Development Commission

CFH - Creativity, Fashion and Habitats

CoLAB - Collaborative Laboratories

COMPETE 2020 - Competitiveness and Internationalisation Operational Programme 2014-2020

CRIN - Norte Regional Innovation Council

ERDF - European Regional Development Fund

ESF - European Social Fund

ESIF - European Structural Funds

EU - European Union

EU27 - European Union of 27 Member States

EU28 - European Union of 28 Member States

FCT - Foundation for Science and Technology

GDP - Gross Domestic Product

GHG - Greenhouse Gases

HLS – Health and Life Sciences

HORIZON 2020 - Research and Innovation Community Framework Programme for 2014-20

HORIZON EUROPE - Research and Innovation Community Framework Programme for 2021-27

IAMS - Industrialisation and Advanced Manufacturing Systems

ICET - Information, Communication and Electronic Technologies

IMC - Intermunicipal Communities

INE - National Institute of Statistics

INTERREG - European Territorial Cooperation

LQ - Location Quotient

NORTE 2020 - Norte Regional Operational Programme for 2014-20

NORTE 2030 - Norte Regional Development Strategy for the Programming Period 2021-27 of European Union Policies

NUTS - Nomenclature of Territorial Units for Statistics

OECD - Organisation for Economic Co-operation and Development

OP - Operational Programmes

PERIN - Portugal in Europe Research and Innovation Network

PO1 - Policy Objective 1

PORTUGAL 2020 - Partnership Agreement established between the Portuguese State and the European Commission for the programming period 2014-20

PORTUGAL 2030 - Partnership Agreement established between the Portuguese State and the European Commission for the programming period 2021-27

PREI - Regional Smart Specialisation Platforms

R&D - Research and Development

R&D&I - Research and Development and Innovation

RII - Regional Innovation Index

RIS - Regional Innovation System

RIS2019 - Regional Innovation Scoreboard – Edition of 2019

RIS2021 - Regional Innovation Scoreboard – Edition of 2021

RIS3 - Research and Innovation Strategies for Smart Specialisation

RIS3 NORTE 2020 – Norte Region Smart Specialisation Strategy for 2014-20

RIS3T - Cross-Border Smart Specialisation Strategy of Galicia-Norte of Portugal

RRP - Recovery and Resilience Plan

S3 - Smart Specialisation Strategies

S3 NORTE 2027 - Norte Region Smart Specialisation Strategy for 2021-27

SME - Small and Medium Enterprises

SMET - Sustainable Mobility and Energy Transition

SRE – Sea Resources and Economy

STS - Scientific and Technological System

TA - Thematic Agendas

TeSP – Professional Higher Technical Courses

TIC - Technological Interface Centres

TSES - Technologies, State, Economy, and Society

TSTA - Tourism Services and Territorial Assets

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**NORTE REGION SMART
SPECIALISATION STRATEGY
2021-27**

Introduction

In the 2014-20 programming period of European Union policies, the Research and Innovation Strategies for Smart Specialisation, or RIS3, were an ex-ante conditionality for access to european financial support in the areas of research, development and innovation (R&D&I) from the European Structural Funds. An ex-ante conditionality concerns a concrete and precisely predefined critical factor and constitutes a prerequisite for the effective and efficient achievement of a specific objective of a Union investment priority. The Norte Region Smart Specialisation Strategy for 2014-20 (RIS3 NORTE 2020) was thus the strategic reference for the implementation of financial resources in the areas of R&D&I, particularly in the Norte Regional Operational Programme for 2014-20 (NORTE 2020).

In the Cohesion Policy regulations approved by the European Commission for the new programming period (2021-27), the smart specialisation strategies and their governance model continue to assume identical relevance, constituting the only enabling condition for funding under Policy Objective 1 (PO1), which includes support in the areas of innovation, digitalisation, economic transformation and support for SMEs. To fulfil this enabling condition, on 23rd September of 2019, the Norte Regional Innovation Council (CRIN) approved the S3 NORTE 2027 Initiative, for the revision of RIS3 NORTE 2020 in the context of the 2021-27 programming period, after listening to the different regional stakeholders as part of the work developed in the respective Regional Smart Specialisation Platforms (PREI).

The review activities of the Regional Smart Specialisation Strategy started with the engagement of regional stakeholders in the context of the monitoring exercise which took place in 2019. According to the respective approved methodology, during 2020, further interactions with stakeholders were developed in the context of each regional smart specialisation platform for the review of the different priority domains, namely through surveys. Following these interactions, the final documents of this S3 NORTE 2027 review exercise were approved by written consultation of with CRIN on 27th November and 17th December of 2020. The analysis of the results of the surveys of the PREI members and the prospective exercise of the medium to long term trends for each of the priority areas of smart specialisation allowed the identification of the eight priority areas of the Norte Region Smart Specialisation Strategy 2021-27 (S3 NORTE 2027) and respective public policy rationales for the 2021-27 programming period of the European Union policies.

The institutional dimension of the preparation of S3 NORTE 2027 was strengthened with the need to proceed with the approval by the Regional Council of the NORTE 2030 Strategy to comply with point 3 of the Resolution of the Council of Ministers No. 97/2020, of 13th November, according to the terms of reference established by the Secretary of State for Regional Development, on 6th of February of 2020. In these terms of reference, it is established that chapter 2 consists of the "Critical review of the Regional Innovation Smart Specialisation Strategies (RIS3), [...] incorporating each of these exercises in the respective Regional Strategy 2030 and presenting a reasoned response for the fulfilment of the RIS3 enabling condition". The drafting exercise of S3 NORTE 2027 was thus concluded with its presentation at the meeting of the Regional Council of the Norte Regional Coordination and Development Commission (CCDR-Norte) on 16th December of 2020 and subsequent approval through written consultation to this body completed on 30th December of 2020, thus appearing in Chapter 2 of the Norte Development Strategy for the 2021-27 Programming Period of European Union Policies (NORTE 2030).

The approved S3 NORTE 2027 essentially includes the updated diagnosis of the Norte Regional Innovation System (RIS), the summary of the conclusions and recommendations of the monitoring exercise of the RIS3 NORTE 2020, the presentation of priorities or priority domains for smart specialisation, the characterisation of the respective public policy rationales and the identification of the main international demand trends in a medium-term perspective. The Annex to the Regional Strategy contains the fulfilment with this enabling condition criteria established in the proposed EU regulations, namely: (1) Up-to-date analysis of challenges for innovation diffusion and digitalisation.; (2) Existence of competent regional or national institution or body, responsible for the management of the smart specialisation strategy; (3) Monitoring and evaluation tools to measure performance towards the objectives of the strategy; (4) Functioning of stakeholder co-operation ("entrepreneurial discovery process"); (5) Actions necessary to improve national or regional research and innovation systems; (6) Actions to support industrial transition; and (7) Measures for enhancing cooperation with partners outside a given Member State in priority areas supported by the smart specialisation strategy.

Given the importance of S3 NORTE 2027 in boosting the regional innovation system and in its support framework, namely, in the scope of Policy Objective 1 (PO1) of the period 2021-27, which includes the areas of innovation, digitalisation, economic transformation and support to SMEs, it is considered essential to

proceed with the preparation of an autonomous publication to ensure greater visibility of S3 NORTE 2027 and its appropriation by all actors that integrate the Regional Innovation System (RIS), as well as its governance model, involving, namely: (i) the public administration entities with responsibilities in the development and funding of public innovation policies; (ii) the non-business entities of the regional Scientific and Technological System (STS) responsible for R&D and knowledge transfer, such as higher education entities, R&D Institutions and Infrastructures, Centres and Technological Interfaces (CTI), among others; (iii) companies as responsible for the transformation of knowledge into products and services; and (iv) civil society as advanced users representing the demand side of innovation.

This document of S3 NORTE 2027 aims, therefore, to replicate the strategy already approved on 30th December of 2020, namely all the sub-chapters included in chapter 2 of NORTE 2030 strategy, with an update of the sub-chapter on the diagnosis of Norte RIS, considering that a new edition of the Regional Innovation Scoreboard was published. It also aims to make an autonomous and detailed publication of the component parts of S3 NORTE 2027 that are included in other chapters of the NORTE 2030 strategy, such as a socio-economic diagnosis, the vision and the strategic and transversal objectives and the governance model. Finally, a more detailed description was also made of two fundamental components for the implementation of S3 NORTE 2027 that are indicated in the Annex in the NORTE 2030 strategy, namely the monitoring system and the internationalisation measures of the smart specialisation strategy.

Thus, after this introduction, the first chapter presents a summary of the socio-economic characterisation of Norte Region regarding the most relevant variables to frame this regional smart specialisation strategy. The second chapter updates the diagnosis of Norte's RIS, analysing its performance using the Regional Innovation Scoreboard of the European Commission, the technological profile of regional exports and territorial specialisation and the systemic relationship between structural weaknesses of Norte's RIS, with implications for public policy.

The third chapter seeks to systematise the main conclusions of the monitoring exercise of RIS3 NORTE 2020, carried out as part of the respective report approved by the Norte's Regional Innovation Council on 8th October of 2019 and published in December 2019. These conclusions are selected based on their intrinsic relevance, but also, and above all, because they constitute lessons of experience and key recommendations for reviewing RIS3 NORTE 2020 and drafting S3 NORTE 2027. The fourth chapter presents the priorities or priority domains of smart specialisation, the characterisation of the respective public policy rationales and the identification of the main international demand trends in a medium-term perspective. The fifth chapter includes an analysis of the innovation ecosystem of the regional smart specialisation strategy, based on a characterisation exercise of the network of institutions that forms the regional Scientific and Technological System.

The internationalisation of the smart specialisation strategy is developed in chapter six, as a relevant dimension to enhance the participation of regional actors in international networks and global value chains. The strategic statement itself begins in the seventh chapter, presenting its vision, guiding principles, strategic and transversal objectives. This strategy is complemented in the following chapter with the respective governance model that will underpin the management and implementation of the regional smart specialisation strategy. Chapter nine describes the monitoring system that will ensure the follow-up of the strategy and support decision making. Finally, chapter ten describes compliance with the criteria of the enabling condition associated with the Smart Specialisation Strategy established in EU regulations.

1.

Socio-economic characterisation of Norte Region

This chapter presents a socio-economic characterisation of Norte Region, based on the prospective diagnosis made in the NORTE 2030 Strategy, updating the analysis carried out around a set of relevant topics in terms of context to frame this regional smart specialisation strategy, namely, territory and population, economic dynamics of Norte in the national and European context, production specialisation and competitiveness, exports of goods and international trade indicators and education and human capital.

Territory and population

Norte Region of Portugal is located in the southwest of the European continent, being strategically positioned between Europe, America and Africa. Norte is the most populated NUTS II region of Portugal, with a population of about 3.6 million, in 2020, representing 35% of the Portuguese population, with an area extension of 21 286 Km^2, corresponding to 23.1% of the Portuguese territory and presenting a population density of 168.5 inhabitants/Km^2, higher than the population density in Portugal of 112.2 inhabitants/Km^2.

The integration of Norte with the European Union makes it a privileged region that serves as a gateway to a market of 500 million consumers. Endowed with good communication and internationalisation infrastructures, Norte has been taking important steps to strengthen regional connectivity, highlighting a diversified set of infrastructures and services which, in different aspects, reconciles high levels of competitiveness with an orientation towards assuring equitable access, growing digitalisation, and fostering carbon neutrality.

In administrative terms, Norte Region is composed of 86 municipalities and 1 426 parishes. The municipalities are organised into eight Intermunicipal Entities, which correspond to NUTS III level, namely, Alto Minho, Alto Tâmega, Ave, Cávado, Douro, Tâmega e Sousa, Terras de Trás-os-Montes and Metropolitan Area of Porto (AMPorto), the latter sub-region being the main population centre of Norte Region, with approximately 1.7 million inhabitants.

The territorial system of Norte Region is thus characterised by sub-regions located in the interior with a lower population density as Terras de Trás-os-Montes, Alto Tâmega, and Douro and the sub-regions with higher population densities as Alto Minho, Tâmega e Sousa, Ave and Cávado, with emphasis on the Metropolitan Area of Porto with 850.7 inhabitants/Km^2 in 2020. At a municipal level, population density is particularly high in eight municipalities of the Metropolitan Area of Porto, namely Porto, Matosinhos, São João da Madeira, Vila Nova de Gaia, Maia, Espinho, Valongo and Gondomar, whose values exceed 1 000 inhabitants/Km^2.
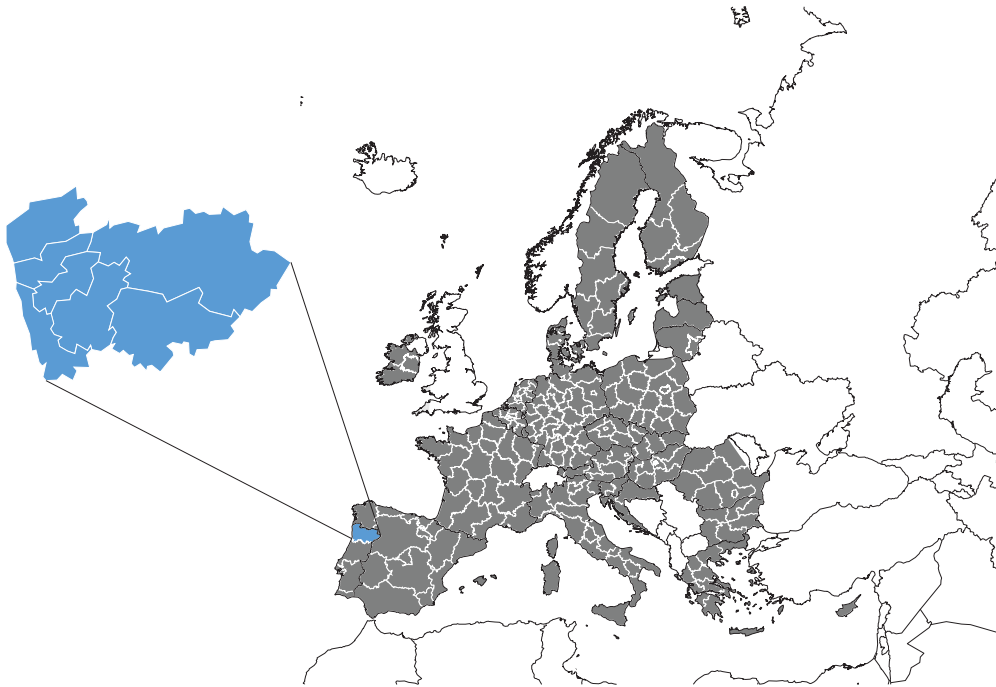
Figure 1 • Map of Norte Region and the European Union

Economic dynamics of Norte in the national and European context

After two deep recessions, resulting from the 2008 international financial crisis and the national sovereign debt crisis that followed, Norte Region's economy entered a period of economic recovery during the previous programming period (2014-20). Except for 2015 (and 2020, due to the pandemic crisis associated with COVID-19), Norte Region's economic growth outperformed the country and the European Union. This double convergence in too many consecutive years is unparalleled in the current century. While it is true that there were several factors that have contributed to this new trajectory, the following should be highlighted: industrialisation, export competitiveness and the valorisation of specific territorial assets.

From 2013 to 2019, the GDP in volume of Norte Region's economy increased every year, observing an average annual growth of 2.4% during that period. The increased competitiveness at this stage was certainly a factor that contributed to the level of development of Norte converging with the national level and that of the EU28 average. In the comparison with economic development of the European Union (EU27), the year 2020 marked the reverse of the convergence trend that had been observed in Portugal and in Norte between 2017 and 2019 and which had been founded on a dynamic of economic growth.

Contrary to this trajectory, and in the context of a sharp economic recession in all regions of Portugal and the European Union, the national GDP per capita, measured in purchasing power standards, diverged from 78.6% to 76.4% of that of the EU27 between 2019 and 2020. In Norte, the same indicator fell from 67.0% to 66.4% of the EU27 average. On a long-term basis, the relative development level of Portugal and Norte diverged from that of the European Union between 2000 and 2020. In that first year, Portugal's GDP per capita, measured in purchasing power standards, was 85.3% of that of the EU27 and that of Norte Region was 68.5%.
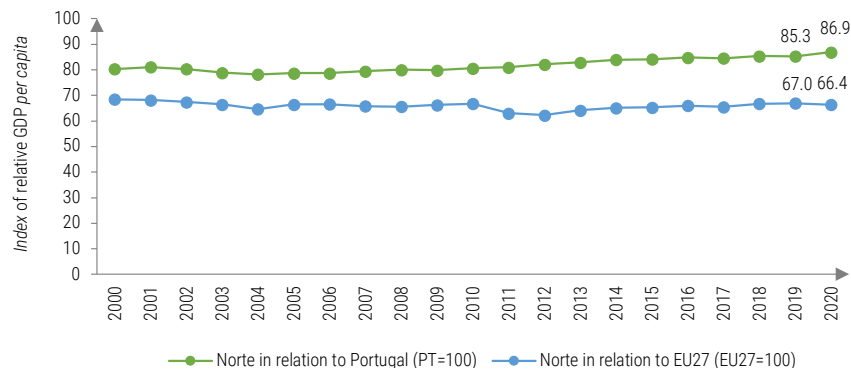
Figure 2 • GDP per capita of Norte Region in relation to Portugal and the European Union[1]

In the case of Norte Region, different circumstances explain the extent to which good competitive factors can coexist with low income. One part of the explanation lies in the history of this region, that is, its economy has developed from sectors of low productivity, although this indicator has grown above the national average throughout the 21st century, precisely because the manufacturing industries have made significant gains in economic efficiency, resulting from its greater exposure to international competition. Another part of the explanation lies in the difficulty that Norte has in obtaining the necessary capital, in a context in which the different levels of indebtedness at the level of NUTS II regions have caused, throughout the national financial system, a drain on the savings of the less indebted regions (such as Norte) to other more indebted regions with deficits in the balance of goods and services and/or the balances of income and transfers.

Norte Region, despite being a contributor to the strengthening of the country's international competitiveness and its external financial sustainability, and despite having made a fundamental contribution to balancing public accounts through the significant improvement in employment indicators, continues to have salaries significantly lower than the national average. The region continues to have indicators that compare poorly with most of the country and with the European Union. In 2020, it had the lowest GDP per capita in Portugal, corresponding to 86.9% of the national average. This position in the national context results from the low level of development of its sub-regions, with most of them occupying the lowest places in the national ranking.

The macroeconomic model based on these three vectors (industrialisation, internationalisation, and innovation) had a slightly asymmetric impact on the evolution of the relative levels of wealth. Norte Region is composed of different sub-regions from the point of view of economy, population and dynamism in external markets, so that significant differences are observed in the evolution of GDP. Between 2013 and 2019, before the pandemic crisis, wealth creation in Douro and in Terras de Trás-os-Montes resulted, exclusively, from increases in labour productivity, while in the more populated, industrialised, urban, and externally open sub-regions, such as AMPorto, Cávado, Ave and Tâmega e Sousa, employment was the main driver of economic growth. In Alto Tâmega, the growth was null in employment with slight gains in productivity, while in Alto Minho the positive dynamics of employment stood out.

This development has not significantly altered internal cohesion and, therefore, intra-regional disparities have not been significantly aggravated. Taking as a reference the regulation of the 2014-20 programming period, in 2020 all sub-regions have a GDP per capita in purchasing power standards below 75% of the Community average, a threshold below which they are classified as "less developed". The difference between the sub-regions with the lowest (Tâmega e Sousa) and highest (AMPorto) GDP per capita is lower than the difference between the second and the sub-region (NUTS III) or region (NUTS II) with the highest GDP per capita in the country.

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[1]   The per capita GDP of Norte relative to that of the EU27 is measured in purchasing power standard.

Productive specialisation and competitiveness

Over the course of the current century, it was thus possible to observe three heavy trends in the evolution of the employment structure of Norte: rising of the service sector, deindustrialisation, and a reduction in the importance of agriculture, forestry, and fishing sector. Development of the service sector was explained by two movements that occurred on both the demand and supply sides. On the demand side, the growth of average income, albeit low, motivated the demand for new individual services, such as health and education, an evolution compatible with the desirable human, social and economic progress. On the supply side, the growth in labour productivity observed in the other sectors, together with the phenomena of globalisation and relocation of industrial activity, freed up labour for the various branches of the services sector, allowing their relative importance to increase. Similarly, the process of deindustrialisation and the reduction in the relative importance of the primary sector resulted from the development dynamic itself, characterised by a sequence of technological shocks and significant changes in international competition.

Despite the deindustrialisation, Norte Region is still, notably, the most industrialised region in the country, being the 11th most industrialised region among the 246 NUTS II regions of the EU27. In 2021, the population employed in manufacturing industries represented 25.0% of the total, a figure significantly higher than the proportion of this branch in the national total (16.9%). At the same time, between 2013 and 2021, the population employed in manufacturing industries increased by approximately 61 thousand individuals, contributing to the beginning of a new cycle of industrialisation.
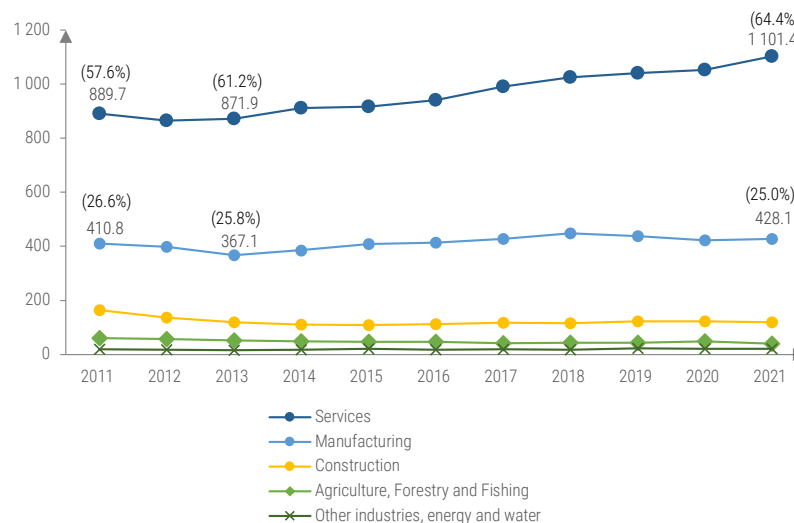
Figure 3 • Evolution of employment by sectors of activity in Norte Region, in thousands[2]
Source: Employment Survey, INE

In 2013, the beginning of a new phase of industrialisation of Norte's economy was also followed by an increase in employment in the services sector, especially in branches of activity important for social, human and technological development. Between 2013 and 2021, the population employed in the services sector increased by 229.4 thousand individuals, an evolution that allowed reaching a level of employment slightly above 1.1 million individuals in 2021, equivalent to 64.4% of the total, a proportion that compares with 61.2% in 2013. The most accentuated growths, in absolute value, were observed in human health and social support activities (+54.2 thousand), wholesale and retail trade (+47.6 thousand), education (+40.6 thousand), consulting, scientific, technical, and similar activities (+14.4 thousand), information and communication activities (+28.9 thousand), consulting, scientific, technical, and similar activities (+26.2 thousand) and financial and insurance activities (+16.7 thousand).

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[2]   The percentages refer to the proportion of each sector in the total employment of Norte Region.

The reinforcement of employment in services is important for opening society to economic and structural change that is intended to be long-lasting. Besides the human development dimensions, associated to the growth trends in education, health, and social support services, the technological dimension has gained importance with the increase in employment in services that, by their nature, contribute to the production of knowledge and its application, as is the case of consulting, scientific, technical, and similar activities and information and communication activities.

The low productivity of labour is a structural problem that has limited economic growth and increases in salaries in Norte Region throughout the current century and is even the main cause for the low level of development in the national and European context, within a framework in which the negative demographic evolution has reduced the labour force and limited its contribution to growth. Despite the convergence in productivity levels observed over almost two decades, Norte continues to be the region with the lowest productivity in Portugal. In 2020, the value of apparent labour productivity at current prices was 31 312 euros, 87.3% of the national average value.

This lower productivity results from the intersection of two weaknesses: one of a sectoral nature and the other of regional scope. In the first case, employment is mostly allocated to branches of activity with productivity levels below the regional average, presenting a structural bias of labour towards economic activities of low added value. In the second case, the regional weakness is related to the fact that the level of productivity in each of the sectors of activity in Norte (except for real estate activities) is lower than the national average, which reflects the region's difficulty in producing and retaining income from each of its economic activities.

Given the different technological bases in the various sectors of activity and being a strategic objective of Norte Region to significantly increase labour productivity in order to correct its backwardness in terms of social welfare, manufacturing industries will undoubtedly be instrumental to this process of real convergence. The great challenge, then, consists of accelerating the industrialisation process through job creation and the promotion of technological innovation, enabling productivity increase in this sector.

The productive specialisation of Norte's sub-regions results from a set of variables, such as the availability of productive factors, public intervention, and the degree of geographical mobility of assets. The different endowment of productive factors (endogenous resources, human resources, capital, and knowledge) in each sub-region plays a determining role in the location of economic activities. The sub-regions oriented towards the industrialisation, internationalisation and innovation vectors observed slightly higher wealth growths than the sub-regions with economic structures supported on different competitiveness factors, such as tourism or local trade. The spatialisation of this model allows the identification of the following three economic bases:

· AMPorto, Cávado and Alto Minho have a more diversified economic base, with a more balanced proportion of production of tradable (industry or higher tertiary) and non-tradable (wholesale or retail) goods and services;

· The second economic base is observed in sub-regions strongly specialised in the manufacture, utilities and construction sectors, although with small differences: in Ave, the manufacturing industries are the main branch of activity; in Tâmega e Sousa, the greater importance of the manufacturing industries coexists with the relevant dimension of the construction sector;

· The third economic base is concentrated in the territories of smaller population size and low density (Alto Tâmega, Douro and Terras de Trás-os-Montes), in which the agriculture, forestry, and fishing sector and public employment guarantee the highest percentage of employment.

Exports of goods and international trade indicators

Norte has been, prominently, the most exporting region of the country. In 2021, exports of goods reached a value of 23 292 million euros, 36.6% of the national total, contributing decisively to mitigate the country's structural imbalances in terms of external indebtedness. At the same time, in dynamic terms, it observed a significant improvement in its international competitiveness, with the value of exports increasing by 45.4% between 2011 and 2021.

Other important indicators are suggestive of a greater dynamism of Norte in the process of internationalisation of the economy. Indicative of a strengthening of comparative advantages, the proportion of exports in GDP (export intensity) was 36.1% in 2019 (the year 2020 was atypical and there is still no GDP information for 2021), a figure that compares with 27.8% in Portugal.

The year of 2021, also stands out in the difference between exports and imports: the rate of coverage of imports by exports was 116.7%, a figure that again allowed for a surplus in the trade balance of goods of 3 332 million euros, in clear contrast with a new deficit observed in Portugal (-19 146 million euros).
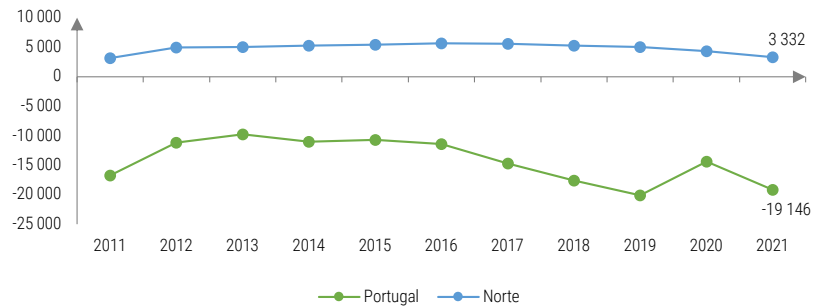
Figure 4 • Balance of trade in goods (million euros)
Source: International Trade Statistics, INE

Between 2011 and 2021, all sub-regions showed an overall positive evolution in terms of the value of exports of goods, although the annual growth dynamics and contributions of each to the overall growth of exports in Norte Region were quite distinct, highlighting, due to their relative importance, those with the largest population size and, within these, AMPorto in particular. In 2021, exports of goods from companies headquartered in AMPorto represented 50.2% of the total, followed by those from the Ave (18.4%), Cávado (11.9%), Alto Minho (8.2%), Tâmega e Sousa (7.3%), Terras de Trás-os-Montes (3.3%), Douro (0.5%) and Alto Tâmega (0.3%).

In 2019, for the major product groups (8 classes according to the SITC rev.4 classification), Norte generally has strong revealed comparative advantages[3] in "Class 8 - Miscellaneous manufactured articles". This class, composed mostly of light industry, includes the most traditional products (footwear, clothing, textiles), furniture and parts, seating, professional, scientific and control instruments and appliances, as well as photographic and optical appliances and equipment and watches. Overall, this class accounted for 32.1% of total exports, compared to a share of 11.8% for the contribution of this class to world exports.

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[3]   Comparative advantages are empirically measured by "revealed comparative advantages", which express the proportion of a product's exports in the region's total exports divided by the proportion of that product's exports in the world's total exports.
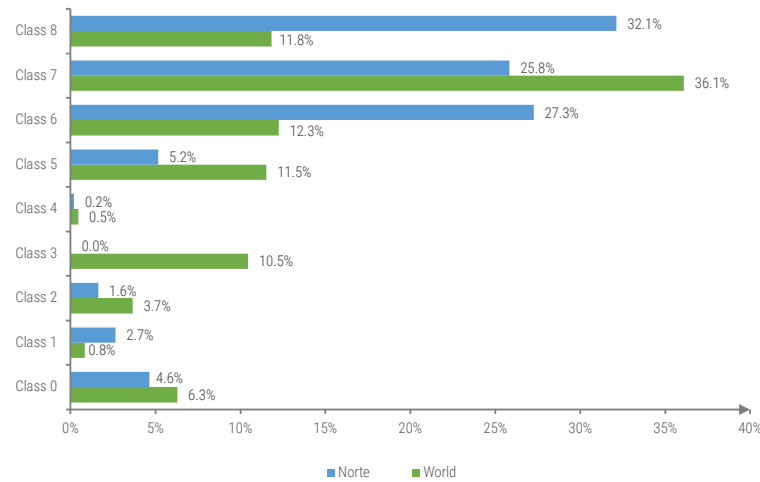
Legend: 8 - Miscellaneous manufactured articles; 7 - Machinery and transport equipment; 6 - Manufactured goods classified chiefly by material; 5 - Chemicals and related products, n.s.; 4 – Animal and vegetable oils, fats, and waxes; 3 - Mineral fuels, lubricants, and related materials; 2 - Crude materials, inedible, except fuels; 1 - Beverages and tobacco; 0 - Food and live animals.

Figure 5 • The share of each product class in total exports from Norte and in total world exports in 2019[4]

Source: International Trade Statistics, INE; UN with trade, United Nations

Since Norte Region is specialised in industrial activities, it is natural to note the existence of revealed comparative advantages greater than 1 in several products belonging to "Class 6 - Manufactured articles, classified mainly according to raw material". The products in this class represent 27.3% of all exports, a proportion clearly higher than that observed in the world (12.3%). Particularly in this group with significant revealed comparative advantages, predominate the exports of yarns, fabrics, articles made with textile fibres, the works of metal, manufactured rubber (where pneumatic products are included) and cork works (except furniture).

The third class, where Norte Region observes revealed comparative advantages, is "Class 1 - Beverages and Tobacco", almost exclusively due to the export of alcoholic beverages in the wine segment. In 2019, it accounted for 2.7% of exports, a proportion that compares with 0.8% in the world. While in the previous classes comparative advantages have historically been developed through regional industrialisation strategies oriented towards foreign trade based on competitive factors associated with low labour costs (although the increase in international competition has driven up the value chain in some products), in the beverages class competitiveness derives mainly from the increase in the quality of wines and the strengthening of their international notoriety.

In the remaining classes, it is important to highlight the high relative importance of exports from Norte in "Class 7 - Machines and transport equipment". Overall, this class represents 25.8% of total exports, with machinery as such contributing with 14.6% and transportation equipment with 11.2%. Even though the proportion of exports of this class is lower than the proportion in the world (36.1%), which apparently reveals a comparative disadvantage as a whole, the reading of the various product segments shows, nevertheless, strong comparative advantages of Norte Region in specific products. In machinery, it has comparative advantages of more than 1 in the motors and direct current generators segment. In the transport equipment segment, the comparative advantages are even more significant, with the parts, spare parts and accessories of motor vehicles and bicycles segment standing out due to its importance in exports.

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[4]   World exports refer to the year 2018.

Education and human capital

In the last decade, Portugal has maintained an improvement path in education outcomes, especially in the education levels of the younger population, approaching the European average values. In most indicators, the progress of Norte is higher than that of the other NUTS II regions, contributing decisively to the improvement of results in the country. Community support was decisive for the convergence with the European reference values, as can be seen by the evolution of results in indicators regarding the attendance of pre-school education, the early abandonment of education and training or the completion of secondary and higher education in different age groups.

Despite the evolution registered in recent years in terms of attendance and completion of higher education, indicators such as the number of higher education graduates per 1 000 inhabitants of the resident population aged 20 to 29 years old or the rate of enrolment in higher education (42.5% in Norte vs. 43.7% in Portugal vs. 41.6% in the EU27) shows that Norte Region is in a more unfavourable position than in 2009.
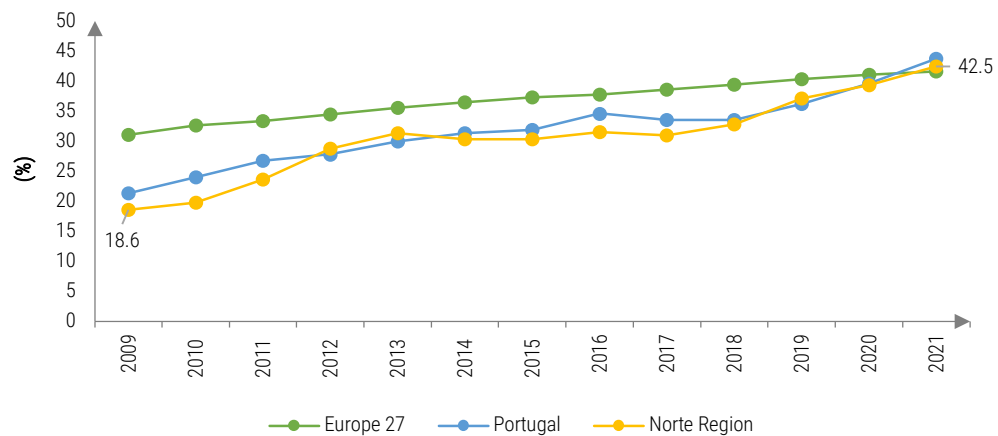
Figure 6 • Tertiary education attainment rate in the 30-34 age group (%)
Source: Eurostat; INE

In recent years, there has been a recovery in the number of students of Norte Region enrolled in higher education, after a fall in the middle of the last decade. This recovery occurs at all levels of training, with emphasis on the contribution of the most recent modality — the Professional Higher Technical courses (TeSP). These courses have attracted new publics to higher education, particularly those coming from secondary level vocational training paths. More limited has been their capacity to contribute to professional requalification and reorientation, responding to significant qualification mismatches of an important part of the most educated active population, who do not have the higher education required for the exercise of certain functions or have outdated higher education or in more surplus areas.

The present and the near future bring unexpected challenges, which give new expression to the mismatch between academic and professional qualifications and the qualified jobs available in the country and in Norte Region. The pandemic, even more in interaction with the response to the climate emergency, has heavy impacts on the labour market, enunciating processes of industrial reconversion and industrialisation, which will require technical and technological training at the various levels of qualification, within the framework of a rereading of the regional smart specialisation strategies and redefinition of investment priorities in the coming years, with the flexibility that the present situation recommends.

2.

Updating the diagnosis of Norte's Regional Innovation System

This chapter is divided into three sections. In the first, the evolution of the Regional Innovation System (RIS) of Norte is analysed, using the Regional Innovation Scoreboard[5] developed and published by the European Commission. The Regional Innovation Scoreboard allows to compare the performance of the European regions, highlighting the strengths and weaknesses of Norte Region in relation to the others. In the weakest points, the economic structure emerges and, thus, the relative importance of low, medium and high technology sectors in the regional economy. This structural dimension is then analysed in the section dedicated to the technological profile of regional exports and territorial specialisation. It concludes by establishing a systemic relationship between structural weaknesses of Norte RIS with implications for public policies.

2.1 Innovative performance of Norte Region in the context of the *Regional Innovation Scoreboard*

In conceptual terms, innovation is a complex process, highlighting its dynamic and systemic nature. The dynamic nature is strongly associated with the increasing generation and accumulation of scientific knowledge over time and its permanent experimentation to produce successful innovations. The systemic nature refers to the interdependence between the various dimensions of a RIS, in the sense that the evolution and magnitude of each one partially conditions the success of the others, being necessary to consider the harmonious development of this system to improve the innovative performance of the regions.

The integrated vision of innovation is present in the methodology adopted in the Regional Innovation Scoreboard[6] to measure the overall innovation performance of a region. It is based on the determination of a Regional Innovation Index (RII), a composite indicator of the following four groups of indicators which, to a large extent, reflect the dimensions of a RIS: (i) Structural Conditions; (ii) Investments; (iii) Innovation Activities; and (iv) Impacts. Within these dimensions, there are also domains and 21 innovation indicators that allow the final calculation of the RII.

It is an analytical tool that allows, from a set of indicators, to identify strengths and weaknesses of regional innovation systems, as well as to produce synthetic information in the form of a composite index measuring the quality of the innovation performance of each region. Its regular edition and the availability of information from different NUTS II regions of the European Union allow the analysis of the evolution of the RIS in Norte Region in comparison with others from Portugal and other Member States.

After the calculation of the RII for each region, the 240 regions under analysis are grouped into four classes of relative performance, comparing the attributed value with the average of the European Union (EU27). The classes considered are the following:

- **Leading Innovators:** regions with a Global Innovation Index above 125% of the EU27 average;

- **Strong Innovators:** regions with a Global Innovation Index between 100% and 125% of the EU27 average;

- **Moderate Innovators:** regions with a Global Innovation Index between 70% and 100% of the EU27 average;

- **Emerging Innovators:** regions with a Global Innovation Index below 70% of the EU27 average.

In order to make the wide variety of regional situations more visible, the Regional Innovation Scoreboard also considers, within each of these four classes, three subclasses: the one third of the regions with the best RII score are given a score of '+'; the one third of the regions with an intermediate score do not receive any score; the one third of the regions with the worst score receive a score of '-'. Thus, the complete ranking grid of regions comprises twelve relative innovation performance bands (Table 1).

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[5]   The performance of Norte Region in terms of innovation has been evaluated according to this methodology and respective classification, which is available on the Regional Innovation Scoreboard.

[6]   Hollanders, Hugo, Es-Sadki, Nordine & Merkelbach, Iris (2021). Regional Innovation Scoreboard 2021. Luxembourg: Publications Office of the European Union.

Table 1 • Innovation relative performance scales

RII >125%	100%< RII <=125%	70%<= RII <=100%	70%< RII
Leaders +	Strong +	Moderate +	Emerging +
Leaders	Strong	Moderate	Emerging
Leaders -	Strong -	Moderate -	Emerging -

Source: Regional Innovation Scoreboard, 2021

According to the 2019 edition of the Regional Innovation Scoreboard, Norte had made remarkable progress over the last decade, approaching the European Union (EU28) average level of innovation. The region had been the 100th most innovative region in Europe among the 238 European regions and the second most innovative in Portugal, immediately after the Lisbon Metropolitan Area. The same report stated that Norte Region had been classified for the first time as "Strong Innovator -", the best classification since the performance of the NUTS II regions began to be systematized by European entities. In Portugal, only the Metropolitan Area of Lisbon and Centro Region obtained the same rating.

However, according to the Regional Innovation Scoreboard - 2021 Edition (RIS2021), following a methodological revision of the index, Norte Region was classified as a moderate innovator, a worse attribution than that obtained in the previous edition (2019). In comparative terms, Norte became the 151st most innovative region in 2021, a position clearly lower than the 100th place occupied in 2019. The unfavourable evolution of Norte Region with regard to innovative activity was also observed in all NUTS II of Portugal, so that the most recent negative dynamic was not only confined to the context of Norte Region. Analysing the other two most innovative regions in Portugal, both Lisbon Metropolitan Area and Centro Region saw their classification decrease from "Strong Innovative -" to "Moderate Innovative" between RIS2019 and RIS2021. In Centro Region the evolution was even more negative as it was given the classification "Moderate Innovative -".

Despite the lower innovative dynamics of Norte, this region continues to be the second most innovative in Portugal. According to RIS2021, the overall innovation index of Norte Region was equivalent to 80.3% of the EU27 average, which compares with 89.7% in Lisbon Metropolitan Area and 78.8% in Centro. In the remaining national NUTS II, the relative levels of innovation are well below the European average. In descending order, the values were 66.7% in Alentejo, 57.6% in Algarve, 53.6% in the Autonomous Region of Madeira and 46.0% in the Autonomous Region of Azores.
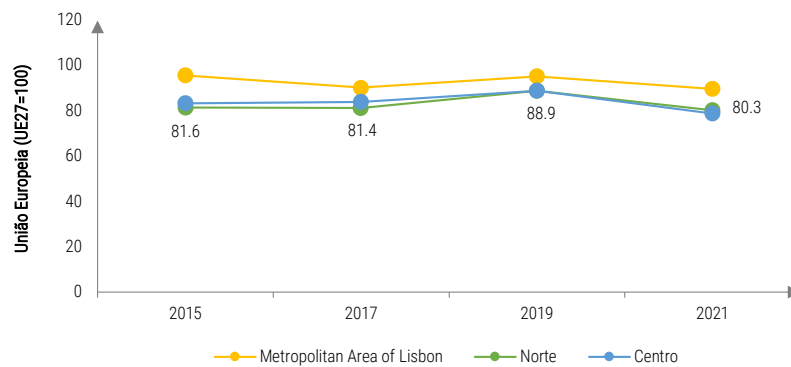
Figure 7 • Innovation Index (EU27=100)
Source: Regional Innovation Scoreboard, 2021
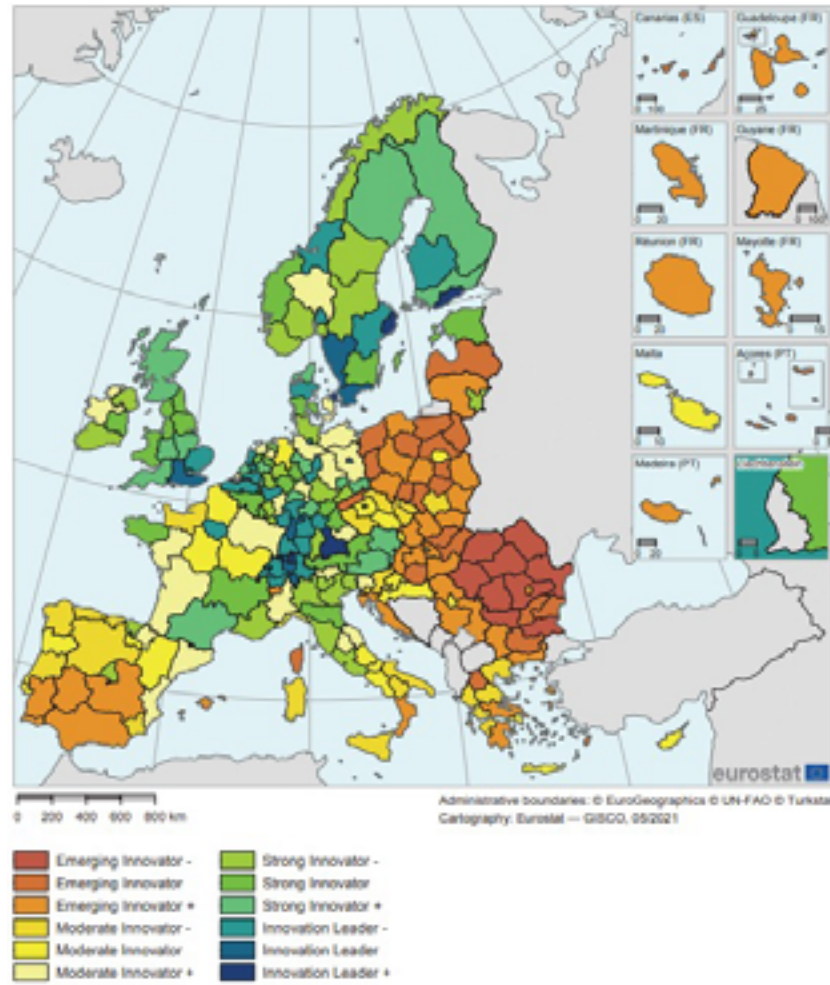
Figure 8 • Norte's Innovation Ranking in the national and European context in 2021
Source: Regional Innovation Scoreboard, 2021

The innovative activity of a region results, to a large extent, from the functioning of the RIS, which encompasses different public and private institutions, such as universities, research laboratories, technology centres and companies, and the interaction between these institutions, motivated by social and market incentives, that tends to accelerate the pace of innovations and structural change in the economy.

Norte Region's potential has a deep connection with the industrial nature and entrepreneurial profile of a catching-up region that, on the one hand, benefits from the incorporation of technology through diffusion and, on the other, develops product and process innovations, in order to move up the value chain through product differentiation and increased labour productivity. The summary of these potentialities is reflected in the indicators in which it stands out vis-à-vis the European Union.
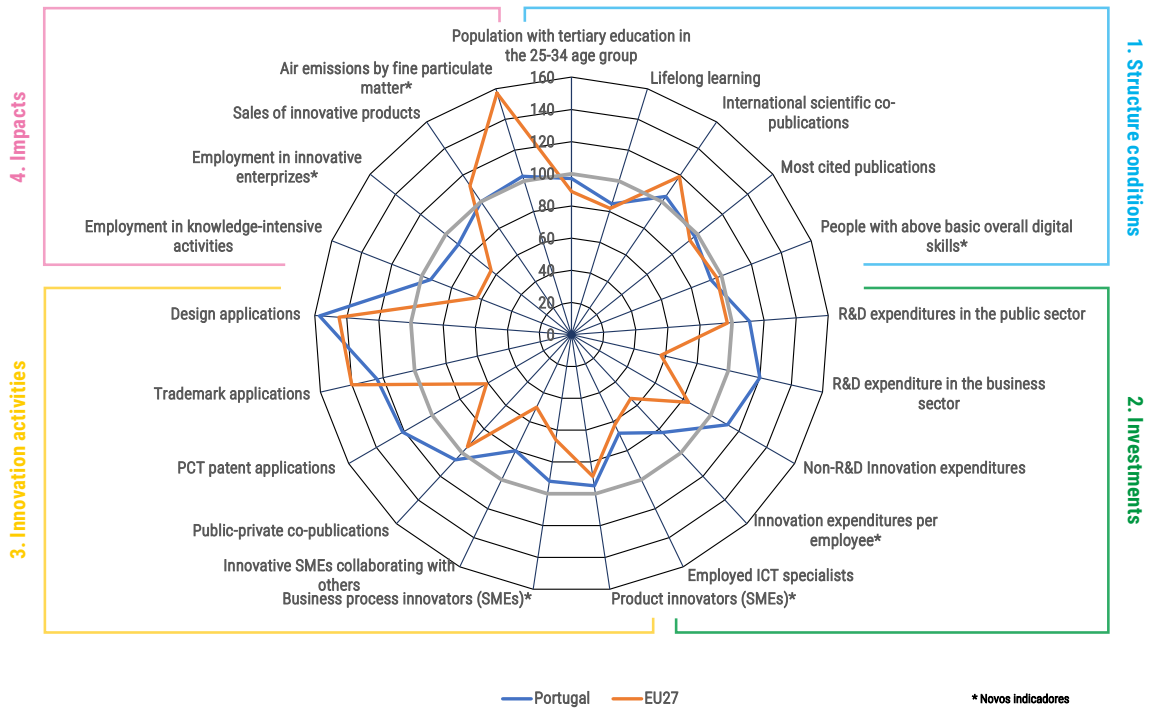
Figure 9 • Innovation Indicators of Norte in relation to Portugal and the EU27

Source: Regional Innovation Scoreboard, 2021

Table 1 • Innovation Indicators of Norte Region in relation to Portugal and the EU27

Domain	Subdomain	Subdomain	Norte face to:	
			Portugal	European Union
Structural conditions	Human resources	Population with tertiary education aged 25-34	97	89
	Human resources	Lifelong learning	85	82
	Attractiveness of the research system	International scientific co-publications	104	119
	Attractiveness of the research system	Most cited scientific publications	98	94
	Digitisation	Individuals with general digital skills above basic	93	97
Investments	Support and finance	R&D expenditure by the public sector	111	97
	Business investment	Business R&D	120	57
	Business investment	Innovation expenditure on non-R&D	112	84
	Business investment	Innovation expenditure per person employed	83	54
	TIC	Information and communication technology specialists	68	62
Innovative activities	Types of innovation	SMEs with product innovations	95	89
	Types of innovation	SMEs with process, marketing, and organisational innovations	92	66
	Links	SME with collaborative innovations	80	50
	Links	Public-Private Co-publications	106	95
	Industrial property	PCT patent registrations	121	61
	Industrial property	Brand registrations	124	140
	Industrial property	Design registrations	157	145
Impacts	Employment Impacts	Employment in knowledge-intensive activities	94	63
	Employment impacts	Employment in innovative enterprises	90	64
	Sales impacts	Sales with innovative products	100	112
	Environmental sustainability	Atmospheric emissions by fine particles	103	157

Source: Regional Innovation Scoreboard, 2021

On the side of potentialities, as measured by the innovation indicators in which Norte Region is above the European Union average, it is important to highlight the registration of brands and design. The innovative activity has been associated with the growing differentiation of products in a logic of moving up the value chain, mitigating the threats arising from globalisation in traditional segments of the regional economy, which gives rise to the registration of this type of industrial property. Other potentialities remain anchored to the dimension and dynamism of the private economy. Sales with innovative products in the region are above the European Union average, an important result for the positioning of Norte. At the same time, still as potentialities evident in RIS2021 are the low atmospheric emissions by fine particles and the international scientific co-publications.

In the previous edition, in RIS2019, potentialities had been identified in a set of innovation indicators in Norte Region, which observed, however, a punctual negative evolution in RIS2021, standing at a lower level than in the European Union. In this group are the percentage of SMEs that have carried out in-house activities or in collaboration with other companies for the development of innovations, expenditure on non-R&D innovation activities of small and medium enterprises (SME), the percentage of SMEs that have implemented the most diverse formats of innovation (technological innovation and organisational and marketing innovation, two modes often associated with strengthening the quality of management in companies).

The good position in the aforementioned innovation indicators contrasts with a less positive classification in the remaining indicators, with values below the EU27 average. The majority of these indicators belong to areas in which Norte Region is weak in innovation within the European framework, such as lifelong learning, economic structure, links between the scientific system and the business system and, also, the registration of industrial property of greater complexity (patents).

On the structural weaknesses side, measured by the innovation indicators in which Norte Region is significantly below the European Union average, it is important to highlight the low patent registrations (61% of the EU27 average) and the reduced number of SMEs with collaborative innovations (50% of the EU27 average), being a structural bottleneck to innovation because it limits the transfer of knowledge between the Scientific and Technological System and the production system. This reality is essentially the result of the combined effect of four factors: the lack of an innovation strategy, the availability of adequate human resources in companies for interaction with R&D centres, the still limited orientation of R&D&I structures towards valorisation activities for products and production systems, and the slowness of public support systems.

Also indicated as a constraint to innovation, the value of R&D expenditure by companies (57% of the EU27 average) continues to be well below the European Union average, a situation that is also explained by low economic incentives to conduct enterprise R&D in sectors with low technological incorporation, in which the costs and risks borne in R&D activities are not compensated by the sale of innovative products to the market. This situation results from the still relatively small number of enterprises where the innovation strategy is on its critical development path. As many companies are in a more upstream position in the value chain, innovation projects develop as an attempt to respond in a differentiated way to products that are designed and marketed by their customers. Their progressive positioning further downstream and the strengthening of design and development processes for products and services are essential for the establishment of robust and consolidated innovation strategies.

In contrast, R&D expenditure in the public sector (97% of the EU27 average), especially in higher education institutions, was more in line with the European average, because its implementation depends much more on funding through public policy instruments than on the degree of sophistication of the economic structure. The articulation between public and private agents is fundamental for the technological intensification of the regional productive base and the sustainable increase of regional expenditure on R&D (currently situated at 1.8% of GDP, around 34% of the national total), public and private, which are also fundamental for the achievement of the national goal (to rise from 1.6% to 3% of Portugal GDP).

Taking this exercise into account, it is possible to draw the following conclusions on the performance of RIS in Norte in its multiple dimensions and respective indicators:

- **Dimension 1** (Structural conditions) - most of the structural indicators are below the EU27 average, requiring an additional funding effort in this area.

- **Dimension 2** (Investment) - all indicators referring to investment in innovation activities (R&D and non-R&D) are below the EU27 average. However, non-R&D innovation expenditure had always been higher than the EU27 average, so the most recent evolution may have been one-off.

- **Dimension 3** (Innovation activities) - in this dimension there are contrasting indicators: if, on the one hand, Norte Region is clearly in the European leadership in the registration of trademarks and design, it still remains well below in the registration of patents. At the same time, the introduction of new products, processes, organisational methods, and marketing are, traditionally, strengths of the region, but have observed a negative evolution in the current RIS2021, which may have been occasional, added by the reduced number of SMEs with collaborative innovations.

- **Dimension 4** (Impacts) - impacts are conditioned by the economic structure and by the absence of a significant number of companies in medium-high and high technology industries and knowledge-intensive services.

Between 2014 and 2021, most innovation indicators in Norte Region have seen growth in absolute value, which has partially mitigated some structural weaknesses and strengthened innovation potential, regardless of the developments observed in the European Union and Portugal during that period.

Indicator	Value
Trademark applications	70.22
Innovation expenditures per employee *	46.35
International scientific co-publications	39.52
Public-private co-publications	32.41
Sales of innovative products	31.34
Population with tertiary education in the 25-34 age group	30.96
Employment in knowledge-intensive activities	29.79
Individuals with above basic overall digital skills*	21.93
Product innovators (SMEs)*	15.75
R&D expenditure in the business sector	13.39
Innovative SMEs collaborating with others	12.42
Air emissions by fine particulate matter*	11.78
PCT patent applications	8.36
R&D expenditures in the public sector	2.82
Lifelong learning	-6.06
Most cited publications	-10.77
Design applications	-27.12
Business process innovators (SMEs) *	-38.43
Employment in innovative enterprises*	-45.10
Non-R&D Innovation expenditures	-55.30

Variation in p.p. in 2021 compared to the EU27 value in 2014

Figure 10 • Innovation Indicators of Norte Region in 2021 relative to the EU27 value in 2014
(Percentage-point change)
Source: Regional Innovation Scoreboard, 2021

With regard to the dynamics that mitigate structural weaknesses in innovation, it is important to highlight the increases recorded in the population with higher education, employment in medium-high and high-tech industries and in knowledge-intensive services, and also in patenting between 2014 and 2021. These developments are in line with the systemic perspective of innovation mentioned above. The convergence in these indicators was also accompanied by a strengthening in dimensions where Norte Region already stood out in 2011, such as the registration of trademarks.

The less positive side of Norte's evolution in innovation is related to the reduction observed in a set of indicators where it was already significantly below the EU27 average in 2014. Within this group of counter-cyclical indicators, it is important to highlight the reduction in the most cited publications and employment in innovative companies. This divergence dynamic raises, once again, the problem of the existence of a deficient impact of innovation in the economic structure of the region.

2.2 Technological profile of exports and territorial specialisation

There is a concern to transform innovation into economic resilience and international competitiveness. This section analyses the evolution of exports of goods between 2005 and 2019 according to the technological level of the goods. The year 2005 was chosen because it coincides with the year following the enlargement of the European Union to the East, a clear threat to the growth of exports from Norte Region in the medium technology segments, especially in the automobile branch.

According to the methodology used by the OECD[7] for export classification, Norte countered this threat by achieving growth in medium technology exports from 21.7% of the total to 28.5% between 2005 and 2019. The main driver of exports in this category was the automotive cluster (mostly composed of parts, spare parts, and accessories of motor vehicles), which saw its exports grow by 10.0% on average per year, a pace clearly higher than that observed in overall exports, which increased by 5.1%. As a result of its greater dynamism, the proportion of exports of the automobile branch increased from 5.7% to 10.9% of total exports from Norte Region.
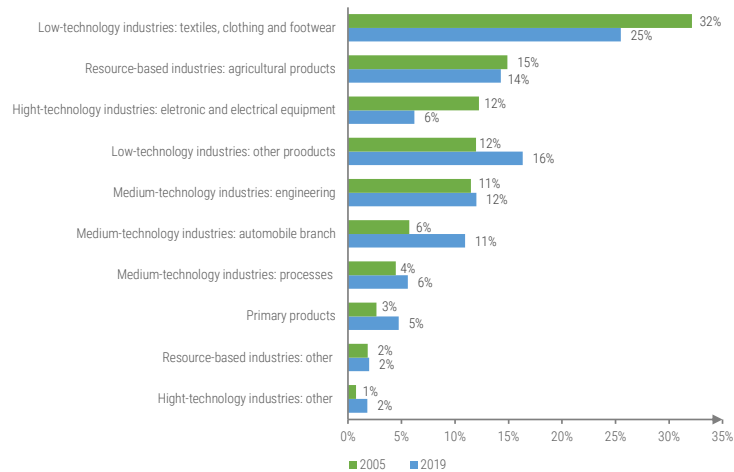
Figure 11 • Share of each class of goods in total exports from Norte[8]

Source: International Trade Statistics, INE

In addition to the automotive industry, the OECD classification also considers two further types of medium-tech industries with relevance in Norte Region, namely:

- **Medium process technology industries** (which includes the transformation of plastics, fabrics made of synthetic or artificial textile materials, tubes, hollow profiles and accessories made of cast iron, iron or steel, perfumery products, pigments, paints, varnishes, among others of lesser importance);

- **Medium engineering technology industries** (which includes meters and measuring instruments, switches, commutators, circuit breakers; parts, non-electrical parts of machines and appliances; heating and cooling machines, explosion and internal combustion engines, machines, and appliances for domestic use, among others of lesser importance).

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[7]   Lall, S. (2000). The Technological Structure and Performance of Developing Country Manufactured Exports1985-1988. QEH Working Paper Series-WEHWPS44, June 2000.

[8]   The products of "resource-based industries: other" mainly include resources from the extractive sector. The products of the "low technology industries: other" mainly include furniture goods.

In both cases, reflecting a good economic dynamism, medium technology exports (processes and engineering) observed an average annual growth higher than the total, which allowed for a slight increase in the importance of the two classes in the export structure of Norte Region. In relation to the first group, the proportion of exports of medium-technology industries in processes increased from 4.5% to 5.6%, values that compare with a slight increase from 11.5% to 12.0% in the case of medium-technology industries in engineering products.

Despite the growth observed in medium-tech exports, Norte remains largely an exporting region for low-tech products, which accounted for 41.8% of the total in 2019, slightly lower than the proportion in 2005 (44.1%). The class of low-tech products is divided into two groups with significant importance in Norte's international trade. The first group comprises exports of textile, clothing and footwear products, accounting for 25.5% of total exports in 2019, a figure that compares with a much higher relative importance observed in 2005 (32.1%). Even if this group has lost some importance, it does not mean that exports have suffered a reduction. On the contrary, between 2005 and 2019, they increased by an annual average of 3.4%, translating into an increase of €2 170 million, a remarkable growth in an environment marked by an unprecedented increase in international competition from Asia.

The second group of low-tech products (referred to as low-tech: other) comprises goods such as furniture, mattresses, pillows, and similar, constructions and parts thereof of cast iron, iron, steel or aluminium, manufactured articles of base metal, articles of plastics and glassware. Between 2005 and 2019, exports in this category saw an annual average growth of 7.5%, allowing its relative importance in total exports to increase from 12.0% to 16.3% between 2005 and 2019. In value, this category of goods recorded an increase of 2 379 million euros during that period, the highest among all the classes considered.

The strengthening of medium-tech exports and the resilience of low-tech exports were joined by a third trend for the evolution of exports from Norte Region, namely the decline in the proportion of high-tech exports. In 2019, this category represented 8.0% of total exports, compared to 13.0% in 2005.

Although exports of high-tech products declined, two opposite developments in this class are worth mentioning. Exports of electronics and electrical goods saw a residual growth of 0.1%, while exports of other products (mainly medicines for human or veterinary medicine) grew by 11.9%. The latter represent, however, a very small share of exports (1.8%), compared to a proportion of 6.2% for the former.

The territorial distribution of exports of goods reveals two clearly distinct phenomena. The origin of exports of products associated with endogenous resources is more dispersed in the territory, in clear opposition to the geographical concentration of exports of industrial goods (low, medium, and high technology) in territories with higher population and urban density. The mono-specialisation of low-density territories reveals itself, above all, in exports of agriculture, forestry, and fishing products, processed products of agricultural origin and, also, in products from industries based on the extraction of other resources.
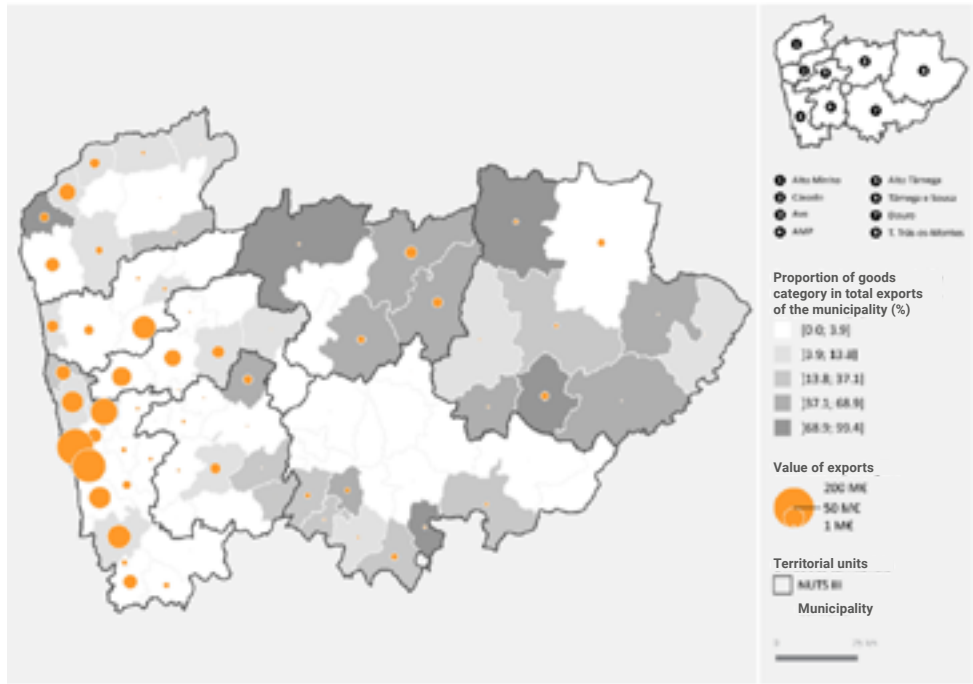
Figure 12 • Geographical distribution of agriculture, forestry, and fishing goods exports in 2019
Source: International Trade Statistics, INE

Figure 13 • Geographical distribution of exports of goods from resource-based industries: agro,
in 2019
Source: International Trade Statistics, INE

Figure 14 • Geographical distribution of exports of goods from resource-based industries: other (non-agro goods), in 2019

Source: International Trade Statistics, INE

The companies that export low, medium, and high technology products are mostly located in the municipalities with the highest population density, a reality largely explained by the market dynamics that lead to the agglomeration of industrial activity, which can be summarised in two points. Firstly, there are reasons on the side of the companies that justify this concentration, namely the greater availability of input suppliers, the greater quantity and diversity of qualified and specialised human resources in industrial activities, a greater number of university and polytechnic centres and, obviously, a greater stock of knowledge. Secondly, on the labour demand side, there are also significant forces for the mobility and retention of human resources in the most populated territories, namely the greater availability of jobs for different professional and academic backgrounds.

Industrial activity has, however, different levels of territorial concentration depending on the degree of technology and type of product concerned. Among the exports of low-tech products, those of the group composed of footwear, clothing and textile clearly observed a higher geographical concentration than the exports of the remaining low-tech products, which is related to the strong historical implementation of these sectors. Specifically, the municipalities of Guimarães (17.5%), Barcelos (12.3%), Felgueiras (11.6%) and Vila Nova de Famalicão (7.6%) concentrate almost half (48.9%) of all exports of the footwear, clothing and textile sectors.
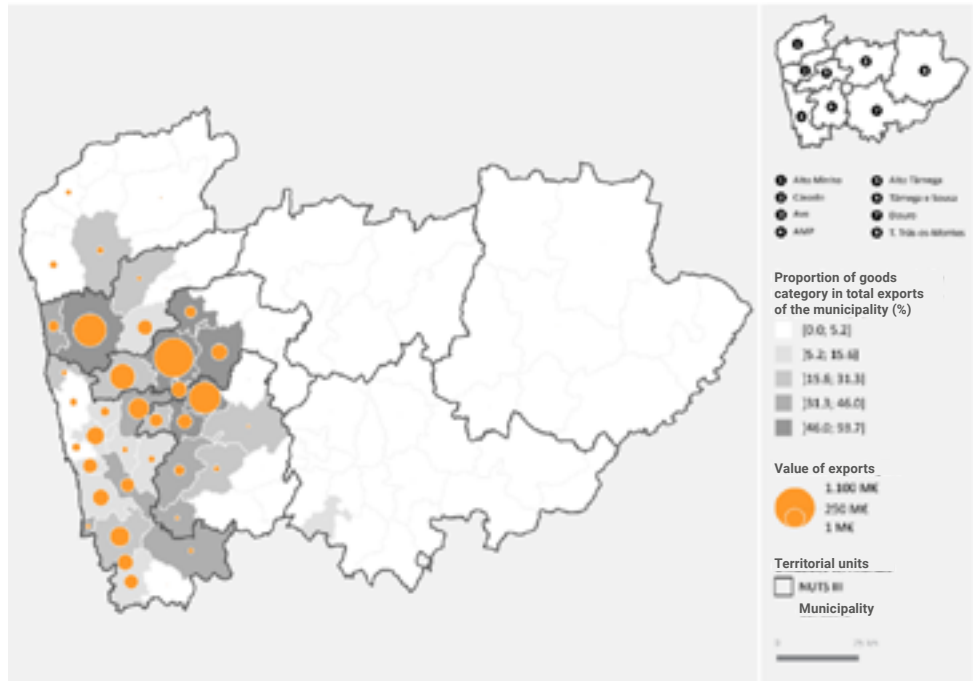
Figure 15 • Geographical distribution of exports of goods from low-tech industries: textiles, clothing and footwear, in 2019
Source: International Trade Statistics, INE

At the same time, exports of other low-tech products (furniture, mattresses, cushions and similar, constructions and parts thereof of iron or steel or aluminium, articles manufactured from base metal, articles of plastics and glassware) have a lower degree of geographical concentration, since the four main municipalities are responsible for 42.2% of all exports of this class: São João da Madeira (13.0%), Maia (13.0%), Vila Nova de Gaia (8.8%) and Paços de Ferreira (7.4%).

Exports of medium-technology industries (automotive branch) show an atypical geographical pattern, with the municipalities of Bragança (28.8%) and Vila Nova de Cerveira (23.1%), two municipalities located outside the most densely populated territories, being responsible for more than half of all exports in this category. The location of these industries in Vila Nova de Cerveira is partly explained by the integration of their firms in cross-border value chains. In the case of the municipality of Bragança, the explanation lies mainly in the availability of skilled labour in a municipality located close to the Iberian and European markets.

Figure 16 • Geographical distribution of exports of goods from low-tech industries: other
products, in 2019
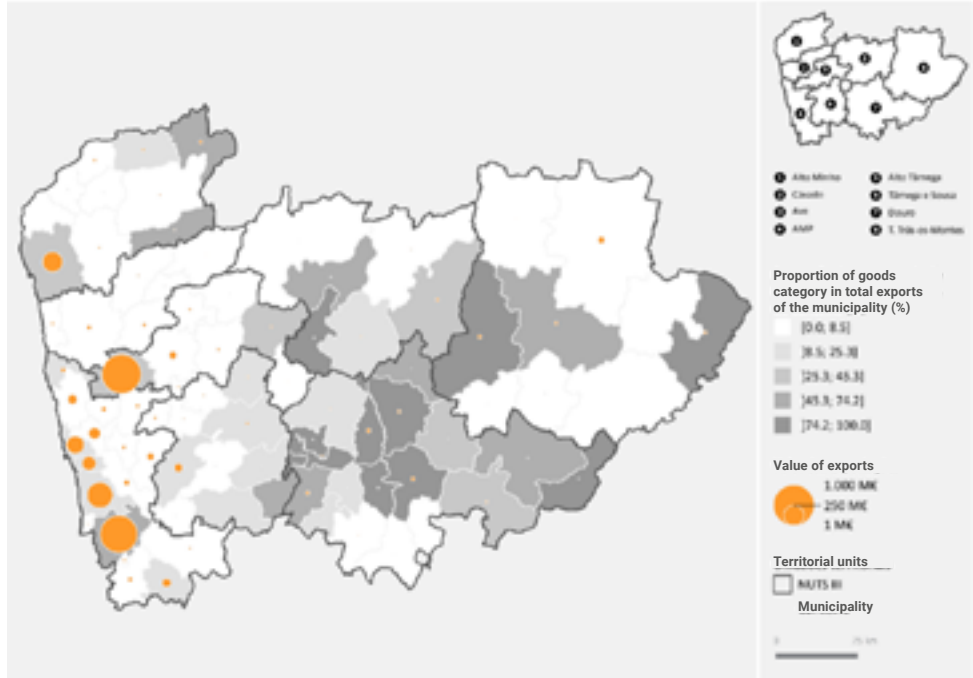Source: International Trade Statistics, INE

Figure 17 • Geographical distribution of exports of goods from medium-tech industries:
automobiles, in 2019
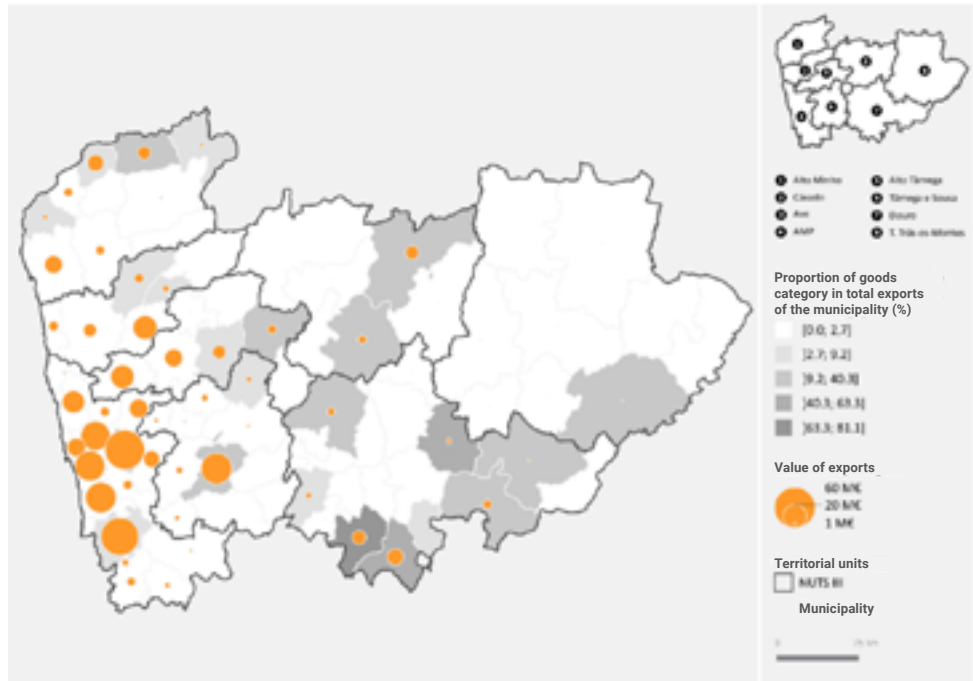Source: International Trade Statistics, INE

Still within medium-tech industries, exports of products that integrate productive processes (such as plas-
tics, iron and steel) and exports of engineering goods (such as meters and explosion engines) observe a
very similar level of geographic concentration. In the first case, the municipalities of Santo Tirso (18.6%),

Oliveira de Azeméis (12.2%), Vila Nova de Famalicão (12.1%) and Maia (11.6%) represent more than half (54.5%) of the exports. In the second case, the municipalities of Braga (25.0%), Trofa (10.0%), Vila Nova de Gaia (9.7%) and Oliveira de Azeméis (6.4%) account for 51.4% of exports.
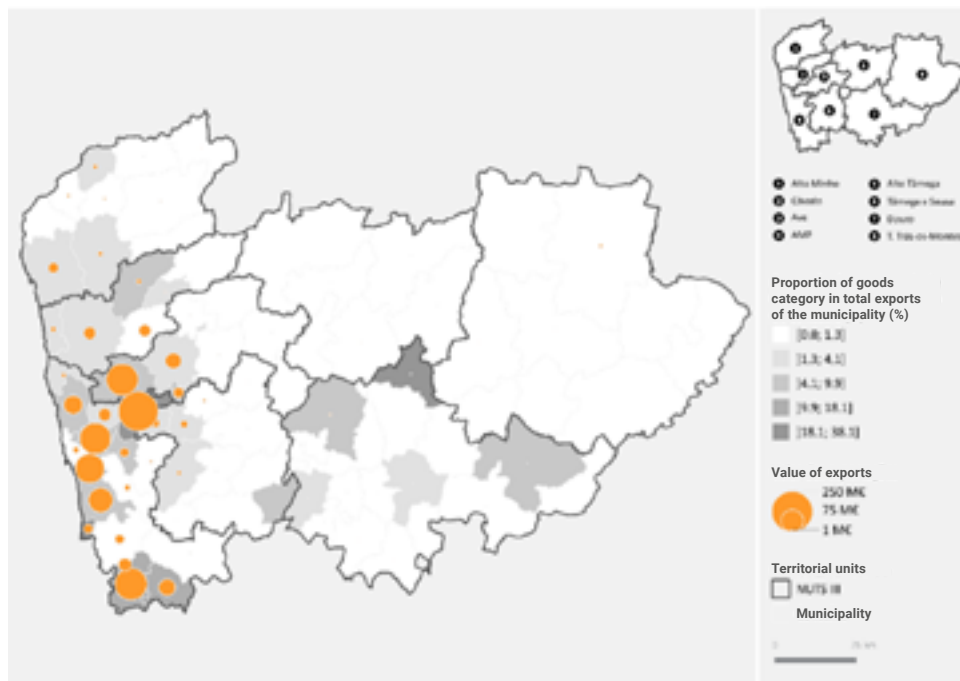
Figure 18 • Geographical distribution of exports of goods from medium-tech industries:
processes, in 2019
Source: International Trade Statistics, INE

As the technological basis of products evolves to a higher degree of technological sophistication, a greater spatial concentration of exports is observed. In concrete terms, 75% of exports of high-tech products (electronic and electrical) are concentrated in 4 municipalities, namely Braga (30.3%), Vila do Conde (20.7%), Matosinhos (15.9%) and Viana do Castelo (8.0%). This logic of spatial agglomeration is also observed in other high-tech products, where 4 municipalities are responsible for 77.5% of total exports. Once again, the highlight goes to the municipality of Braga (41.1%), followed by the municipalities of Trofa (17.4%), Porto (10.8%) and Maia (8.2%).
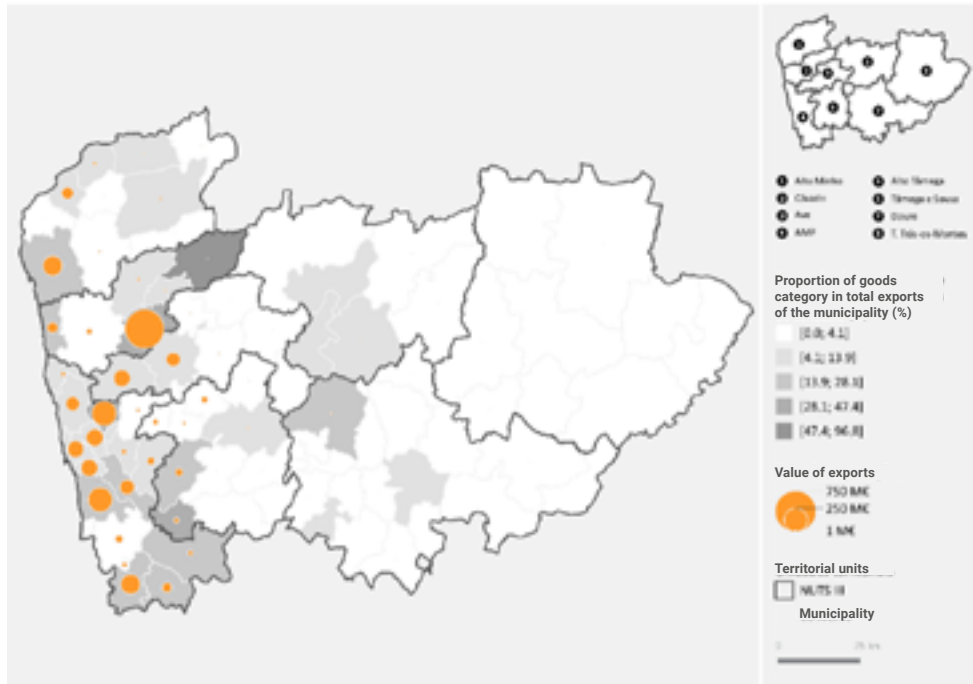
Figure 19 • Geographical distribution of exports of goods from medium-tech industries:
engineering, in 2019

Source: International Trade Statistics, INE
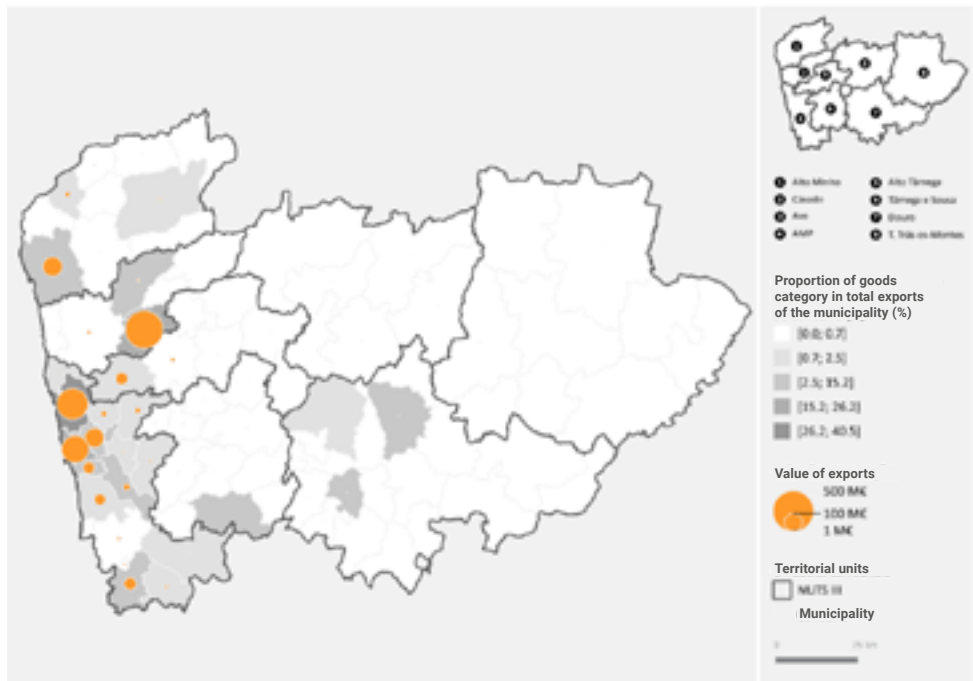
Figure 20 • Geographical distribution of exports of goods from high-tech industries: electronics
and electrical, in 2019

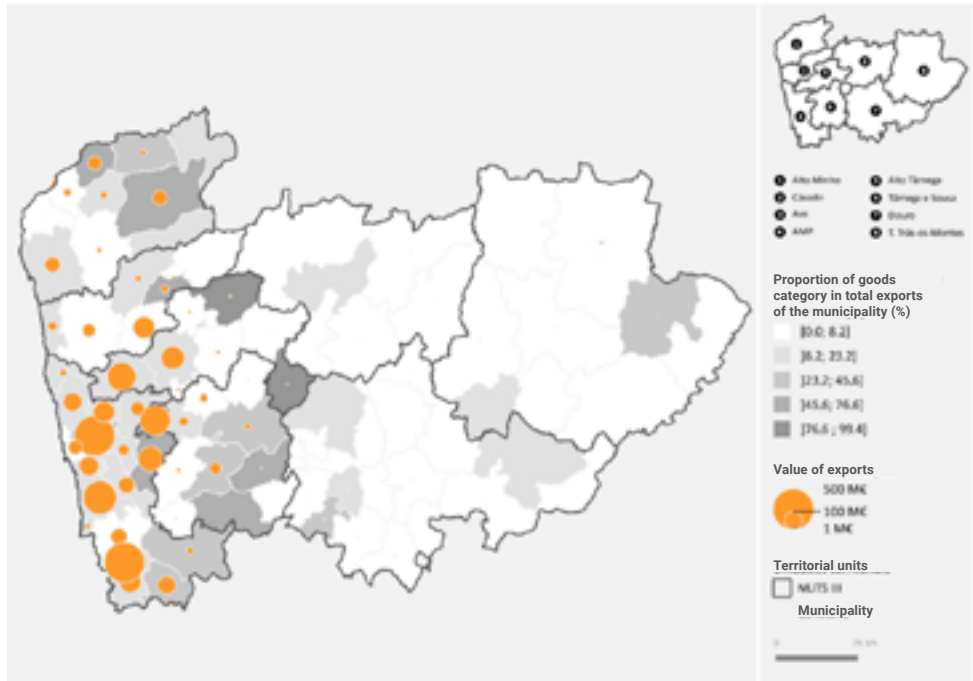Source: International Trade Statistics, INE
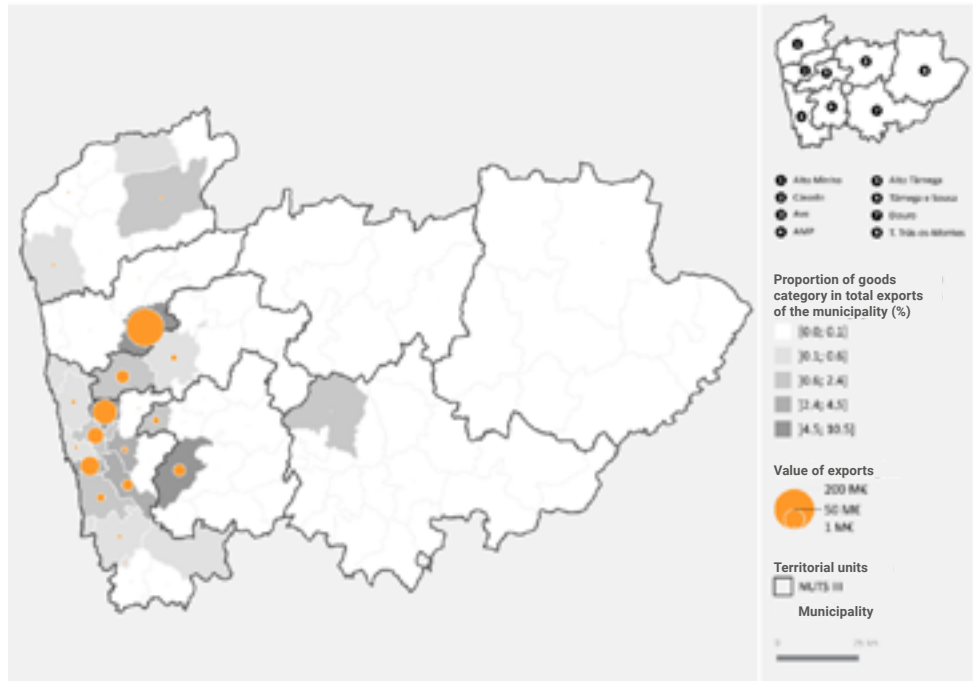
Figure 21 • Geographical distribution of exports of goods from high-tech industries: other
products, in 2019
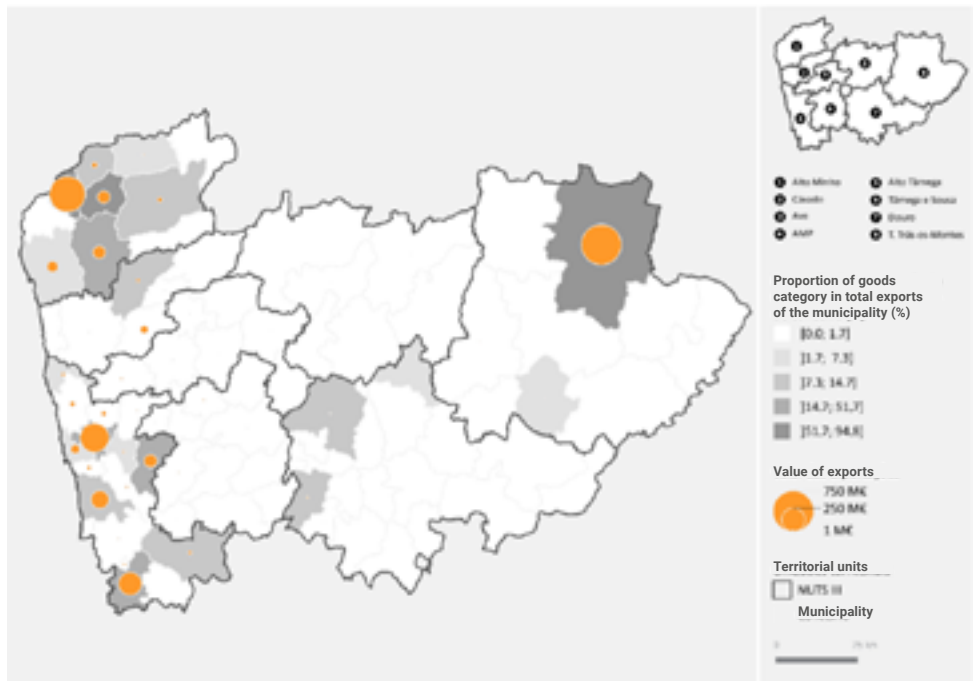Source: International Trade Statistics, INE

In summary, the geographical origin of exports of goods clearly depends on the type of product under consideration. It was shown that exports of products based on endogenous resources are the main good exported in low-density territories, while products of different technological bases (low, medium, and high) are clearly more concentrated in territories with higher population density. At the same time, exports of high-tech goods tend to be more concentrated in the territory, due to local innovation networks that have been intensified over time. The major exception to a littoralisation phenomenon of industrial goods exports lies in the automobile components industries, which have concentrated preferentially in cross-border municipalities, taking advantage of the economic integration in the Iberian space.

From the public policy point of view, the territorial enlargement of the economic base to counties that still have low levels of exports is a gradual process that should obey the economic rationality of companies in the location process. Companies continue to look for places with networks where they can absorb knowledge and share common technological bases, which is why the strengthening of competitiveness in these territories should not be subject to merely distributive policy designs with unknown impacts.

2.3 Systemic relationship between the various structural weaknesses of innovation: a synthesis with implications for public policy

According to the Regional Innovation Scoreboard, Norte Region has been making remarkable progress for almost a decade, ranking in 2019 as "Strong Innovator -". However, in 2021, it was once again classified as "Moderate Innovative", after a methodological revision of the index. The main conclusions regarding the analysis of the "Innovation and R&D Indicators in Norte Region"[9] carried out in 2018 are maintained. In comparative terms, Norte became the 151st most innovative region in 2021, a position clearly lower than the 100th place occupied in 2019. Notwithstanding this negative evolution in the European context, in national terms Norte continues to be the 2nd most innovative region in Portugal, maintaining the position it held in 2019.

This divergence of Norte from the EU27 was mainly the result of the reduction in the strongest innovation indicators in the region. First of all, non-R&D innovation expenditure (related to the purchase of innovative machinery and other equipment) saw the sharpest reduction among all innovation indicators. Other traditionally strong innovation indicators in Norte also diverged, namely process, marketing and organisational innovations and product innovations. At the same time, in more favourable terms, sales of innovative products increased.

In this framework, new constraints to the innovative activity of companies have emerged which, not being associated with the sale price of products, have limited the number of innovations of companies in Norte Region. In fact, Norte's main indicators related to industrial property rights, namely trademark registrations and design registrations, diverged significantly with the EU27 between 2019 and 2021. Only patent registrations, an indicator in which Norte Region is still well below the EU27, grew at a pace close to the European one.

Some innovation indicators, where the region historically observes significant gaps, have also accentuated the divergence, worsening the position of Norte Region in the European context, namely employment in innovative companies, SMEs with collaborative innovations and innovation expenditure per person employed. In this context, there are still notable barriers to collaboration with STS by Norte firms, as well as a strong bias in the employment structure towards firms that do not innovate, which limits the productivity gains from innovation expenditure.

However, in the opposite direction, positive developments were observed in some important indicators for innovation in Norte, namely in the population with tertiary education aged 30-34 years, lifelong learning, international scientific co-publications, public-private co-publications, sales of innovative products, business sector R&D expenditure and public sector R&D expenditure.

Convergence with the EU27 average was observed, above all, in input indicators associated with education and training, the internationalisation of the scientific system and public and business R&D expenditure. On the other hand, the greatest impact on the negative evolution of Norte's innovation performance was registered in indicators related to the output of innovation, such as expenditure on non-R&D innovation, innovation activities per se, employment in innovative companies, SMEs with collaborative innovations, innovation expenditure per person employed and the registration of industrial property (brands and design), which is associated with the systemic relationship between low qualifications and a production structure with low levels of technological intensification, which constitutes the main structural weakness of the regional economy.

The observation that a significant part of Norte's innovation problems still lies in a low-skilled labour force obviously does not imply that correcting this weakness will by itself have the desired impact on innovation and structural change. These objectives are better achieved if, in parallel, public policy instruments are used in other fields, such as incentives for public and private R&D. The reciprocal reinforcement of public policies in education and these fields, together with an industrial strategy based on smart specialisation, are integral parts of the socio-economic development of Norte. In summary, there have been no structural changes in RIS and the main weaknesses remain, namely low investment in entrepreneurial R&D, low qualification of human resources, reduced links between the scientific and entrepreneurial systems and low economic valuation of knowledge.

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[9]   Pereira, Eduardo, Leite, Vasco & Gomes, Josefina (2018). Indicadores de Inovação e de I&D na Região do Norte. Norte Estrutura, 4, 16-23.

It is still necessary to promote the consolidation of Norte's RIS, basing investment in knowledge and technology on nodal points with strong economic and/or scientific potential within the framework of a more global strategy of smart specialisation. From the perspective of RIS actors, it is also necessary to strengthen articulation between STS entities and technology production and development companies and advanced users, evolving towards a more robust system, both from a horizontal industrial policy perspective, based on the promotion of structuring conditions, and from a vertical industrial policy perspective, selecting sectors where current and latent comparative advantages exist.

These weaknesses do not cease to be rooted in the predominance of certain priority areas of the regional smart specialisation strategy over others. There are areas more aligned with the strategic objective of technological intensification of the regional productive base, associated with advanced manufacturing systems, mobility and energy transition, life sciences and health or resources and economy of the sea, than others, associated with fashion industries or tourism. The pursuit of this objective proves to be fundamental to the structural change of the regional economy, which is indispensable to the improvement of the performance of Norte's RIS.

3.

Conclusions and recommendations of the monitoring exercise of Norte Region Smart Specialisation Strategy for 2014-20

This section seeks to systematise the main conclusions of the monitoring exercise of RIS3 NORTE 2020 carried out as part of the report[10] approved by the Norte Regional Innovation Council (CRIN) on 8th October of 2019 and published in December of 2019. These conclusions are selected on the basis of their intrinsic relevance but also, and above all, because they constitute lessons learned and fundamental recommendations for the revision of RIS3 NORTE 2020 and the preparation of S3 NORTE 2027.

These conclusions and recommendations are structured into five topics (i) priority areas; (ii) effectiveness of the regional smart specialisation strategy; (iii) policy mix; (iv) governance and entrepreneurial discovery; (v) internationalisation of the regional smart specialisation strategy. It concludes with a note of prospective nature, seeking to analyse the changes in the economic and social context since the preparation of RIS3 NORTE 2020 in order to thus fine-tune the areas of focus or priority domains according not only with the development registered but, above all, what is expected in the medium term.

Priority areas

The RIS3 NORTE 2020 and its priority domains constitute an especially relevant grid for the analysis of strategic coherence in the implementation of NORTE 2020 programme. From this grid it is possible to analyse the thematic, temporal, and spatial articulation of about 50% of its allocation. There is no other reading grid that allows an analysis with this amplitude, constituting a good practice of the current programming period.

The priority domains of RIS3 NORTE 2020 were based on a conceptual and participatory methodology rather than using quantitative methods. These domains, especially their business bases, do not cease to be made by distinctive and differentiated economic activity sectors, revealing adequate representativeness of the main economic specialisation profiles of Norte as a whole and of its different sub-spaces.

These domains are applicable in the analysis of different public policy instruments, differentiating the projects and their absolute and relative merit. The result of the distribution of approved projects by priority domains is consistent with their relative importance defined in RIS3 NORTE 2020, with a higher concentration of investment in the core domains, i.e., those with larger critical masses of resources and assets and business base in Norte Region.

The nuclear areas are the most representative, particularly those associated with fashion industries, mobility and advanced manufacturing systems. The wild-card domains have a very low expression, with only 3% of the eligible investment in the field of sea resources and economy, for example.

As far as the articulation of the different public policy instruments is concerned, there seem to be difficulties in alignment by priority domain: those that are more supported through a given instrument are not always those that are more supported through another, even when these instruments reveal potential complementarity. The core domains are those that receive more significant support in the Business Incentive Schemes, namely in the modalities with a larger financial dimension, while the emerging and wild-card domains are more expressively supported in relative terms in R&D projects or in human capital.

According to the methodology established by the European Commission, there is a clear association between critical mass of resources and assets and of companies and regional competitiveness (and priorities). Taking into account the evolution of the regional economy and the very significant support to companies in the nuclear domains, it is worth considering whether some of the emerging and wild card domains could be enhancers of higher levels of technological intensification of the regional productive base, one of the strategic objectives of S3 NORTE 2027, even as a result of the effort developed in R&D.

Regarding the domains that contribute most to the objective of economic valorisation of territory-intensive assets and resources, another of the strategic objectives of S3 NORTE 2027, the possible review of the domain associated with the agro-food industry and environment should consider greater valorisation of regional production, generating greater broadening of the territorial base for the promotion of competitiveness in Norte Region.

[10]   Monteiro, R., Meira, R. Santos, P., Leite, V., Guimarães, C. & Gomes, J. (2019). Estratégia de Especialização Inteligente da Região do Norte. Relatório de Monitorização. Porto: Comissão de Coordenação e Desenvolvimento Regional do Norte

In this same context, and as far as the domain associated with tourism is concerned, focusing on boosting tourism activity as a way of economically valorising material and symbolic resources and assets, intensive in territory, namely in regional sub-areas that have few resources and assets beyond these, should be reinforced, and not so much on the expansion of tourism supply and, in particular, accommodation. This focus on the spill-over effects in the surroundings of the local economic activities should allow greater selectivity of the supports and focus on routes and itinerancies that allow desirable increase in the average stay of visitors.

In summary, the priority areas of smart specialisation and the concepts associated to them constitute appropriate reading grids for the regional economy and investment dynamics. An adequate review of the rationales of each one will be necessary in order to respond to the insufficiencies detected, taking into account the evolution of the regional economy. In this review, an adequate articulation with transversal dimensions of public policies, such as digitalisation, circular economy or active and healthy ageing is necessary so that these dimensions that are present in the most diverse priority areas are not confused with the priority areas themselves.

Effectiveness

The implementation of RIS3 NORTE 2020 through NORTE 2020 shows deviations from its programming. These deviations are not limited to the smart specialisation strategy but also to NORTE 2020 itself. The smaller the focus of the Specific Objective and respective Result Indicator of NORTE 2020 on a particular Strategic Objective of smart specialisation, the greater tends to be the level of alignment *ceteris paribus*, i.e., the broader and more generic is that Specific Objective, the simpler becomes its achievement, extending the number of possible combinations of priority areas that allow it to be achieved.

However, public policies should not be generic, implying contrasted alternatives and choices, not being desirable that the Specific Objectives are articulated in an undifferentiated way with the Strategic Objectives of smart specialisation and with reduced levels of intensity. Thus, the greater the desirable focus of each NORTE 2020 Specific Objective on one or another of the Strategic Objectives, the greater the relevance of using the smart specialisation strategy to ensure this greater focus and alignment between Specific Objectives and Strategic Objectives.

In practical terms, this importance is evidenced when comparing the Specific Objectives of the support in the areas of research, technological development, and innovation (Thematic Objective 1) and the competitiveness of Small and Medium Enterprises (Thematic Objective 3). Whenever the RIS3 NORTE 2020 is an admissibility condition, the degree of heterogenous selection of projects and investments increases, i.e., the selectivity of support increases in the priority areas most relevant to ensure not only the achievement of the Specific Objective of NORTE 2020 as well as its desirable alignment with the Strategic Objective of smart specialisation. The use of priority domains for project analysis proves to be fundamental not only for adequate articulation between Specific Objectives and Strategic Objectives but also for the achievement of the former themselves, according to the respective Result Indicator.

This analysis allows a decisive conclusion: smart specialisation strategy proves to be particularly effective in making relevant choices according to contrasted alternatives established in strategies and their objectives. However, the choices do not depend exclusively on the admissibility conditions and merit criteria, they depend above all on the budget allocations available in each call and each decision. It is important not to confuse the degree of discrimination of selection criteria with selectivity in project approval.

More than the criteria, this degree of selectivity depends on the financial amounts put out on calls and their relationship with the demand. If the criteria do not always prove to be effective in the approval, or not, of the projects, this fact does not result from the methodological and scoring options defined, but rather from decisions of the governance model of PORTUGAL 2020 regarding the extent of support and the approval objectives. Greater restraint and respect for the financial allocations of the calls is needed, increasing the number of calls for tenders and holding thematic and territorial specific calls, in order to increase demand without increasing transaction costs.

Policy mix

The Regional Smart Specialisation Strategy, as a regional innovation policy, has no autonomous public policy instruments, being its implementation dependent on the support of NORTE 2020 and the Thematic Operational Programmes (OP), especially COMPETE 2020. The excessive dependence on support from COMPETE 2020, especially for investments with greater potential for structural change, where the regional strategy for smart specialisation is a less relevant differentiating strategic element for project approval, does not allow its execution in the same terms if the support was exclusively from NORTE 2020. There is no accountability for the implementation of the regional smart specialisation strategy if the policy instruments are not managed in space and time according to the needs.

Thus, the financial dimension of the Regional Programmes in the new programming period is critical for the successful implementation of a new generation of regional strategies for smart specialisation. To the dimension of support is added the need for a wide range of public policy instruments co-financed by different European Structural Funds, at least in a multi-fund logic as in the current programming period.

The issue of policy mix also arises in the model of public policy announcements and management. What matters is the alignment of projects in each investment priority with the different priority domains. In addition to this more vertical dimension, another one of a transversal nature should be associated. In practice, all policy instruments contribute to the consolidation of priority areas, although in different and complementary ways.

Thus, it is necessary to ensure a greater articulation in thematic, temporal, and spatial terms of the different projects. For example, R&D projects are not indissociable from advanced training and from the articulation between that scientific dimension and business demand, as far as technological development is concerned. It is mainly at the level of governance and, particularly, in its management dimension of the operational programmes, that this revision should focus.

Governance and entrepreneurial discovery

The characteristics of RIS imply autonomous governance models capable of generating the necessary interactions between relevant stakeholders, namely in entrepreneurial discovery processes. These processes worked properly in the first and second phase of implementation of RIS3 NORTE 2020, i.e., in its preparation and in the design and establishment of admissibility conditions and merit criteria in the calls for proposals.

In the first phase, a strong involvement of stakeholders in the drafting process of RIS3 NORTE 2020 was ensured, having been possible to constitute eight Regional Smart Specialisation Platforms (PREI), which allowed establishing the rationale of each of the priority domains. This first phase was very important for the preparation of RIS3 NORTE 2020 and its approval as an ex-ante conditionality of NORTE 2020.

In the second phase, the bulk of the work on the implementation of RIS3 NORTE 2020 involved the preparation of calls for proposals in terms of criteria, the preparation of analysis guides and the analysis of applications, reaching to almost ten thousand approved applications in types of projects with conditions for alignment with RIS3 NORTE 2020. As shown in the Evaluation of the Implementation of the National and Regional Strategy for Smart Specialisation: Network, Outputs and Results[11], there is a high level of appropriation of the different concepts and rationales by the main regional stakeholders.

The difficult articulation between entrepreneurial discovery processes and the necessary capacity of the PORTUGAL 2020 governance model (Interministerial Coordination Commission, Management Authorities or Networks) to respond in the plan of opening calls to potential specific investment opportunities made it less relevant to use the promotion of stakeholder interaction processes, except in RIS3 NORTE 2020 internationalisation activities.

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[11] Quaternaire Portugal (2019). Avaliação da Implementação da Estratégia Nacional e Regionais para uma Especialização Inteligente: Rede, Realizações e Resultados. Preliminary Final Report. Copied Document.

After the first two phases, the main activities developed are those of monitoring and evaluation of the smart specialisation strategy, which presuppose acceptable levels of approval and physical and financial execution of the investments made. This new phase of the entrepreneurial discovery process involved the promotion of the PREI and then of the Norte Regional Innovation Council (CRIN).

There are market failures that the regional entrepreneurial discovery processes cannot and should not (try to) overcome, namely those that refer to regulatory activities, such as tax incentives, innovative public procurement, revision of the university teaching career (valuing applied research and technology transfer activities, for example) or integration in the universities and their research centres of doctoral researchers. To these activities are added those resulting from the necessary governance of the different regional strategies for smart specialisation and in the context of the multi-level strategy, with regional and other national dimensions, established by the Portuguese State and the articulation between funding from the Regional OP and the Thematic OP.

In order to take greater advantage of entrepreneurial discovery processes in the correction of market failures concerning the coordination of actors in the cruise phase of project approval, the capacity of the PORTUGAL 2030 governance model is required to respond at a practical level to the detection of new investment opportunities. This articulation between the governance of the Regional Smart Specialisation Strategy and the governance of the PORTUGAL 2030 has to be greatly improved in order to meet the demand raised by these processes. This improvement also involves the technical reinforcement of the management team of the governance model of the regional smart specialisation strategy, which is clearly insufficient for the development of entrepreneurial discovery processes and the analysis of applications.

Internationalisation

As a strategy, the implementation of RIS3 NORTE 2020 goes beyond PORTUGAL 2020 and NORTE 2020. Thus, internationalisation is a crucial component in the implementation of smart specialisation strategies, being particularly important for regions to access wider business and knowledge networks, increase their research capacity, reach new markets, expand business opportunities, and integrate in global value chains.

RIS3 NORTE 2020 played a relevant role in the framework of internationalisation processes of regional entities in different contexts, with emphasis on the submission of applications to European programmes, such as Interreg or Horizon 2020, and the participation in international networks associated with smart specialisation, such as the S3 Platform and the Vanguard Initiative. It is necessary to reinforce the development of national and international networking activities of the smart specialisation strategy that allow to enhance the participation of regional actors in international networks and global value chains.

In the case of the smart specialisation strategy of Norte Region, one of the most important initiatives of its internationalisation was the development of the Cross-border Smart Specialisation Strategy of Galicia-Norte of Portugal (RIS3T), the first cross-border RIS3 at European level. It is important to continue the implementation of this strategy with the objective of mobilizing new initiatives and joint projects of the Euroregion and attracting funds from specific funding sources, such as Horizon 2020 and the future Horizon Europe.

Prospective note

As could be expected, there was a concentration of support in the core priority domains. In the context of these areas, the one associated to the fashion industry gains special relevance. It is characterised by some of the (so-called) traditional activities of Norte, such as textiles and clothing, footwear and wood and furniture. Despite the structural adjustment registered in the last two decades, these are industries that continue to be characterised in relative terms by greater labour intensity and dependence for their development on more immaterial and less technological dynamic factors for the promotion of competitiveness. The focus on this domain is understandable in the context of the preparation of RIS3 NORTE 2020, strongly recessive with falls in product and high unemployment levels. The subsequent economic growth, more dependent on increased employment than on productivity, implicitly validated this commitment.

But the economic and social context of the regional economy has changed, moving from historically high unemployment rates to a situation of (almost) full employment, before the appearance of the pandemic crisis. Economic growth, in a medium-term perspective, becomes conditioned by productivity gains, which have not been significant. This particular focus on productivity gains should be given special attention in the potential hierarchy of priority domains of smart specialisation.

Perhaps, some potential for productivity gains and economic growth may be more associated with other priority areas, more dependent on technology for their development, namely in the context of the ongoing digital transformation process. There are areas associated with advanced manufacturing systems, mobility and energy transition, life sciences and health or resources and economy of the sea that seem to reveal this potential, especially when associated with the investment effort, public and private, in R&D, namely the one carried out in the current programming period.

These are priority areas characterised by economic activities more comparable to high and medium-high technology sectors, according to the OECD classification. A more proactive logic of public policy is funda-mental to support entrepreneurship and investment in these priority domains, where there is a critical mass of resources and assets, but which is not always compatible with the dimension of the business base that is indispensable to valorise them economically.

4.

Priority Domains of Norte Region Smart Specialisation Strategy for 2021-27

Having as a reference the paradigm of smart specialisation and its concepts (choices and critical mass, related variety, competitive advantages, connectivity and clustering, quadruple helix and entrepreneurial discovery process), the preparation of RIS3 NORTE 2020[12] had as a starting point the construction of a conceptual framework that allowed the identification of the respective priority domains (Figure 22).
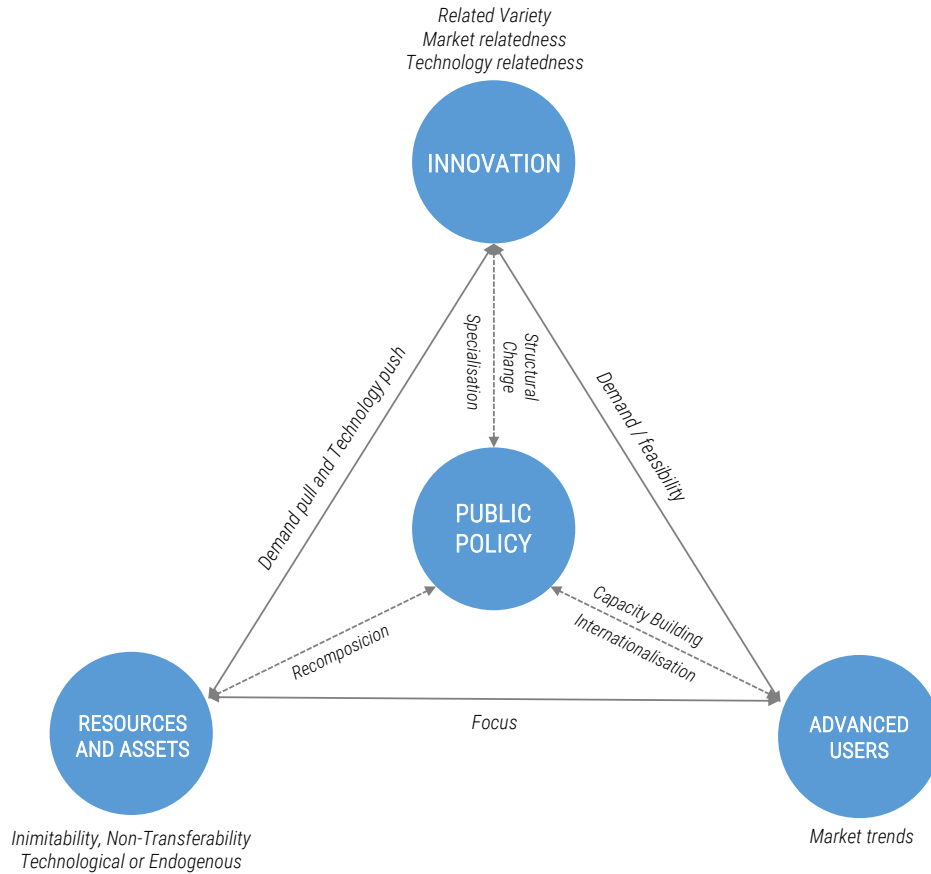
Figure 22 • Analytical framework for the definition of priority domains of smart specialisation[13]

A certain domain is thus considered a priority whenever relevant regional critical masses are or may be gathered at the three corners of the triangle, each one corresponding to: (i) the regional entities of the STS; (ii) the technology producers; and (iii) the advanced users of that technology. At the centre of this triangle it is established the rationale for the public policy to be developed aiming to promote the interaction of these three corners in the context of the ecosystem of each priority domain and the territorial enlargement of the economic base.

The first vertex of the triangle (resources and assets) assumes that smart specialisation should be based on the regional potential in resources and assets with inimitable and non-transferable characteristics, on which tradable and globally competitive goods and services can be developed. These resources and assets may be technological (analytical and synthetic knowledge) or non-technological (for example, symbolic

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12   Comissão de Coordenação e Desenvolvimento Regional do Norte (2014). Estratégia Regional de Especialização Inteligente

13   This methodolgy is especially developed in: Monteiro, Meira, Santos, Leite, Guimarães & Gomes (2019). Estratégia de Especialização Inteligente da Região do Norte. Relatório de Monitorização. Porto: Comissão de Coordenação e Desenvolvimento Regional do Norte e Monteiro, Santos, Guimarães & Silva (2018). Norte Region Smart Specialisation Strategy (NORTE RIS3). A Monitoring System Methodological Approach for MONITORIS3 Project

capital). At the second vertex of this model is the business base which integrates and economically valorises the resources and assets, through the production of innovative tradable goods and services, namely of a technological nature and aimed at satisfying intermediate demand, in particular.

The third vertex is made up of advanced users, which are fundamental to the exercise of prospective international evolution of demand, since they represent companies and other organisations that produce goods and services, public and private, aimed primarily at final demand. The exercise of building this vertex is fundamental to assess the viability of the smart specialisation priority domains, given the market trends (international, domestic and local) and the potential of innovative public demand, also allowing the identification of the intervention needs of public policies to support the rearrangement of the resource and asset base and the promotion of structural change in the regional economy.

Based on the analytical model described and the methodology developed, eight priority domains of RIS3 NORTE 2020 were identified. These eight priority domains were the starting point for its revision, taking into consideration the conclusions and recommendations of the monitoring developed in the previous chapter and the methodology established in the S3 NORTE 2027 Initiative, approved by the Norte Regional Innovation Council.

This methodology was based on conducting surveys to the members of the PREI. Most of the survey questions aimed at validating (or not) the structure of each priority domain in the RIS3 NORTE 2020 in terms of designations, rationales, resources and assets, business bases, advanced users, international demand trends, R&D&I strategies and policies, public policy instruments and integration of societal challenges.

Surveys were sent to 235 entities that, in the first half of 2020, composed the eight PREI, having obtained 133 responses, representing 57% of the total. This value is representative of the total and much higher than that obtained in enquiry processes of this nature, particularly, in the context of the preparation of RIS3 NORTE 2020.

This survey exercise was preceded by an update of the foresight exercise on medium and long-term trends for each of the priority domains of smart specialisation. Market trends and technological trends are not, and cannot be, mutually exclusive; quite the contrary, technological and demand dynamics interact with each other amplifying the effects of (pre-existing) trends.

The exercises of technology relatedness (technological possibilities) and market relatedness (market possibilities), which make possible to consolidate each of the priority domains of smart specialisation, must be simultaneous. The answers to the surveys on these trends are crucial to carry them out, as each PREI representative is asked about its relative (ordinal) importance in different scopes: global, regional and of the (own) institution. The analysis of the combination of these answers allows a better understanding of the dimension of the regional possibilities of technological transformation and participation in the market of the innovation ecosystem of each priority domain, especially the potential for the entry of new products.

The current expression of these trends presupposed a rereading of those expressed in the RIS3 NORTE 2020, verifying their timeliness and relevance in the current historical moment. This re-reading also presupposed the comparison with other readings and, thus, its first step consisted in the selection of relevant bibliography, given the multiple works developed, individual and collective, on the themes under consideration and their relative importance.

It should be highlighted several documents of public policies developed by national and international organisations. At national level, the Foundation for Science and Technology developed various research and innovation agendas in areas such as: (i) Agrifood, Forests and Biodiversity; (ii) Circular Economy; (iii) Culture and Cultural Heritage; (iv) Sustainable Energy Systems; (v) Labour, Robotisation and Employment Qualification; (vi) Tourism, Leisure and Hospitality; (vii) Health, Clinical Research and Translational; (viii) Sea; (ix) Industry and Manufacturing; (x) Space and Earth Observation.

At an international level, the work developed by the European Commission is particularly relevant, assuming that regional policies for research and development and innovation cannot fail to be aligned with the corresponding strategies and policies established by the European Union for the new programming period (2021-27). The proposal of the new Framework Programme for Research and Development and Innovation of the European Union (HORIZON EUROPE) should be highlighted, particularly with regard to its second

pillar (Global Challenges and Competitiveness of European Industry), in areas such as: (i) Health; (ii) Culture, Creativity and Inclusive Society; (iii) Digital, Industry and Space; (iv) Climate, Energy and Mobility; (v) Food, Bioeconomy, Natural Resources, Agriculture and Environment.

The crisis caused by the Covid-19 pandemic was an element of disruption, requiring the adoption of measures to control the transmission of the disease and thus introducing discontinuities in the international chains of production, processing and distribution of goods and services. It was considered in this exercise of review of RIS3 NORTE 2020 the consequences of this crisis, namely in the retreat of the globalisation process, in the diversification of production locations and their greater proximity to consumption destinations, in the acceleration of digital transformation and its effects in different sectors of economic activity and in the support of countries in greater industrial sovereignty[14].

In this context, concepts and respective technologies gain relevance, such as the low touch economy, characterised by fewer interactions between people and with no or low contact[15] with equipment and surfaces, by health and safety protection, by new consumer behaviours and by (permanent) changes in some sectors. It should be highlighted the concept of one health, which consists of the integrated approach planet-plants-animals-humans in the health area, in particular epidemiology.

Given the extent of the bibliography consulted, its selection depended on whether it was more or less appropriate in relation to the different productive specialisations in Norte Region. In this selection process, the aim was then to verify how the trends expressed in the documents consulted were (or were not) susceptible of fitting into the (potential) trends of the priority domains of regional smart specialisation. From that point of view, by concluding on the ability of those priority domains to represent the regional economic reality and the respective investment dynamics, the monitoring work of RIS3 NORTE 2020[16] allows a safe option to this analysis methodology.

In the opposite direction, the use of this methodology in a reasonably successful way also allows strengthening the conclusion that the priority domains established in RIS3 NORTE 2020 remain globally relevant. However, it also becomes evident that some of them need adjustments, in designations, rationales, resources and assets, business bases or advanced users. The analysis of the results of the surveys of the PREI members and the prospective exercise of the medium and long-term trends for each of the priority domains of smart specialisation allow the identification of eight priority domains of S3 NORTE 2027[17] (cf. figure below).

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[14]   Estado português (2020). Proposta de Lei n.º 60/XIV – Lei das Grandes Opções 2021-2023 (LGO 2021-2023) do XXII Governo Constitucional

[15]   Board of Innovation (2020). Board of Innovation (2020). The winners of the Low Touch Economy – How companies can recover and grow in the new normal – Strategy Report

[16]   Monteiro, Meira, Santos, Leite, Guimarães & Gomes (2019). Estratégia de Especialização Inteligente da Região do Norte. Relatório de Monitorização. Porto: Comissão de Coordenação e Desenvolvimento Regional do Norte

[17]   There is an association between the priority domains of RIS3 NORTE 2020 and S3 NORTE 2027. This association is as follows: to the domains (i) Health and Life Sciences, (ii) Advanced Manufacturing Systems, (iii) Mobility Industries and Environment, (iv) Culture, Creativity and Fashion, (v) Symbolic Capital, Technology and Tourism Services, (vi) Sea Resources and Economy, (vii) Human Capital and Specialised Services, (viii) Food and Agro-Environmental Systems, correspond, now, the domains, respectively (i) Health and Life Sciences, (ii) Industrialisation and Advanced Manufacturing Systems, (iii) Sustainable Mobility and Energy Transition, (iv) Creativity, Fashion and Habitats, (v) Tourism Services and Territorial Assets, (vi) Sea Resources and Economy, (vii) Technologies, State, Economy and Society, (viii) Agro-Environmental and Food Systems.
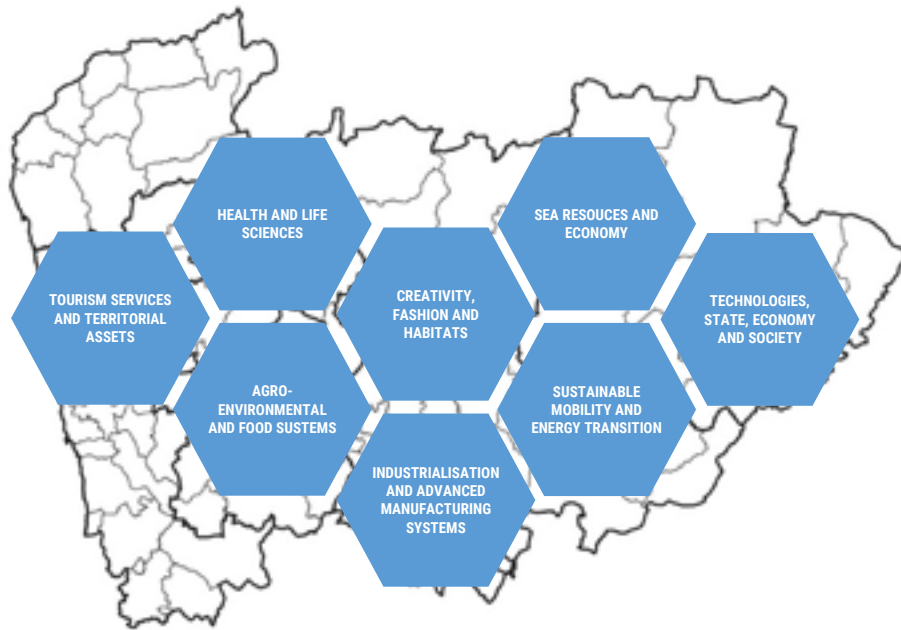
Figure 23 • Priority domains of Norte Region Smart Specialisation Strategy for 2021-27

This exercise also made it possible to identify the respective public policy rationales for the 2021-27 programming period of European Union policies:

- **Creativity, Fashion and Habitats** (CFH) - exploiting the potential of creative industries (in the areas of design, architecture, IT, etc.), new materials and innovative technologies to create new competitive advantages in sectors with a strong symbolic capital component (culture and creativity), namely fashion (textiles and clothing, footwear, jewellery, etc.), habitat (furniture, home textiles, building materials and solutions, built heritage, etc.) and other symbolically related activities, in a context of global adjustment of supply chains, as well as increasing digitalisation, environmental and social responsibility and energy transition;

- **Industrialisation and Advanced Manufacturing Systems** (IAMS) - development of clusters associated to enabling technologies (namely materials engineering, nanotechnologies, biotechnology and biological transformation, artificial intelligence, nano and microelectronics, photonics, mechatronics, systems engineering, etc.), combining the existent scientific and technological capacities and infrastructures, consolidated business bases (machinery and equipment manufacturing, industrial engineering and consultancy, industrial information systems, etc.) and the presence of advanced user sectors (manufacturing and extractive industries, construction, water, energy, primary sector, etc.), in the context of digital, energy and environmental transformation processes and of new production, management, business and work models;

- **Agro-Environmental and Food Systems** (AEFS) - articulation of the regional agricultural potential, namely in high added value products (wine, olive oil, chestnuts, Protected Designation of Origin (PDO) and Protected Geographical Indications (PGI), etc.), with scientific and technological skills (oenology, engineering, biology, biotechnology, ICT, robotics, etc.) and business (food industries, agriculture and animal production, forestry, forest-based industries, etc.), capable of promoting an agrifood and forestry sector with greater added value, in a way that is compatible with the preservation and management of resources such as water, forests and ecosystems, and contributing to a greater valorisation of endogenous resources as an opportunity to increase territorial competitiveness;

- **Sustainable Mobility and Energy Transition** (SMET) – consolidate the scientific and technological capacities (in the areas of production technologies, materials, digital technologies, biotechnology, etc.) to promote the upgrading of the component's and system's automotive industries (from the production of moulds and tools to the assembly of complex systems) in the context of global value chains, as well as

to provide higher added value in other mobility industries and their infrastructures (such as aeronautics, railways, maritime transport, urban mobility, logistics, energy, space, etc.), ensuring a more competitive and sustainable mobility system, in a context of decarbonisation of the economy, energy transition, digitalisation and new mobility concepts;

- **Health and Life Sciences** (HLS) – consolidate and promote interactions between research capacity at regional level (namely in the areas of tissue engineering and regenerative medicine, cancer, neurosciences, development of surgical techniques, etc.) and companies in the health industry and services in the broad sense (pharmaceuticals, medical devices, ICT, health services, personal protective equipment, health and wellness tourism, social support and physical activity, cosmetics, etc.), driving the development of new products and services capable of responding to current challenges (ageing population, chronic diseases, pandemics or digital transformation), and contributing to the sustainability and resilience of the health systems;

- **Tourism Services and Territorial Assets** (TSTA) - valorisation of territory-intensive resources, namely cultural resources (UNESCO world heritage, classified cultural heritage networks and routes, intangible heritage, etc.), natural resources (national park, natural parks, protected landscapes of national and local interest, sites of community interest, special protection areas integrated into the natura 2000 network, UNESCO world geoparks, etc.), creative resources (relevant and symbolic infrastructures, cultural agendas, events, etc.) and endogenous resources (gastronomy, wines, authenticity, etc.), taking advantage of scientific and technological capacities (namely, in the areas of management, marketing, arts, digital technologies, etc.) and the relevant tourist offer (accommodation, restaurants, tourist entertainment, etc.), aiming at the promotion of tourism services and a better integration of tourism in different cultural, modern and traditional contexts, as a way of expanding the territorial base of promotion of regional competitiveness;

- **Sea Resources and Economy (SRE)** – consolidate the relations between applied engineering (civil, mechanical, naval, robotics, biotechnology, energy, information technology, materials), sea resources (living marine resources, non-living marine resources and marine and coastal ecosystem services) and economic activities that value them (renewable marine energy, coastal, nautical and cruise tourism, naval industry, biotechnology, aquaculture, maritime equipment, infrastructures, etc.), favouring the creation of a set of synergies that enhance the value creation and generation of employment in activities related to the sea economy, preserving and promoting the sustainable use of marine resources;

- **Technologies, State, Economy and Society** (TSES) – promotion of accumulated skills in the areas of science, technology, engineering and mathematics aiming the digital transformation of the economy and society as a process based on a set of digital technologies (internet of things, next generation wireless networks [5G], cloud computing, data analytics, artificial intelligence, cybersecurity or high performance computing) ensuring the integration of digital technologies in businesses, the use of internet services, the promotion of digital skills, the provision of connectivity infrastructure and mobile services and the development of digital public services and open and networked administration.

The following table presents, for each priority domain of regional smart specialisation, the international demand trends and the corresponding R&D&I strategies and policies.

Table 3 • International demand trends and corresponding R&D&I strategies and policies for the priority domains of regional smart specialisation

TRENDS	STRATEGIES AND POLICIES
Creativity, Fashion and Habitats	
a) Symbolically related activities related diversification of producers and brands, involving in whole or in part different design-intensive goods or where design, aesthetics or symbolic value function as main differentiating factors of the offer, in clothing, footwear, leather products and accessories, sporting goods, games and toys, habitat (furniture, kitchenware, glassware and crystalware, home textiles, coverings and building materials, walls and windows, upholstery, etc.), eyeglasses, watchmaking, jewellery and gold smithery, cosmetics and beauty products, etc;	**a) Symbolically related activities** development and consolidation of clusters of cultural and creative industries for the creation and reproduction of symbolic capital (assets that tend to be inimitable and non-transferable) indispensable for the economic valorisation of products, namely in the sectors of fashion (clothing, footwear, watches and jewellery, etc.), habitat (furniture, home textiles, construction materials and solutions, built heritage, etc.) and other symbolically related activities;
b) Social and environmental responsibility reducing energy and material consumption, as well as waste resulting from the fashion and habitat sectors, as an effective commitment to consumers/citizens, and to mitigate the effects of climate change, particularly in less developed countries (producers of raw materials and further up the value chains), along with greater promotion of diversity and inclusion, respecting environmental and social rights throughout the supply chain(s);	**b) Social and environmental responsibility** development of new bio- and eco-materials to replace raw materials intensive in non-renewable resources; development of advanced materials that reconcile aesthetics, performance and functionality; respect for animal welfare standards and replacement of animal materials by degradable and non-polluting synthetic or vegetable alternatives; reverse engineering and logistics in the context of the circular economy paradigm; reuse market (2nd hand), especially in the fashion sector; efficiency of buildings in terms of energy and resource use.
c) Sociodemographic changes population ageing in western countries, implying changes in consumption profiles in terms of quantity and quality, and the growth of middle classes in (traditionally) less developed countries with natural aspirations of consumption and emulation, changing the regional dynamics of demand on a global scale and respective market segments and target consumers;	**c) Sociodemographic changes** focus on high ranges in internationalisation processes in mature and consolidated markets, based on the image of origin and tradition, on the sustainability of materials and processes; differentiation or diversification of markets and development of international sourcing competences that compensate potential losses in the value chains of more labour-intensive processes with less added value;
d) Mass customisation and personalisation increase in niche markets and segmentation processes (tending towards personalisation, individualisation and tailor-made manufacturing), as a way of responding to more sophisticated demand and societal needs, in functional products (in the area of health and well-being, for example) and that allow for greater involvement and cultural and emotional interaction of consumers, together with the growing globalisation, dimension and scale of markets;	**d) Mass customisation and personalisation** business-to-consumer (B2C) and business-to-business (B2B) strategies that respond to the uniqueness of consumer preferences and, above all, to the speed at which these preferences change and are expressed (producing small series and partially replacing them according to their market potential), involving, namely, cyber-physical systems, including 3D printing, virtual modelling and design, automation and robotics, sensing and digital identification (e.g. by radio frequency RFID), supported by artificial intelligence applications and by cybersecurity algorithms (e.g, Blockchain);
e) Digitalisation and Digital Market increasing physical and digital integration of communication and distribution in the fashion and its brands fields, ensuring equivalent consumption experiences regardless of the interaction channels with customers, and migration of online commerce (e-commerce) operators to traditional retail, bringing digital practices and strategies regarding pricing promotions, loyalty, consumer engagement, producing experiences and attracting traffic, digital transformation with cyber-physical technologies that enable disruption in processes and businesses, namely in operating models, value chains and customer relations, and reinforcing the importance of online commerce (e-commerce) in the post-Covid era.	**e) Digitalisation and Digital Market** adoption of new cyber-physical technologies and transformation of processes and businesses, leveraging new products and services in the fashion and habitat sectors; promotion of online commerce (e-commerce) and, in particular, multichannel communication and distribution models that provide integrated and consolidated involvement of consumers and distributors, regardless of the different sales channels (physical and digital) and platforms used, as well as (automatic) integration with the company's information system (ERP), transforming the traditional retail space of exhibition and purchase into a place for socialising, sharing experiences and providing leisure services, and enabling the construction of stories and narratives that generate identification and transformation of products and brands into cultural goods and services application of new construction technologies associated with Industry 4. 0 (e.g., Building Information Modelling or BIM), internet of things (sensors and smart devices), home automation and building personalisation, advanced analytics and cloud computing (building personalisation), digitisation of value chains, etc.

TRENDS	STRATEGIES AND POLICIES
Sustainable Mobility and Energy Transition	
a) Decarbonisation reducing the use of oil and other fossil fuels and increasing the use of (more) clean and renewable energy sources, such as electricity, hydrogen, fuel cells or biofuels, as well as the use of new materials (biomaterials and intelligent materials), improving the energy balance and circularity of production processes and the development of aerodynamics to reduce greenhouse gas (GHG) emissions, in particular carbon dioxide emissions, and thus reduce the effects of transport on climate change;	**a) Decarbonisation** development, in most cases of components, of (i) electric vehicles, plug-in hybrid electric vehicles and fuel cell electric vehicles; (ii) hydrogen, biodiesel and bioethanol vehicles for heavy duty passenger and freight transport; (iii) battery autonomy, durability and recharging speed; (iv) concentrated and decentralised storage solutions (including chemical, electrochemical, electrical, mechanical and thermal storage); and (v) re-use, remanufacturing and recycling (second life) in the context of the circular economy paradigm;
b) Mobility as a service new business model with a change from the paradigm of ownership by ownership to one to ownership by use, with less use of individual transport and growth of integrated, shared and multimodal mobility services (car, soft modes, rail, etc.), based on digital technologies to offer tailor-made transport, together with increased digitalisation of logistics and supply chains and the need to make improving the mobility of people and goods compatible with vehicle efficiency and reverse logistics;	**b) Mobility as a service** technological synergies between transport modes; maintenance and rehabilitation of infrastructure for transport integration, interoperability and intermodality; multimodal mobility, including planning, pricing and payment; new business models, driven by fleet purchasing for tailor-made (collective) mobility; tailor-made vehicle sharing on demand, regardless of location and (occasional) solidarity and citizen initiatives;
c) Smart vehicles and infrastructures increased automation and connectivity of vehicles and between vehicles and their infrastructure (such as road signs, traffic lights, dynamic speed limits, indication of parked vehicles or obstacles to movement) and different modes of transport and their integration and interoperability within the overall transport system, associating networks of electric recharging and refuelling with less polluting fuels, of specialised parking areas and of digital support (5G), with greater importance of user experience or emotional design in the interaction between people and vehicles, central in the future of driving-free use;	**c) Smart vehicles and infrastructure** merging the physical and digital conception of vehicles, as well as their manufacturing and operation; automation of part or all of the driving functions of vehicles in real time in road traffic; technologies for communication of vehicles with each other (Car2Car) and with the transport infrastructure (Car2X) for optimisation and safety of traffic flows; networking of vehicle occupants with the outside, allowing communication, work or access to multimedia content; business models progressively more based on software and application upgrades than on hardware and vehicle exchange; complementary approaches, whose combined use will increase the level of safety and functionality, such as artificial vision devices and vehicle sensing; Car2X interaction; high-precision satellite information; Car2Car interaction; vehicle cognitive capabilities; complementary services provided by the vehicle to its users;
d) Internationalisation, economy and mobility reducing the ecological footprint of international transport, implying sustainable aeronautics (with GHG emissions reduction), safe (for passengers and in the management of airspace and ground logistics), reliable (in time and punctuality) along with the development of railways for distances under 1 000 Km, as a means of transport with greater potential energy efficiency and thus better dissociating traffic growth and respective environmental impacts and greater relevance of health and hygiene issues, namely in shared vehicles;	**d) Internationalisation, economy and mobility** air traffic management and logistics systems (commercial aviation, unmanned aircraft, vertical mobility, military aircraft, etc.); non-intrusive security and screening processes without interruptions and delays; new aircraft configurations and propulsion systems (hybrid, electric, etc.); widespread use of drones; smart materials and structures; advanced aerodynamics and flight mechanics; widespread electrification of rail networks; energy recovery by rolling stock and use of renewable energy sources; smart, connected and autonomous rolling stock;
e) Space economy significant growth rate in the space economy, almost double that of the world economy, using skills and technologies at the frontier of knowledge, transferable to other application areas, such as aeronautics and transport in general, in energy networks and mobility infrastructures, increased satellite navigation systems meteorological services, remote, assisted, autonomous and connected transportation and driving, monitoring of space assets and debris, and traffic management, space software and hardware, and development of systems and components for space vehicles (propulsion, transportation, exploration, control) and ground services solutions, etc.	**e) Space economy** development of satellite launch vehicles and launch facilities; new generation of satellites, following the trend of miniaturisation (mini, micro and nano satellites); satellite services (communication, earth observation, navigation and integrated applications) for different users (agriculture, forestry, environment, commercial, civil and military); development of hardware and software for mission control centres; telemetry and telecommand systems; GNSS (Global Navigation Satellite System) receivers and communication terminals; manned and robotic exploration vehicles, involving probes and orbiters.

TRENDS	STRATEGIES AND POLICIES
Industrialisation and Advanced Manufacturing Systems	
a) Resources sustainability growing importance of (future) sustainability as a determinant of production processes, from design and conception to marketing, prototyping and industrialisation, particularly as regards the use of resources (such as water, energy or materials) and their life cycles and the corresponding products;	**a) Resources sustainability** progressive circular economy approaches, as well as practices to reduce (e.g, via design and waste reduction) of materials use; life-cycle analysis (LCA) practices; use of bio- and eco-materials and new materials to increase biodegradability and recyclability and decrease the ecological footprint; industrial eco-design and re-use, disassembly, remanufacturing and recycling processes; minimisation of industrial waste and reuse of related raw materials and materials; energy recovery technologies and smart management of energy exchanges of manufacturing processes and industrial equipment;
b) Digitalisation permanent adaptability of productive systems to improve the efficiency of processes (flexibility, precision, deadlines, etc.) and products (functionality, etc.), as a response to highly competitive contexts and changes in demand, arising from the increased amount and availability of data (big data) and the improvement of its intelligibility (data science) for real-time decision-making, and developments in computing, from edge computing, of great importance for the Internet of Things (IoT), to high performance computing (HPC) and new emerging technologies DARQ Technologies (distributed registry, blockchain case, artificial intelligence, mixed or extended reality and quantum computing).	**b) Digitalisation** upstream and downstream interoperability for integration into supply chains; efficient data storage, management and protection systems; data analysis as a core business asset (data driven enterprises); remote monitoring, control and maintenance of production units, namely through advanced digital twins (with real-time data feeds) of production operations; new human-machine interfaces, namely in mixed realities and natural voice processing communication systems between infrastructures, equipment and (stock) storage for production management and optimisation; real-time supervision, monitoring and control of processes during the life-cycle of products and their manufacture; multisensorial digital solutions for connection, control and optimisation of manufacturing operations; development of autonomous diagnostic and self-optimisation, self-configuration and self-healing capabilities;
c) Enabling technologies relevant impact of cross-cutting technologies in different sectors and value chains, such as advanced materials and nanotechnologies in sustainability and circular economy, artificial intelligence and cybersecurity in the automation of production processes and collaborative practices and global interaction, micro and nanoelectronics and photonics in functionalisation and miniaturisation;	**c) Enabling technologies** converging development of technologies, associated namely to materials engineering, nanotechnologies, biotechnology and biological transformation, artificial intelligence, nano and microelectronics, photonics, mechatronics, systems engineering, indispensable to improve industrial performance, aiming at a production process with zero defects, zero delays, zero unforeseen events and zero waste;
d) Automation, robotics and smart industry progressive change of the manufacturing paradigm as a production mode, integrating cyber-physical systems, provided, namely, by the internet of things and services and composed of networks of autonomous entities with physical (sensors, intelligent machines and robotics), digital or mixed (cooperative work between humans and machines) elements, in new, evolutive, adaptable, flexible, customizable and scalable processes;	**d) Automation, robotics and smart industry** development of mass production systems that are both mass production but also flexible (to meet changing demand) and customised (customer-driven), involving, inter alia, task-based programming to be developed by robots, mobile manipulators for logistics, shared autonomy, augmented reality, internet of things, flexible industrial systems architecture, robotisation and flexible manufacturing systems, reconfigurable production systems; collaborative robotics, artificial vision, mixed reality, digital twins, etc. ; new design and production technologies, such as additive manufacturing (3D printing) and additive/subtractive hybrids, micro and nano manufacturing, moulded and flexible electronics and smart design (generative design);
e) Production, management, business and work models transformation of industry as a sector of activity into a socio-technical system based on the dynamics of collaborative networks and supply chains, with accelerated vertical and horizontal integration alongside greater decentralisation (of the blockchain type), extension of human capabilities by association with machines and robots and the need for new qualifications, employment patterns, education and lifelong learning and intense collaboration between universities, research centres and companies.	**e) Production, management, business and work models** development of dynamic and digitally integrated value chains, functioning as mobile and collaborative platforms; redistribution of manufacturing activities in contexts of human-machine interaction, with highly skilled workers controlling automated systems of high complexity and performance; permanent adjustment of the offer of qualifications to meet the demand for workers with STEM (Science, Technology, Engineering and Mathematics) qualifications and appropriate skills in creativity, communication, collaboration or problem solving; promotion of business models based on Home Fabrication, through the use of 3D Printing for the manufacture of small objects, with customisation and environmental advantages.

TRENDS	STRATEGIES AND POLICIES
Agro-Environmental and Food Systems	
a) Precision agriculture transformation of the current chemical-mechanical model of agricultural development, ensuring greater efficiency of intermediate inputs and reduction of nutrients in the environment (especially nitrogen and phosphorus), resulting from their excessive use and not being fully absorbed by plants, which are also a major source of air, soil and water pollution;	**a) Precision agriculture** development of digitalisation, geographical information systems, digitalisation of the territory, sensing, automation or robotic technologies, microsatellites for e.g. forest growth monitoring, which increase the economic efficiency of intermediate inputs (the relationship between the level of input use and the level of output), such as fertilisers, plant protection products, water or energy, by using them in the most appropriate quantity, time and place;
b) Agriculture and ecological transition reproduction in agricultural activity of ecological processes resulting from successive adaptations of natural ecosystems (predation, parasitism, symbiosis, etc.) as a way to improve not only the efficiency of production factors, particularly energy-intensive ones, but also to reduce the environmental footprint and atmospheric emissions, preserve biodiversity and improve the process of adaptation to climate change;	**b) Agriculture and ecological transition** widespread application of integrated protection (and of the concept of economic level of attack); use of pollination services, biotic pest and disease control, mycorrhizae (to improve water and nutrient uptake), symbiotic synthesis of atmospheric nitrogen maintenance of land on permanent fallow or in rotation, involving annual and multi-annual crops and legumes; eradication of invasive species; practices improving the levels of organic matter in soils and carbon sequestration; use of techniques controlling metabolism and producing anti-microbial substances;
c) Livestock and atmospheric emissions the need to reduce greenhouse gas (GHG) emissions from agriculture, not only of carbon dioxide but also of methane and nitrous oxide, overwhelmingly originating from intensive livestock farming, which occupies most arable land with possible alternative sustainable uses, based on the cereal-soy-cattle complex, the consumption of critical raw materials and the excessive use of antimicrobial agents;	**c) Livestock and atmospheric emissions** improving animal husbandry techniques and the quality of pasture and forage; reducing dependence on critical raw materials and developing sustainable, innovative additives through cultivated plant proteins, seafood, such as algae, and bio-economy by-products; improving indigenous breeds and extensification of livestock production; compliance with animal welfare standards and the collection, treatment, recycling and reuse of effluent; reducing the veterinary application of antimicrobials;
d) Ecosystem services and sustainable agri-forestry-pastoral activities growing importance of species and their genome and of ecosystem services as production factors in different sectors of activity, and investment in natural capital, namely in the restoration of carbon-rich habitats and climate compatible agriculture, is fundamental for innovation and economic and social progress;	**d) Ecosystem services and sustainable agri-forestry-pastoral activities** articulation of the forest's woody material production function with its conservation and protection functions (of water resources, erosion, biodiversity, etc.), carbon storage and sequestration, production of biofuels and biomaterials; reconversion of abandoned territories into biodiverse landscape elements, namely buffer strips, fallow land, non-productive trees, terraced walls; mapping of ecosystems and monitoring of their produced goods and services; combating forest and ecosystem pests; development and application of new technologies to fight forest fires;
e) Healthy and sustainable food the importance of food models compatible with the biophysical limits of the planet and the needs of the population, while ensuring traceability, food safety, quality and resilience, reducing obesity, the prevalence of diseases related to unbalanced diet, the health care costs and waste, and manufacturing, processing, packaging and transport processes compatible with the circular economy paradigm and reduction of greenhouse gas (GHG) emissions, promoting waste reduction and its valorisation throughout the food chain.	**e) Healthy and sustainable food** smart labelling, packaging and materials, reusable and recyclable, that improve food safety and public health and reduce waste; promoting safe and functional food, involving actions such as product traceability, post-harvest techniques, nutritional quality, bioactive substances, risk assessment and management, minimum processing technologies; use of by-products in the context of the circular economy paradigm; promotion of the Mediterranean and Atlantic diet, with increased consumption of protein of plant origin and sustainable fish farming; more sustainable processing or transformation technologies for new foods or improvement of traditional foods promoting their authenticity (e.g. Protected Designations of Origin (PDO) and Protected Geographical Indications (PGI); use of food industry by-products in bioproducts with high added value.

TRENDS	STRATEGIES AND POLICIES
Health and Life Sciences	
a) Active and healthy ageing increased life expectancy and the need to ensure autonomy, quality of life and well-being for as long as possible;	**a) Active and healthy ageing** promotion of physical activity, leisure, sport and involvement in social activities and in strengthening the socialisation of (older) people; provision of health care such as rapid response to warning signs or remote monitoring that enhance community ageing;
b) Chronic diseases prevalence of oncological, cardiovascular and degenerative diseases and of those resulting from unhealthy lifestyles (such as obesity and diabetes);	**b) Chronic diseases** promotion of healthy eating and lifestyle habits (such as physical activity and sport); improvement of screening and early diagnosis processes; permanent monitoring; increased provision of long-term and palliative care;
c) Medicine and advanced technologies development of new therapeutic solutions and treatments from R&D in biomedicine, biotechnology and biochemistry, associated with information analysis and construction of predictive models and data platforms;	**c) Medicine and advanced technologies** development of new therapeutic solutions, involving areas such as biological medicines, vaccines and their components; regenerative medicine and tissue engineering, gene therapies or bioinformatics; incorporation of advanced technologies in the development of medical devices;
d) Personalised medicine greater focus on the patient, with access to information, participation in decision-making, permanent surveillance and monitoring, early diagnosis, use of electronic data records;	**d) Personalised medicine** validation and introduction of new biomarkers for diagnosis, monitoring, prognosis and therapeutic decision; development of representative models for each type of disease and its aetiology; sharing of electronic patient records, customisation of services and fast and convenient access; personalised genetics; research on the human microbiome; digital medicine (telemedicine, preventive and permanent monitoring);
e) Sustainability and resilience of health systems increase in quantity and quality (differentiation, specialisation, etc.) of health services and consequently of private and, above all, public costs and their financing needs, together with the need for permanent installed capacity to respond to health events and occurrences to protect people and their social and economic life.	**e) Sustainability and resilience of health systems** the efficiency of services and the cost-effectiveness of treatments are incentives for innovation, namely through telemedicine and remote diagnosis (such as imaging), assessment of the effectiveness of technologies, interventions, systems, programmes and policies, training in health literacy of the population, use of mobile applications and simple-to-use medical devices or personal protective equipment, along with the development of health risk prevention and management plans and intervention in infrastructures and equipment to strengthen action in extreme situations.

TRENDS	STRATEGIES AND POLICIES
Tourism Services and Territorial Assets	
a) Ageing populations and tourism increased life expectancy in the main source countries and a significant increase in the market segment dedicated to senior tourism, involving tourists with time and resources available for long stays but demanding in terms of the quality of the service related to safety (people and goods), logistics, health and medical support or qualified and (permanently) available support;	**a) Cultural heritage and tourism** promotion of networks and routes of classified cultural heritage in different themes, such as: (i) Romanesque; (ii) monasteries; (iii) cathedrals; (iv) religious heritage; (v) castles and fortresses; (vi) Baroque; (vii) fortified settlements; promotion of UNESCO World Heritage: (i) Alto Douro Wine Region; (ii) Prehistoric Côa Valley Rock Art Sites; (iii) Historic Centre of Porto; (iv) Historic Centre of Guimarães; (v) Bom Jesus do Monte Sanctuary; (vi) consolidation of the Way of St. James (Santiago) as a cultural itinerary; (vii) enhancement of intangible cultural heritage, namely inscribed on the respective UNESCO list;
b) Work, family organisation and tourism reduction in the size of households, postponement of the birth of the first child, growing number of single-parent families and very active working lives with little time available for long stays, implying a propensity for frequent tourism and leisure weekends and short breaks, often as a complement to travel or professional networking exercises;	**b) Natural resources and tourism** promotion of nature conservation and biodiversity areas, comprising the only National Park, 4 Natural Parks, various Protected Landscapes of national and local interest, 19 Sites of Community Interest and 6 Special Protection Zones integrated in the Natura 2000 Network and 2 geoparks classified by UNESCO, for leisure and sporting activities in the context of Nature Tourism (rafting, kayaking, hiking, climbing, birdwatching, etc.); enhancement of the different spas in the context of preventive medicine and Health and Well-being Tourism;
c) Sustainability, authenticity and tourism growing importance given to issues of the environment, history and local cultural heritage, healthy living, social justice by successive generations (namely millennials and generation Z), being more informed and independent in their choices and consumption, assessing destinations and products in advance, preferring flexible itineraries and seeking experiences with authenticity that promote learning and self-realisation;	**c) Creativity, creation and tourism** development of cultural and creative industries, namely performing arts, music, cinema and video, publishing, to affirm the cosmopolitanism of the main regional urban centres and tourism animation, through the construction of dense cultural agendas of activities and events, taking advantage of relevant and symbolic infrastructures (Serralves Museum of Contemporary Art, Casa da Música, Theatro Circo, Vila Flor Cultural Centre, Côa Museum, etc.);
d) Digitalisation and tourism progressive disintermediation of the sector and of the reservations, increasing the use of platforms, mobile applications (including integrated ticketing and payment systems) and, in general, the Internet for the promotion, marketing and sharing of information and experiences, along with the virtualisation and availability of other content before, during and after visiting the different destinations;	**d) Local development and tourism** development of local and sub-regional strategies for tourism promotion and entertainment, namely in low density territories, taking advantage of local accommodation, the natural and built heritage, the landscape, the practices, traditions and festivities, the endogenous products and resources (gastronomy, wines, etc.), the connection of oenology with signature cuisine and cultural contexts, as a way of boosting demand not only for the production but also for the associated services, placing the local agents closer to the final consumers and downstream of the respective value chains;
e) Mobility, environment and tourism increasing mobility of people, resulting in particular from the rising income of the middle classes in emerging countries and the improved cost/benefit ratio of air travel, and consequent congestion of transport infrastructure, increased carbon footprint of the economy and increased risk of exceeding the tourism carrying capacity of the most popular or ecologically vulnerable.	**e) Business plans and tourism** development of business plans with more autonomous and adjustable distribution channels, allowing the construction of diversified tourism packages according to consumer preferences, less dependent on intermediation and increasingly using online platforms for prior assessment of destinations, products, price, service quality and own construction of flexible itineraries according to their needs and enjoyment desires.

TRENDS	STRATEGIES AND POLICIES
Sea Resources and Economy	
a) Blue energy significant growth in the production of offshore wind energy and the respective installed capacity and market shares (global and renewable), although more moderate as regards other sources such as tidal and wave energy, due to the development and maturity of the current technological solutions, tidal power plants and wave turbines, respectively;	**a) Blue energy** development of technologies to meet the challenges associated with the use of wind turbines in open sea (offshore), such as transport and anchoring of structures, mooring systems, mechanical wear, new materials, connections to the grid or maintenance operations, and selection and commercial optimisation of different technologies available in the experimental phase for the use of wave and tidal energy;
b) Aquaculture growth in offshore aquaculture fish production at a rate higher than that of the world population and of animal protein consumption, being the fastest growing food production sector of animal origin and thus contributing not only to the improvement of human nutrition but also to the sustainability of fish stocks in the oceans;	**b) Aquaculture** differentiation of supply and investment in the production of juveniles and species suited to the Portuguese coast; development of structures for open sea aquaculture in the particular conditions of the continental shelf; automation of aquaculture units, using remote and real-time monitoring through life support analysis equipment and physical-chemical (water) and biological (organisms) parameters;
c) Maritime, Coastal and Cruise Tourism growth in activities that enable combating the traditional seasonality of demand, such as cruise shipping, in association with shipbuilding, water sports (sailing, surfing, etc.) and green tourism (marine species observation and diving), and reducing the carbon footprint and, in general, the environmental impact of (traditional) coastal tourism;	**c) Maritime, Coastal and Cruise Tourism** development of (i) new tourism concepts and products associated with recreational boating and high competition sports practised at sea, (ii) maritime transport solutions to support tourism in riverside areas and (iii) new technologies to monitor pollution and its pathways and biological and ecosystem effects, and for recycling and new material uses for such waste;
d) Marine Mineral Resources potential exploration and production of minerals from the ocean beds, including cobalt, copper and zinc, and, depending on technological development and market developments, of minerals dissolved in seawater, such as boron, lithium and potassium, in a foreseeable global context of increased demand and prices of non-energy raw materials and possible extension of the continental shelf;	**d) Marine Mineral Resources** mapping of marine mineral resources and possible associated critical and reserve areas, such as sensitive ecosystems; development of technology for the exploration and exploitation of marine minerals; assessment of the sea's potential for reducing risks arising from climate change and possible practical solutions for carbon sequestration;
e) Blue Biotechnology potential development and production of new drugs from research and development associated with the knowledge of marine organisms, such as some recent successes (Zovirax, Acyclovir and Yondelis), as well as products for the cosmetics, industrial biomaterials and food sectors, resulting from the production of metabolites and primary compounds, such as polymers, sugars, lipids and proteins.	**e) Blue Biotechnology** development of technologies for commercialisation of marine bioactive compounds for the pharmaceutical, nutraceutical and cosmetic industries, as well as for the production of biofuels; promotion of pre-commercial initiatives of bioactive compounds through processing technologies and separation of metabolites; knowledge of the diversity of marine organisms and their biochemical processes and ecosystems; sustainable production of bioactive compounds.

TRENDS	STRATEGIES AND POLICIES
Technologies, State, Economy and Society	
a) Global connectivity, digital infrastructures and mobile services Internet as a good of merit, i.e. the generalisation of its access in good conditions of security, reliability and performance is a fundamental element for equal opportunities in learning and knowledge, personal and professional development, economic activity, socialisation and, in general, in the exercise of citizenship, respecting civic and political rights of citizens regardless of their place of residence and work and their economic and social condition;	**a) Global connectivity, digital infrastructures and mobile services** provision of broadband infrastructures (fixed and mobile), with networks enabling higher access and data transfer speeds (Very High Capacity Networks or VHCN, Fibre to the Premises or FTTP, Data Over Cable Service Interface Specification or DOCSIS and 5G technology), enabling widespread use by families and companies, in rural or urban areas, in a competitive and permanently regulated market context that ensures prices are as low as possible so that they do not become factors of exclusion;
b) Digital as an ecosystem of (related) technologies digital transformation as a process based on a set of interdependent technologies whose developments reinforce each other, amplifying their economic and social effects, which implies a permanent effort of investment in research and development, of adaptation of institutions, public and private, to change as a new normal and of accumulation of human capital in relevant scientific and technological areas;	**b) Digital as an ecosystem of (related) technologies** permanent investment in R&D, public and private, in the technology cluster: internet of things, next-generation wireless networks (5G), from edge to cloud computing, big data analytics, artificial intelligence, cybersecurity or high-performance computing (HPC); support for advanced training in the sciences, technologies, engineering and mathematics; attracting FDI in ICT, taking advantage of business process outsourcing (BPO) and, above all, knowledge process outsourcing (KPO) trends, such as software factories and engineering centres, for fixing and accumulating human capital.
c) Inclusion, training, skills and labour market growing need for labour with digital skills and need for an adequate response in the various degrees of education and in vocational training and re-qualification of workers, along with a profound (and disruptive) process of creation and destruction of jobs and the emergence of new forms of labour relations, boosted by automation and the breakdown of work into specific tasks and remote and occasional work, namely on platforms, with little or no conventional professional status and greater (potential) polarisation of income between people, regions and countries;	**c) Inclusion, training, skills and labour market** transversal integration of digital technologies in the different curricular areas of basic and secondary education; broadening the training offer of higher education institutions (increasing the number of students) to meet the digital skills needs of companies; training and re-qualification actions for assets (to adapt to the digital change in progress) and for inclusion and digital literacy; regulation of new labour relations, ensuring adequate conditions and professional status according to the type of work and its intensity and frequency; analysis of changes in employment and work concepts and development of policies to mitigate the social impact of those changes;
d) Digital as a market tendency towards the hegemony of the digital market in service areas (such as financial services) or in the distribution of dematerialized goods (music, cinema, video, books, newspapers, etc.) and towards its growing importance in the remaining markets, resulting from combined effects such as: existence of network economies (economies of scale on the demand side); reduction of costs and the cost of additional units (marginal costs); reduction of transaction costs (costs of transactions per se and resulting from market frictions, such as distance or asymmetric information);	**d) Digital as a market** promoting e-commerce, both between companies along the supply chains (B2B) and online sales (B2C); dematerialisation and digitalisation of services and goods and making them available online; development of applications and platforms for online interaction and making services available or improving their provision; digital marketing and respective strategies, involving fusion between the cyber-physical, analogical and retail; market regulation, boosting competition and investment and reducing inefficiencies due to excessive concentration or abuse of dominant position;
e) Digital public services and open and networked administration providing services to citizens and businesses preferably (and by definition) electronically, through interoperable and seamless desks, ensuring: sharing and re-use of data between institutions and users; digital inclusion and accessibility, including for target groups such as the elderly and people with disabilities; smart and connected territories, in areas such as transport, energy, education, health or culture; legal, regulatory and IT security framework for protection of personal data and privacy and cyber security.	**e) Digital public services and open and networked administration** increasing users of online services and the availability of pre-filled forms and open data; increasing telemedicine, electronic prescriptions and medical data exchange; production and distribution of multimedia content on platforms to support distance learning development of applications and platforms for traffic management, public transport and energy (smart grids) in cities; promotion of living labs in territories with characteristics of agglomeration and density of interactions; reconversion of processes to the digital universe and training and empowerment of workers.

Source: Monteiro, R., Meira, R., Santos, P., Guimarães, C., Silva, A., & Lopes, P. (2020)

The expression of forty international demand trends and the respective forty R&D&I strategies and policies, each with several examples, gives this exercise a fragmented character, difficult to understand as a whole. Bearing in mind that we are dealing with eight different priority domains made by resources and assets and business bases that are also diverse, it is normal that this should be the case.

There are, however, recurring expressions and concepts. These recurrences reveal that, despite the sectoral and thematic specificities, there are common elements in the trends and in the strategies and policies, regardless of the eight priority domains of smart specialisation. The transversal character of these elements

reveals heavy trends of structural change in the economy and society that are perhaps beyond the simple scientific, technological and innovation dimensions considered in each priority domain. This more aggregated (and aggregating) analysis can be developed with regard to the "societal challenges" and their relationship with the trends and the strategies and policies in the context of each priority area.

In the current programming period, "societal challenges" emerge in the European Union's R&D&I policies from Horizon 2020 (the European Union's Framework Programme for Research and Innovation)[18]. There are seven such challenges:

· Health, demographic change and well-being;

· Food security, sustainable agriculture and forestry, marine, maritime and inland water research, and the bioeconomy;

· Safe, non-polluting and efficient energy;

· Smart, green and integrated transport;

· Climate action, resource efficiency and raw materials;

· Europe in a changing world - Inclusive, innovative and reflective societies;

· Secure societies - protecting freedom and security of Europe and its citizens.

These "societal challenges" were considered in PORTUGAL 2020 in the context of calls for proposals and project analysis criteria, namely in the Business Incentive Schemes. The aim was to ensure strategic coherence of PORTUGAL 2020 with European Union policies and, at the same time, possible complementarities of funding with HORIZON 2020.

As can be seen, these challenges have a high thematic and sectorial amplitude, being able to include the most diverse economic activities, areas of research and development and social, economic, technological, and environmental problems. These challenges have been restricted and aggregated around three issues relevant for the development of the countries of the European Union and, in particular, of Portugal: population ageing, energy transition and digital transformation. These issues have been expressed with some liberality, coexisting overlapping but also complementary and redundant expressions and concepts, often considered as synonyms.

A first exercise was carried out within the scope of the surveys conducted among PREI members. The purpose was to ascertain their agreement or disagreement as to whether the rationale for each priority area took account of "societal challenges" and the corresponding transversal public policy priorities. The analysis of the results shows that the "societal challenges" were duly considered in the rationale of the priority domains, and the relative and absolute expression of the answers is a fundamental element in validating the diagnosis of international demand trends.

This validation allowed to conclude that the adopted methodology of considering these challenges in each priority domain, and not autonomously, was the most appropriate. These challenges by themselves, when transformed into public policy priorities of transversal nature, cancel out the analytical content, mainly, the operational and practical. In fact, the same challenges and trends have different expressions and impacts depending on the interfaces between technologies and sectors of economic activity in each priority domain of smart specialisation.

In this exercise, the following expressions and concepts that have been recurrently used in the PORTUGAL 2020 were considered: (i) Active and Healthy Ageing; (ii) Energy Efficiency; (iii) Decarbonisation of the Economy; (iv) Circular Economy; (v) Digitalisation; (vi) Industry 4.0. As mentioned, some of these expressions are used as synonyms without the concepts being exactly the same, although related, relatable and, sometimes, redundant. Next, an attempt is made to explain the concepts underlying each of these expressions so that they may be used in the exercise of association with the previously identified trends.

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18 Direção-Geral da Investigação e da Inovação. Comissão Europeia (2014). HORIZON 2020 em breves palavras. O programa-quadro de investigação e inovação da União Europeia. Luxembourg: Publications Office of the European Union.

Population ageing is the result of two demographic dynamics: on the one hand, the decrease in mortality and the increase in longevity; on the other hand, the reduction in fertility. Without immigration, this tendency tends to be structural, considering that the reduction in the number of women of fertile age cannot be compensated by the increase in fertility levels. This change in the demographic pyramid has consequences in different economic and social dimensions, in savings, in investment, in the labour market, in the financing of social security or health expenses. But being 65 years old today is different from being 65 years old 30 years ago or 30 years from now. People are expected to live longer but at the same time healthier and more independent lives, maintaining economic and socially relevant activities and a sense of belonging and personal fulfilment.

Energy efficiency is about reducing the use of energy per unit of production or consumption. This efficiency does not in itself lead to an overall reduction in energy consumption. The increase in production and consumption can more than compensate for this improvement in efficiency, determining the overall increase in energy consumption. The existence of public policies in this area aims to compensate for market failures, given that the price system does not always reflect the relative scarcity of resources and the negative externalities generated by energy production and consumption. These market failures are particularly evident in the transport sector and in the mobility of people and goods.

Energy efficiency is an indispensable component of the challenge of **decarbonising** the economy. However, as mentioned above, the improvement of energy efficiency alone does not guarantee the global reduction of energy consumption and, in particular, of fossil energy consumption. The decarbonisation of the economy goes a little further, ensuring the reduction of energy consumption especially relevant for the Greenhouse Gas (GHG) emissions, in particular carbon dioxide. The paradigm shift in energy production, using renewable sources, and in energy consumption, reducing its use and improving storage and distribution systems, is fundamental for mitigating the effects of climate change, as per commitments made in and from the Paris Agreement, under the United Nations Framework Convention on Climate Change.

The **circular economy** paradigm incorporates these concerns with energy efficiency and decarbonisation of the economy, intending to change the current linear paradigm of production and consumption, which begins with the mobilisation of materials and energy to transform them into goods and services to meet intermediate and final demand, and which, after being used and consumed, ends with waste in the form of heat loss and waste. The circular economy aims to transform this degenerative process into a regenerative and circular one, using biological nutrients to produce biomaterials that can be successively broken down and regenerated, and non-biological nutrients whose transformation and use allow their return by repairing, reusing, refurbishing or recycling.

This paradigm assumes that, from conception and design, goods and services are produced in short cycles so that their constituents can be broken down and regenerated or returned. The reduction element of the circular economy concept stands out, given that by improving the design and/or project of a component or product, the amount of material used is reduced, leading to energy savings, namely in the manufacturing, logistics (transport) and recycling processes.

Digitalisation, in practical terms, consists of a set of interdependent technologies associated with (i) the collection, transmission, processing and storage of information, including the generation of data through the mass of sensors and other devices (IoT), and its communication through different types of wired or wireless networks; (ii) the use of data science to handle large volumes of information (big data), based on different algorithms, including artificial intelligence; (iii) cybersecurity systems for the integrity of this information; (iv) processing hardware, from proximity or edge computing, to cloud computing, supported by advanced computing systems. It also includes human-machine interface systems, notably associated with artificial vision and mixed reality and natural voice processing, as well as cyber-physical devices for robotics, autonomous mobility or digital manufacturing.

However, this interdependence results in mutually reinforcing developments, amplifying their economic and social effects, implying a permanent effort of investment in R&D&I, of adaptation of institutions, both public and private, to change as a new normal and of accumulation of human capital in relevant scientific and technological areas. This technological transition is not neutral, it reproduces itself in the current economic and social context, changing production and the primary formation of income, generating asymmetries in market power, changing the way people work and socialise and work as an identity, personal and professional element.

Industry 4.0 is the application of this digital transition process to specific sectors of economic activity, such as industry, with the addition of other enabling technologies, such as biotechnology, nanotechnology or photonics. The application of these technologies to these sectors will have a strong impact on business investment and the reconfiguration of global value chains. Industry 4.0 is connected downstream and upstream of the production process; hyperautomated, including robotisation, incorporating new types of human-machine interaction; intelligent and data-based for its decision-making processes; and environmentally less impactful.

In Table 4, the direct (D) or indirect (I) association between the forty trends of the eight priority domains of smart specialisation and the referred "societal challenges" is carried out.

This analysis allows to conclude that the challenges have different relevance depending on the various priority domains. The areas of Creativity, Fashion and Habitats, Sustainable Mobility and Energy Transition, Industrialisation and Advanced Manufacturing Systems and Agro-Environmental and Food Systems are those where the relevance is more significant. These are areas whose business bases characterise the main productive specialisations of Norte Region and thus, in the absence of adequate public policies, the impact of these challenges may be disruptive to the current structure and dynamics of the regional economy. The crossing of trends with the "societal challenges" allows us to conclude that the main regional specialisations are at the centre of structural transformation trends, in demography, in the energy transition and in digital transformation, requiring appropriate public policies to reduce the the economic and social impacts arising from the natural adjustment process.

Table 4 • Articulation of trends identified in the eight priority domains for smart specialisation with "societal challenges"

Domains and Trends		Ageing		Energy Efficiency		Decarboni- sation		Circular Economy		Digitali- sation		Industry 4.0	
		D	I	D	I	D	I	D	I	D	I	D	I
Creativity, Fashion and Habitats	a) Symbolically related activities												
	b) Social and environmental responsibility			●			●	●					
	c) Sociodemographic changes	●											
	d) Mass customisation and personalisation		●										
	e) Digitalisation and digital market									●		●	
Sustainable Mobility and Energy Transition	a) Decarbonisation			●		●		●					
	b) Mobility as a Service			●			●		●	●			●
	c) Smart vehicles and infrastructures	●								●		●	
	d) Internationalisation, economy and mobility			●		●			●				
	e) Space Economy									●			●
Industrialisation and Advanced Manufacturing Systems	a) Resources sustainability			●		●		●					
	b) Digitalisation									●		●	
	c) Enabling technologies								●	●		●	
	d) Automation, robotics and smart industry									●		●	
	e) Production, management, business and work models										●		●

Domains and Trends		Ageing		Energy Efficiency		Decarboni-sation		Circular Economy		Digitali-sation		Industry 4.0	
		D	I	D	I	D	I	D	I	D	I	D	I
Agro-Environmental and Food Systems	a) Precision agriculture			●			●		●	●		●	
	b) Agriculture and ecological transition			●		●		●					
	c) Livestock and atmospheric emissions			●		●			●				
	d) Ecosystem services and sustainable agri-forestry-pastoral activities						●	●					
	e) Healthy and Sustainable Food	●					●		●				
Health and Life Sciences	a) Active and healthy ageing	●											
	b) Chronic diseases		●										
	c) Medicine and advanced technologies									●		●	
	d) Personalised medicine									●			
	e) Sustainability and resilience of health systems		●							●			
Tourism Services and Territorial Assets	a) Ageing population and tourism	●											
	b) Work, family organisation and tourism												
	c) Sustainability, authenticity and tourism							●					
	d) Digitalisation and tourism									●			
	e) Mobility, environment and tourism				●	●					●		
Sea Resources and Economy	a) Blue Energy			●		●							
	b) Aquaculture							●		●			
	c) Maritime, Coastal and Cruise Tourism					●							
	d) Marine Mineral Resources									●			
	e) Blue Biotechnology									●			●
Technologies, State, Economy and Society	a) Global connectivity, digital infrastructures and mobile services									●			
	b) Digital as an ecosystem of (related) technologies				●		●		●	●		●	
	c) Inclusion, training skills and labour market				●		●		●	●		●	
	d) Digital as a market				●		●		●	●		●	
	e) Digital public services and open and networked administration		●							●			

Source: Monteiro, R., Meira, R., Santos, P., Guimarães, C., Silva, A., & Lopes, P. (2020)

5.

Innovation ecosystem and Norte Region Smart Specialisation Strategy for 2021-27

Regional Innovation Systems (RIS) imply autonomous governance models capable of generating the necessary interactions between relevant stakeholders, namely in entrepreneurial discovery processes. The governance model of RIS3 NORTE 2020[19] established, for the first time, the creation of the Norte Regional Innovation Council[20] (CRIN), as a consultative body to ensure the active participation of regional stakeholders in the monitoring and continuous evaluation of the strategy implementation and to contribute to the strategic decision-making process. This consultative body respects the quadruple helix model, involving representatives from companies, educational, research and development institutions, public entities for planning and managing R&D&I policies and innovation users or entities representing the demand dimension and innovation consumers.

The exercise of characterising the network of institutions that constitute the regional STS cannot fail to consider this framework in the regional smart specialisation strategy. Thus, the identification of the main institutions of this network should take into account the criteria that were present in the definition of the governance model of RIS3 NORTE 2020, namely in the composition of CRIN and respective Regional Smart Specialisation Platforms (PREI) for each priority domain of smart specialisation.

Not only for their scope of intervention but also for their representativeness in the governance model, the analysis of the sectoral and territorial distribution of the regional network entities considers the R&D institutions and the technology transfer institutions that integrate the PREI by priority domain, namely the R&D Units and Technology Transfer Centres, this last including the Collaborative Laboratories (CoLAB) and the Technological Interface Centres (TIC)[21]. The same criteria applied to the composition of the PREI were considered in the identification of the entities, namely:

- R&D Units located in Norte with recognised merit in the evaluation and funding exercise carried out by the Foundation for Science and Technology (FCT), i.e., that have obtained a classification of "Exceptional", "Excellent" or "Very Good" in one of the Evaluation and Funding of R&D Units exercises carried out by FCT in 2013[22] and in 2017/2018[23] (the classification "Exceptional" did not apply in 2017/2018);

- Collaborative Laboratories (CoLAB) located in Norte Region recognised by FCT in 2018[24] and 2019[25];

- Technological Interface Centres recognised by the Ministry of Economy, in 2017[26] and 2019[27].

The application of these criteria resulted in the identification of 74 institutions, namely 49 R&D Units, 12 CoLAB and 13 Technological Interface Centres, which integrate the PREI and constitutes the universe of entities to be considered in this exercise to characterise the entities of the regional STS.

The best way to analyse the sectoral and thematic alignment of these institutions that integrates the network is to associate them with the different priority domains of S3 NORTE 2027, defined in the previous chapter, namely: (i) Creativity, Fashion and Habitats; (ii) Sustainable Mobility and Energy Transition; (iii) Industrialisation and Advanced Manufacturing Systems; (iv) Agro-Environmental and Food Systems; (v)

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[19] Comissão de Coordenação e Desenvolvimento Regional do Norte (2014). NORTE 2020 – Estratégia Regional de Especialização Inteligente

[20] Comissão de Coordenação e Desenvolvimento Regional do Norte (2019). Comissão de Coordenação e Desenvolvimento Regional do Norte (2019). Constituição do Conselho Regional de Inovação do Norte (CRIN) – (Aprovada em abril de 2017 e alterada em dezembro de 2017 com a indicação dos representantes no CRIN e em julho de 2019 com a indicação dos representantes das plataformas regionais de especialização inteligente)

[21] This methodology is compatible with Law-Decree No. 63/2019, of May 16, which establishes that the national system of science and technology is made up of entities, structures and networks dedicated to the production, dissemination and transmission of knowledge, among which: a) R&D institutions, namely: (i) R&D units; (ii) state laboratories; or (iii) the associated laboratories; b) collaborative laboratories; c) technological interface centers; d) science and technology infrastructure; e) science and technology networks and consortia. Although the science and technology infrastructures that constitute the national road map of scientific infrastructures are present in the PREI, it was decided not to consider them in this exercise, taking into account that the entities representing these infrastructures are at the same time R&D Units or Technological Interface Centers.

[22] Accessed at: https://www.fct.pt/apoios/unidades/avaliacoes/2013/index.phtml.pt.

[23] Accessed at: https://www.fct.pt/apoios/unidades/avaliacoes/2017/

[24] Accessed at: https://www.fct.pt/apoios/CoLAB/

[25] Accessed at: https://www.fct.pt/apoios/CoLAB/

[26] Accessed at: https://dre.pt/application/conteudo/114248338

[27] Accessed at: https://dre.pt/application/conteudo/125008696

Health and Life Sciences; (vi) Tourism Services and Territorial Assets; (vii) Sea Resources and Economy; (viii) Technologies, State, Economy and Society. This association exercise allows to identify 151 participations of R&D and technology transfer institutions in the PREI (this number results from the fact that there are institutions that, given their scope of intervention, participate in more than one PREI and are therefore relevant in more than one priority domain).

The following table shows the distribution of the entities participation by PREI and the respective priority domains.

Table 5 • Institutions of the regional scientific and technological system and priority domains

Institutions	S3 NORTE 2027 Priority Domains								Total
	CFH	IAMS	AEFS	SMET	HLS	TSTA	SRE	TSES	
R&D Units	8%	18%	21%	13%	22%	2%	11%	5%	100%
Collaborative Laboratories	6%	24%	29%	12%	0%	6%	6%	18%	100%
Technological Interface Centres	16%	26%	9%	21%	14%	0%	9%	5%	100%
Total	10%	21%	19%	15%	17%	2%	10%	7%	100%

Source: RIS3 NORTE 2020 Governance Model

The overall data allows the conclusion that all the priority domains of smart specialisation are associated with institutions of the regional STS. However, relative concentration is not indifferent in this analysis, with the largest number of institutions associated with four domains: Sustainable Mobility and Energy Transition; Industrialisation and Advanced Manufacturing Systems; Agro-Environmental and Food Systems; and Health and Life Sciences. On the other hand, the Tourism Services and Territorial Assets domain has the fewest entities, perhaps because it has fewer resources and knowledge and technology-intensive assets.

This alignment is also not homogeneous with regard to the type of institutions, given that the different domains of smart specialisation have different levels of knowledge and technology-intensive resources and assets. In terms of R&D Units, the domain of Health and Life Sciences stands out, followed by the domains of Industrialisation and Advanced Manufacturing Systems, Agro-Environmental and Food Systems, and Sustainable Mobility and Energy Transition. At the other extreme are domains such as Creativity, Fashion and Habitats, more associated with more labour-intensive economic activities and intangible factors promoting competitiveness. On the other hand, in the case of the Technology Interface Centres, the field of Creativity, Fashion and Habitats has a relevant relative expression, just behind domains such as Industrialisation and Advanced Manufacturing Systems and Sustainable Mobility and Energy Transition. As for the Collaborative Laboratories, two domains clearly stand out: Industrialisation and Advanced Manufacturing Systems and Agro-Environmental and Food Systems.

The coherence of the regional network of these institutions should also be territorially relevant, in its articulation with the specialisation profiles of the different sub-regional areas. As mentioned in the previous chapter, the priority domains were established based on a conceptual and participatory methodology rather than using quantitative methods. These domains, especially their business bases, are still constituted by distinctive and differentiated sectors of economic activity, revealing adequate representativeness of the economic specialisations of Norte Region as a whole and of its different sub-spaces.

For this purpose, a set of criteria was defined for the identification of the most relevant priority domains in each municipality, using the framework of the projects approved in the incentive systems for business support in NORTE 2020 and COMPETE 2020[28]. Since this is a thematic specialisation and, thus, considering that the only relevant variable in the Information System is the statistical classification of economic activities (CAE Rev. 3), a CAE is considered relevant when it represents at least 5% of the total eligible investment approved in each priority domain.

The specialisation profile of each municipality in each priority domain is then identified on the basis of the Location Quotient (LQ) of each CAE, measured by the respective employment volume[29]. Thus, in a given municipality, whenever the LQ, in employment volume, of at least one relevant CAE in a priority area is greater than one, it is considered specialised in that domain. The analysis of the relevant priority domains in each county allows the mapping of the smart specialisation of the business base in the different sub-areas of Norte Region[30].

Taking this methodology into account, the territorial distribution of scientific and technological institutions and their association with the smart specialisation of the business base of the different municipalities by priority domain is presented in the next figure.

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[28]   The universe considered covers 4 059 projects that fit the RIS3 NORTE 2020 approved in the NORTE 2020 and COMPETE 2020 incentive systems to companies, until December 31, 2018. In the case of COMPETE 2020, only projects of the incentive systems to companies exclusively located in the NUTS II Norte region are considered.

[29]   Persons employed (No.) of establishments by geographic location (NUTS - 2013) and Economic activity (NACE Rev. 2); Annual (2018) - INE, System of integrated company accounts.

[30]   Figueiredo, J. (2019). Estratégias Regionais de Especialização Inteligente (RIS3): Estudo de Caso da Região do Norte. (Dissertação de Mestrado em Economia, Faculdade de Economia da Universidade do Porto).
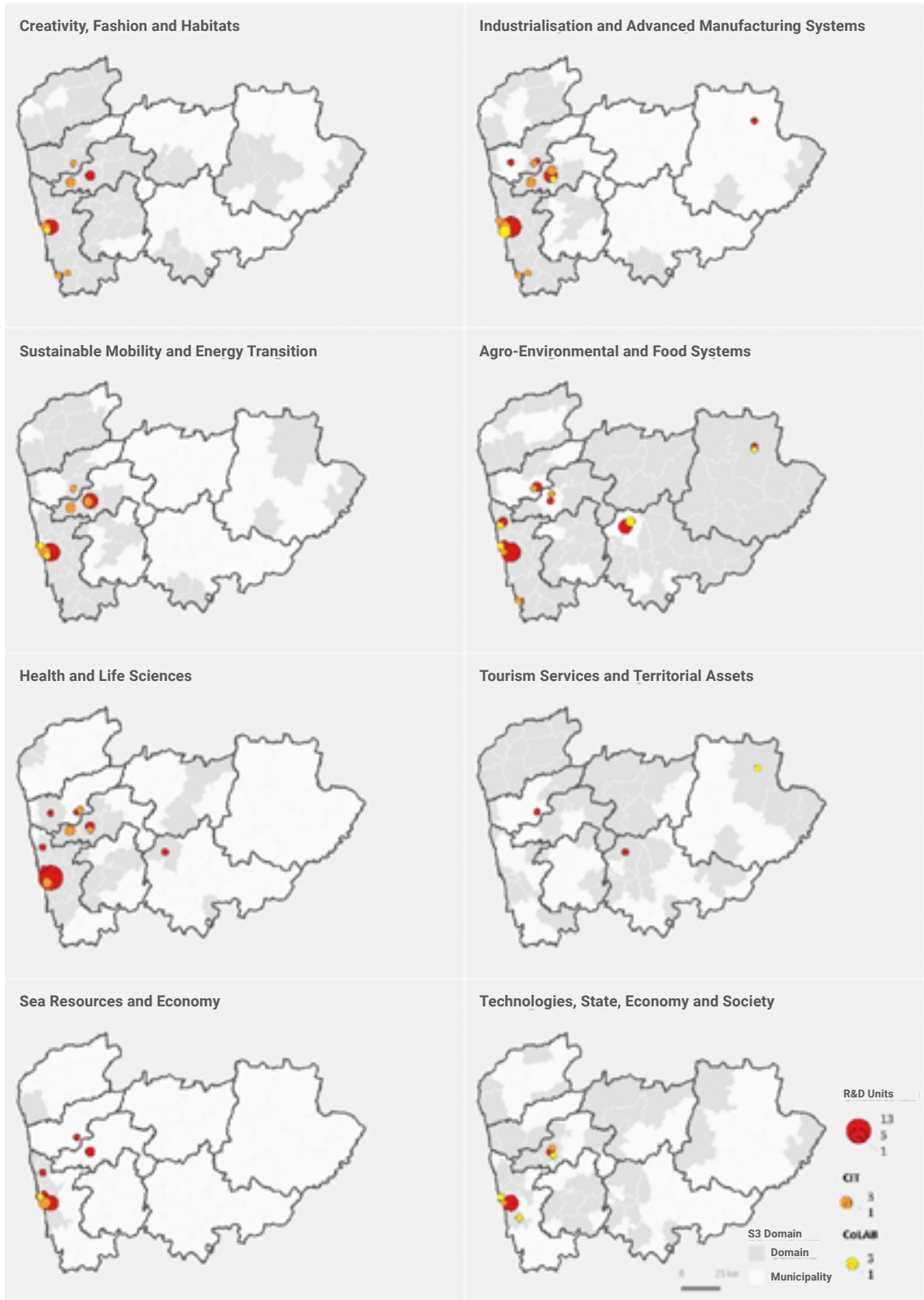
Figure 24 • Smart specialisation by municipality and scientific and technological institutions[31]

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[31]   In the domain Sea Resources and Economy, only the specialisation in coastal municipalities was considered, assuming as coastal municipalities those comprising more than 50% of coastal parishes in the total number of parishes.

Aggregating the mapping by priority domains it allows to analyse the relationship between the network of scientific and technological institutions and the number of municipal specialisations, as shown in the following figure.
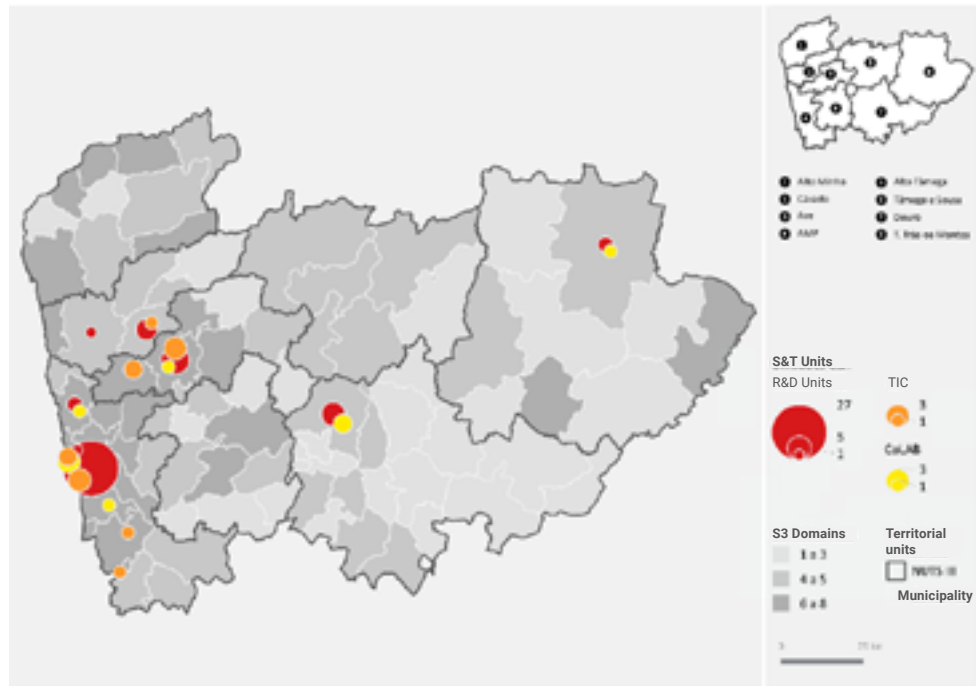
Figure 25 • Number of municipal specialisations and scientific and technological institutions

All municipalities have specialisation in at least one priority domain, reflecting the spatial representativeness of these areas and the potential for application of the regional smart specialisation strategy in the territorial broadening of the economic base for the promotion of regional competitiveness. There is also a greater concentration of regional STS institutions in municipalities with more diversified and resilient economies, characterised by a greater number of smart specialisations or priority domains, namely in the AMPorto, Cávado and Ave sub-regions. This concentration is even more accentuated when considering the R&D Units, with more than 50% located in the municipality of Porto. With regard to TICs and CoLABs, despite the higher concentration in the three sub-regions mentioned above, there is a greater territorial distribution.

This analysis should also be complemented with the spatial distribution of Higher Education Institutions, given that they are highly relevant entities for the production and dissemination of knowledge, fundamental in the production of resources and assets in various priority domains. These institutions are expected to play a catalysing role in boosting the smart specialisation strategy, through the creation and accumulation of human capital through the production, dissemination and transfer of scientific and technological knowledge associated with different priority domains of smart specialisation.

The distribution by sub-regions of the students enrolled in higher education institutions[32] reveals a high geographical concentration in AMPorto, with the University of Porto, the Polytechnic Institute of Porto and the Catholic University of Porto standing out, followed by Cávado e Ave, with the University of Minho (Braga and Guimarães poles) and the Polytechnic Institute of Cávado e Ave. With less expression, appears the sub-region Douro, with the University of Trás-os-Montes e Alto Douro, the sub-region Terras de Trás-os-Montes, with the Polytechnic Institute of Bragança, and the sub-region Alto Minho, with the Polytechnic Institute of Viana de Castelo.

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[32]   Students enrolled in the 2019/2020 academic year at public and private higher education institutions. It includes the following courses/study cycles: 1st cycle degree, 2nd cycle masters, integrated masters, 3rd cycle doctorate, post-graduate specialisation, higher professional technical course. Source: Higher Education data tables (Direção-Geral de Estatísticas de Educação e Ciência).

The consolidation of the previous figure with the distribution of students enrolled in higher education institutions allows mapping the Regional Innovation Ecosystem or RIS (cf. figure below).
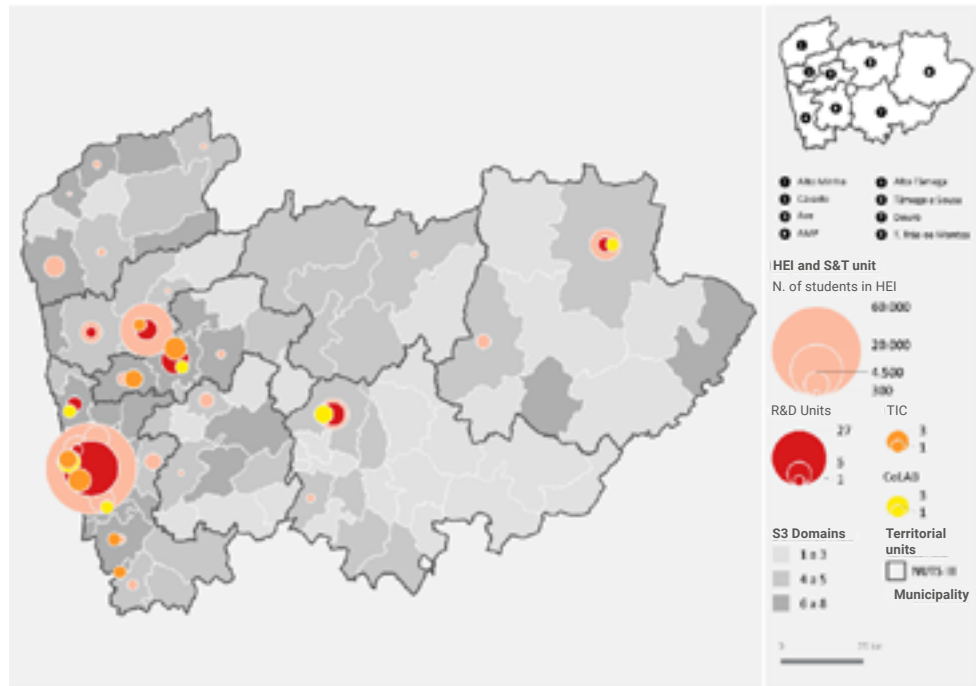

Figure 26 • Norte Region Innovation Ecosystem

The figure shows that there is a strong correlation between the location of higher education institutions and R&D institutions and technology transfer institutions. In fact, Higher Education Institutions are mainly responsible for promoting R&D Units, which constitute one of the elements of RIS. On the other hand, it is also found that these institutions tend to be located in the most densely populated areas and those with the most business activity, as measured by municipalities with more specialisation in priority domains. This analysis is in line with the work carried out in the mapping exercise of the technological infrastructures[33] carried out in 2017, which concluded that there is a strong correlation between the location of technological infrastructures and knowledge production centres (universities and polytechnics) and the business environment.

Despite this relationship, the network of RIS institutions is still spatially unbalanced. There is a clear division between the main urban centres and, in particular, AMPorto, and the rest of the Region in the distribution of this type of institution, or, in other words, between the low density territories and the others, which display greater economic and demographic dynamism. At the same time, there is a pattern of low density territories compared to the others, with mono-specialisation predominating in the former as opposed to greater diversification and resilience in the latter.

Thus, it is necessary to promote a more territorially distributed and balanced RIS capable of responding to the challenges of valorising the products and activities of Norte Region, based on a network of institutions with different profiles, from fundamental research to support for business innovation, in close articulation with higher education institutions. This rebalancing of RIS is fundamental to support economic activities with greater potential for territorial broadening of the economic base to promote competitiveness, namely in areas more characterised by territory-intensive assets and resources, such as Agro-Environmental and Food Systems and Tourism Services and Territorial Assets.

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[33] Comissão de Coordenação e Desenvolvimento Regional do Norte (2017). Mapeamento dos Investimentos em Infraestruturas Tecnológicas.

The expression Norte's RIS has been used to represent a reality based on a concept, the concept of a regional innovation system. CRIN was a first step towards its formalisation, its institutionalisation. However, it is necessary to establish it, to formalise it in fact, so that the R&D&I policies in the context of S3 NORTE 2027 and the 2021-27 programming period of the European Union policies can promote the consolidation and strengthening of Norte's RIS.

6.

Internationalisation of Norte Region Smart Specialisation Strategy for 2021-27

Internationalisation is a fundamental component of the implementation process of smart specialisation strategies[34]. The economic transformation potential of these strategies relies on the capacity of regions to combine locally accumulated knowledge and technologies in international knowledge and production networks.

In the context of smart specialisation, internationalisation includes, besides exports and Foreign Direct Investment (FDI), other relevant dimensions such as: strategic alliances, joint research and development activities, outsourcing and joint promotion actions. Internationalisation is particularly important for regions to access wider business and knowledge networks, increase their research capacity, reach new markets, expand business opportunities and insert themselves in global value chains[35].

Interregional and macro-regional cooperation thus allows supporting regions in exploiting the complementarities necessary to participate in global value chains, encouraging the alignment between private and public investment. The existence of these strategies in European regions has accelerated interregional and international collaboration as a platform for understanding between regions, contributing to project development, providing a strategic framework for aligning priorities between public policies and investment initiatives, promoting a wider scope of funding opportunities, increasing the critical mass of initiatives, sharing knowledge and experience and extending international networks.

The regional smart specialisation strategies have been assuming an important role in the framework of internationalisation processes of regional entities in different contexts, with emphasis on the submission of applications to European programmes and participation in international networks. This collaboration between entities from different regions and countries is driven, namely, by the European S3 Platform of the European Commission, through different initiatives (peer-review and peer-learning workshops, dissemination of information, studies, etc.).

The following figure represents the different levels and instruments of international cooperation within the framework of smart specialisation strategies.

Phase 6 — Development of joint, cross-border, interregional, transnational or macro-regional strategies

Phase 5 — Formation of strategic platforms

Phase 4 — Development of joint actions or projects in specific priority areas

Phase 3 — Opening of programmes to partners from outside

Phase 2 — Implementing good practices from other regions

Phase 1 — Sharing of information and good practices

Figure 27 • Phases and instruments of international cooperation in the context of smart specialisation
Source: Gianelle, Kyriakou, Cohen & Przeor (2016)

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[34]   Foray, D., Goddard, J., Beldarrain, X. G., Landabaso, M., McCann, P., Morgan, K., Nauwelaers, C. & Ortega-Argilés, R. (2012). *Guide to Research and Innovation Strategies for Smart Specialisation (RIS 3). Brussels: European Commission.*

[35]   Gianelle, C., Kyriakou, D., Cohen, C. and Przeor, M. (eds) (2016*). Implementing Smart Specialisation: A Handbook. Brussels: European Commission.*

The lowest level (Stage 1) corresponds to the sharing of information and good practices between regions, followed by the level of implementing good practices from other regions (Stage 2). The opening of programmes to partners from outside (Phase 3) and the development of joint actions or projects in specific priority areas (Phase 4) constitute the intermediate levels of international cooperation. The most advanced levels of cooperation encompass the formation of strategic platforms (Phase 5) and the development of joint, cross-border, interregional, transnational or macro-regional strategies (Phase 6).

Norte Region Smart Specialisation Strategy for 2014-20 period played a relevant role in the framing of internationalisation processes of regional entities in different contexts, with emphasis on the development of the joint smart specialisation strategy with Galicia region, the participation and framing of applications to European programmes, such as INTERREG or HORIZON 2020, and the participation in international networks associated with smart specialisation, such as the S3 Platform and the European Vanguard Initiative network.

In the case of Norte Region, one of the most important initiatives of its internationalisation was the development of the Cross-border Smart Specialisation Strategy of Galicia-Norte of Portugal (RIS3T)[36], the first cross-border RIS3 at European level. The RIS3T defined a strategic cooperation framework to provide a coordinated response to shared challenges that, within the scope of innovation policies, can be jointly dealt with more effectively and efficiently, mobilising new initiatives and projects and increasing the attraction of community funds at a European level. This strategy was considered by the European Commission as a good practice of transnational cooperation regarding smart specialisation[37].

The participation in the HORIZON 2020 Framework Programme constituted another relevant dimension of the internationalisation process of the regional smart specialisation strategy. In this context, it should be highlighted the support from HORIZON 2020 to Teaming projects, also developed with the support of the Norte Regional Operational Programme for 2014-20 (NORTE 2020) and framed within priority domains of RIS3 NORTE 2020. Also emphasised should be the participation in European cooperation projects related to smart specialisation under the INTERREG EUROPE Programme, namely the MONITORIS3 project, with the main objective of exchanging experiences in terms of monitoring mechanisms and policy development methodologies in the implementation of regional smart specialisation strategies. Under this project, Norte Region developed the work on the methodological approach for structuring the monitoring system of the regional smart specialisation strategy[38], considered a good practice by the "Interreg Europe Policy Learning Platform" and published on the website of the S3 platform of the European Commission.

Regarding the participation in European networks, Norte is a founding member of the Vanguard Initiative, a network of around 40 European Union regions that have made a political commitment to use their regional smart specialisation strategies to drive new economic growth in areas considered to be priorities at European level. CCDR-Norte's involvement has been assured by its Presidency in meetings at the political level. At the technical level, participation in the working groups of the pilot initiatives is mainly the responsibility of regional stakeholders. Norte Region has also been actively participating in the network of thematic platforms for smart specialisation promoted by the European Commission under the S3 Platform.

The internationalisation work of RIS3 NORTE 2020 has been recognised at European level, as has been highlighted by the European Commission in different initiatives, documents and formal and/or institutional publications. In this regard, the publication by the S3 Platform of two Smart Stories identified as good practices regarding the implementation of Norte Region Smart Specialisation Strategy also stands out, namely, "Monitoring the Norte Region Smart Specialisation Strategy (NORTE RIS3)" published in 2020 and "A triangular methodological framework for priority setting" published in 2016.

Thus, RIS3 NORTE 2020 and CCDR-Norte, as the entity responsible for its promotion, have been involved at the five levels established for international cooperation in the context of smart specialisation, namely: (i) a joint smart specialisation strategy was developed with Galicia region; (ii) the formation of platforms was supported at the most diverse levels, ensuring adequate participation of regional actors; (iii) joint projects

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[36]   Galician Innovation Agency & Norte Regional Coordination and Development Commission (2015). *Cross-border Smart Specialisation Strategy of Galicia-Norte de Portugal (RIS3T)*

[37]   Gianelle, C., Kyriakou, D., Cohen, C. and Przeor, M. (eds) (2016). *Implementing Smart Specialisation: A Handbook. Brussels: European Commission.*

[38]   Monteiro, Rui, Santos, Paulo, Guimarães, Carolina & Silva, Alina (2018). *Norte Region Smart Specialisation Strategy (NORTE RIS3). A Monitoring System Methodological Approach for MONITORIS3 Project*

were implemented with various regions from other European Union countries; and (iv and v) there was active involvement with partners from other regions in the stimulation of activities, the exchange of information and experience and the sharing and adoption of good practices.

In the context of the new programming period 2021-27, one of the criteria established for the fulfilment of the enabling condition regarding smart specialisation strategies is the development of international cooperation measures. Therefore, it is necessary to consolidate and strengthen the development of international networking activities in strategies, projects, networks and programmes, which allow to enhance the participation of regional actors in international networks and global value chains in the priority domains of S3 NORTE 2027.

As already mentioned, the development of joint strategies corresponds to the most advanced level of internationalisation of the smart specialisation strategies and, in the case of RIS3 NORTE 2020, the most advanced stage has been reached with the development of the Cross-border Smart Specialisation Strategy of Galicia-Norte of Portugal (RIS3T). In the Joint Investment Plan (PIC) of the Euroregion Galicia-Norte de Portugal 2021/2027[39] is identified as one of the investment priorities the updating of the Euroregion cross-border RIS3, from the review of regional RIS3. It is thus important to proceed with the update of this strategy, aiming at the mobilisation of new initiatives and joint projects of the Euroregion and the attraction of funds from specific funding sources, such as HORIZON EUROPE. The dimension of cooperation on smart specialisation strategies with other cross-border and macro-regional territorial spaces integrated by Norte Region should also be deepened.

The participation in European networks associated with smart specialisation will also be one of the important dimensions in the internationalisation of the regional smart specialisation strategy. It is therefore important to continue to ensure the participation of Norte in the Vanguard Initiative network, namely in the policy level meetings, in the general assembly of the network and in the network activities, as well as in the working groups of the pilot initiatives under the responsibility of the partner entities of Norte Region. The participation of Norte Region in the S3 Platform of the European Commission, namely in its activities, should also continue to be boosted as an important European network that integrates 180 smart specialisation strategies.

A relevant dimension of the internationalisation of S3 NORTE 2027 also involves its contribution in the framework of the participation of actors from Norte Region in European cooperation projects, namely, in the scope of the Programmes with centralised management at European level. At this level it is considered necessary to fully exploit the synergies and develop complementarities between the different European Union funds for research and innovation. Smart specialisation constitutes a fundamental strategic dimension for the development of such complementarities, namely through prior actions aimed at enabling the participation of stakeholders, subsequent actions to exploit and disseminate the results of the research and innovation developed or actions aimed at combining funds in an integrated research and innovation project.

In the period 2021-27 there is a set of important European programmes for the internationalisation of S3 NORTE 2027. The programmes identified by the PERIN network (Portugal in Europe Research and Innovation Network) were the HORIZON EUROPE Framework Programme for Research and Innovation, DIGITAL EUROPE Programme, ERASMUS+ Programme, EUREKA Programme and the SPACE Programme. In the context of the PERIN network[40], Portugal has set a goal of doubling national participation in the HORIZON EUROPE 2021-27 programme compared to participation in the previous HORIZON 2020 programme, attracting around two billion euros for research and innovation activities, as well as tripling the number of mobile students in Higher Education. Norte Region should be aligned with this strategy and seek to strengthen its participation in European programmes, particularly, in programmes in the area of research and innovation such as HORIZON EUROPE.

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[39]   Comissão de Coordenação e Desenvolvimento Regional do Norte e Xunta da Galiza (2021). *Plano de Investimentos Conjunto (PIC) da Eurorregião Galiza − Norte de Portugal 2021/2027*

[40]   Ministério da Ciência, Tecnologia e Ensino Superior (2021). *Estratégia de promoção da participação nacional nos programas de financiamento da União Europeia 2021-2027: Investigação & Inovação, Erasmus+, Espaço e Digital*

Under the HORIZON 2020 Programme[41], Portugal registered 3 930 participations in projects, correspond-ing to an European co-funding of around 1 150 million euros. At the regional level, the Lisbon Metropolitan Area had the largest participation with around 47% of the total funds raised for Portugal, followed by Norte Region, with 1 063 participations and around 333 million euros of co-funding allocated, corresponding to around 30% of the national total. If the weight of Norte in the funds allocated to Portugal in HORIZON 2020 is maintained, around 30% of the total, and in order for Portugal to meet the established target, Norte needs to be able to attract around 600 million euros of co-funding from the new HORIZON EUROPE Programme.

It should be noted that, in the preparation of S3 NORTE 2027, the different works developed by the European Commission were particularly relevant, assuming that regional policies for research and development and innovation are aligned with the corresponding strategies and policies established by the European Union for the new programming period (2021-27), in particular from HORIZON EUROPE. The following table shows the alignment between the pillars and scope of action of HORIZON EUROPE and the priority domains of S3 NORTE 2027. It can be concluded that the priority domains of S3 NORTE 2027 are strongly aligned with the pillars and scopes of HORIZON EUROPE.

Table 6 • Association between the eight priority domains of smart specialisation and the fields of action of HORIZON EUROPE [42]

Pillars	Scope of activity	Priority Areas S3 NORTE 2027							
		CFH	IAMS	AEFS	SMET	HLS	TSTA	SRE	TSES
Pillar 1 Science for excellence	European Research Council (ERC)	●	●	●	●	●	●	●	●
	Marie Sktodowska-Curie Actions (MSCA)	●	●	●	●	●	●	●	●
	Research Infrastructures (INFRA)	●	●	●	●	●	●	●	●
Pillar 2 Global challenges and European industrial competitiveness	Health					●			
	Culture, Creativity and the Inclusive Society	●					●		
	Civil security for society								●
	Digital, industry and space		●		●				●
	Climate, energy and mobility	●	●	●	●			●	
	Food, bio-economy, natural resources, agriculture and environment			●				●	
	Joint Research Centre (JRC)	●	●	●	●	●	●	●	●
Pillar 3 Innovative Europe	European Innovation Council (ERC)	●	●	●	●	●	●	●	●
	European Innovation Ecosystems	●	●	●	●	●	●	●	●
	European Institute of Innovation and Technology (EIT)	●	●	●	●	●	●	●	●
Broadening participation and strengthening the European Research Area		●	●	●	●	●	●	●	●

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[41]   Source: Dashboard Horizon 2020, accessed at 31/01/2022

[42]   Regulation (EU) 2021/695 of the European Parliament and of the Council of 28 April 2021 establishing Horizon Europe – the Framework Programme for Research and Innovation

Besides this Programme, it should be added the European territorial cooperation programmes under the EU's cohesion policy for 2021-2027, namely, cross-border cooperation, transnational and maritime cooperation, interregional cooperation and the new Interregional Innovation Investment Programme (I3). These programmes are fundamental to strengthen cooperation networks between territorial spaces with common challenges, contributing to achieve higher levels of critical mass in terms of R&D and Innovation based on synergies and complementarities between regions, enhancing the integration in inter-regional value chains in the priority areas of S3 NORTE 2027.

For the implementation of smart specialisation strategies, the new Interregional Innovation Investment instrument (I3) is a very important instrument. It aims to support the commercialisation and expansion of interregional innovation projects in priority areas of common smart specialisation between regions and countries, with the objective of encouraging the development of European value chains with a strong territorial cohesion dimension.

The European Commission also considers that there is a need to fully exploit synergies and develop complementarities between the different European Union funds for research and innovation, particularly those managed directly at European level with those managed at national and regional level. Indeed, Portugal has defined that the promotion of synergies and complementarities with the HORIZON EUROPE Programme is one of the guiding principles of the programming period of European funds of the cohesion policy for 2021-2027, as defined in the resolution of the Council of Ministers No. 97/2020, 13 November.

In the case of HORIZON EUROPE, the following typologies for promoting synergies between this Programme and the ERDF could be implemented[43]: (i) Sequential combination (upstream/downstream): Use of ESIF to support actions that build Research & Innovation (R&I) capacities needed to compete under HORIZON EUROPE and participate in international networks or for dissemination of results from HORIZON EUROPE funded projects; (ii) Alternative funding: Use of ESIF resources for applications that have been positively evaluated under HORIZON EUROPE, but were not funded due to insufficient budget. The most emblematic initiative in this area is the Seals of Excellence; and (iii) Combined use of funds: Combining funding from HORIZON EUROPE and ESIF in an integrated Research & Innovation project, with the ERDF funding the national counterpart or components of the project. This includes, as an example, European Partnerships and Teaming.

The international dimension is thus fundamental in the implementation of the regional smart specialisation strategy. In the context of the new programming period 2021-2027, through the criterion related to the development of international cooperation actions defined in the framework of the enabling condition associated with the smart specialisation strategy, the development of international networking activities in strategies, projects, networks and programmes will be further strengthened, as well as the promotion of synergies and complementarities between programmes, which will allow to enhance the participation of regional actors in international networks and global value chains.

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[43]   The identification of the types of promotion of synergies between the HORIZON EUROPE Programme and the ERDF was based on the types of projects that were considered within the scope of the calls launched by the Norte Regional Operational Programme 2014-20 (NORTE 2020).

7.

Vision and Objectives of Norte Region Smart Specialisation Strategy for 2021-27

This chapter aims to set out the vision, the guiding principles, the strategic objectives and the transversal objectives for the Norte Region Smart Specialisation Strategy for 2021-27. At the end, it also seeks to associate the strategy with the public policy objectives of the 2021-2027 programming period, namely the Thematic Agendas of the PORTUGAL 2030.

This chapter begins with an analysis of the main elements that best characterise RIS in the current historical context, through a synthesis based on SWOT analysis. The relevant aspects of the diagnosis are set out in four quadrants: the "strengths" and "weaknesses", which correspond to the analysis of the "internal environment", understood in this case as the set of elements concerning the regional context that can be strengthened or improved through policy actions specifically defined by and for Norte Region; the "opportunities" and "threats", which constitute the characterisation of the "external environment", i.e. the set of elements related to the national or international context that will influence the evolution of RIS in this NUTS II Region.

Next, the SWOT analysis of Norte Region and its RIS is presented in the next table.

Strengths	Weaknesses
• Innovative performance progress over the last decade, being the 2nd most innovative in Portugal • Economic structure with a strong industrial and entrepreneurial tradition and high export orientation • Companies' resilience to external shocks • Growing differentiation of products moving up in the value chain, namely through the registration of brands and of design • Innovative behaviour of companies, expressed in innovation expenditure per person employed, sales with innovative products and employment in knowledge-intensive activities • Strong progress in the evolution of higher education levels in the 30-34 age group • Gradual change in international specialisation, with the proportion of medium-technology goods increasing in total exports, especially in the automobile sector • Strong comparative advantages in industrial sectors such as textiles, clothing, footwear, furniture, automobile components, beverages and cork • Internationalisation of the regional entities of the SCT and consolidation of the network of institutions of the RIS3 priority domains • Important endogenous resources for energy, agri-food and tourism purposes • Vast historical, cultural, architectural, natural and landscape heritage of excellence • Suitable and functional governance model for the regional smart specialisation strategy • Priority given, within the framework of national and Community public policies, to strengthening the industrialisation of economies • Growth of European protectionism with a positive impact on the creation of companies and on the supply of inputs and intermediate goods • Reduction in the importance of geographical centrality in the location of production	• Structural weaknesses of the Regional Innovation System presenting a strong systemic relationship • Reduced connection between the scientific and business systems and low economic valuation of knowledge (e.g. patents) • Low qualification of human resources and reduced investment in entrepreneurial R&D and innovation • Spatially unbalanced network of RIS institutions, with a clear division between low-density territories and the rest of the Region • Region with the lowest productivity in Portugal as a result of sectorial weaknesses (activities of low added value) and of regional scope (difficulty in producing and retaining income) • Productive structure still based on sectors of low added value with little propensity for the registration of more sophisticated industrial property • International pattern of exports of goods based on low technology products with strong territorial concentration • Uncompetitive real salaries for attracting and retaining qualified human resources • Mismatches between professional qualifications, the education system and the training offer in relation to the needs and future challenges of the Region's productive sector • Sharp demographic decline in low density territories, extensification of agricultural activities and reduction of agricultural surface area • Weak digital connectivity in the interior of the region, associated with low digital literacy • Strong economic contraction caused by the pandemic with falling external demand • Slower recovery of national and European economic growth, accelerating the drain of capital to other regions

Strengths	Weaknesses
• New post-Covid-19 technological trends associated with the digitalisation of consumption, distribution and production of goods and services • Acceleration of the energy transition process and the creation of new international markets for the production and diffusion of technologies • Changes in the productive profile that mobilize the training potential of human resources • Increase the national incorporation in products of the large companies installed in Norte Region • Relevance of smart specialisation strategies and their governance models for innovative and smart economic transformation in the EU context • Technological intensification of the regional industrial base in the production of technologies (equipment, etc.), final goods and knowledge and services in the areas of engineering (e.g. fashion, habitats, mobility and advanced manufacturing systems) • Productivity gains and economic growth associated with priority domains that are more dependent on technology (e.g. advanced manufacturing systems, mobility, health and the economy of the sea) • Territorial broadening of the economic base from the valorisation of territory-intensive assets and resources (e.g. agro-environmental and tourism) • Growth of the space economy in global terms, using skills and technologies at the frontier of knowledge, transferable to other application areas • Potential for articulation with other cross-border and European programmes, networks and strategies in the framework of the internationalisation of the regional smart specialisation strategy • Progressive enhancement of the territorial dimension, whether regional or sub-regional, as an integrating matrix of various sectoral policies	• Persistence of the excess installed capacity due to the health crisis and consequent delay in the process of industrialisation of the economy and in the level of investment by companies • Worsening of the difficulties faced by companies in accessing credit and maintenance of insufficiencies in venture capital • Difficulty in retaining and attracting qualified labour given the wage levels practised • Ageing trend with repercussions on the size of the labour pool available in the future • Insufficient capacity for change in the educational and training system for the active population to interact effectively with the challenges of digital transformation • Fall in tourism demand as a result of the pandemic and possible disinvestment in culture and material cultural heritage • Advancement of climate change with harmful consequences for the territory (e.g. loss of biodiversity, coastal erosion, floods, droughts and rural fires, among others) • Agricultural and rural exodus with the consequent reduction of the population in agricultural, farming and forestry activities • Difficulties of articulation between entrepreneurial discovery processes of the smart specialisation strategies and the responsiveness of the governance model of community funds

Following this SWOT analysis and even before carrying out any exercise to define the regional smart specialisation strategy for the 2021-2027 period, it is important to revisit the strategy established in the previous programming period (2014-2020). In that context, the following vision was presented: "Norte Region will be, in 2020, a bastion of Industrial Europe, asserting itself through innovation and building dynamic competitive advantages that support a new trajectory of strong economic growth and job creation".

After two deep recessions, resulting from the 2008 international financial crisis and the ensuing national sovereign debt crisis, Norte's economy entered a period of economic recovery during the previous programming period (2014-2020). With the exception of 2015 (and 2020, due to the pandemic crisis associated with COVID-19), Norte's economic growth outperformed that of the country and the European Union. This double convergence in so many consecutive years is unparalleled in the current century. While it is true that there are several factors that have contributed to this new trajectory, the following should be highlighted: industrialisation, export competitiveness and the valorisation of specific territorial assets.

The increase in the relative importance of activities that are more open to the exterior has accompanied the growth in external demand directed to Norte Region, having been, prominently, the most exporting region of the country. In 2021, exports of goods reached a value of 23 292 million euros, 36.6% of the national total, contributing decisively to mitigate the country's structural imbalances in terms of external indebtedness. At

the same time, in dynamic terms, it has seen a significant improvement in its international competitiveness, with the value of exports increasing by 45.4% between 2011 and 2021. As a result of more inclusive and more competitive growth, Norte was the region of the country that contributed most to both fiscal balance and the promotion of external balance, due essentially to its strong export-oriented industrial tradition and the resilience of its companies to external shocks.

According to the Regional Innovation Scoreboard, Norte Region has been making remarkable progress for almost a decade, ranking in 2019 as "Strong Innovator -". However, in 2021, it was once again classified as "Moderate Innovative". The main conclusions made regarding the analysis of the "Innovation and R&D Indicators in Norte Region" carried out in 2018 are maintained. In comparative terms, Norte became the 151st most innovative region in 2021, a position clearly lower than the 100th place occupied in 2019. Notwithstanding this negative evolution in the European context, in national terms Norte continues to be the 2nd most innovative region in Portugal, maintaining the position it held in 2019. Thus, there continue to be no structural changes in the RIS, with the main weaknesses remaining, namely, reduced investment in business R&D, low qualification of human resources, reduced links between the scientific and business systems and low economic valuation of knowledge.

As regards RIS, it should be noted that the network of institutions in this system is spatially unbalanced in Norte. There is a clear division between the main urban centres, and in particular the Metropolitan Area of Porto, and the rest of the region in the distribution of this type of institution, or in other words, between the low density territories and the others, which are more economically and demographically dynamic. At the same time, there is a pattern of low density territories compared with the others, with mono-specialisation predominating in the former as opposed to greater diversification and resilience in the latter.

In this context, it is necessary to formalise and consolidate the RIS, strengthening the articulation between the STS entities and the business fabric and the alignment of innovation support with the regional strategy, based on the governance model of the regional smart specialisation strategy and a better articulation with the European Structural and Investment Funds. On the other hand, it was also defined as a priority the promotion of a more territorially distributed and balanced RIS, capable of responding to the challenges of valorising the products and activities of Norte, based on a network of institutions with different profiles, from fundamental research to support for business innovation, in close articulation with higher education institutions. This rebalancing of the RIS is fundamental to support economic activities with greater potential to broaden the territorial economic base and promote competitiveness.

Thus, in a context of profound technological and geopolitical transformations, the smart specialisation strategy of Norte Region has to be at the service of a broader vision from that set out in the Norte Development Strategy for the 2021-2027 Programming Period of European Union Policies (NORTE 2030). In this sense, the vision for S3 NORTE 2027 is as follows:

> *"Development of Norte Region and its international affirmation through a focus on knowledge and competitiveness of the economy, supporting a new trajectory of strong economic growth, job creation and territorial cohesion"*

This vision presupposes the following principles that should shape the consequent action to pursue it:

- **Retaining and attracting people** and enhance their multiple and irreplaceable talents, from the creative to the entrepreneurial, in a context of permanent improvement of their educational and skills levels;

- **Develop differentiating knowledge in the most diverse areas of smart specialisation** oriented to enhance economic and social activities, the supply of their goods and services and their tangible and intangible heritage;

- **Promote and attract selective investment** to boost economic activities of high added value, with environmentally friendly technologies and production processes that respect human rights and citizenship.

Enunciating a vision and a series of principles does not configure a development strategy by itself. It also presupposes the definition of strategic and transversal objectives that should be based on the NORTE 2030 Strategy. It will be difficult to strengthen the regional economy without continuing the effort of **technological intensification of its productive base**. This strategic objective of technological intensification is mainly aimed at the regional industrial base, either in the production of technologies (equipment, etc.), or in the production of final goods, or in the production of knowledge and services in the areas of engineering. There are priority domains of smart specialisation that are closer to this industrial base, such as: "Creativity, Fashion and Habitats", "Sustainable Mobility and Energy Transition", "Industrialisation and Advanced Manufacturing Systems".

This strategic objective aims to respond to the need to develop and valorise the industrial sector (including its products) by: (i) integrating the best practices leveraged by digital and biological transformations, as well as advances in the fields of manufacturing and materials technologies; and (ii) leveraging new business models, namely those resulting from the growing mix between products and services.

The technological intensification effort must be accompanied by the **economic valuation of assets and resources intensive in territory** that are susceptible for the production of goods and services tradable in a wider market. Territory-intensive assets are understood as natural productive, heritage, built and symbolic resources that tend to be inimitable and non-transferable. Their economic valorisation is more closely associated with priority domains of smart specialisation such as: "Agro-environmental and Food Systems" or "Tourism Services and Territorial Assets". It aims to meet the need to develop and enhance the agrifood sector (including forestry, agriculture, livestock and food processing), in order to promote agriculture that generates greater added value (including precision agriculture) and is compatible with the preservation and management of resources such as water, forests and ecosystems.

An economic development strategy sustained on external demand, as the one enunciated, taking into account its regional specificities, also requires the **improvement of the regional competitive positioning on a global scale.** This strategy is aligned with the national economic policy goal of reducing the current account deficit and, especially, its balance of goods and services. It will be very difficult for such a policy to be implemented at national level without the active participation of Norte, the most exporting Portuguese region and the one with the greatest knowledge and experience in international markets.

This strategy is faced with the need to explore new markets and new business models, the internationalisation of companies and the commercial positioning of companies in emerging markets. However, this strategy also confronts geopolitical changes in the large regional economic blocks and the emergence of new industrialisation processes and business models, whose effects are amplified in the current context of the Covid-19 pandemic, with disruption of global value chains and the importance of macro-regional, national and regional manufacturing capacity to ensure sovereignty.

In a transversal way, it is also important to **increase the qualifications of the population**, namely at the higher education and advanced training levels, as well as lifelong training. The present and the near future bring unexpected challenges, which give new expression to the mismatch between qualifications and jobs. The consequences of the pandemic, in interaction with the response to the climate emergency and the geopolitical and geostrategic evolution, have impacts on the labour market, demanding industrial reconversion and industrialisation processes, which will require adequate technical and technological training.

Two more objectives are added to this transversal objective: one regarding **territorial equity in the supply of quality public goods and services**, in areas such as education, culture, health or social support, as a way to ensure effective equal opportunities for citizens. At the level of higher education and to consolidate the growth of its attendance, it is additionally justified to: (i) continue the path of diversification of supply; (ii) strengthen continuous and post-graduate training; (iii) positive discrimination of institutions located in low density territories; (iv) internationalisation of the system, mobility and integration into European and global networks; and (v) improve the response of social action.

The other transversal objective is associated with **improving the effectiveness and efficiency of the regional governance model**, ensuring more and better public scrutiny and full representation of the main actors and regional institutions, without resulting in conflicts of interest, and with a sense of commitment. This objective is fundamental to the achievement of the priorities established for RIS that aim at its formalisation and consolidation, as well as the promotion of a more territorially distributed and balanced system capable of responding to the challenges of valorising the products and activities of Norte Region.

The following figure presents this strategy in its different strategic and transversal objectives, naturally aligned with the regional development strategy NORTE 2030.
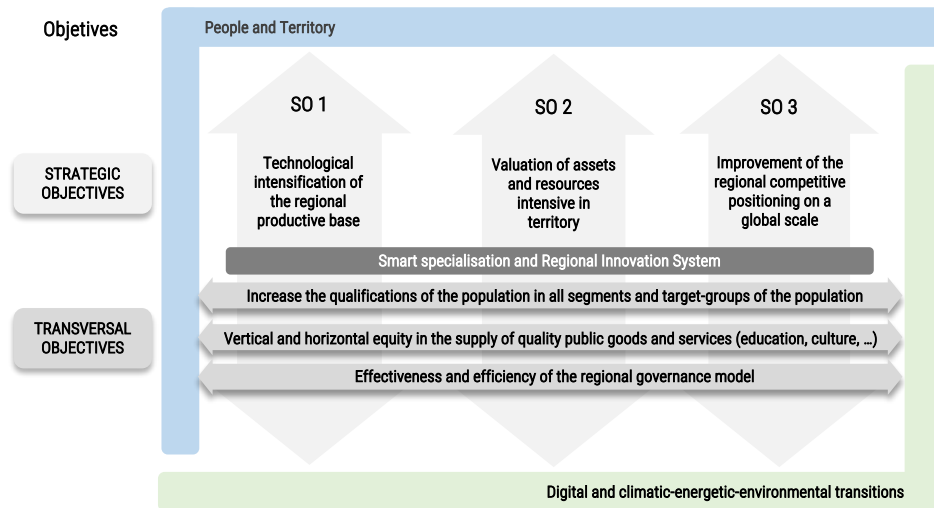

Figure 28 • Norte Region Smart Specialisation Strategy • S3 NORTE 2027

Thus, the strategic objectives of the Smart Specialisation Strategy are the following: (SO1) technological intensification of the productive base; (SO2) economic valorisation of assets and territory-intensive resources; (SO3) improvement of competitive positioning on a global scale. To these strategic objectives are added three transversal objectives: (TO1) increasing the qualifications of all segments of the population; (TO2) vertical and horizontal equity in the access to quality public goods and services; (TO3) effectiveness and efficiency of the model of regional governance.

In addition to the objectives, was taken into account the context of the strategy marked by the digital and climate-energy-environment transitions, in accordance with the European Ecological Pact. However, technologies are not neutral in terms of their economic, social and territorial effects, producing and reproducing themselves differently in different contexts. The opportunities for some correspond to threats for others, while the central concern is always people, their social and territorial contexts of life and their aspirations and dignity.

It is also important to establish the articulation of this strategy S3 NORTE 2027 with the Thematic Agendas (TA) of the PORTUGAL 2030, defined by the Resolution of the Council of Ministers no. 98/2020 of 13 November, namely: (1) People first: a better demographic balance, greater inclusion, less inequality (TA1); (2) Digitalisation, innovation and skills as engines of development (TA2); (3) Climate transition and sustainability of resources (TA3); and (4) An externally competitive and internally cohesive country (TA4).

The articulation of S3 NORTE 2027 with the Transversal Objectives is presented in the following table. The intensity of this articulation is given by the number of "+" signs, the greater the number of these signs, the greater articulation.

Table 7 • Articulation of the Strategic and Cross-cutting Objectives of S3 NORTE 2027 with the Thematic Agendas of PORTUGAL 2030

Thematic Agendas	Strategic Objectives			Transversal Objectives		
	SO1	SO2	SO3	TO1	TO2	TO3
TA1	+	++		+	+	+
TA2	+++	++	+++	+++	++	+
TA3	++	++	++	++	++	+
TA4	+	++	+++	++	++	+

Finally, it should be noted that the financing of this strategy is not limited to the Cohesion Policy, but may include investment from other sources of financing, such as the Recovery and Resilience Plan, the Strategic Plan of the Common Agricultural Policy or the centrally managed Programmes of the European Commission (e.g. HORIZON EUROPE, DIGITAL EUROPE Programme, InvestEU, I3, etc.).

8.

Governance of Norte Region Smart Specialisation Strategy for 2021-27

The innovation system is the result of the influence generated in a set of elements and interconnections at the moment of production, diffusion and use of new and useful knowledge from the economic point of view. This concept, in its regional dimension, is inspired by a rationale that emphasises the territorial basis of these systems. This rationale derives, on the one hand, from the existence of knowledge-based technological trajectories that reveal high levels of territorial adherence and localised learning within a given region and, on the other hand, from the presence of knowledge-generating organisations whose product can be economically exploited, emerging new economic activities.

A Regional Innovation System can be seen as the institutional infrastructure that supports innovation in the regional productive structure, consisting of two subsystems: the subsystem for the application and exploitation of knowledge, mainly composed of enterprises vertically integrated in supply chains, and the subsystem for the generation, dissemination and transfer of knowledge, consisting essentially of entities of the STS, including higher education institutions, research and development (R&D) institutions, as well as technology transfer and interface institutions with enterprises.

Each RIS implies the existence of an autonomous governance model capable of generating the necessary interactions between relevant stakeholders, namely in entrepreneurial discovery processes. Norte's RIS is formed by a series of agents from different areas and competences, whose interactions among themselves and with other entities contribute to the production, dissemination and valorisation of knowledge. The following figure shows the identification of the main groups of agents that currently structure Norte's RIS.
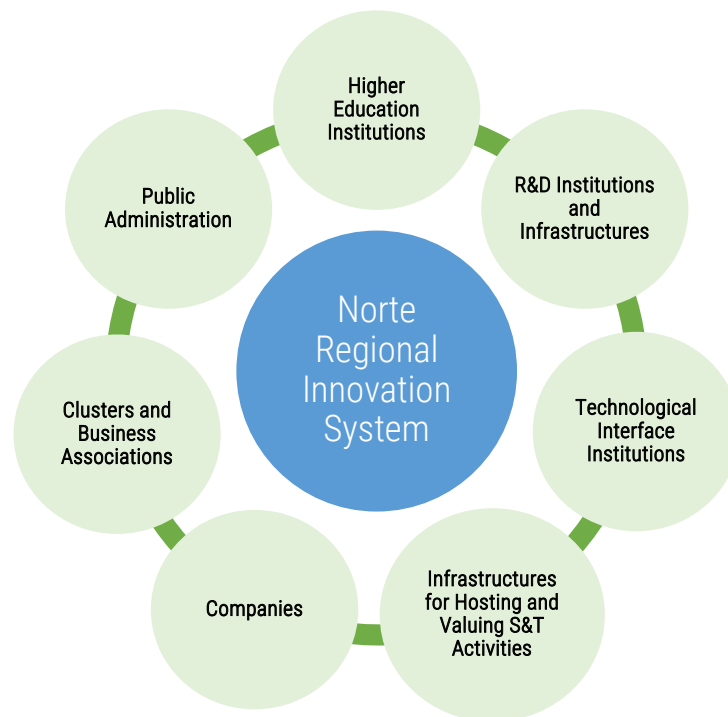
Figure 29 • Agents of Norte's Regional Innovation System[44]

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[44]   In the case of "R&D Institutions and Infrastructures", R&D Units, State Laboratories, Associated Laboratories and Science and Technology Infrastructures are included. With regard to "Technological Interface Institutions", it includes Technology Centers and Interfaces (CIT), Collaborative Laboratories (CoLAB), Technology and Innovation Centers (CTI), Technology Transfer Offices (TTO) and other interface entities between the academic, scientific and technological system and the business fabric. The "Infrastructures for Hosting and Valuing S&T Activities" include Science and Technology Parks and Technology-Based Incubators.

The governance model of RIS3 NORTE 2020 assumed the creation of the Norte Regional Council for Innovation (CRIN), aiming to ensure active participation in the monitoring and continuous evaluation of the implementation of the regional strategy and contribute to the decision-making process. In late 2017, at the proposal of the Presidency of CCDR-Norte, the constitution and competences of this body were assessed and decided by the CCDR-Norte Regional Council[45], in accordance with the provisions of Article 7 of Decree-Law 228/2012 of 25 October, thus gaining increased institutional legitimacy.

This advisory body is chaired by the President of CCDR-Norte and includes representatives of technology producers and advanced users, STS entities, higher education institutions, business and trade union associations, competitiveness poles and clusters, national planning and management entities for research and development and innovation policies and intermunicipal entities. Its competences are namely the following: (i) to appraise the strategy and operation of Norte's RIS (to be established); (ii) to appraise and approve recommendations and proposals for action lines to be submitted to the Managing Authorities of the relevant Operational Programmes; (iii) to appraise and approve the RIS3 monitoring reports; and (iv) to appraise and approve proposals for the revision of RIS3.

The CRIN met in plenary and in sections oriented to the priority areas of regional smart specialisation, which were constituted as Regional Smart Specialisation Platforms (PREI). These platforms aimed to ensure a regional multi-institutional and multi-sectoral response for the monitoring and evaluation of RIS3, seeking to boost cooperation and networking, internationalisation and entrepreneurial discovery spaces. Involving around 170 entities divided by the eight platforms, they consist of: R&D infrastructures and units, technology transfer centres, clusters, business associations and public entities. The following figure shows the distribution of the entities that constitute the PREI.
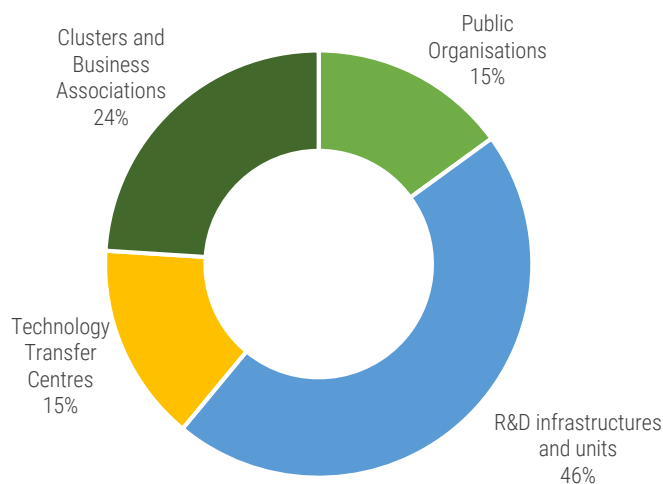
Figure 30 • Constitution of Regional Smart Specialisation Platforms
Source: RIS3 monitoring system

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[45]   Comissão de Coordenação e Desenvolvimento Regional do Norte (2019). *Constituição do Conselho Regional de Inovação do Norte (CRIN) Aprovada pelo Conselho Regional da Comissão de Coordenação e Desenvolvimento Regional do Norte* (Approved in April 2017 and amended in December 2017 with the appointment of representatives at CRIN and in July 2019 with the appointment of representatives of the regional smart specialisation platforms).

Taking into account the guidelines established by the European Commission[46], CRIN and its PREI respect the following principles:

- **Quadruple Helix** – allow a broad participation of the main regional actors, based on the quadruple helix model, involving representatives of companies, educational, research and development institutions, public entities for planning and managing R&D&I policies and innovation users or entities representing the demand dimension and innovation consumers;

- **Collaborative Leadership** - promote and implement flexible decision-making processes that enable each actor involved to play a proactive role, taking the lead in certain projects or issues, according to their skills and knowledge;

- **Multi-level governance** - ensure the cross-participation of national bodies responsible for the implementation of research and innovation policies in CRIN and CCDR-Norte in the governance bodies of the national dimension of the multi-level smart specialisation strategy;

- **Entrepreneurial Discovery Spaces** - create virtual or physical, thematic and regional spaces for interaction and articulation between institutional actors and stakeholders, whether in the academic, scientific and technological or in the business environment, that induce and nurture the entrepreneurial discovery;

- **Adequate Dimension** - ensure that CRIN is adequately sized for the exercise of its competences, namely by ensuring an effective model for the involvement of the main actors.

In this governance model, a management team was also formed to support CRIN and the different platforms, ensuring the collection, processing and availability of qualitative and quantitative information relevant to monitoring the implementation of the strategy. This information is essential for monitoring and evaluating the strategy and its different priority areas of smart specialisation, namely regarding its implementation by the funding from Operational Programmes.

Since its establishment, this model allowed meetings of CRIN and the different platforms to analyse the information regarding the monitoring of each priority area of smart specialisation. The interactions in this context served to prepare the CRIN plenary meeting for the appraisal and approval of the strategy monitoring report[47]. CRIN was also responsible for the approval of S3 NORTE 2027 - Initiative for the Revision of the RIS3 NORTE 2020 in the Context of the Programming Period 2021-27. According to the approved methodology, further interactions were developed in the context of each platform for reviewing the different priority domains, namely through surveys. After these interactions, the first revision works of RIS3 NORTE 2020 were appreciated by CRIN[48/49].

This description and analysis allows us to conclude that the RIS3 governance model has proved adequate and functional in the development of its competences. Essentially, this model will be maintained for the new programming period 2021-27, with the possibility of making specific changes, such as updating the entities that constitute the different categories of participants. Perhaps it may be necessary to establish new sections of the CRIN according to certain sectoral areas, such as higher education, a situation that is provided for in its operating rules. Other changes may result from the need to articulate the regional level and the national level, assuming that the Portuguese State intends to meet this enabling condition through a multi-level strategy, as in the 2014-20 programming period of European Union policies.

Based on the review of the priority domains set out in the S3 NORTE 2027, the governance model of this strategy for the period 2021-27, involving the CRIN, its smart specialisation platforms and its management team, is represented in the next figure.

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[46]   Foray, D., Goddard, J., Beldarrain, X. G., Landabaso, M., McCann, P., Morgan, K., Nauwelaers, C. & Ortega-Argilés, R. (2012). *Guide to Research and Innovation Strategies for Smart Specialisation (RIS 3). Brussels: European Commission.*

[47]   Monteiro, R., Meira, R. Santos, P., Leite, V., Guimarães, C. & Gomes, J. (2019). Estratégia de Especialização Inteligente da Região do Norte. Relatório de Monitorização. Porto: Comissão de Coordenação e Desenvolvimento Regional do Norte.

[48]   Monteiro, R., Meira, R., Santos, P., Guimarães, C., Silva, A., & Lopes, P. (2020). Domínios prioritários de especialização inteligente: tendências internacionais de procura e políticas e estratégias de investigação, desenvolvimento e de inovação - Relatório final. Porto: Comissão de Coordenação e Desenvolvimento Regional do Norte.

[49]   Monteiro, R., Meira, R., Santos, P., Guimarães, C., Silva, A., & Lopes, P. (2020). S3 NORTE 2027- Inquéritos aos membros das Plataformas Regionais de Especialização Inteligente. Apresentação e discussão de resultados.
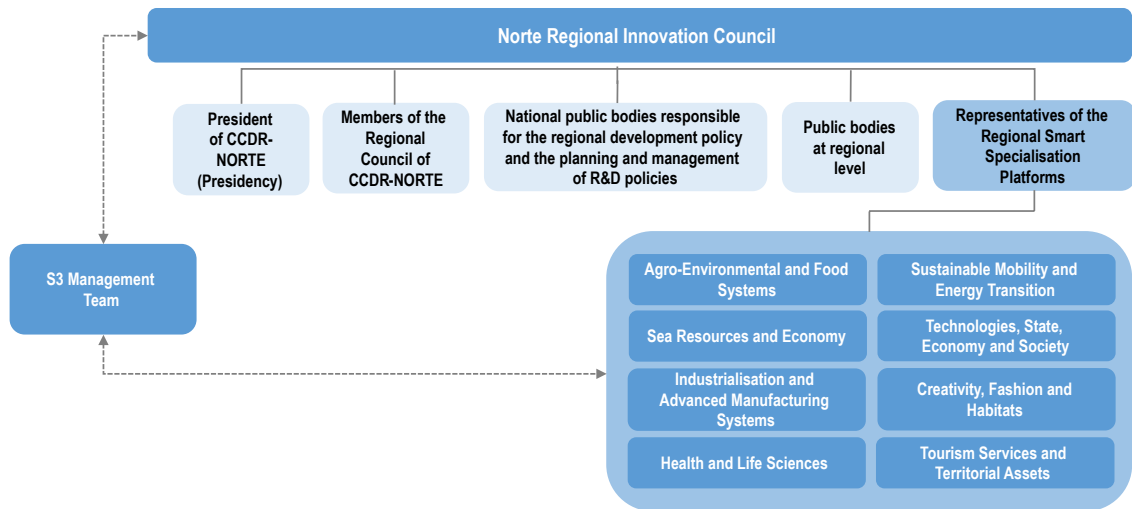
Figure 31 • Governance model of Norte Region Smart Specialisation Strategy for 2021-27

The main change is not about the governance model itself, but in its relationship with the PORTUGAL 2030 governance model. As concluded in the monitoring report of RIS3 NORTE 2020 approved by CRIN, the very difficult articulation between entrepreneurial discovery processes and the necessary capacity of the governance model of PORTUGAL 2020 (CIC, Management Authorities, Networks) to respond with specific calls to potential specific investment opportunities, made it less relevant to use the promotion of interaction processes between stakeholders, except in internationalisation activities of RIS3 NORTE 2020. These articulation difficulties should be overcome and, for that purpose, the governance model enunciated constitutes an adequate response.

The Cohesion Policy regulations for the new programming period 2021-27[50] define that smart specialisation strategies (S3) and their governance model continue to be of equal relevance and constitute the only enabling condition for funding under Policy Objective 1 (PO1), which includes support in the areas of innovation, digitalisation, economic transformation and SME support. This enabling condition of the S3 concerns mainly their good governance, being one of the criteria for its fulfilment the effective functioning of the entrepreneurial discovery process.

In this context, the Specific Objective (SO) 1.4, foreseen in PO1, which aims to develop skills for smart specialisation, industrial transition and entrepreneurship, will be very important for smart specialisation strategy implementation. With the mobilisation of this SO, the aim is to boost the regional innovation systems or innovation ecosystems of the different priority areas of smart specialisation, ensuring adequate levels of interaction between their agents within the governance models of the respective regional smart specialisation strategies.

To this end, it is necessary to empower and stimulate the concerted action of public and private entities that support the business environment, promoting cooperation, coordination and the constitution of networks and partnerships for the implementation of smart specialisation strategies based, namely, on entrepreneurial discovery processes. The implementation of this SO will thus contribute to the identification of competitive advantages and distinctive resources of the regions, as well as to the mobilisation of the relevant actors for the operationalisation of the smart specialisation strategies.

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[50]   Regulation (EU) 2021/1060 of the European Parliament and of the Council of 24 June 2021 laying down common provisions on the European Regional Development Fund, the European Social Fund Plus, the Cohesion Fund, the Just Transition Fund and the European Maritime, Fisheries and Aquaculture Fund and financial rules for those and for the Asylum, Migration and Integration Fund, the Internal Security Fund and the Instrument for Financial Support for Border Management and Visa Policy.

9.

Monitoring and evaluation system of Norte Region Smart Specialisation Strategy for 2021-27

The development of a monitoring system is essential to assess whether the regional smart specialisation strategy is being implemented according to plan, thus supporting decision-making on proposals for action lines and the maintenance of priority domains or the possible need to undergo adjustments, constituting a step towards in-depth evaluations. It also serves the purpose of disseminating information on the implementation of the strategy to build a transparent process of interaction with stakeholders involved in its governance model.

According to the Cohesion Policy Regulations for 2021-27, the fulfilment of the enabling condition associated with the governance of smart specialisation strategies presupposes the definition of monitoring mechanisms that ensure follow-up and evaluation to measure the performance of the regional smart specialisation strategy. The monitoring system should follow the development of the priority domains and analyse how the implementation of the strategy articulates with its strategic objectives and its transversal objectives in order to achieve the defined vision.

Considering that the governance of smart specialisation strategies is an enabling condition for funding Policy Objective 1 (PO1) in the period 2021-27, which includes support in the areas of innovation, digitalisation, economic transformation and support for SMEs, its monitoring process will have to be aligned with the monitoring system of the Operational Programmes of the European Structural and Investment Funds, in particular the Operational Programme for Norte Region for 2021-27 and its achievement and result indicators.

In the working document on monitoring the European Regional Development Fund for 2021-27[51], the European Commission sets out the main concepts and terms that should be used in the Horizon of monitoring systems for this new programming period. The main changes compared to the previous period are the following: (i) simplification of the intervention logic by reducing the number of policy objectives, specific objectives and programme content; (ii) change in the focus of result indicators from measuring impacts to measuring the direct effect of the supported interventions; (iii) development of a more complete list of common output indicators and a new list of common result indicators with the intention to improve the investment coverage of common indicators; (iv) reforming the performance framework to cover all output and outcome indicators; (v) using specific objectives for defining the intervention logic, articulated with data on output, outcome and input indicators; and (vi) simplifying evaluation requirements.

Indicators are thus the main monitoring tool, expressing outputs, outcomes and inputs, as well as monitoring measurable progress towards the achievement of the defined objectives. The European Commission establishes that the monitoring of outputs and results is essential for the pursuit of Cohesion Policy objectives, defining for the 2021-27 period the following structure of indicators:

- **Input indicators** - Indicators that refer to the budget allocated to each level of public policy priority;

- **Output indicators** - Indicators measuring the specific deliverables of the intervention;

- **Result indicators** - Indicators that measure the effects of the supported interventions, in particular as regards the direct beneficiaries, the target population or the users of the infrastructures.

As part of the implementation activities of RIS3 NORTE 2020, a Monitoring System was structured with the aim of coherently monitoring different public policy objectives. This system was based on the methodology developed by CCDR-Norte in the document "Norte Region Smart Specialisation Strategy (NORTE RIS3). A Monitoring System Methodological Approach for MONITORIS3 Project"[52]. The publication is available on the European S3 Platform website, and the methodology developed was considered good practice by the "Interreg Europe Policy Learning Platform" and selected for presentation at the thematic workshop, organised by the Interreg Europe Joint Secretariat Team, "Better Monitoring, Evaluating, and Designing Regional Research and Innovation Strategies for Smart Specialisation (RIS3)", held on 25th September of 2019.

The main result of this monitoring system was the elaboration of the RIS3 NORTE 2020 monitoring report, approved by the Norte Regional Innovation Council (CRIN) on 8th October of 2019. As referred in the previous chapter, this is the consultative body designed to ensure the active participation of regional stakeholders

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[51]   Commission Staff Working Document SWD (2021) 198 final. Performance, monitoring and evaluation of the European Regional Development Fund, the Cohesion Fund and the Just Transition Fund in 2021-2027.

[52]   Monteiro, Rui, Santos, Paulo, Guimarães, Carolina & Silva, Alina (2018). Norte Region Smart Specialisation Strategy (NORTE RIS3). A Monitoring System Methodological Approach for MONITORIS3 Project.

and other actors of a more transversal or supra regional nature in the monitoring and continuous evaluation of the implementation of the strategy and to contribute to the strategic decision-making process of Norte Region.

The RIS3 monitoring activities continued with the public dissemination of the monitoring report and the launch of the participatory process for its review held as part of the annual event on "Norte of Portugal: The paths of an innovative region", which took place on 6th December of 2019, chaired by the Minister of Science, Technology and Higher Education. This monitoring was also fundamental to support the review process of the regional smart specialisation strategy for 2021-27.

The system of indicators thus constitutes the main tool for monitoring and evaluating the implementation of the smart specialisation strategies. However, the monitoring exercise of the smart specialisation strategy is not restricted to checking compliance with the input, output and result indicators associated with the Regional Operational Programme for 2021-27. The concentration of these indicators on the established priority areas constitutes one of the main differences between monitoring a smart specialisation strategy and an operational programme[53], i.e. the indicators can be the same, the difference being in their distribution by priority domains of smart specialisation.

In this sense, the monitoring of the smart specialisation strategy presupposes that the input, result and output indicators of the Regional Programme for 2021-27 are disaggregated by priority domains of S3 NORTE 2027. Thus, the information system of the Regional Programme for 2021-27 has to guarantee the production of information necessary for the adequate monitoring of the implementation of S3 NORTE 2027, both in overall terms and in each priority domain of smart specialisation.

The monitoring of a strategy such as S3 NORTE 2027 thus consists in verifying the level of achievement of its objectives. Since this is a strategy, there are different objectives and these objectives are not all at the same hierarchical level. Although all are important, the achievement of the strategy as a whole implies the existence of objectives which, due to their amplitude, present a greater relative importance than others.

It is thus a matter of coherently monitoring different public policy objectives which are not always situated at the same hierarchical level in the "tree of objectives" of the strategy and the implementation of the respective funding instruments. The indicators and respective targets assume an instrumental dimension: they serve to verify the achievement of the objectives at the different levels.

The regional strategy for smart specialisation has a monitoring system that makes it possible to follow the development of the priority domains and analyse how the implementation of the strategy is articulated with its strategic objectives and transversal objectives in order to achieve the defined vision. The indicators associated to the priority domains constitute the nodal point of the entire monitoring model. It is the information obtained at this level that enables at each moment the fine tuning of public policies.

In this sense, the structure of this monitoring system is based on the model developed in the previous Norte Region Smart Specialisation Strategy for 2014-20 with the necessary adaptations arising from the changes established for the monitoring indicators of the European Regional Development Fund in the period 2021-27. The following figure represents the updated structure of the Monitoring System of S3 NORTE 2027.

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[53]   Gianelle & Kleibrink (2015). Monitoring Mechanisms for Smart Specialisation Strategies.
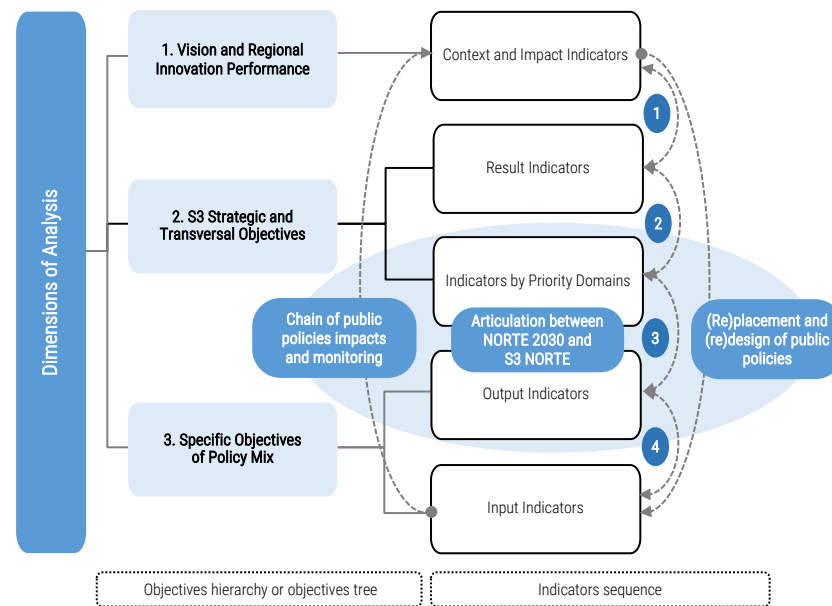
Figure 32 • Structure of the monitoring system of S3 NORTE 2027

Source: Adapted from Monteiro, Rui, Santos, Paulo, Guimarães, Carolina & Silva, Alina (2018).

On its left side are the duly hierarchised objectives or "tree of objectives". The first two levels constitute the two groups of objectives referred to when defining the S3 NORTE 2027, namely the defined vision and the strategic and transversal objectives of this regional smart specialisation strategy. As this strategy does not have its own budget and it is necessary to mobilise the resources from the Norte Regional Programme, of which it is an enabling condition, below these two levels, there is a last level that corresponds to the objectives of the public policy instruments that are mobilised for the financing of S3 NORTE 2027.

On the right side of the figure with the monitoring system structure, the sequence of indicators is represented, with each type of indicator corresponding to a certain level of the hierarchy of objectives: "Context and impact indicators" correspond to the "Vision and regional performance of the innovation system"; "Result indicators" and "Indicators by priority areas" correspond to the "Strategic and transversal objectives of S3"; "Specific objectives of the Policy Mix" correspond to "Output indicators" and "Input indicators".

In the preparation of S3 NORTE 2027, as in any other planning exercise, a top-down approach is chosen. The diagnosis is made based on context indicators to identify strengths, weaknesses, opportunities and threats of a regional innovation system, allowing the preparation of the strategic vision. The achievement of this vision also presupposes the accomplishment of strategic and transversal objectives, which are measured by relevant result indicators.

The existence of different priority domains in S3 NORTE 2027 requires the inclusion of another type of indicator, which aims to measure the relative importance attributed to each of these domains. This specificity results from the fact that not all priority areas contribute equally to the achievement of the first and second level objectives defined. In turn, the achievement of the strategic and transversal objectives presupposes that the specific objectives of the policy mix are also achieved, measured by input and output indicators.

Monitoring is a bottom-up exercise and therefore inverse to the planning exercise. It begins by verifying whether the specific objectives of the policy mix are being achieved through input and output indicators. The next step is to check whether the strategic and transversal objectives are being achieved by means of result indicators and indicators per priority domain. Finally, the aim is to understand whether the desired vision is being achieved, verifying the potential for structural change in the regional economy through context and impact indicators.

The monitoring exercise serves mainly to check if there are deviations in the execution of the strategy compared to what was planned. If there are deviations, management decisions need to be taken to bring the execution in line with the plan. If there are no deviations and the first and second level objectives are not being achieved, it becomes necessary to review the strategy, adjusting it to the current circumstances and considering constraints or potentialities that were not considered in its preparation.

Monitoring is therefore not an end in itself. It serves to support management or strategic nature decision. The bottom-up and top-down perspectives are complementary and articulate in time. Policy monitoring and planning exercises are mutually supportive throughout the life cycle of strategy implementation.

S3 NORTE 2027 is differentiated by the fact that the thematic and sectoral commitments in the priority domains of smart specialisation allow, with the same mix of public policies, to obtain better results, expressed in the respective indicators, and to accelerate the process of structural change of the regional economy, expressed in the change of the context indicators. The output indicators associated with each priority domain of smart specialisation thus enable the analysis of the strategic dimension and the respective objectives defined. They also assume the characteristics of result indicators, given that they result from public policy options.

The monitoring of indicators associated with the priority domain of S3 NORTE 2027 is absolutely critical in this exercise. In the implementation of public policies, more resources than planned may be allocated to certain areas than to others, requiring corrections in the management trajectory. The allocation of resources may be adequate in relation to the planning and the results may not always be as desirable, requiring changes in strategy.

In summary, the Norte Region Smart Specialisation Strategy for 2021-27 has a monitoring system that allows to follow the development of the priority domains and analyse how the implementation of the strategy is articulated with its strategic objectives and transversal objectives, in order to achieve the defined vision. The indicators associated to the priority domains constitute the nodal point of the entire monitoring model. It is the information obtained at this level that enables at each moment to improve the fine-tuning of public policies.

The following table summarises, as an example, the main policy instruments foreseen for the new programming period 2021-27 in the draft version of the PORTUGAL 2030[54] Partnership Agreement that will contribute to the implementation of S3 NORTE 2027. These policy instruments correspond to the project typologies that are foreseen in Specific Objectives 1.1, 1.3 and 1.4 of Policy Objective 1 (OP1) "A more competitive and smarter Europe" associated with support for R&D, innovation, SME competitiveness and skills for smart specialisation.

[54]   Ministério do Planeamento (2021). *Draft* version of the Partnership Agreement Portugal 2030.

Table 8 • Main PO1 public policy instruments with relevance to S3 NORTE 2027

Specific Objectives	Examples of policy measures
SO 1.1 Develop and strengthen research and innovation capacities and the adoption of advanced technologies	Support the Creation of Scientific and Technological Knowledge (including support for scientific infrastructure and equipment)
	Support the Creation, Transfer and Valorisation of Knowledge (including support for R&DT)
	Support Qualified Entrepreneurship associated to knowledge
	Support Collective Actions for the transfer of knowledge and technology
	Support Technological System to strengthen Competitiveness (including the support for technological infrastructures and equipment)
SO 1.3 Strengthen sustainable growth and competitiveness of SMEs and job creation in SMEs, including through productive investment	Support business investment to strengthen competitiveness
	Support qualification, digitalisation and internationalisation of companies
	Support investment on a territorial basis
	Support Collective Actions
	Infrastructures and equipment (non-technological based) to support Competitiveness
SO 1.4 Developing skills for smart specialisation, industrial transition and entrepreneurship	Strategic concertation and coordination of actors
	Plans for concerted impact investment
	Capacity-building for smart specialisation
	Capacity-building for qualified entrepreneurship
	Innovation platforms

In addition to these policy instruments related to PO1, in this monitoring system should be a set of input indicators related to other programmes supporting R&D, innovation, SMEs competitiveness and qualifications, such as the thematic and multiregional operational programmes of the PORTUGAL 2030, the rural development programme, the European territorial cooperation programmes, the centralised managed programmes of the European Commission (such as HORIZON EUROPE) and the Recovery and Resilience Plan (RRP), thus allowing for a more complete understanding of the implementation of S3 NORTE 2027.

In terms of products, this monitoring system will enable the production of monitoring reports to be elaborated by the S3 NORTE 2027 management team. These periodic reports are an effective way to resume all the activities developed within the scope of the implementation of the Norte Region Smart Specialisation Strategy. In addition, the aim is to create a digital observatory to provide information on the RIS and on the implementation of S3 NORTE 2027.

In this context, the digital observatory will aim to provide information, through an interactive interface, on the entities that constitute the RIS, the statistical context indicators on RIS performance and the monitoring indicators of S3 NORTE 2027. Another important dimension of the observatory will be the presentation of territorialised information on RIS. This observatory will also provide information on publications, events and other initiatives relevant to RIS and S3 NORTE 2027.

The monitoring of public policies and of S3 NORTE 2027, in particular, thus constitutes a coherent way of gathering, processing and systematising information. This information is important in itself and also allows for different uses. One of the main uses is also evaluation exercises. Monitoring and evaluation of public policies use the same information; the way it is used and the purposes are different, although complementary, as there is no good evaluation without good monitoring.

The monitoring of the implementation of S3 NORTE 2027 requires that additionally exercises to evaluate its effectiveness and efficiency are conducted in order to improve the quality of the design and implementation of programmes and strategies. Based on the experience of the previous programming period, these evaluations can be carried out at different stages of their life cycle, from design to implementation and on different thematic and territorial scopes. The conclusions and recommendations of these evaluation studies will be fundamental for improving implementation in this current and in the new programming period.

10.

Verification of compliance with the enabling condition associated with Norte Region Smart Specialisation Strategy for 2021-27

In the proposal for Cohesion Policy regulations presented by the European Commission for the new programming period (2021-27), the smart specialisation strategies and their governance model constitute the only enabling condition for funding under Policy Objective 1 (PO1) "A smarter Europe, promoting innovative and smart economic transformation", which includes support in the areas of innovation, digitalisation, economic transformation and support for SMEs.

According to the referred regulatory proposal, this enabling condition can only be considered as fulfilled when the smart specialisation strategy is supported by the following elements: (1) up-to-date analysis of bottlenecks to the diffusion of innovation, including digitalisation; (2) existence of a competent regional and/or national institution or body responsible for managing the smart specialisation strategy; (3) existence of systems for monitoring and evaluating the performance of the smart specialisation strategy; (4) effective functioning of the entrepreneurial discovery process; (5) actions needed to improve national or regional research and innovation systems; (6) actions to promote industrial transition; and (7) international collaboration measures.

The purpose of this document is to demonstrate that Norte is in position to ensure the compliance with all the criteria defined in the enabling condition applicable to PO1 concerning the regional smart specialisation strategy and its governance model. The verification, criterion by criterion, can be found in the table below.

1. Updated analysis of obstacles to the diffusion of innovation, including digitalisation

- Chapter 2 provides an updated analysis of Norte Region's RIS. In conceptual terms, innovation is a complex process, highlighting its dynamic and systemic nature. The dynamic and systemic vision of innovation is present in the methodology adopted by the Regional Innovation Scoreboard to measure the overall innovation performance of a region. It is an analytical tool that allows, from a set of indicators, to identify strengths and weaknesses of regional innovation systems, as well as to produce synthetic information in the form of a composite index that measures the quality of the innovation performance of each region. Its regular edition, with information from different NUTS II regions of the European Union, allows an analysis of the evolution of the regional innovation system in comparison with others in Portugal and other Member States.

- The analysis of Norte Region's RIS begins by developing the methodology of the Regional Innovation Scoreboard and the respective ranking of the innovation performance of the European Union regions. Understanding this methodology is fundamental to the analysis of the most recent performance of Norte. Subsequently, an analysis of the innovation performance of Norte in the European and national context is carried out and the strengths and weaknesses of RIS are identified based on a comprehensive analysis of each of the 21 innovation indicators that constitutes the Regional Innovation Index from the Regional Innovation Scoreboard. From this analysis, conclusions are drawn on the performance of Norte's RIS in its multiple dimensions, namely, structural conditions, investments, innovation activities and impacts.

- Following the foresight exercise of medium and long-term trends for each of the priority domains of smart specialisation, eight priority domains have been identified for the period 2021-27 that constitute the regional strategic commitments in the areas of innovation and competitiveness. Cross-referencing trends with "societal challenges" leads to the conclusion that the main regional specialisations are at the centre of structural transformation trends, in demography, environmental and energy transition and digital transformation, requiring appropriate public policies to reduce the economic and social impacts resulting from the natural adjustment process.

- In particular, digitalisation is even the main focus of one of the priority domains of smart specialisation (Technology, State, Economy and Society), being present in 21 of the medium-term demand trends and respective strategies and public policies, as referred to in chapter 4. The association between digitalisation and Industry 4.0 is present in 14 of the medium-term demand trends and their respective strategies and public policies, according to the same chapter.

| COMPLIANCE | YES | NO |

2. Competent regional institution or body

- Norte Regional Coordination and Development Commission (CCDR-Norte) is the body responsible for managing the Smart Specialisation Strategy (RIS) for Norte Region. In 2012, CCDR-Norte began the process of drafting the strategy with the corresponding registration on the S3 Platform of the Joint Research Centre, the European Commission structure responsible for supporting Member States and their regions in the development, implementation and review of their respective RIS3. RIS3 for the 2014-20 period was thus prepared by CCDR-Norte, and the process was concluded in December 2014, with its approval by the Government of Portugal and, subsequently, by fulfilling the respective ex-ante conditionality for the approval of the Regional Operational Programme of Norte 2014-20 in the context of the European Commission's Implementing Decision C(2014) 10188 of 18 December 2014.

- Following the approval of RIS3, CCDR-Norte was responsible for its implementation, mobilising the necessary financial resources from the Regional Operational Programme (ROP), in accordance with the investment priorities and respective relevant typologies of action. At the same time, CCDR-Norte developed national and international networking activities to explore other sources of European funding, such as INTERREG or HORIZON 2020. Having passed the first phases, the main activities developed by CCDR-Norte were those of monitoring, governance and evaluation of RIS3, which presuppose acceptable levels of approval and physical and financial execution of the investments. At the end of 2017, the Norte Regional Innovation Council (CRIN), chaired by CCDR-Norte, was set up, having met in plenary and in sections oriented towards the priority areas of regional smart specialisation, which are constituted as Regional Smart Specialisation Platforms (PREI). This monitoring and evaluation phase concluded with the preparation, by CCDR-Norte, of the RIS3 NORTE 2020 monitoring report, approved by CRIN in October 2019 and published in December 2019.

- In September 2019, CRIN approved the S3 NORTE 2027 Initiative, for the revision of RIS3 NORTE 2020 in the context of the 2021-27 programming period. The S3 NORTE 2027 Initiative was coordinated by CCDR-Norte. Its governance model is based on the CRIN and its smart specialisation platforms which, through its approval, ensures the political-institutional support for its development and, upon its conclusion, for the approval of S3 NORTE 2027. Thus, with the S3 NORTE 2027 Initiative, CCDR-Norte is the entity responsible for developing the review of the smart specialisation strategy that will enable the application of European Union policy funds in Norte Region during the 2021-27 programming cycle.

- It can thus be concluded that the RIS3 governance model, where CCDR-Norte assumes management and governance responsibility, chairing the CRIN, has proved adequate and functional in the development of its competences. This model will essentially be maintained for the next programming period, with the possibility of making specific changes. It may be necessary to set up new CRIN sections according to certain sectoral areas, such as higher education, and this is provided for in its operating rules. Other changes may result from the need to articulate the regional level and the national level. This model and its possible developments are described in chapter 8 of this document.

CUMPRIMENTO	SIM	NÃO

3. Monitoring and evaluation tools to measure performance

- The development of a monitoring system is essential to assess whether the regional smart specialisation strategy is being implemented as planned, thus supporting decisions on proposals for action lines and the maintenance of priority domains or the possible need to adjust them, as a step towards further evaluation. It also serves the purpose of disseminating information on the implementation of the strategy to build a transparent process of interaction with stakeholders involved in its governance model.

- As part of the RIS3 implementation activities, a Monitoring System has been structured to coherently monitor different public policy objectives that are not always at the same hierarchical level in the strategy's "tree of objectives" and the implementation of the respective financing instruments. The indicators and respective targets assume an instrumental dimension, with each type of indicator corresponding

to a certain level of the hierarchy of objectives: "Context indicators" correspond to the "Vision and Regional Innovation Performance"; "Result indicators" and "Indicators by priority areas" correspond to the "Strategic and Transversal Objectives of RIS3"; "Input indicators" and "Output indicators" correspond to the "Specific Objectives of the Policy Mix". In this context, the monitoring of priority areas constitutes a nodal element of the Monitoring System of NORTE RIS3.

- CCDR-Norte presented this methodology in the document "Norte Region Smart Specialisation Strategy (NORTE RIS3). A Monitoring System Methodological Approach for MONITORIS3 Project" (Monteiro, Santos, Guimarães & Silva, 2018), which is available on the S3 Platform website, having been considered good practice by the INTERREG EUROPE Policy Learning Platform and selected for presentation at the thematic workshop, organised by the INTERREG EUROPE Joint Secretariat Team, "Better Monitoring, Evaluating, and Designing Regional Research and Innovation Strategies for Smart Specialisation (RIS3)" on 25th September of 2019.

- The RIS3 NORTE 2020 monitoring report was approved by the CRIN, in 8th October of 2019, as a consultative body aimed at ensuring the active participation of regional stakeholders and other actors of a more cross-cutting or supra regional nature in the monitoring and ongoing evaluation of the implementation of the strategy and contribute to the strategic decision-making process. The RIS3 monitoring activities continued with the public dissemination of the monitoring report and the launch of the participatory process for its review held as part of the annual event on "Norte of Portugal: The paths of an innovative region", which took place on 6th December 2019. This event was chaired by the Minister of Science, Technology and Higher Education, and had interventions from representatives of the European Commission's Directorate-General for Regional Policy, CCDR-Norte, the team responsible for the Evaluation of the Implementation of RIS3 in Portugal and an expert from the European Commission's Joint Research Centre. The main conclusions and recommendations of this monitoring exercise can be found in chapter 3 of this document, and the monitoring system is developed in chapter 9.

- In summary, the regional strategy for smart specialisation has a monitoring system that allows to follow the development of the priority domains and analyse how the implementation of the strategy is articulated with its strategic objectives and transversal objectives, in order to achieve the defined vision. The indicators associated to the priority domains constitute the nodal point of the whole monitoring model. It is the information obtained at this level that enables the fine tuning of public policies to be improved at each moment.

COMPLIANCE	YES	NO

4. Effective functioning of the entrepreneurial discovery process

- The Entrepreneurial Discovery Process (EDP) is a bottom-up approach in which different types of stakeholders (companies and their associations, universities, research centres, public institutions, etc.) interact in order to identify new opportunities for economic development, while assessing their potential for enabling public policies. This process thus aims to reduce market failures resulting, namely, from asymmetric information (adverse selection and moral hazard), actor coordination problems (especially in emerging activities), regulation needs or differences between private and social returns in knowledge production. The activities and methodologies to be developed depend on: (i) the market failures that are intended to be overcome and the existing conditions to overcome them; (ii) the implementation phase of RIS3 (conception or implementation), involving, for example, the development of mechanisms for the interaction of actors, the organisation of seminars, workshops and other public actions for information dissemination, networking activities and support to demonstrator projects.

- The EDP revealed its main virtues in the design phase of RIS3. It was possible to set up eight Smart Specialisation Platforms, involving 148 participants, and to establish the rationale for each of the priority domains. This first phase was important for the preparation of RIS3 and its approval as an ex-ante conditionality of NORTE 2020. In a second phase, the establishment of the rationale of these priority

domains allowed the development of admissibility criteria and merit criteria of the typologies framed in RIS3 of the Norte Regional Operational Programme (NORTE 2020). These criteria were essential for the preparation and dissemination of the respective calls for proposals to guide the investment opportunities identified in these stakeholder interaction exercises. In this phase, as in the previous one, their market failures were associated with asymmetric information and the need for coordination of actors. In the next phase, national and international networking activities were developed to explore other European funding sources, such as INTERREG or HORIZON 2020.Efforts were made to encourage the regional actors to achieve coherent EDP's from the point of view of public policies.

- After the first phases, the main activities to be developed are those of monitoring and evaluation of RIS3, which presuppose acceptable levels of approval and physical and financial implementation of the investments made. This new phase involves the mobilisation of the Regional Smart Specialisation Platforms (PREI), involving representatives of different entities, public and private, with intervention in the priority domains of RIS3. This monitoring and evaluation phase concluded with the presentation and discussion of the monitoring report by CRIN at a plenary meeting held on 23 September 2019 and subsequent approval by written consultation concluded on the 8th October of the same year. In addition to this approval, the S3 NORTE 2027 Initiative was also approved, with a view to revising RIS3 in the context of the 2021-27 programming period.

- The S3 NORTE 2027 Initiative opened a new phase of relevant interaction between regional actors and entrepreneurial discovery, coordinated by CCDR-Norte. It is an initiative that combined operational dimensions with others of representation and institutional validation. Its governance model is based on the CRIN and its Smart Specialisation Platforms which, through its approval, ensures the political-institutional support for its development and, upon its conclusion, for the approval of S3 NORTE 2027. As shown in chapter 8, this process was developed effectively and efficiently in the context of the CRIN and its Regional Specialisation Platforms, from entrepreneurial discovery processes.

- It should be noted that there are market failures that regional entrepreneurial discovery processes cannot, and should not, fill, namely those that refer to regulatory activities, such as tax incentives, innovative public procurement, review of university teaching careers (valuing applied research and technology transfer activities, for example) or the integration of doctoral researchers into universities and their research centres. Added to these activities are those resulting from the necessary governance of the different regional smart specialisation strategies in the context of the national smart specialisation strategy and the articulation between funding from the Regional and National Thematic Programmes.

COMPLIANCE	YES	NO

5. Actions needed to improve the regional research and innovation system

- Despite the improvements recorded in innovative performance, there are no structural changes in Norte Region' RIS, being necessary to promote its consolidation through investment in knowledge and technology on nodal points with strong economic and/or scientific potential within the framework of a more global strategy of smart specialisation. From the point of view of RIS actors, it is also necessary to strengthen articulation between STS entities and technology production and development companies and advanced users, both from a horizontal industrial policy perspective, based on the promotion of structuring conditions, and from a vertical industrial policy perspective, selecting sectors where there are current and latent comparative advantages.

- The regional smart specialisation strategy, as a regional innovation policy, does not have autonomous public policy financial instruments, being its implementation dependent on the support of the operational programmes financed by the cohesion policy, namely the Regional Operational Programme and the National Thematic Operational Programmes. In this way, the actions necessary to improve the regional innovation system will necessarily derive from the specific objectives foreseen in the draft regulation of the Cohesion Policy Funds for 2021-27, namely, from PO1 that aims at a smarter Europe, promoting an innovative and smart economic transformation.

- For ERDF, the contribution to this PO1 is foreseen through the following specific objectives: (i) strengthening research and innovation capacities and the uptake of advanced technologies, (ii) harnessing the benefits of digitisation for citizens, businesses and governments, (iii) enhancing the growth and competitiveness of SMEs, and (iv) developing skills for smart specialisation, industrial transition and entrepreneurship. In the case of the ESF, it supports PO4 "A more social Europe, implementing the European Pillar of Social Rights", but also contributes to other objectives, namely PO1, by developing skills for smart specialisation and in key enabling technologies, industrial transition, sectoral cooperation and entrepreneurship, training of researchers and networking and partnerships between higher education institutions, vocational education and training institutions, research and technological centres and enterprises and clusters, support for micro, small and medium-sized enterprises and the social economy.

- Mobilising resources and policy instruments is thus a key step in delivering the Regional Smart Specialisation Strategy. In this context, the financial dimension of the next Regional Programme and the broadening of policy instruments are critical for a successful regional smart specialisation strategy. The operational concretisation of these specific cohesion policy objectives in policy instruments will result from the process of drafting and negotiating the Partnership Agreement and the OPs foreseen under the Council of Ministers Resolution no. 97/2020 of 13 November which sets out the guiding principles and operational structure for the 2021-27 programming period for European cohesion policy funds.

- Chapter 5 characterises RIS in Norte and identifies different initiatives to consolidate it, stating the following:

"Despite this relationship, the network of RIS institutions is still spatially unbalanced. There is a clear division between the main urban centres and, in particular, AMPorto, and the rest of the Region in the distribution of this type of institution, or, in other words, between the low density territories and the others, which display greater economic and demographic dynamism. At the same time, there is a pattern of low density territories compared to the others, with mono-specialisation predominating in the former as opposed to greater diversification and resilience in the latter.

Thus, it is necessary to promote a more territorially distributed and balanced RIS capable of responding to the challenges of valorising the products and activities of Norte Region, based on a network of institutions with different profiles, from fundamental research to support for business innovation, in close articulation with higher education institutions. This rebalancing of RIS is fundamental to support economic activities with greater potential for territorial broadening of the economic base to promote competitiveness, namely in areas more characterised by territory-intensive assets and resources, such as Agro-Environmental and Food Systems and Tourism Services and Territorial Assets.

The expression Norte's RIS has been used to represent a reality based on a concept, the concept of a regional innovation system. CRIN was a first step towards its formalisation, its institutionalisation. However, it is necessary to establish it, to formalise it in fact, so that the R&D&I policies in the context of S3 NORTE 2027 and the 2021-27 programming period of the European Union policies can promote the consolidation and strengthening of Norte's RIS".

| COMPLIANCE | YES | NO |

6. Actions to manage industrial transition

- Norte is the most industrialised NUTS II region in Portugal, being the 11th most industrialised region among the 246 NUTS II regions of the EU27. In 2021, the population employed in manufacturing industries represented 25.0% of the total, significantly higher than the proportion of this branch in the national total (16.9%). At the same time, between 2013 and 2021, the employed population in manufacturing industries increased by approximately 61 thousand individuals, contributing to the beginning of a new cycle of industrialisation.

- The industrialisation of Norte's economy is, however, still a purpose with numerous uncertainties, concerns and challenges. The challenges are related to the new geography of value chains and to the logic of greater regional economic integration, both at the level of the European Union and at the level of the Iberian Peninsula, as a result of the deepening of economic, social and institutional relations. The industrialisation of Europe will obviously lead to new forms of protectionism (investment support) with an impact on the birth and relocation of companies to the European Continent, an opportunity for the strategic repositioning of Norte's manufacturing industries in a digital age and energy transition.

- In this context, actions to manage the industrial transition are present in the domains of smart specialisation with a greater industrial vocation that constitute the core of the Regional Smart Specialisation Strategy. The domains Creativity, Fashion and Habitats, Sustainable Mobility and Energy Transition, Industrialisation and Advanced Manufacturing Systems and Agro-Environmental and Food Systems are those where the relevance is more significant. These are domains whose business bases characterise the main productive specialisations of Norte and thus, in the absence of adequate public policies, the impact of these challenges may be disruptive to the current structure and dynamics of the regional economy. The crossing of trends with the "societal challenges" allows to conclude that the main regional specialisations are at the centre of structural transformation trends, in demography, the energy transition and digital transformation, requiring appropriate public policies to reduce the economic and social impacts arising from the natural adjustment process.

- As mentioned with regard to the first criterion, the digital transition is present in 21 of the medium term demand trends and respective strategies and public policies, as referred to in chapter 4. The association between digitalisation and Industry 4.0 is present in 14 of the medium-term demand trends and respective strategies and public policies, according to the same chapter. In chapter 4 of this document, in addition to these trends and respective strategies and policies, others are identified concerning decarbonisation (16) and the circular economy (16), associated with the energy-environmental transition.

COMPLIANCE	YES	NO

7. International cooperation measures

- Internationalisation is a crucial component in the implementation of smart specialisation strategies and is particularly important for regions to access wider business and knowledge networks, increase their research capacity, reach new markets, expand business opportunities and insert in global value chains. The existence of these strategies in European regions has accelerated interregional and international collaboration, as a platform for understanding between regions, contributing to project development, providing a strategic framework for aligning priorities between public policies and investment initiatives, promoting a wider scope of funding opportunities, increasing the critical mass of initiatives, sharing knowledge and experience and expanding international networks.

- The Norte Region Smart Specialisation Strategy played a relevant role in framing the internationalisation processes of regional entities in different contexts, with emphasis on the development of the joint smart specialisation strategy with Galicia region, the submission of applications to European programmes such as INTERREG or HORIZON 2020, and the participation in international networks associated with smart specialisation, such as the S3 Platform and the Vanguard Initiative.

- In the case of Norte Region, one of the most important initiatives in its internationalisation was the development of the Cross-border Smart Specialisation Strategy of Galicia-Norte of Portugal (RIS3T), the first cross-border RIS3 at European level. It is important to continue the implementation of this strategy with the aim of mobilising new joint Euroregion initiatives and projects and attracting funds from specific funding sources, such as the HORIZON EUROPE.

- The participation in the HORIZON 2020 Framework Programme was another relevant dimension of the internationalisation process of the regional smart specialisation strategy. In this context, it is important to highlight the support from HORIZON 2020 to projects in Norte such as the Research Centre of

Excellence in Regenerative and Precision Medicine (The Discoveries CTR) and the Research Centre in Biodiversity and Genetic Resources (CIBIO-InBIO), developed with the support of NORTE 2020 and also aligned with the RIS3 priority domains.

- It is also worth noting is the participation in European cooperation projects related to smart specialisation approved by INTERREG EUROPE Programme, namely the MONITORIS3 project, with the main objective of exchanging experiences in terms of monitoring mechanisms and policy development methodologies in the implementation of regional smart specialisation strategies. This project involved the following entities from different regions and different Member States: Galician Innovation Agency (Spain), Regional Development Agency of the West Romania (Romania), DUNEA IIc – Regional Development Agency, Dubrovnik and Neretva Region (Croatia), Veneto Region – Research and Innovation Section (Italy), Nordland County Council (Norway), Norte Regional Coordination and Development Commission (Portugal) and National Innovation Agency (Portugal). It should be noted that the work developed by Norte Region in this project about the methodological approach for structuring the monitoring system of the regional smart specialisation strategy was considered good practice by the INTERREG EUROPE Policy Learning Platform and is published on the S3 Platform website, as mentioned in relation to the assessment of compliance with criterion 3.

- Regarding European networks, Norte has been a founding member since the foundation of the Vanguard Initiative, a network of around 40 regions in the European Union that have made a political commitment to use their regional smart specialisation strategies to drive new economic growth in areas considered to be priorities at European level. CCDR-Norte's involvement has been ensured by its presidency in meetings at the political level. At the technical level, the participation in the working groups of the pilot initiatives is mainly the responsibility of partner entities in Norte. Norte Region has also been actively participating in the network of thematic platforms for smart specialisation promoted by the European Commission, being in the group of regions with the highest number of participations in the partnerships established under these platforms.

- This work has been recognised at European level, as highlighted by the European Commission in different initiatives, documents and formal and/or institutional publications. In this regard, the publication by the S3 Platform of two Smart Stories identified as good practices regarding the implementation of Norte regional smart specialisation strategy should also be highlighted, namely, "Monitoring the Smart Specialisation Strategy of Norte Region (NORTE RIS3)" published in 2020 and "A triangular methodological framework for priority setting" published in 2016.

- The international dimension is thus fundamental in the implementation of the regional smart specialisation strategy. In the context of the next programming period 2021-2027, the development of international networking activities will be further strengthened in strategies, projects, networks and programmes, which will allow to enhance the participation of regional actors in international networks and global value chains. This dimension of the internalisation of S3 is described in chapter 6 of this document.

COMPLIANCE   YES   NO

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S3NORTE

2027

**NORTE REGION SMART
SPECIALISATION STRATEGY
2021-27**

CCDR NORTE

Comissão de Coordenação e Desenvolvimento Regional do Norte, I.P.

Priority Domains Characterisation

S3NORTE

2027

CCDR NORTE

Comissão de Coordenação e Desenvolvimento Regional do Norte, I.P.

Technical Data Sheet

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List of acronyms and abbreviations

AESF - Agro-Environmental and Food Systems

AMPorto - Metropolitan Area of Porto

CCDR-Norte - Norte Regional Coordination and Development Commission

CFH - Creativity, Fashion and Habitats

CoLAB - Collaborative Laboratories

DGEEC - Directorate-General for Education and Science Statistics

FCT - Foundation for Science and Technology

CAE - Portuguese Classification of Economic Activities

GHG - Greenhouse Gases

HLS - Health and Life Sciences

HORIZON 2020 - Research and Innovation Community Framework Programme for 2014-20

HORIZON EUROPE - Research and Innovation Community Framework Programme for 2021-27

IAMS - Industrialisation and Advanced Manufacturing Systems

ICET - Information, Communication and Electronic Technologies

INE - National Institute of Statistics

NORTE 2020 – Norte Regional Operational Programme for 2014-20

NORTE 2030 - Norte Regional Development Strategy for the Programming Period 21-27 of European Union's policies

NUTS - Nomenclature of Territorial Units for Statistics

OECD - Organisation for Economic Co-operation and Development

OP - Operational Programmes

PDO - Protected Designation of Origin

PGI - Protected Geographical Indication

PORTUGAL 2020 - Partnership Agreement established between the Portuguese State and the European Commission for the programming period 2014-20

PORTUGAL 2030 - Partnership Agreement established between the Portuguese State and the European Commission for the programming period 2021-27

PREI - Regional Smart Specialisation Platforms

R&D - Research and Development

R&D&I - Research and Development and Innovation

RIS - Regional Innovation System

RIS3 - Research and Innovation Strategies for Smart Specialisation

RIS3 NORTE 2020 - Norte Region Smart Specialisation Strategy for 2014-20

S3 - Smart Specialisation Strategies

S3 NORTE 2027 - Norte Region Smart Specialisation Strategy for 2021-27

SME - Small and Medium Enterprises

SMET - Sustainable Mobility and Energy Transition

SRE - Sea Resources and Economy

STS - Scientific and Technological System

TA - Thematic Agendas

TIC - Technological Interface Centres

TSES - Technologies, State, Economy and Society

TSTA - Tourism Services and Territorial Assets

TSG - Traditional Speciality Guaranteed

UNESCO - United Nations Educational, Scientific and Cultural Organisation

Introduction

Having as a reference the paradigm of smart specialisation and its concepts (choices and critical mass, related variety, competitive advantages, connectivity and clustering, quadruple helix and entrepreneurial discovery process), the preparation of RIS3 NORTE 2020[1] had as a starting point the construction of a conceptual framework that allowed the identification of the respective priority domains (Figure 1).
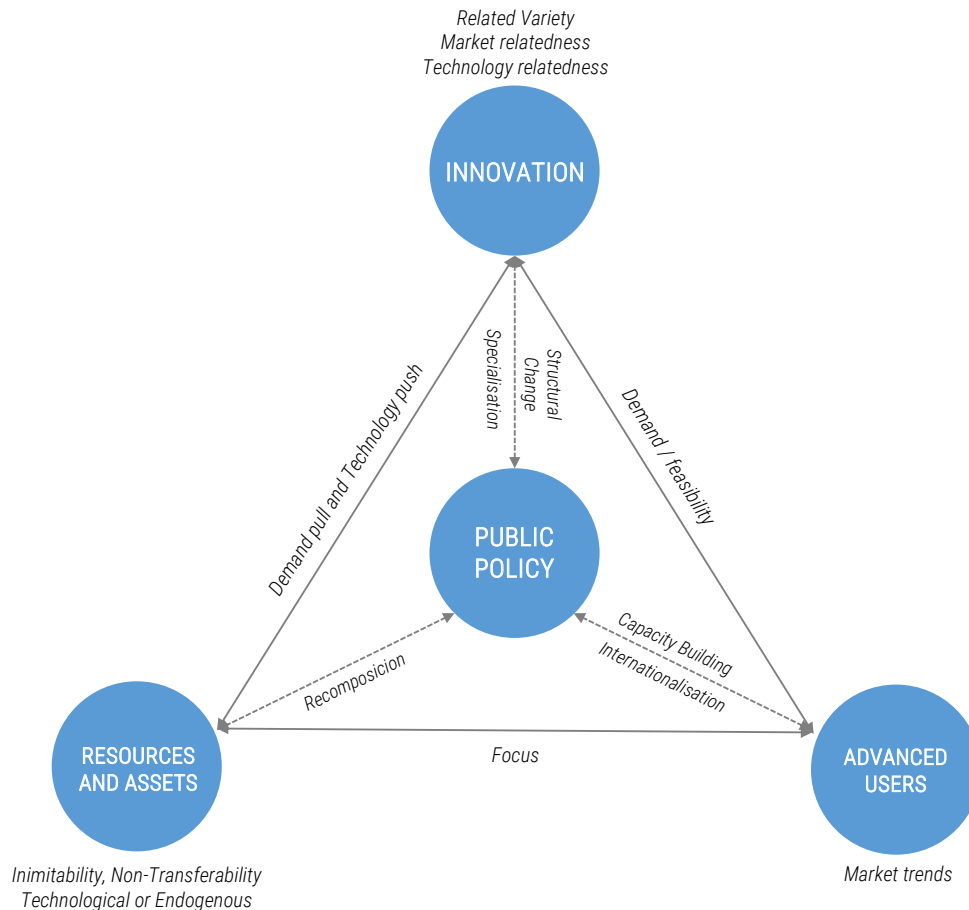
Figure 1 • Analytical framework for the definition of priority domains of smart specialisation[2]

A certain domain is thus considered a priority whenever relevant regional critical masses are or may be gathered at the three corners of the triangle, each roughly speaking corresponding to: (i) the regional entities of the scientific and technological system; (ii) the technology producers; and (iii) the advanced users of that technology. At the centre of this triangle, it is established the rationale of the public policy to be developed aiming to promote the interaction of these three vertices in the context of the ecosystem of each priority domain and the territorial enlargement of the economic base.

The first vertex of the triangle (resources and assets) assumes that smart specialisation should be based on the regional potential in resources and assets with inimitable and non-transferable characteristics, on which tradable and globally competitive goods and services can be developed. These resources and assets may be technological (analytical and synthetic knowledge) or non-technological (for example, symbolic

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[1] Comissão de Coordenação e Desenvolvimento Regional do Norte (2014). Estratégia Regional de Especialização Inteligente.

[2]   This methodology is especially developed in: Monteiro, Meira, Santos, Leite, Guimarães & Gomes (2019). Strategy for Smart Specialisation of the Norte Region. Monitoring Report. Porto: Comissão de Coordenação e Desenvolvimento Regional do Norte and Monteiro, Santos, Guimarães & Silva (2018). Norte Region Smart Specialisation Strategy (NORTE RIS3). A Monitoring System Methodological Approach for MONITORIS3 Project

capital). At the second vertex of this model is the business base which integrates and economically values the resources and assets, through the production of innovative tradable goods and services, namely of technological nature and aimed at satisfying intermediate demand, in particular.

The third vertex is constituted by advanced users, which are fundamental for the exercise of prospective international evolution of demand, since they represent companies and other organisations that produce goods and services, public and private, mainly aimed at final demand. The exercise of building this vertex is fundamental to assess the viability of the smart specialisation priority domains, given the market trends (international, domestic and local) and the potential of innovative public demand, also allowing the identification of the intervention needs of public policies to support the recomposing of the resources and assets base and the promotion of structural change in the regional economy.

Based on the analytical model described and the methodology developed, eight priority domains of RIS3 NORTE 2020 were identified. These eight priority domains were the starting point for its revision, taking into consideration the conclusions and recommendations of the monitoring developed and the methodology established in the S3 NORTE 2027 Initiative, approved by the Norte Regional Innovation Council.

This methodology was based on conducting surveys to the members of the PREI. Most of the survey questions aimed at validating (or not) the structure of each priority domain of RIS3 NORTE 2020 in terms of designations, rationales, resources and assets, business bases, advanced users, international demand trends, R&D&I strategies and policies, public policy instruments and integration of societal challenges.

Surveys were sent to 235 entities that, in the first half of 2020, composed the eight PREI, having obtained 133 responses, representing 57% of the total. This value is representative of the total and much higher than that obtained in enquiry processes of this nature, particularly, in the context of the preparation of RIS3 NORTE 2020.

This survey exercise was preceded by the updating of the prospective exercise of medium and long-term trends for each of the priority domains of smart specialisation. Market trends and technological trends are not and cannot be mutually exclusive; quite the contrary, technological and demand dynamics interact with each other, amplifying the effects of (pre-existing) trends. Therefore, international demand trends cannot fail to be also international trends of technological evolution and transformation and vice-versa.

The exercises of technology relatedness (technological possibilities) and market relatedness (market possibilities), which make possible to consolidate each of the priority domains of smart specialisation, must be simultaneous. The answers to the surveys on these trends are crucial in order to carry them out, since each PREI representative is asked about their relative (ordinal) importance in different areas: global, regional and the (own) institution. The analysis of the combination of these answers allows a better understanding of the dimension of the regional possibilities of technological transformation and market participation of the innovation ecosystem of each priority domain, especially the potential for the entry of new products.

The current expression of these trends presupposed a rereading of those expressed in the RIS3 NORTE 2020, verifying their timeliness and relevance in the current historical moment. This rereading also presupposed the comparison with other readings and, thus, its first step consisted in the selection of relevant bibliography, given the multiple works developed, individual and collective, on the themes under consideration and their relative importance.

It should be highlighted the development of several documents of public policies by national and international organisations. At national level, the Foundation for Science and Technology developed various research and innovation agendas in areas such as: (i) Agrifood, Forests and Biodiversity; (ii) Circular Economy; (iii) Culture and Cultural Heritage; (iv) Sustainable Energy Systems; (v) Labour, Robotisation and Employment Qualification; (vi) Tourism, Leisure and Hospitality; (vii) Health, Clinical Research and Translational, (viii) Sea; (ix) Industry and Manufacturing; (x) Space and Earth Observation.

At an international level, the work developed by the European Commission is particularly relevant, assuming that regional policies for R&D&I cannot fail to be aligned with the corresponding strategies and policies established by the European Union for the next programming period (2021-27). Of particular note is the proposal of the new framework programme for research and development and innovation of the European Union (HORIZON EUROPE) with regard to its second pillar (Global Challenges and Competitiveness of European

Industry), in areas such as: (i) Health; (ii) Culture, Creativity and Inclusive Society; (iii) Digital, Industry and Space; (iv) Climate, Energy and Mobility; (v) Food, Bioeconomy, Natural Resources, Agriculture and Environment.

The crisis caused by the Covid-19 pandemic was an element of disruption, requiring the adoption of measures to control the transmission of the disease and thus introducing discontinuities in the international chains of production, processing and distribution of goods and services. It was considered, in this exercise of review of RIS3 NORTE 2020 the consequences of this crisis, namely in the retreat of the globalisation process, the diversification of production locations and their greater proximity to consumption destinations, the acceleration of digital transformation and its effects in different sectors of economic activity and in the support of countries in greater industrial sovereignty[3].

In this context, concepts and respective technologies gain relevance, such as the low touch economy[4], characterised by less interaction between people and, without or with low contact, with equipment and surfaces, by health and safety protection, by new consumer behaviours and (permanent) changes in some sectors. It should be highlighted the concept of one health, which is the integrated planet-plants-animals-humans approach to health, in particular epidemiology.

Given the extent of the bibliography consulted, its selection depended on whether it was more or less appropriate in relation to the different productive specialisations in Norte Region. In this selection process, the aim was then to verify how the trends expressed in the documents consulted were (or were not) susceptible of fitting into the (potential) trends of the priority domains of regional smart specialisation. From that point of view, by concluding on the ability of those priority domains to represent the regional economic reality and the respective investment dynamics, the monitoring work of RIS3 NORTE 2020[5] allows a safe option to this analysis methodology.

In the opposite direction, the use of this methodology, in a reasonably successful way, also allows strengthening the conclusion that the priority domains established in RIS3 NORTE 2020 remain globally relevant. However, it also becomes evident that some of them need adjustments, in designations, rationales, resources and assets or business bases. The analysis of the results of the surveys to the PREI members and the prospective exercise of the medium and long term trends for each priority domain of smart specialisation allow the identification of eight priority domains of S3 NORTE 2027[6] (see figure 2).

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[3]   Estado português (2020). Proposta de Lei n.º 60/XIV – Lei das Grandes Opções 2021-2023 (LGO 2021-2023) do XXII Governo Constitucional

[4]   Board of Innovation (2020).

[5]   Monteiro, Meira, Santos, Leite, Guimarães & Gomes (2019).

[6]   There is an association between the priority domains of RIS3 NORTE 2020 and S3 NORTE 2027. This association is as follows: to the domains (i) Health and Life Sciences, (ii) Advanced Manufacturing Systems, (iii) Mobility Industries and Environment, (iv) Culture, Creativity and Fashion, (v) Symbolic Capital, Technology and Tourism Services, (vi) Sea Resources and Economy, (vii) Human Capital and Specialised Services, (viii) Agro-Environmental Systems, correspond, now, the domains, respectively (i) Health and Life Sciences, (ii) Industrialisation and Advanced Manufacturing Systems, (iii) Sustainable Mobility and Energy Transition, (iv) Creativity, Fashion and Habitats, (v) Tourism Services and Territorial Assets, (vi) Sea Economy and Resources, (vii) Technologies, State, Economy and Society, (viii) Agro-Environmental and Food Systems.
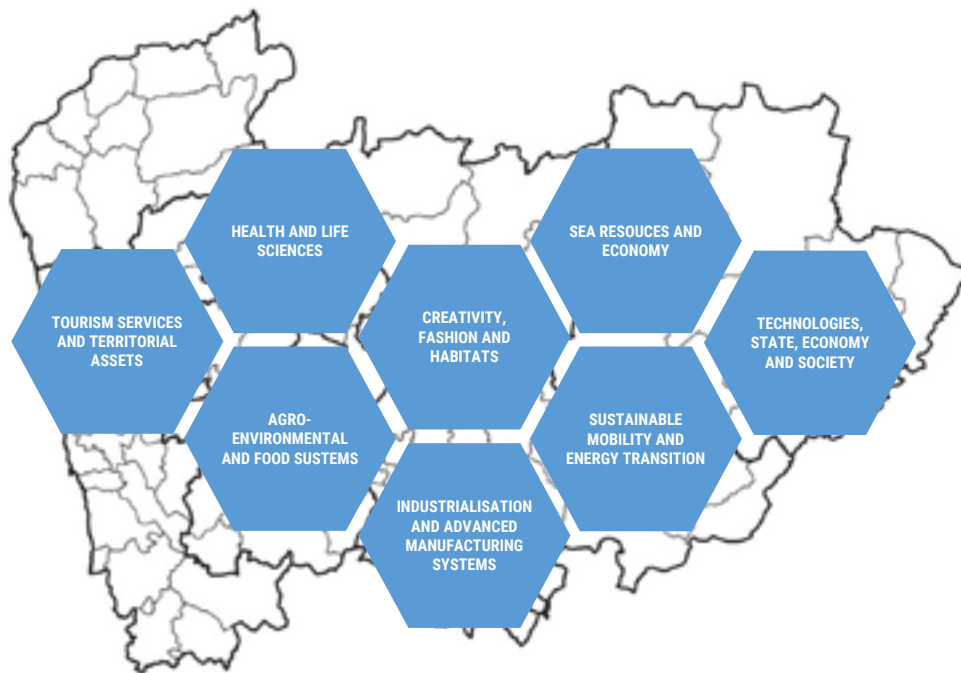
Figure 2 • Priority domains of Norte Region Smart Specialisation Strategy for 2021-2027

This exercise also made it possible to identify the respective public policy rationales for the 2021-27 programming period of European Union policies:

- **Creativity, Fashion and Habitats (CFH)** - exploiting the potential of creative industries (in the areas of design, architecture, IT, etc.), new materials and innovative technologies to create new competitive advantages in sectors with a strong symbolic capital component (culture and creativity), namely fashion (textiles and clothing, footwear, Jewelry, etc.), habitat (furniture, home textiles, building materials and solutions, built heritage, etc.) and other symbolically related activities, in a context of global adjustment of supply chains, as well as increasing digitalisation, environmental and social responsibility and energy transition;

- **Industrialisation and Advanced Manufacturing Systems (IAMS)** - development of clusters associated to enabling technologies (namely materials engineering, nanotechnologies, biotechnology and biological transformation, artificial intelligence, nano and microelectronics, photonics, mechatronics, systems engineering, etc.), combining existent scientific and technological capacities and infrastructures, consolidated business bases (machinery and equipment manufacturing, industrial engineering and consultancy, industrial information systems, etc.) and the presence of advanced user sectors (manufacturing and extractive industries, construction, water, energy, primary sector, etc.), in the context of digital, energy and environmental transformation processes and of new production, management, business and work models;

- **Agro-Environmental and Food Systems (AEFS)** - articulation of regional agricultural potential, namely in high added value products (wine, olive oil, chestnuts, Protected Designations of Origin (PDO) and Protected Geographical Indications (PGI), etc.), with scientific and technological skills (oenology, engineering, biology, biotechnology, ICT, robotics, etc.) and business (food industries, agriculture and animal production, forestry, forest-based industries, etc.), capable of promoting an Agro-food and forestry sector with greater added value, in a way that is compatible with the preservation and management of resources, such as water, forests and ecosystems, and contributing to a greater valorisation of endogenous resources as an opportunity to increase territorial competitiveness;

- **Sustainable Mobility and Energy Transition (SMET)** – consolidate the scientific and technological capacities (in the areas of production technologies, materials, digital technologies, biotechnology, etc.) to promote the upgrading of the component's and system's automotive industries (from the production of

moulds and tools to the assembly of complex systems) in the context of global value chains, as well as to provide higher added value in other mobility industries and their infrastructures (such as aeronautics, railways, maritime transport, urban mobility, logistics, energy, space, etc.), ensuring a more competitive and sustainable mobility system, in a context of decarbonisation of the economy, energy transition, digitalisation and new mobility concepts;

- **Health and Life Sciences (HLS)** – consolidate and promote interactions between research capacity at regional level (namely in the areas of tissue engineering and regenerative medicine, cancer, neurosciences, development of surgical techniques, etc.) and companies in the health industry and services in the broad sense (pharmaceuticals, medical devices, ICT, health services, personal protective equipment, health and wellness tourism, social support and physical activity, cosmetics, etc.), driving the development of new products and services capable of responding to current challenges (aging population, chronic diseases, pandemics or digital transformation), and contributing to the sustainability and resilience of the health systems;

- **Tourism Services and Territorial Assets (TSTA)** - valorisation of territory-intensive resources, namely cultural resources (UNESCO world heritage, classified cultural heritage networks and routes, intangible heritage, etc.), natural resources (national park, natural parks, protected landscapes of national and local interest, sites of community interest, special protection areas integrated into the natura 2000 network, UNESCO world geoparks, etc.), creative resources (relevant and symbolic infrastructures, cultural agendas, events, etc.) and endogenous resources (gastronomy, wines, authenticity, etc.), taking advantage of scientific and technological capacities (namely, in the areas of management, marketing, arts, digital technologies, etc.) and the relevant tourist offer (accommodation, restaurants, tourist entertainment, etc.), with the aim of boosting tourism services and better integrating tourism in different cultural, modern and traditional contexts, as a way of expanding the territorial base of promotion of regional competitiveness;

- **Sea Resources and Economy (SRE)** – consolidate the relations between applied engineering (civil, mechanical, naval, robotics, biotechnology, energy, information technology, materials), sea resources (living marine resources, non-living marine resources and marine and coastal ecosystem services) and economic activities that value them (renewable marine energy, coastal, nautical and cruise tourism, naval industry, biotechnology, aquaculture, maritime equipment, infrastructures, etc.), favouring the creation of a set of synergies that enhance value creation and generation of employment in activities related to the sea economy, preserving and promoting the sustainable use of marine resources;

- **Technologies, State, Economy and Society** – promotion of accumulated skills in the areas of science, technology, engineering and mathematics aiming the digital transformation of the economy and society as a process based on a set of digital technologies (internet of things, next generation wireless networks [5G], cloud computing, data analytics, artificial intelligence, cybersecurity or high performance computing) that ensure the integration of digital technologies in businesses, the use of internet services, the promotion of digital skills, the provision of connectivity infrastructure and mobile services and the development of digital public services and open and networked administration.

The institutional dimension of the preparation of S3 NORTE 2027 was strengthened with the need to proceed with the approval by the Regional Council of the NORTE 2030 Strategy to comply with point 3 of the Resolution of the Council of Ministers No. 97/2020, of 13 November, according to the terms of reference established by the Secretary of State for Regional Development, on 6 February 2020. In these terms of reference, it is established that chapter 2 consists of the "Critical review of the Regional Innovation Strategies for Smart Specialisation (RIS3), [...] incorporating each of these exercises in the respective Regional Strategy 2030 and presenting a reasoned response for the accomplishment of the favourable condition of RIS3". The exercise of drawing up the S3 NORTE 2027 was thus concluded with its presentation at the meeting of the Regional Council of the Norte Regional Coordination and Development Commission (CCDR-Norte) on 16th December 2020 and subsequent approval through written consultation to this body completed on 30th December 2020, thus appearing in chapter 2 of the Norte Development Strategy for the 2021-27 Programming Period of European Union Policies (NORTE 2030).

The approved S3 NORTE 2027 essentially includes the updated diagnosis of the Regional Innovation System of Norte Region (RIS), the summary of the conclusions and recommendations of the monitoring exercise of the Regional Smart Specialisation Strategy for 2014-20, the presentation of priorities or priority domains for

smart specialisation, the characterisation of the respective public policy rationales and the identification of the main international demand trends in a medium-term perspective. The Annex to the Regional Strategy contains the compliance with this enabling condition established in the proposed EU regulations, namely: (1) updated analysis of bottlenecks to the diffusion of innovation, including digitisation; (2) existence of a competent regional and/or national institution or body responsible for managing the smart specialisation strategy; (3) existence of systems for monitoring and evaluating the performance of the smart specialisation strategy; (4) effective functioning of the entrepreneurial discovery process; (5) actions needed to improve national or regional research and innovation systems; (6) actions to promote industrial transition; and (7) international collaboration measures.

Given the importance of S3 NORTE 2027 in boosting the regional innovation system and in the support framework, namely, within the scope of Policy Objective 1 (PO1) for the period 2021-27, which includes the areas of innovation, digitalisation, economic transformation and support to SMEs, it is considered fundamental to proceed with the preparation of a publication with the characterisation of the priority domains in order to explain in more detail the different components that support the respective public policy rationales and, at the same time, ensure greater visibility to S3 NORTE 2027 and the appropriation by all the actors that integrate the Regional Innovation System, as well as to its governance model, involving, namely: (i) the public administration entities with responsibilities in the development and funding of public innovation policies; (ii) the non-business entities of the regional Scientific and Technological System responsible for R&D and knowledge transfer, such as higher education entities, R&D Institutions and Infrastructures, Centres and Technological Interfaces, among others; (iii) companies as responsible for the transformation of knowledge into products and services; and (iv) civil society as advanced users representing the demand side of innovation.

Thus, after this point of introduction, the summary sheets of the eight priority domains that support the respective smart specialisation rationales of the S3 NORTE 2027 are presented. The structure of these sheets is based on the three dimensions established in the methodological framework of the definition of the smart specialisation rationale for each of the priority domains, in particular, the regional potential in terms of scientific, technological and endogenous resources and assets, the relevant or potential business bases that integrate and economically valorise the resources and assets and the advanced users and medium and long-term technological and social trends that underpin the viability assessment of the smart specialisation domains. At the end of each sheet, the analytical framework and the public policy rationale of the respective priority domain for the 2021-27 programming period of the European Union policies are presented. Attached to each characterisation form is the main supporting bibliography, the list of non-corporate entities of the scientific and technological system and the delimitation of the main sectors of activity that integrate each priority domain of the S3 NORTE 2027.

1.

Priority domain characterisation

Creativity, Fashion and Habitats

1.1. Resources and Assets

The aim of the "Creativity, Fashion and Habitats" domain is to articulate cultural and creative activities and the expressive regional industrial base specialised in the production of intensive goods and services with a strong symbolic capital component, namely in fashion (textiles and clothing, footwear, Jewelry, etc.), habitat (furniture, home textiles, construction materials and solutions, built heritage, etc.) and other symbolically related activities.

As part of the exercise to assess the existence of critical mass in this priority domain, it is important to analyse the resources and technological assets to be integrated by the main business bases of the fashion, habitat and other symbolically related activities. The first point characterises the stock of human capital with advanced skills by main areas of education and training through the indicator "Number of graduates in higher education by areas of education and training", already used in the preparation of RIS3 NORTE 2020, with accumulated values for the academic years from 2008/2009 to 2017/2018.

Based on the methodology established, the education and training areas considered to have the greatest potential for the achievement of the rationale defined for this domain are the following[7]:

- **"Engineering and related techniques":** such as "Electronics and Automation", "Chemical Process Technology", "Metallurgy and Metalworking" and "Electricity and Energy";

- **"Manufacturing industries":** such as "Textiles, Clothing, Footwear and Leather industries", "Materials (wood, cork, paper, plastic, glass and other industries)" and "Mining and quarrying"

- **"Science, mathematics and computing":** such as "Biology and biochemistry", "Chemistry" and "Computer Science";

- **"Arts and Humanities":** such as "Fine Arts", "Performing Arts", "Audiovisual and Media Production", "Design", "Crafts" and "History and Archeology";

- **"Social sciences, commerce and law":** such as "Commerce" and "Marketing and advertising";

- **"Architecture and Construction":** such as "Architecture and Urbanism" and "Building and Civil Engineering".

Between 2009 and 2018, 103 663 students graduated in Norte Region in these training areas, distributed by the different types of courses, namely, professional higher technical courses, bachelor's degrees, master's degrees and doctorates. Of this total, during this period, 3 262 obtained a PhD degree and 45 418 obtained a Master's degree. In terms of education and training areas, the number of graduates in the following areas stands out: (i) "Engineering and related techniques": with 15 986 graduates in "Electronics and automation", 7 331 in "Metallurgy and metalworking" and 6 671 in "Chemical process technology"; (ii) "Manufacturing": with 246 graduates in "Textile, clothing, footwear and leather industries", 973 in "Materials (wood, cork, paper, plastic, glass and other industries)" and 471 in "Extractive industries"; (iii) "Science, mathematics and computing": with 4 470 in "Computer Sciences" and 7 337 in "Biology and Biochemistry"; (iv) "Arts and Humanities": with 4 310 graduates in "Design" and 5 102 in "Audiovisuals and media production"; (v) "Social Sciences, Commerce and Law": with 10 482 graduates in "Psychology" and 4 223 in "Marketing and Advertising"; and (vi) "Architecture and Construction": with 8 827 graduates in "Building and Civil Engineering" and 7 168 in "Architecture and Urban Planning". This information is systematised in the following figure.

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[7] The exercise of identifying the most relevant education and training areas for this domain took into consideration: (i) the rationales revised in the new domains of smart specialisation of S3 NORTE 2027; (ii) the responses to the surveys carried out to the Regional Platforms of Smart Specialisation for the revision of S3 NORTE 2027, (iii) the international demand trends and corresponding R&D&I strategies and policies for the priority domains of S3 NORTE 2027 and (iv) the basic resources and assets that are included in RIS3 NORTE 2020.
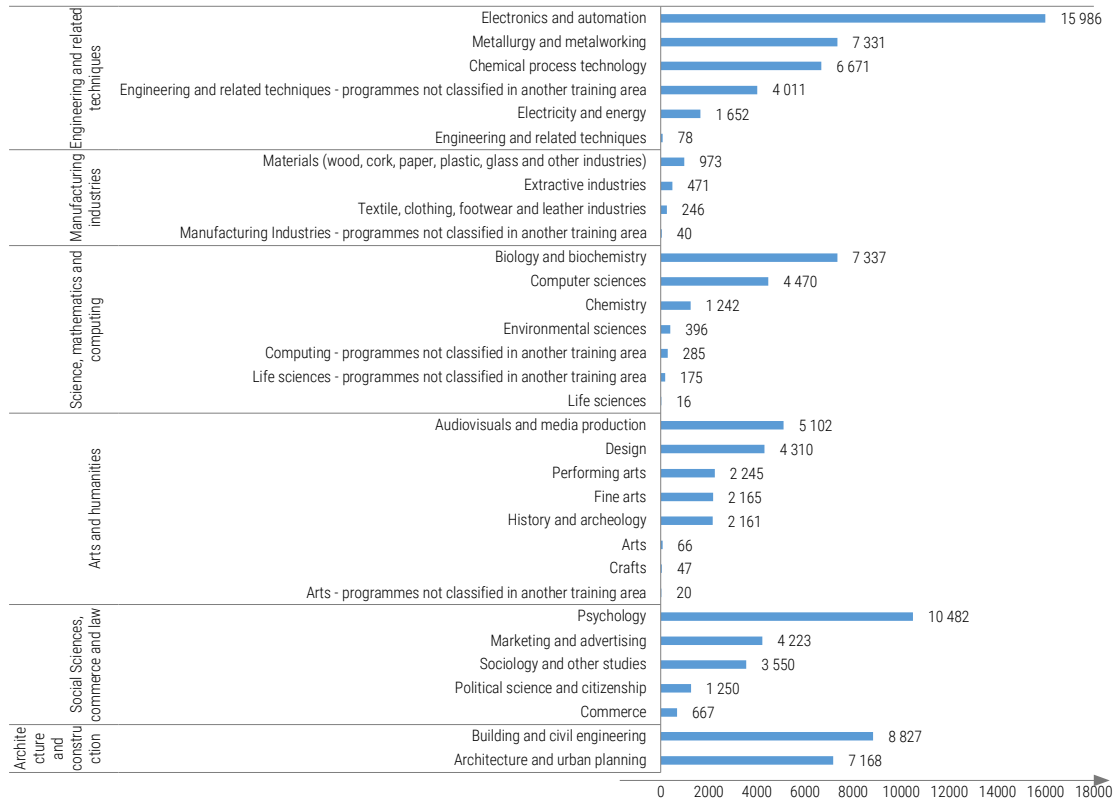
Figure 3 • Number of Graduates by Education and Training Areas in Norte Region, cumulative value from 2008/2009 to 2017/2018

Source: DGEEC

It is also important to characterise the scientific production, namely the publications by scientific and technological areas considered most relevant for the implementation of the rationale of the priority domain "Creativity, Fashion and Habitats" in the region. This analysis is carried out based on the indicator "Number of publications indexed in the Web of Science by scientific area", a variable already used in the preparation of RIS3 NORTE 2020, using the accumulated values from 2008 to 2018.

Taking into account the defined methodology, the most relevant scientific and technological domains for this priority in terms of publications are[8]: (i) in the area of "Exact and natural sciences": "Biological sciences" with 9 739 publications, "Chemistry" with 7 579 publications, "Computer and information sciences" with 5 411 publications, and "Earth Sciences and Environmental Sciences" with 3 947; and (ii) in the area of "Engineering Sciences and Technology": "Materials Engineering" with 4 517 publications, "Electrical, Electronic and Computer Engineering" with 4 202 publications, "Mechanical Engineering" with 2 414 publications and "Environmental Engineering" with 2 414 publications. This information is systematised in the following figure.

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[8]   The exercise of identifying the most relevant scientific and technological domains for this domain took into account: (i) revised rationales in the new smart specialisation domains of S3 NORTE 2027; (ii) responses to surveys carried out to the Regional Smart Specialisation Platforms for the review of S3 NORTE 2027; (iii) international demand trends and corresponding R&D&I strategies and policies for the priority domains of S3 NORTE 2027; and (iv) the resources and assets contained in RIS3 NORTE 2020.
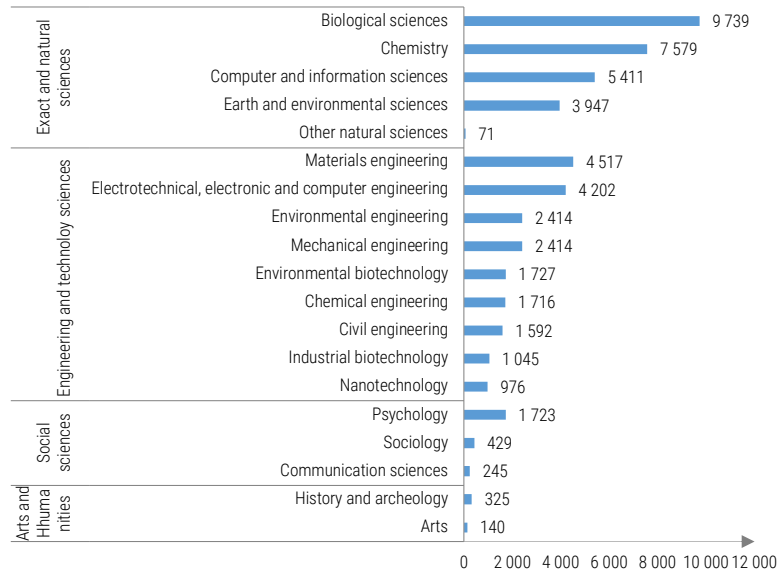
Figure 4 • Number of Publications by Scientific and Technological Areas in Norte Region,
cumulative value from 2008 to 2018
Source: DGEEC

A fundamental element of the characterisation of scientific and technological resources is also related to the identification of the region's installed capacity in terms of non-business R&I scientific and technological infrastructures that constitute the regional scientific and technological system. Based on the established methodology, 39 Research and Technological Infrastructures were identified in this priority domain that fall within its areas of intervention (see Annex 1). The following table shows the main areas of intervention of this type of entity within this priority domain.

Table 1 • Main intervention areas of the Research and Technological Infrastructures in the domain
"Creativity, Fashion and Habitats"

Type of Institution	Main areas of intervention
Research Institutions	Textiles, materials, systems and computer engineering, information systems, computer and information sciences, mechanics, chemistry, energy, environment, geology, arts, design, digital creativity, multimedia and audiovisual, engineering structures, architecture and urbanism, structures and buildings, construction.
Technological Infrastructures	Textiles, clothing, cork, footwear, nanotechnology, technical, functional and intelligent materials, materials engineering, waste recovery, mechanical engineering and industrial management, systems and computer engineering, nanotechnology, polymers, design, energy and geology, arts, chemistry, biosustainability, engineering structures, architecture, engineering and construction, digitalisation, urban sustainability.

1.2. Business Bases

The "Creativity, Fashion and Habitats" domain encompasses a heterogeneous set of activities aimed at boosting the intersection of creative industries, new materials and innovative technologies, in the creation of new competitive advantages in sectors with a strong symbolic capital component (culture and creativity), namely fashion (textiles and clothing, footwear, Jewelry, etc.), habitat (furniture, home textiles, construction materials and solutions, built heritage, etc.) and other symbolically related activities.

For the definition of the main economic activities in this domain, the sectors that constitute its main areas of activity were considered[9]/[10], namely: (i) Fashion: Textile and Clothing, Footwear, Jewelry and Goldsmithery Sectors; (ii) Creativity: Cultural and Creative Sector; and (iii) Habitats: Home products (Furniture, Home Textiles, Cutlery, Ceramics, Equipment and Commerce), Building Materials and Construction. The following figure shows the turnover and persons employed in the main sectors of activity included in the domain "Creativity, Fashion and Habitats".
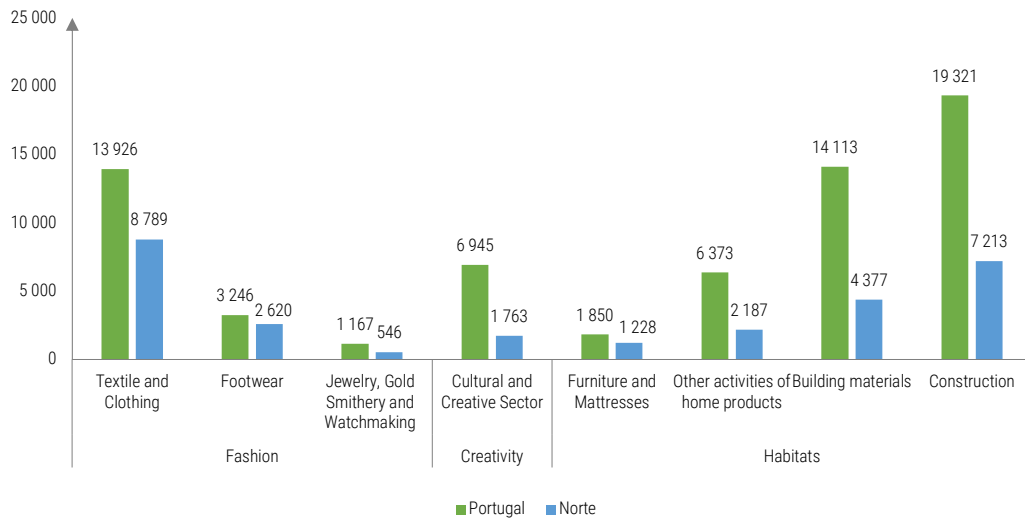
Figure 5 • Turnover in the main sectors included in the domain "Creativity, Fashion and Habitats", Portugal and Norte Region, million euros, 2019

Source: INE, Sistema de contas integradas das empresas
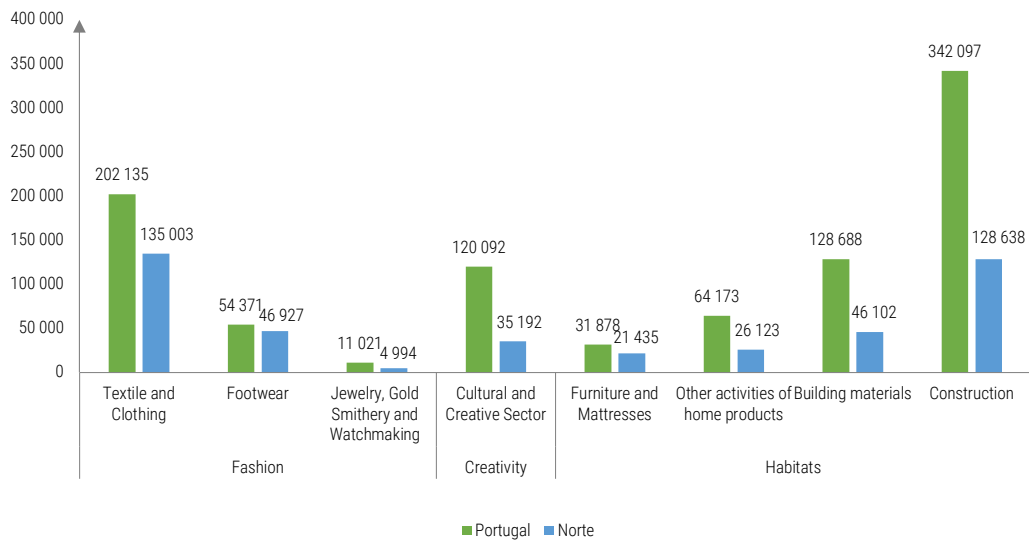
Figure 6 • Personnel employed in the main sectors included in the domain "Creativity, Fashion and Habitats", Portugal and Norte Region, Number, 2019

Source: INE, Sistema de contas integradas das empresas

[9]   Relevant bibliography consulted: Augusto Mateus & Associados (2011); Instituto Nacional de Estatística (2020); Instituto Nacional de Estatística (2007); Deloitte Consultores, S.A. (2018); Direção-Geral das Atividades Económicas (2018); Direção-Geral das Atividades Económicas (2017); Sigma Team Consulting (2017).

[10]   Annex 2 contains the delimitation of the main sectors of activity in terms of the Statistic Classification of Economic Activities (CAE Rev. 3) included in the priority domain "Creativity, Fashion and Habitats".

The Fashion industries have a very relevant economic expression in Norte Region, with a turnover of close to 12 000 million euros and almost 190 000 people employed. These figures correspond, respectively, to 65% and 70% of the national total for these industries in 2019. The textile sector stands out with 8 789 million euros and 135 000 people employed, followed by footwear with 2 620 million euros and around 47 000 people employed.

The cultural and creative sector has a turnover of 1 763 million euros with 35 192 people employed. In this sector, the activities of the performing arts, design, architecture, advertising and printing stand out in terms of turnover. The articulation with the creative industries is important to extend the control over the value chain and to innovate. At the same time, cultural and creative industries are emerging economic activities with high added value, with a particular tendency for territorial clustering, and can act as a cross-cutting technology for the regional economy, fostering innovation and attracting talent.

The sectors included in Habitats also have a significant weight in Norte Region, with turnover in 2019 reaching 15 000 million euros, while the number of persons employed reached nearly 223 000. The construction industry has the greatest weight with 7 213 million euros in turnover, followed by the building materials industry with 4 377 million euros and the home industry with 3 415 million euros, in the latter case with particular emphasis on the furniture and home textiles industry. In terms of personnel employed, the construction sector represents 128 638 people employed, followed by the residential sector with 47 558 people and the construction materials sector with 46 102 people employed.

At the level of international trade[11], the value of exports, in 2019, of the activity sectors included in the domain of "Creativity, Fashion and Habitats" was around 9 300 million euros, representing close to 35% of the total exports of Norte. Within this domain, the exports of the textile and clothing sector stand out, with 48% of the total, followed by the footwear sector with 16%.

Based on the methodology established in the analytical framework for the definition of smart specialisation priority domains, it is also important to consider in the characterisation of the business base the competitiveness clusters and sectorial business associations operating in Norte (see Annex 1). The following table presents the areas of intervention of the competitiveness clusters and sectoral business associations within this priority domain.

Table 2 • Main intervention areas of the Competitiveness Clusters and Business Associations within the domain "Creativity, Fashion and Habitats"

Type of Institution	Main areas of intervention
Competitiveness Clusters and Business Associations	Textile and clothing, footwear, architecture, engineering and construction, mineral resources, habitat, production technologies, ICT, wood and furniture, cork, jewelry and watchmaking.

[11] Source: Data of companies' exports obtained from the Iberinform database. Does not include the referring values to individual companies.

1.3. Advanced Users and Trends

In the priority domain "Creativity, Fashion and Habitats" a prospective analysis was carried out[12] to identify the main global medium and long term trends that shape the intermediate and final demand, allowing the assessment of the regional potential in the construction of competitive advantages and the improvement of the insertion degree in international value chains. The schematic and conceptual dimension of this identification process must consider the interaction of the different trends among themselves, enhancing the effect of each one and of the whole. These trends are structured into the following five topics:

a) **Symbolically related activities** - related diversification of producers and brands, involving in whole or in part different design-intensive goods or where design, aesthetics[13] or symbolic value function as main differentiating factors of the supply, in clothing, footwear, leather products and accessories, sporting goods, games and toys, habitat (furniture, kitchenware, glassware and crystalware, home textiles, coverings and building materials, walls and windows, upholstery, etc.), eyeglasses, watchmaking, jewelry and gold smithery, cosmetics and beauty products, etc.;

b) **Social and environmental responsibility** - reducing energy and material consumption, as well as waste resulting from the fashion and habitat sectors, as an effective commitment to consumers/citizens and to mitigate the effects of climate change, particularly in less developed countries (producers of raw materials and further up the value chains), together with further promotion of diversity and inclusion, respecting environmental and social rights throughout the supply chain(s);

c) **Socio-demographic changes** - population aging in western countries, implying changes in consumption profiles in terms of quantity and quality, and the growth of middle classes in (traditionally) less developed countries with natural aspirations of consumption and emulation, changing the regional dynamics of demand on a global scale and respective market segments and target consumers;

d) **Mass customisation and personalisation** - increase in niche markets and segmentation processes (tending towards personalisation, individualisation and tailor-made manufacturing), as a way of responding to more sophisticated demand and societal needs, in functional products (in the area of health and well-being, for example) and that allow for greater involvement and cultural and emotional interaction of consumers, together with the growing globalisation, dimension and scale of markets;

e) **Digitalisation and Digital Market** - growing physical and digital integration of communication and distribution in the fashion and its brand fields, ensuring equivalent consumption experiences regardless of the interaction channels with customers, and migration of online commerce (e-commerce) operators to traditional retail, bringing digital practices and strategies regarding pricing promotions, loyalty, consumer engagement, producing experiences and attracting traffic, digital transformation with cyber-physical technologies that enable disruption in processes and businesses, namely in operating models, value chains and customer relations, and reinforcing the importance of online commerce (e-commerce) in the post-Covid era.

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[12]   Relevant bibliography consulted: Associação Têxtil e Vestuário de Portugal (2017), Centro Tecnológico do Calçado de Portugal (2018), Comissão de Coordenação e Desenvolvimento Regional do Norte (2014), Comissão Europeia (2015, 2018, 2019, 2020a, 2020b), Deloitte Consultores, S.A. (2018), Ellen MacArthur Foundation (2017), Estado português (2013, 2017, 2019a, 2019b), European Construction Technology Platform (2019). European Technology Platform. Fibres Textiles Clothing (2016), Executive Agency for Small and Medium sized Enterprises (2015), Fundação para a Ciência e Tecnologia (2019a, 2019b, 2019c), IDEA Consult (2012), McKinsey & Company (2020), Monteiro, Meira, Santos, Leite, Guimarães & Gomes (2019), Sectoral Policies Department. International Labour Organisation (2019), Sociedade de Consultores Augusto Mateus & Associados (2016).

[13]   Also noteworthy in this topic is the recent initiative of the European Commission called «New European Bauhaus», as a movement that should assume an experimental and interdisciplinary nature, contributing to the reinforcement of a «new European aesthetic», with artistic, cultural, scientific and environmental dimensions, centered on people and urban renewal within a renewed framework of ecological transition and sustainability, which is of the greatest relevance and interest for Europe and Portugal.

The R&D&I strategies and public policies associated with this priority domain cannot be found dissociated from the global trends structured into the five topics mentioned in the previous point and are not and cannot be mutually exclusive. Resulting from the analysis of different documents from national and international organisations, the R&D&I strategies and public policies for this domain are the following:

a) **Symbolically related activities** - development and consolidation of clusters of cultural and creative industries for the creation and reproduction of symbolic capital (assets that tend to be inimitable and non-transferable), which is indispensable for the economic valorisation of products, namely in the fashion (clothing, footwear, watches and jewelry, etc.), habitat (furniture, home textiles, construction materials and solutions, built heritage, etc.) and other symbolically related activities;

b) **Social and environmental responsibility** - development of new bio- and eco-materials to replace raw materials that are intensive in non-renewable resources; development of advanced materials that reconcile aesthetics, performance and functionality; respect for animal welfare standards and replacement of animal-based materials with degradable, non-polluting synthetic or plant-based alternatives; reverse engineering and logistics in the context of the circular economy paradigm; reuse market (2nd hand), especially in the fashion sector; efficiency of buildings in terms of energy and resource use.

c) **Sociodemographic changes** - focus on high ranges in internationalisation processes in mature and consolidated markets, based on the image of origin and tradition, sustainability of materials and processes; differentiation or diversification of markets and development of international sourcing competencies that offset potential losses in the value chains of more labour-intensive processes with less added value;

d) **Mass customisation and personalisation** - business-to-consumer (B2C) and business-to-business (B2B) strategies that respond to the uniqueness of consumers' preferences, and especially to the speed with which they change and express themselves (producing small runs and partially replacing them depending on their market potential), involving, inter alia, cyber-physical systems, including 3D printing, virtual modelling and design, automation and robotics, sensing and digital identification (e.g. by radio frequency RFID), supported by artificial intelligence applications and by cybersecurity algorithms (e.g, Blockchain).

e) **Digitalisation and Digital Market** - adoption of new cyber-physical technologies and transformation of processes and businesses, enhancing new products and services in the fashion and habitat sectors; promotion of online commerce (e-commerce) and, in particular, multi-channel communication and distribution models that provide integrated and consolidated involvement of consumers and distributors, regardless of the different sales channels (physical and digital) and platforms used, as well as (automatic) integration with the company's information system (ERP), transforming the traditional retail space of exhibition and purchase into a place for socialising, sharing experiences and providing leisure services, and enabling the construction of stories and narratives that generate identification and transformation of products and brands into cultural goods and services application of new construction technologies associated with Industry 4.0 (e.g., Building Information Modelling or BIM), internet of things (sensors and smart devices), home automation and building personalisation, advanced analytics and cloud computing (building personalisation), digitisation of value chains, etc.

The following table presents the association between the trends identified in the domain "Creativity, Fashion and Habitats" and the "societal challenges" that constitute heavy trends of structural change in the economy and society and that present a transversal character to different priority domains. This analysis allows the conclusion that this priority domain is aligned with structural transformation trends such as demographic, energy-environmental transition and digital transformation. It is thus concluded that, despite the sectoral and thematic specificities of this priority domain, there are common elements in the trends and policies of other priority domains of smart specialisation that promote an interpenetration of areas, which, increasingly, will be reflected in various enterprises, institutions, and economic activities.

Table 3 • Association[1] between trends identified in the domain "Creativity, Fashion and Habitats" and "societal challenges"

Trends	Aging		Energy Efficiency		Decarbonisation		Circular Economy		Digitalisation		Industry 4.0	
	D	I	D	I	D	I	D	I	D	I	D	I
a) Symbolically related activities												
b) Social and environmental responsibility			•			•	•					
c) Sociodemographic changes	•											
d) Mass customisation and personalisation		•										
e) Digitalisation and digital market									•		•	

[1] Direct (D) or indirect association (I)

1.4. Rationale

From the domain "Creativity, Fashion and Habitats" it is intended to articulate the cultural and creative activities and the expressive regional industrial base specialised in the production of intensive goods and services with a strong component of symbolic capital, namely in fashion, habitat, and other symbolically related activities. Recognising the importance of culture in the genesis of the creative process and taking advantage of the sector of creative industries present in Norte Region, this domain aims to stimulate innovation based on symbolic knowledge, with particular impact on industries and activities of more traditional specialisation. The following figure shows the referential analysis of the priority domain "Creativity, Fashion and Habitats".
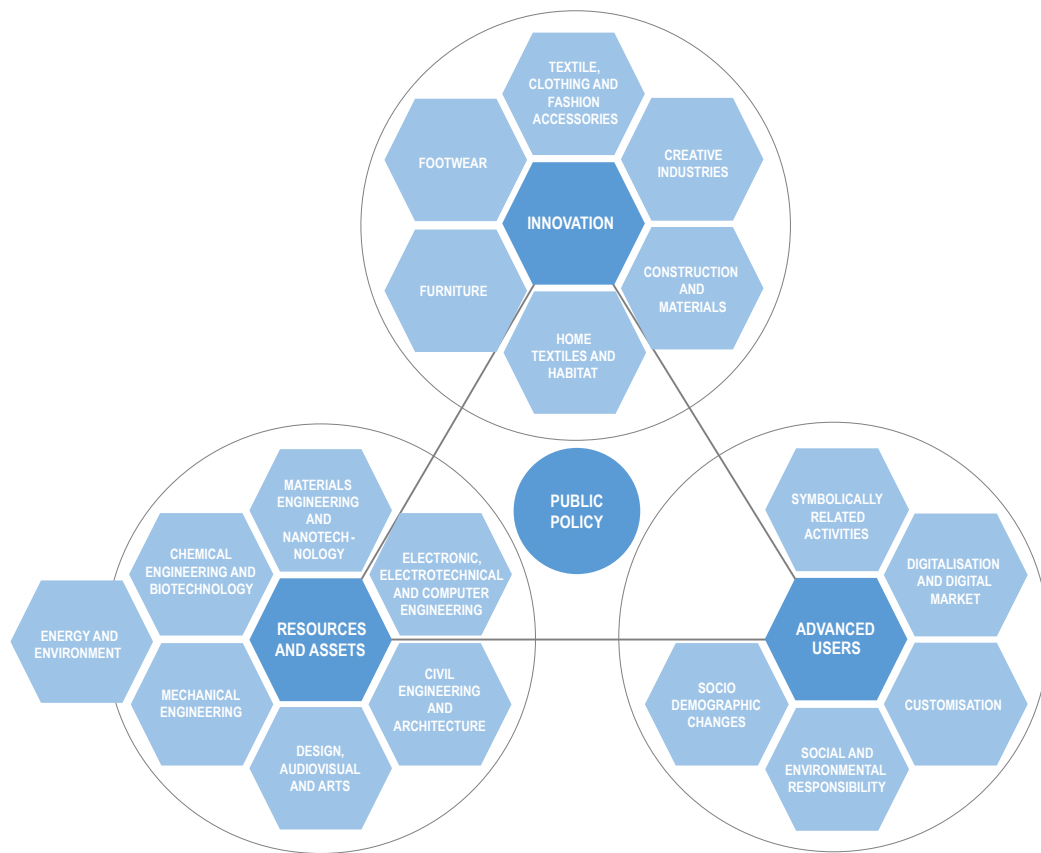
Figure 7 • Analytical framework of the domain "Creativity, Fashion and Habitats"

In terms of policy rationale, the area "Creativity, Fashion and Habitats" aims to promote the exploitation of the potential of creative industries (in the areas of design, architecture, Information Technologies, etc.), new materials and innovative technologies, in the creation of new competitive advantages in sectors with a strong component of symbolic capital (culture and creativity), namely fashion (textiles and clothing, footwear, gold smithery, jewelry, etc.) and habitat (furniture, home textiles, construction materials and solutions, built heritage, etc.) and other related symbolic activities, in a context of global adjustment of supply chains, as well as increasing digitalisation, environmental and social responsibility and energy transition.

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Annex 1

List of the non-business entities of the scientific and technological system identified in the priority domain "Creativity, Fashion and Habitats"[14]

Typology	Acronym	Name
R&D Units	CITAR	Centre for Research in Science and Technology of the Arts
R&D Units	ISISE	Institute for Sustainability and Innovation in Engineering Structures
R&D Units	2C2T	Textile Science and Technology Centre
R&D Units	CEAU	Centre for Architecture and Urbanism Studies
R&D Units	CITCEM	Transdisciplinary Research Centre for Culture, Space and Memory
R&D Units	CONSTRUCT	Institute for R&D in Structures and Constructions
R&D Units	i2ADS	Institute for Research in Art, Design and Society
R&D Units	INESC TEC	INESC TEC - INESC Technology and Science
R&D Units	CEAA	Arnaldo Araújo Study Centre
R&D Units	CQ-UM	Chemistry Centre of the University of Minho
R&D Units	CTAC	Centre for Territory, Environment and Construction
R&D Units	GILT	Games, Interaction & Learning Technologies
R&D Units	proMetheus	Research Unit in Materials, Energy and Environment for Sustainability
Associated Labs.	INESC TEC	INESC TEC - Institute for Systems Engineering and Computers, Technology and Science
Associated Labs.	ARISE	Advanced Manufacturing and Intelligent Systems
State Labs.	LNEG	National Laboratory for Energy and Geology
R&D Infrast. RNIE	CCD	Digital Creativity Centre
Technology Centres	CITEVE	Technological Centre for the Textile and Clothing Industries of Portugal
Technology Centres	CTCOR	Technological Centre of Cork
Technology Centres	CTCP	Portugal Footwear Technology Centre
Technology Transfer and Valorisation Centres	CeNTItvc	Centre for Nanotechnology and Technical, Functional and Intelligent Materials
Technology Transfer and Valorisation Centres	CVR	Centre for Waste Valorisation
Technology Transfer and Valorisation Centres	INEGI	Institute for Science and Innovation in Mechanical and Industrial Engineering
Technology Transfer and Valorisation Centres	INESC TEC	Institute for Systems Engineering and Computers, Technology and Science
Technology Transfer and Valorisation Centres	INL	International Iberian Nanotechnology Laboratory

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[14]   The identification of the entities was based on the analysis of a synthetic characterisation of each institution obtained, namely through consultation of various ANI publications, FCT evaluation reports and the entities' websites. It should be noted that the mere identification of a given infrastructure in each domain is not enough to guarantee its framework in S3 NORTE 2027 for the purposes of support for financing from EU funds. Similarly, the non-inclusion of a given infrastructure may not prevent access to such support and funding, depending always on the project that will be presented.

Typology	Acronym	Name
Technology Transfer and Valorisation Centres	ARCP	Association for the Competence Network in Polymers
Technology Transfer and Valorisation Centres	IDEGUI	Guimarães Institute of Design - Association for Economic Regeneration
Technology Transfer and Valorisation Centres	LNEG	National Energy and Geology Laboratory
Other R&D Infrastructures	CCR - UCatolica	Centre of Conservation and Restoration - Universidade Católica
Other R&D Infrastructures	CQ-UM	Chemistry Centre - University of Minho
Other R&D Infrastructures	FIBRENAM-ICS	FIBRENAMICS - University of Minho
Other R&D Infrastructures	ICIBio	Institute of Science and Innovation for Bio-Sustainability - University of Minho
Other R&D Infrastructures	ISISE	Institute for Sustainability and Innovation in Engineering Structures
Colabs	ARCP	Association Network for Competence in Polymers
Colabs	BUILTCoLAB	Collaborative Laboratory for the Built Environment of the Future
Colabs	Ceiia S2uL	Collaborative Laboratory for Urban Sustainability
Digital Innovation Hubs	-	DIH4ClimateNeutrality
Digital Innovation Hubs	-	DIGI4FASHION
Digital Innovation Hubs	-	DIGITALbuilt
Digital Innovation Hubs	-	PRODUTECH DIH
Competitiveness Clusters	-	AEC Cluster - Architecture, Engineering and Construction
Competitiveness Clusters	-	Footwear and Fashion Cluster
Competitiveness Clusters	-	Mineral Resources Cluster of Portugal
Competitiveness Clusters	-	Sustainable Habitat Cluster
Competitiveness Clusters	-	Textile Cluster: Technology and Fashion
Competitiveness Clusters	-	PRODUTECH Production Technologies Cluster
Competitiveness Clusters	-	TICE.PT
Business Association	AICCOPN	Association of Civil Construction and Public Works Industries
Business Association	AIMMP	Portuguese Wood and Furniture Industries Association
Business Association	ANIVEC/APIV	National Association of Clothing and Apparel Industries
Business Association	AORP	Portuguese Goldsmiths and Watchmakers Association
Business Association	APCOR	Portuguese Cork Association
Business Association	APICCAPS	Associação Portuguesa dos Industriais de Calçado, Componentes e Artigos de Pele e seus Sucedâneos
Business Association	APIMA	Portuguese Association of Furniture and Related Industries
Business Association	ATVP	Portuguese Textile and Clothing Association

Annex 2

Delimitation of the main sectors of activity from the Portuguese Classification of Economic Activities (CAE Rev. 3) of the priority domain "Creativity, Fashion and Habitats"

For the definition of the main economic activities that integrate this domain, it is considered the sectors that constitute the great areas of this domain and reflected in its rationale, namely:

— **Fashion:** Textile and Clothing, Footwear, Jewelry and Gold smithery Sectors
— **Criativity:** Cultural and Creative Sector
— **Habitats:** Home Products, Building Materials and Construction Rows

Delimitation of the priority domain in terms of the Portuguese Classification of Economic Activities (CAE Rev. 3):

(i) <u>**Fashion**</u>

— **Textiles and clothing**
  • **Textiles**
    • 131 - Preparation and spinning of textile fibres
    • 132 - Textile weaving
    • 133 - Textile finishing
    • 139 - Manufacture of other textiles
    • 46410 - Wholesale of textiles
    • 46160 - Agents involved in the sale of textiles, clothing, footwear and leather goods
    • 47510 - Retail sale of textiles in specialised shops
    • 46761 - Wholesale of natural, man-made and synthetic textile fibres
  • **Clothing**
    • 141 - Manufacture of wearing apparel, except fur apparel
    • 142 - Manufacture of articles of fur
    • 143 - Manufacture of knitted and crocheted articles
    • 46421 - Wholesale of clothing and accessories
    • 4771 - Retail sale of clothing in specialised shops
  • **Footwear**
    • 15201 - Shoe manufacture
    • 15202 - Manufacture of footwear components
    • 46422 - Wholesale of footwear
    • 4772 - Retail sale of footwear and leather goods in specialised shops
  • **Jewelry, gold smithery and watchmaking**
    • 2652 - Manufacture of watches and clocks
    • 3212 - Manufacture of Jewelry and related articles
    • 4648 - Wholesale of watches and Jewelry
    • 4777 - Retail sale of watches and Jewelry in specialised shops
    • 9525 - Repair of watches, clocks and Jewelry

(Sources: "Direção-Geral das Atividades Económicas (2018). Sinopse sobre a indústria têxtil e vestuário portuguesa"; "Direção-Geral das Atividades Económicas (2017). Sinopse sobre as indústrias do couro e do calçado"; "Sigma Team Consulting (2017). Study "Joalharia, Ourivesaria e Relojoaria no contexto nacional e internacional: monografia temática e setorial" for AORP")

(ii) <u>**Cultural and Creative Sector**</u>
  • **Printing and reproduction of recorded media**
    • 1811 - Newspaper printing
    • 1812 - Another impression
    • 1813 - Print and media preparation activities
    • 1814 - Bookbinding and related activities
    • 1820 - Reproduction of recorded media
  • **Manufacture of Jewelry and related articles and of musical instrument manufacturing companies**
    • 3212 - Manufacture of Jewelry and related articles
    • 3220 - Manufacture of musical instruments
  • **Retail sale of cultural and recreational goods in specialised shops**
    • 4761 - Retail sale of books in specialised shops
    • 4762 - Retail sale of newspapers, magazines and stationery in specialised shops
    • 4763 - Retail sale of records, CDs, DVDs, cassettes and similar products in specialised shops
  • **Editing activities**
    • 5811 - Book publishing
    • 5813 - Newspaper publishing
    • 5814 - Publishing of magazines and other periodicals
    • 5821 - Editing computer games

- **Motion picture, video, television programme production, sound recording and music publishing activities**
  - 5911 - Film, video and television programme production
  - 5912 - Technical post-production activities for films, videos and television programmes
  - 5913 - Distribution of films, videos and television programs
  - 5914 - Film and video projection
  - 5920 - Sound recording and music publishing activities
- **Radio and television activities**
  - 6010 - Radio activities
  - 6020 - TV activities
  - 6391 - News agency activities
- **Architectural activities, advertising agencies, design activities, translation and interpretation activities, rental of videocassettes and records**
  - 7111 - Architectural activities
  - 7311 - Advertising agencies
  - 7410 - Design activities
  - 7420 - Photographic activities
  - 7430 - Translation and interpretation activities
  - 7722 - Video and disc rentals
- **Teaching of cultural activities**
  - 8552 - Teaching of cultural activities
- **Theatre, music, dance and other artistic and literary activities**
  - 9001 - Performing arts activities
  - 9002 - Performing arts support activities
  - 9003 - Artistic and literary creation
  - 9004 - Operation of concert halls and related activities
- **Libraries, archives, museums and other cultural activities**
  - 9101 - Libraries and archives activities
  - 9102 - Museum activities
  - 9103 - Activities of historical sites and monuments

Note: There are studies that assume a broader concept of the cultural and creative sector in terms of CAE, such as the study "A Economia Criativa em Portugal: relevância para a competitividade e internacionalização da economia portuguesa" for ADDICT (AM&A 2016). However, it is not possible to reproduce the methodology applied as there is a set of CAE where part of the values and not all of them were considered, and the allocation coefficients used are unknown.

(Source: INE (2020) - Estatísticas da Cultura - 2019)

(iii) **Habitats**

- **Row house**
  - **Furniture and bedding**
    - 31010 - Manufacture of office and commercial furniture
    - 31020 - Manufacture of kitchen furniture
    - 31030 - Manufacture of mattresses
    - 31091 - Manufacture of wooden furniture for other purposes
    - 31092 - Manufacture of metal furniture for other purposes
    - 31094 - Furniture finishing activities
    - 95240 - Repair of household furniture and similar
  - **Home textiles**
    - 13920 - Manufacture of made-up textile articles, except apparel
    - 13930 - Manufacture of carpets and rugs
  - **Cutlery**
    - 25710 - Manufacture of cutlery
  - **Decorative and utilitarian ceramics**
    - 23411 - Clay pottery
    - 23412 - Manufacture of earthenware, porcelain and fine stoneware
    - 23413 - Manufacture of ornamental articles of earthenware, porcelain and fine stoneware
    - 23414 - Decorating activities of ceramic household and ornamental articles
  - **Equipment**
    - 27510 - Manufacture of electrical household appliances
    - 27520 - Manufacture of non-electric domestic appliances
  - **Trade**
    - 4615 - Agents involved in the sale of furniture, household goods, hardware and ironmongery
    - 4643 - Wholesale of electrical household appliances, radio and television sets
    - 46441 Wholesale of china and glassware
    - 4647 - Wholesale of household furniture, carpets, rugs and lighting equipment
    - 4753 - Retail sale of carpets, carpets, curtains and wall and floor coverings in specialised shops
    - 4754 - Retail sale of electrical household appliances in specialised shops
    - 4759 - Retail sale of furniture, lighting equipment and other household articles in specialised shops

— **Building materials sector**
- **Extractive industry**
  - 08111 - Extraction of marble and other carbonate rocks
  - 08112 - Extraction of ornamental granite and similar stones
  - 08113 - Limestone and chalk extraction
  - 08114 - Gypsum extraction
  - 08115 - Slate extraction
  - 08121 - Gravel, sand and crushed stone extraction
  - 08122 - Extraction of clays and kaolin
- **Glass**
  - 23110 - Manufacture of flat glass
  - 23120 - Shaping and processing of flat glass
- **Ceramic wall and floor tiles**
  - 23311 - Manufacture of tiles
  - 23312 - Manufacture of ceramic tiles and flags
  - 23420 - Manufacture of ceramic sanitary ware
- **Structural ceramics**
  - 23321 - Brick making
  - 23322 - Tile manufacturing
  - 23323 - Manufacture of domes
  - 23324 - Manufacture of other ceramic products for construction purposes
- **Cement and concrete**
  - 23510 - Manufacture of cement
  - 23610 - Manufacture of concrete products for construction purposes
  - 23650 - Manufacture of fibre cement products
- **Ornamental rocks**
  - 23701 - Manufacture of marble and similar stone
  - 23702 - Manufacture of slate products
  - 23703 - Manufacture of other articles of granite and stone n.e.c.
- **Metal products**
  - 25120 - Manufacture of doors, windows and similar articles of metal
  - 25210 - Manufacture of central heating radiators and boilers
  - 25720 - Manufacture of locks, hinges and other hardware
  - 33110 - Repair and maintenance of metal products (except machinery and equipment)
  - 43320 - Assembly of carpentry and joinery works
- **Carpentry work**
  - 16220 - Parquetry
  - 16230 - Manufacture of other builders' carpentry and joinery
- **Lighting material**
  - 27400 - Manufacture of electric lamps and other lighting equipment
- **Trade**
  - 4613 - Agents involved in the wholesale timber and building materials trade
  - 4673 - Wholesale of wood, construction materials and sanitary equipment
  - 4674 - Wholesale of hardware, plumbing and heating equipment and supplies
  - 4644 - Wholesale of china and glassware and cleaning products
  - 4752 - Retail sale of hardware, paints, glass, sanitary equipment, tiles and similar products in specialised shops

— **Construction sector**
- **Engineering and architecture**
  - 71110 - Architectural Activities
  - 71120 - Engineering and technical activities
- **Building construction**
  - 41200 - Building construction (residential and non-residential)
- **Specialised construction activities**
  - 43120 - Preparing the construction sites
  - 43130 - Drilling and Surveying
  - 43210 - Electrical installation
  - 43221 - Plumbing installation
  - 43222 - Air conditioning installation
  - 43290 - Other installations in buildings
  - 43310 - Plastering
  - 43330 - Floor and wall covering
  - 43340 - Painting and glazing
  - 43390 - Other building completion activities
  - 43991 - Hire of construction and demolition equipment with operator
  - 43992 - Other specialised construction activities n.e.c..
  - 80200 - Activities related to security systems

Note: This domain includes activities associated with the construction of buildings. The activities related to the construction of transport infrastructures are considered in the domain "Sustainable Mobility and Energy Transition".

(Sources: "Augusto Mateus & Associados (2011). Apresentação: Estratégias de Crescimento e Internacionalização no Cluster Habitat no Seminário Plataforma para a Construção Sustentável"; "Deloitte Consultores, S.A. (2018). Plano Estratégico de Inovação e Competitividade 2030 para o Setor AEC. Lisboa: Plataforma Tecnológica Portuguesa da Construção" and "INE (2007). Classificação Portuguesa das Atividades Económicas Rev.3")

2.

Priority domain characterisation

Industrialisation and Advanced Manufacturing Systems

2.1. Resources and Assets

The "Industrialisation and Advanced Manufacturing Systems" domain aims to combine the existence of scientific and technological capacities and infrastructures, consolidated business bases (machinery and equipment manufacturing, industrial engineering and consultancy, industrial information systems, etc.) and relevant user sectors (manufacturing, extractive industry, construction, water, energy, primary sector, etc.), in the context of digital and energy-environmental transformation processes and new production, management, business and work models.

As part of the exercise to assess the existence of critical mass in this priority domain, it is important to analyse the resources and technological assets to be integrated by the main business bases included in this domain. In a first point, the stock of human capital with advanced skills by main areas of education and training is characterised through the indicator "Number of graduates in higher education by areas of education and training", already used in the preparation of RIS3 NORTE 2020, with accumulated values for the academic years from 2008/2009 to 2017/2018.

Based on the established methodology, the education and training areas considered to have the greatest potential for the achievement of the rationale defined for this domain are the following [15]:

- **"Engineering and related techniques":** such as "Metallurgy and Metalworking", "Electronics and automation", "Electricity and energy" and "Chemical process technologies";

- **"Science, mathematics and computing":** such as "Life sciences", "Biology and biochemistry", "Environmental sciences", "Physics", "Chemistry" and "Computer sciences";

- **"Manufacturing industries":** such as "Materials (wood, cork, paper, plastic, glass and other industries)", "Food industries", "Extractive industries" and "Textile, clothing, footwear and leather industries";

- **"Social sciences, commerce and law":** as "Commerce".

Between 2009 and 2018, in these training areas, 54 335 students graduated in Norte Region, distributed by the different types of courses, namely, professional higher technical course, bachelor's degree, master's degree and doctorate. Of this total, during this period, 2 141 obtained a doctoral degree and 27 199 obtained a master's degree. In terms of education and training areas, the number of graduates in the following areas stands out: (i) "Engineering and related techniques": with 15 986 graduates in "Electronics and automation", 6 671 in "Technology of chemical processes" and 7 331 in "Metallurgy and metalworking"; (ii) "Science, mathematics and computing": with 7 337 graduates in "Biology and biochemistry" and 4 470 in "Computer Sciences"; and (iii) "Manufacturing": with 1 458 graduates in "Food industries", 973 in "Materials (wood, cork, paper, plastic, glass and other industries)" and 471 in "Extractive industries". This information is systematised in the following chart.

Figure 8 • Number of Graduates by Education and Training Areas in Norte Region, cumulative value
from 2008/2009 to 2017/2018
Source: DGEEC

It is also important to characterise the regional scientific production, namely the publications by scientific and technological areas considered most relevant for the achievement of the rationale of the priority domain "Industrialisation and Advanced Manufacturing Systems" in the region. This analysis is carried out based on the indicator "Number of publications indexed in the Web of Science by scientific area", a variable already used in the preparation of RIS3 NORTE 2020, using the cumulative values from 2008 to 2018.

Taking into account the defined methodology, the most relevant scientific and technological areas for this domain in terms of publications[16] are: (i) in the area of "Engineering Sciences and Technology": "Materials Engineering" with 4 517 publications, "Electrical, Electronic and Computer Engineering" with 4 202 publications, "Mechanical Engineering" with 24 414 publications and "Environmental Engineering" with 2 414 publications; and (ii) in the area of "Exact and Natural Sciences": "Chemistry" with 7 579 publications, "Physics" with 5 843 publications, "Computer and Information Sciences", with 5 411 publications and "Earth and Environmental Sciences" with 3 947 publications. This information is systematised in the following figure.

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[16]   The exercise of identifying the most relevant scientific and technological domains for this domain took into account: (i) revised rationales in the new smart specialisation domains of S3 NORTE 2027; (ii) responses to surveys carried out to the Regional Smart Specialisation Platforms for the review of S3 NORTE 2027, (iii) international demand trends and corresponding R&D&I strategies and policies for the priority domains of S3 NORTE 2027 and (iv) the resources and assets of base contained in RIS3 NORTE 2020.
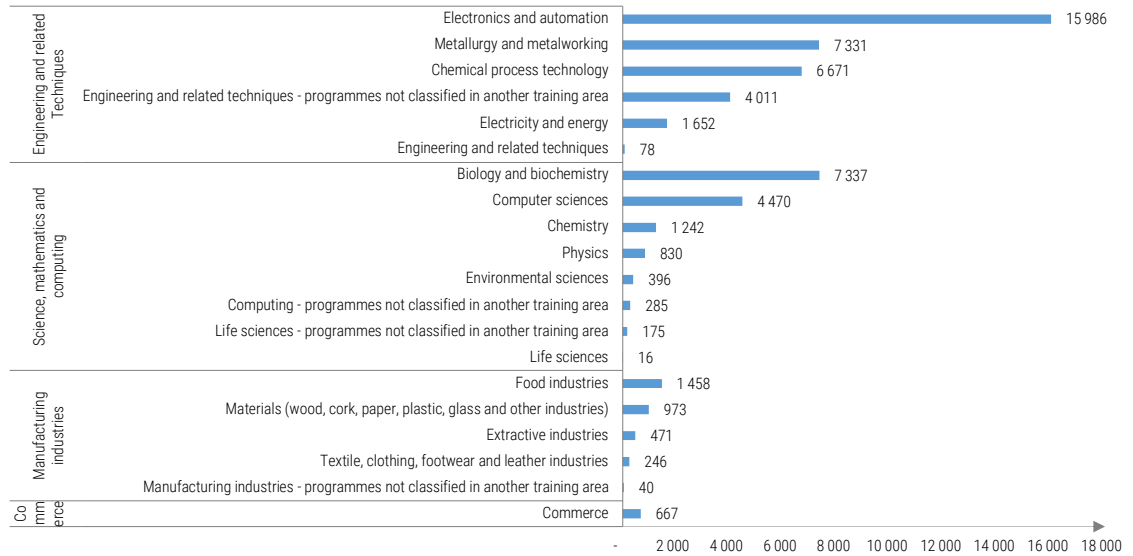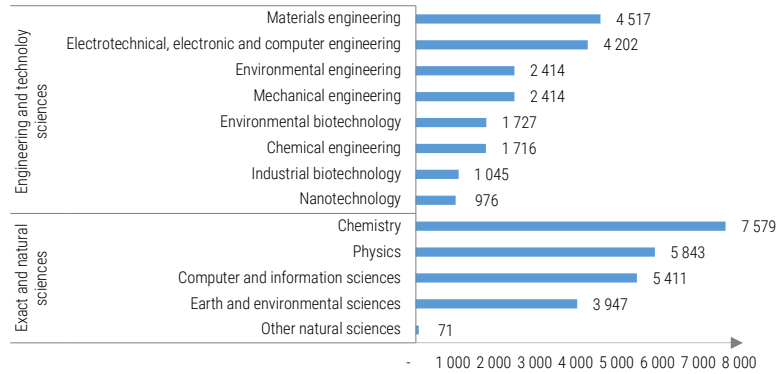
Figure 9 • Number of Publications by Scientific and Technological Areas in Norte Region,
cumulative value from 2008 to 2018
Source: DGEEC

A fundamental element of the characterisation of scientific and technological resources is also related to the identification of the installed capacity in the region in terms of non-business R&I scientific and technological infrastructures that are part of the regional scientific and technological system. Based on the established methodology, 52 R&D institutions and Infrastructures and Technological Centres and Interfaces were identified in this priority domain that fall within its areas of intervention (see Annex 1). The following table shows the main areas of intervention of this type of entity within this priority domain.

Table 4 • Main intervention areas of R&D Institutions and Infrastructures and Technological Centres
and Interfaces within the "Industrialisation and Advanced Manufacturing Systems" domain

Type of Institution	Main areas of intervention
R&D Institutions and Infrastructures	Advanced materials, systems and computer engineering, information systems, computer and information sciences, mechanics, physics, chemistry, energy, environment, digitalisation, robotics, nanotechnology, photonics, engineering structures, artificial intelligence, biotechnology, industrial engineering and technology, chemical engineering, smart systems and circular economy.
Technological Centres and Interfaces	Textiles and clothing, cork, footwear, nanotechnology, technical, functional and intelligent materials, metalworking, waste recovery, mechanical engineering and industrial management, computing, systems and computer engineering, polymer engineering, energy, geology, chemistry, materials engineering, digitalisation and engineering structures.

2.2 Business Bases

The "Industrialisation and Advanced Manufacturing Systems" domain thus encompasses a set of business bases, with the following core activities: machinery and equipment manufacturers (including producers of components, subsystems and support applications), software companies for industry, engineering and industrial consulting companies, systems integrators and other products and services aimed at industry (lato sensu, i.e. including utilities, construction and the primary sector). It also includes machine installers, system and equipment repair, maintenance and reconversion of equipment systems and support services. It interacts downstream with various sectors of manufacturing industry (which, by definition, use production technologies) and upstream with manufacturers of raw materials (e.g. base metals, plastic products) and other intermediate goods (which, by definition, are also, like the sector itself, users of production technologies).

For the definition of the main economic activities that integrate this domain, the sectors that constitute its major areas of activity are considered[17]/[18], namely: (i) "Hard nucleus", which includes the "Manufacture of machinery and equipment for general use", the "Manufacture of other machinery for general use", the "Manufacture of machinery and tractors for agriculture, livestock and forestry", the "Manufacture of machine tools" and the "Manufacture of other machinery and equipment for specific use"; (ii) "Expanded nucleus", that includes, namely, the "Manufacture of other metal tanks and containers", the "Manufacture of steam generators", the "Manufacture of mechanical tools", the "Manufacture of sintered parts", the "Manufacture of metal moulds", the "Manufacture of measuring, checking and navigating instruments and appliances", "Manufacture of electric motors, generators and transformers", "Repair and maintenance of machinery and equipment", "Installation of industrial machinery and equipment", wholesale of such equipment, "Computer programming activities", "Engineering activities and related technical consultancy".

The industries included in this domain represented, in 2019, a total turnover of close to 5 Billion euros and almost 60 000 persons employed. The hard nucleus represents about 28% of the total turnover of this domain and 23% of the people employed. Norte Region represents 50% of the national total in terms of turnover and 53% of the people employed of the CAEs that constitute the hard nucleus of this domain.

The weight of the activities included in this hard nucleus in the national total, in terms of turnover, varies between 59% ("Manufacture of other machinery and equipment for specific use") and 31% ("Manufacture of machinery and tractors for agriculture, livestock and forestry"). In terms of personnel employed, the hard nucleus has a weight in the national total ranging from 64% to 34%.
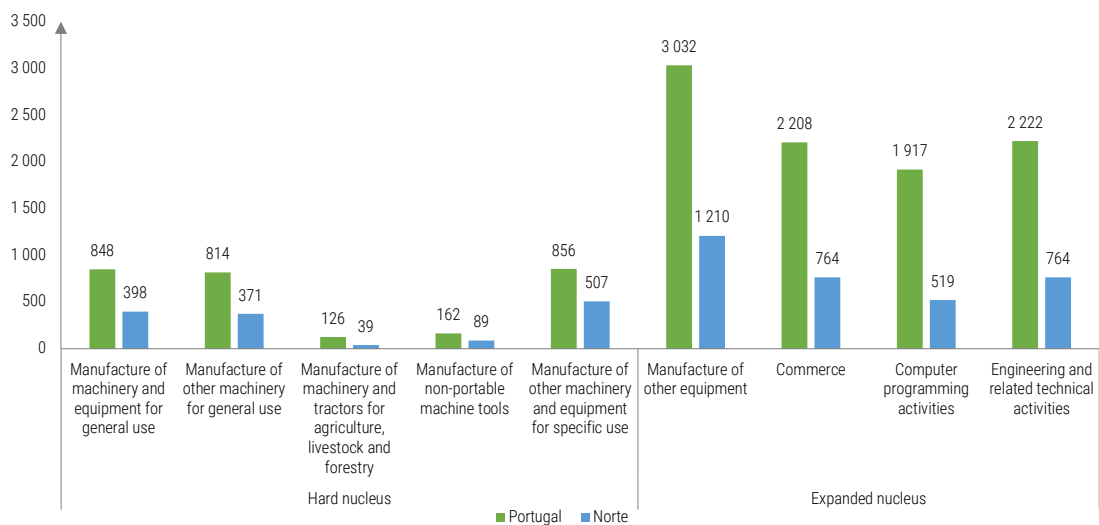
Figure 10 • Turnover in the main sectors included in the domain "Industrialisation and Advanced Manufacturing Systems", Portugal and Norte Region, million euros, 2019

Source: INE, Sistema de contas integradas das empresas

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[17]   Relevant bibliography consulted: Augusto Mateus & Associados (2017); Ministério da Economia e Cluster PRODUTECH (2019).

[18]   Annex 2 contains the delimitation of the main sectors of activity in terms of the Statistic Classification of Economic Activities (CAE Rev. 3) included in the priority domain "Industrialisation and Advanced Manufacturing Systems".
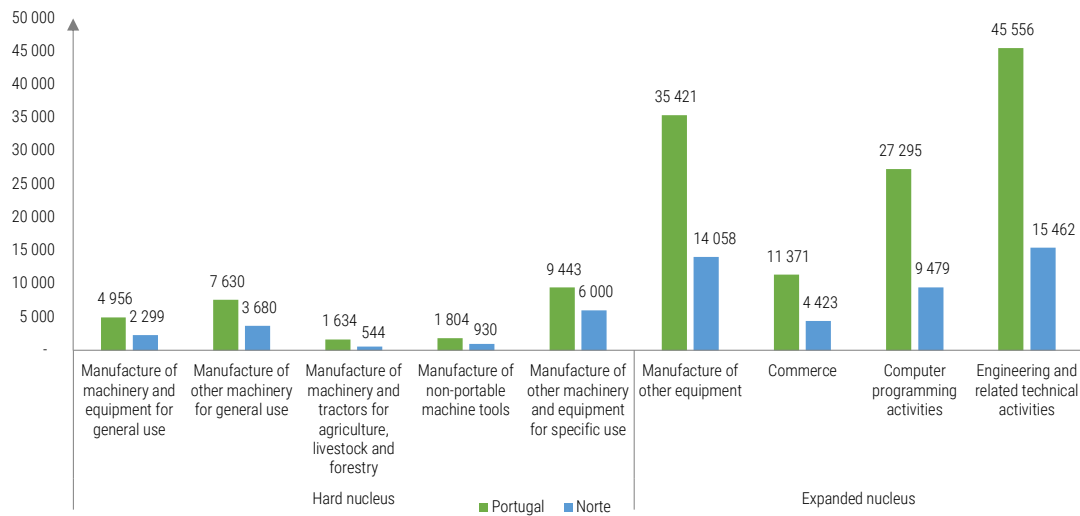
Figure 11 • Personnel employed in the main sectors included in the domain "Industrialisation and Advanced Manufacturing Systems", Portugal and Norte Region, Number, 2019

Source: INE, Sistema de contas integradas das empresas

In the extended core, we highlight the activities of "Manufacture of other metal tanks and containers", "Manufacture of electric motors, generators and transformers" and "Manufacture of measuring, checking and navigating instruments and appliances", which represent respectively 87%, 72% and 55% of the national turnover (aggregated in the chart under "Manufacture of miscellaneous equipment"). In terms of personnel employed, these activities represent 75%, 75% and 58% of the people employed nationally in each of these activities. In terms of the trade of machinery (aggregated under "Trade" in the chart), it should be noted, in particular, that Norte Region represents 87% of the turnover and 90% of the personnel employed in the CAE referring to "Wholesale of machinery for the textile industry, sewing and knitting machines".

In terms of characterising the business base of this domain, it is also important to take into account the activities considered in the strategy annexed to the *"Pacto setorial para a competitividade e internacionalização do Cluster Produtech – Tecnologias de Produção"*[19]. According to the referred strategy, this sector includes the following core activities:

- **Capital goods and components:** machine tools, sensors, transmitters, mechanical and electrical appliances, tanks, electronic boards, speed indicators, base metals, metal structures, telecommunications components, devices (hydraulic, measuring, etc.), robot cells, presses, transformers, miscellaneous equipment (industrial, electrical, electronic, IT, bakery, etc.) with application in numerous manufacturing and transformation industrial sectors (metalworking, footwear, textiles, cork, ceramics, plastics, agro-food...) of various raw materials and products (rubber, cork, wood, leather, natural stone, ceramic products, paper pulp, wine, dairy products, etc.), load handling vehicles, machinery and equipment parts, valves, pumps, etc.

- **System integrators:** development of turnkey solutions for production lines and systems, integrating solutions for equipment goods, advanced automation and robotics systems, production control, production control applications, certification and quality systems, artificial vision systems, etc.

- **Software and services:** Development of information technologies such as management systems, production control systems, solutions integrating RFID technology, software programming, computer assistance and editing, information management and various applications. Consulting and auditing in various areas (industry, environment, energy...).

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[19]   Ministério da Economia and PRODUTECH Cluster (2019).

At the level of international trade, the value of exports[20] of the sectors included in the domain of "Industrialisation and Advanced Manufacturing Systems" was more than 1 800 million euros in 2019, representing 7% of total exports from Norte. Within this domain, the exports of the hardcore sectors of the domain stand out, namely manufacturing of machinery and equipment, with 33% of the total, and of note, in the expanded nucleus, is the sector of manufacturing of electric motors, generators and transformers, with 13%.

Based on the established methodology, it is also important to consider, when characterising the business base, the competitiveness clusters and sectorial business associations operating in Norte (Cf. Annex 1). The following table presents the main areas of intervention of the competitiveness clusters and sectoral business associations within this priority domain.

Table 5 • Main intervention areas of the Competitiveness Clusters and Business Associations within the domain "Industrialisation and Advanced Manufacturing Systems"

Type of Institution	Main areas of intervention
Competitiveness Clusters and Business Associations	Engineering and prototyping, mould making, tools, new materials, engineering and construction, production technologies, metallurgy and metalworking, information, communication and electronic technologies

2.3. Advanced Users and Trends

In the priority domain "Industrialisation and Advanced Manufacturing Systems", a prospective analysis was carried out[21] to identify the main global medium and long-term trends that shape intermediate and final demand, allowing for the assessment of the regional potential in the construction of competitive advantages and the improvement of the level of insertion in international value chains. The schematic and conceptual dimension of this identification process must consider the interaction of the different trends among themselves, enhancing the effect of each one and of the whole. These trends are structured into the following five topics:

a) **Resources sustainability** - increasing importance of (future) sustainability as a determinant of production processes, from design and conception to marketing, prototyping and industrialisation, regarding in particular the use of resources (such as water, energy or materials) and their life cycles and the corresponding products;

b) **Digitalisation** - permanent adaptability of production systems to improve the efficiency of processes (flexibility, precision, deadlines, etc.) and products (functionality, etc.), as a response to highly competitive contexts and changes in demand, arising from the increased amount and availability of data (big data) and the improvement of its intelligibility (data science) for real-time decision-making, and developments in computing, from edge computing, of great importance for the internet of things (IoT), to high performance computing (HPC) and new emerging technologies - DARQ Technologies (distributed registry - the case of blockchain), artificial intelligence, mixed or extended reality and quantum computing.

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[20] Source: Data of companies' exports obtained from the Iberinform database. Does not include the referring values to individual companies.

[21] Relevant bibliography consulted: Comissão de Coordenação e Desenvolvimento Regional do Norte (2014), Monteiro, Meira, Santos, Leite, Guimarães & Gomes (2019), Comissão Europeia (2015a, 2015c, 2018a, 2019, 2020b, 2020d), Estado português (2017a, 2019a, 2019b), Fundação para a Ciência e Tecnologia (2019b, 2019d, 2019e, 2019i), Industry 2030 High Level Industrial Roundtable. European Commission (2019), Manufuture High-Level Group (2018, 2019), Sociedade Portuguesa de Inovação (2017), A.SPIRE (2018), World Manufacturing Forum (2018).

c) **Enabling technologies** - relevant impact of cross-cutting technologies in different sectors and value chains, such as advanced materials and nanotechnologies in sustainability and circular economy, artificial intelligence and cybersecurity in the automation of production processes and collaborative practices and global interaction, micro and nanoelectronics and photonics in functionalisation and miniaturisation;

d) **Automation, robotics and smart industry** - progressive change of the manufacturing paradigm as a production mode, integrating cyber-physical systems, provided namely by the internet of things and services and composed of networks of autonomous entities with physical elements (sensors, smart machines and robotics), digital or mixed (cooperative work between humans and machines) elements, in new, evolving, adaptive, flexible, customizable and scalable processes;

e) **Production, management, business and work models** - transformation of industry as a sector of activity into a socio-technical system based on the dynamics of collaborative networks and supply chains, with accelerated vertical and horizontal integration alongside greater decentralisation (of the blockchain type), extension of human capabilities by association with machines and robots and the need for new qualifications, employment patterns, education and lifelong learning and intense collaboration between universities, research centres and companies.

The R&D&I strategies and public policies associated with this priority domain cannot be dissociated from the global trends structured into the five topics mentioned in the previous point, and are not, nor can they be, mutually exclusive. Resulting from the analysis of different documents from national and international organisations, the R&D&I strategies and public policies for this domain are the following:

a) **Resources sustainability** - progressive circular economy approaches, as well as practices to reduce (e.g, via design and waste reduction) of material use; life cycle analysis (LCA) practices; use of bio- and eco-materials and new materials to increase bio-degradability and recyclability and decrease the ecological footprint; industrial processes of eco-design and re-use, disassembly, remanufacturing and recycling; minimisation of industrial waste and reuse of corresponding raw materials and materials; energy recovery technologies and smart management of energy exchanges of manufacturing processes and industrial equipment;

b) **Digitalisation** - upstream and downstream interoperability for integration into supply chains; efficient data storage, management and protection systems; data analysis as a core business asset (data driven enterprises); remote monitoring, control and maintenance of production units, including through advanced digital twins (with real-time data feeds) of production operations; new human-machine interfaces, including mixed realities and natural voice processing communication systems between infrastructures, equipment and storage (of stocks) for management and optimisation of production; real-time supervision, monitoring and control of processes during the life cycle of products and their manufacture; multisensorial digital solutions for connection, control and optimisation of manufacturing operations; development of autonomous diagnostic capabilities and self-optimisation, self-configuration and self-healing;

c) **Enabling technologies** - converging development of technologies, associated namely with materials engineering, nanotechnologies, biotechnology and biological transformation, artificial intelligence, nano and microelectronics, photonics, mechatronics, systems engineering, indispensable to improve industrial performance, aiming at a production process with zero defects, zero delays, zero unforeseen events and zero waste;

d) **Automation, robotics and smart industry** - development of mass production but also flexible (to meet changing demand), and customised (customer-driven), involving in particular task-based programming to be developed by robots, mobile manipulators for logistics, shared autonomy, augmented reality, internet of things, flexible industrial systems architecture, robotisation and flexible manufacturing systems, reconfigurable production systems; collaborative robotics, artificial vision, mixed reality, digital twins, etc.; new design and production technologies such as additive manufacturing (3D printing) and additive/subtractive hybrids, micro and nano manufacturing, moulded and flexible electronics and smart design (generative design);

e) **Production, management, business and work models** - development of dynamic and digitally integrated value chains, functioning as mobile and collaborative platforms; redeployment of manufacturing activities in human-machine interaction contexts, with highly skilled workers in control of highly complex and performing automated systems; permanent adjustment of the supply of qualifications to meet the demand for workers with STEM (Science, Technology, Engineering and Mathematics) qualifications and appropriate skills in creativity, communication, collaboration or problem solving; promotion of business models based on Home Fabrication, through the use of 3D Printing for the manufacture of small objects, with customisation and environmental advantages.

The following table presents the association between the trends identified in the domain "Industrialisation and Advanced Manufacturing Systems" and the "societal challenges" that constitute heavy trends of structural change in the economy and society and that present a transversal character to different priority domains. This analysis allows the conclusion that this priority domain is aligned with structural transformation trends such as the energy-environmental transition, digital transformation, and Industry 4.0. This conclusion thus reveals that, despite the sectoral and thematic specificities of this priority domain, there are common elements in the trends and policies to other priority domains of smart specialisation that promote an interpenetration of areas, which will increasingly exist in various enterprises, institutions, and economic activities.

Table 6 • Association[1] between trends identified in the domain "Industrialisation and Advanced Manufacturing Systems" and "societal challenges"

Trends	Aging		Energy Efficiency		Decarbonisation		Circular Economy		Digitalisation		Industry 4.0	
	D	I	D	I	D	I	D	I	D	I	D	I
a) Resources sustainability			•		•		•					
b) Digitalisation									•		•	
c) Enabling technologies								•	•		•	
d) Automation, robotics and smart industry									•		•	
e) Production, management, business and work models										•		•

[1] Direct (D) or indirect (I) association

2.4 Rationale

The "Industrialisation and Advanced Manufacturing Systems" priority domain aims to combine the existence of scientific and technological capacities and infrastructures, consolidated business bases (machinery and equipment manufacturing, industrial engineering and consulting, industrial information systems, etc.) and relevant user sectors (manufacturing, extractive industry, construction, water, energy, primary sector, etc.), in the context of digital and energy-environmental transformation processes and new production, management, business and work models. The following figure shows the referential analysis of the priority domain "Industrialisation and Advanced Manufacturing Systems".
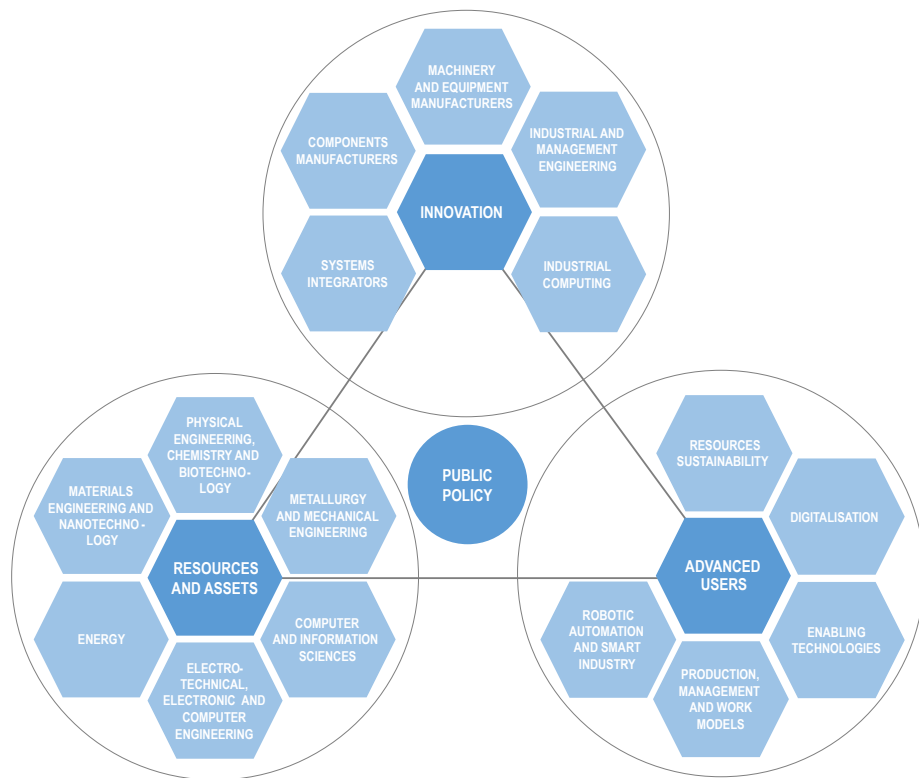
Figure 12 • Analytical framework of the domain "Industrialisation and Advanced Manufacturing Systems"

In terms of policy rationale, the area "Industrialisation and Advanced Manufacturing Systems" aims to develop sectors associated with enabling technologies (namely, materials engineering, nanotechnologies, biotechnology and biological transformation, artificial intelligence, nano and microelectronics, photonics, mechatronics, systems engineering, etc.), combining the existence of scientific and technological capabilities and infrastructures, consolidated business bases (machinery and equipment manufacturing, industrial engineering and consulting, industrial informatics, etc.) and relevant user sectors (manufacturing, extractive industry, construction, water, energy, primary sector, etc.), in the context of digital and energy-environmental transformation processes and new production, management, business and work models.

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Annex 1

List of the non-business entities of the scientific and technological system identified in the priority domain "Industrialisation and Advanced Manufacturing Systems"[22]

Typology	Acronym	Name
R&D Units	CeDRI	Research Centre for Digitisation and Intelligent Robotics
R&D Units	CISTER	Research Centre for Embedded and Real-Time Computing Systems
R&D Units	CMEMS-Uminho	Electromechanical Microsystems Research Unit
R&D Units	GECAD	Research Group on Engineering and Intelligent Computing for Innovation and Development
R&D Units	IFIMUP	Institute for Advanced Materials Physics, Nanotechnology and Photonics - University of Porto
R&D Units	ISISE	Institute for Sustainability and Innovation in Engineering Structures
R&D Units	LAETA	Associated Laboratory for Energy, Transport and Aeronautics
R&D Units	LEPABE	Process, Environmental, Biotechnological and Energy Engineering Laboratory
R&D Units	UACC	Artificial Intelligence and Computer Science Laboratory
R&D Units	2Ai	Applied Artificial Intelligence Laboratory
R&D Units	ALGORITMI	ALGORITMI Research Centre
R&D Units	CF-UM-UP	Physics Centre of the Universities of Minho and Porto
R&D Units	CONSTRUCT	R&D Institute for Structures and Constructions
R&D Units	INESC TEC	INESC TEC - INESC Technology and Science
R&D Units	IPC	Institute for Polymers and Composites
R&D Units	SYSTEC	Centre for Systems and Technology
R&D Units	CIETI	Centre for Innovation in Industrial Engineering and Technology
R&D Units	proMetheus	Research Unit in Materials, Energy and Environment for Sustainability
Associated Labs.	LAETA	Associated Laboratory in Energy, Transport and Aerospace
Associated Labs.	ALICE	Associated Laboratory for Innovation in Chemical Engineering
Associated Labs.	INESC TEC	Institute for Systems Engineering and Computers, Technology and Science
Associated Labs.	LaPMET	Physics Laboratory for Emerging Materials and Technologies
Associated Labs.	ARISE	Advanced Manufacturing and Intelligent Systems
Associated Labs.	LASI	Associated Laboratory for Intelligent Systems
State Labs.	LNEG	National Energy and Geology Laboratory
R&D Infraest. RNIE	CECOLAB	National Infrastructure Network for the Circular Economy
R&D Infraest. RNIE	Micro&NanoFabs@PT	CECOLAB Association - Collaborative Laboratory Towards Circular Economy
R&D Infraest. RNIE	NECL	Network of Micro and Nanofabrication Research Facilities

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[22] The identification of the entities was based on the analysis of a synthetic characterisation of each institution obtained, namely through consultation of various ANI publications, FCT evaluation reports and the entities' websites. It should be noted that the mere identification of a given infrastructure in each domain is not enough to guarantee its framework in S3 NORTE 2027 for the purposes of support for financing from EU funds. Similarly, the non-inclusion of a given infrastructure may not prevent access to such support and funding, depending always on the project that will be presented.

Typology	Acronym	Name
Technology Centres	CATIM	Technological Support Centre for the Metal-Mechanical Industry
Technology Centres	CITEVE	Technological Centre of Textile and Clothing Industries of Portugal
Technology Centres	CTCOR	Technological Centre of Cork
Technology Centres	CTCP	Portugal Technological Centre of Footwear
Technology Transfer and Valorisation Centres	CCG/ZGDV	Association Centre for Computer Graphics
Technology Transfer and Valorisation Centres	CeNTItvc	Centre for Nanotechnology and Technical, Functional and Intelligent Materials
Technology Transfer and Valorisation Centres	INEGI	Institute for Science and Innovation in Mechanical Engineering and Industrial Engineering
Technology Transfer and Valorisation Centres	INESC TEC	Institute for Systems and Computer Engineering, Technology and Science
Technology Transfer and Valorisation Centres	INL	International Iberian Nanotechnology Laboratory
Technology Transfer and Valorisation Centres	ISQ	Institute for Welding and Quality
Technology Transfer and Valorisation Centres	PIEP	Association for Innovation in Polymer Engineering
Technology Transfer and Valorisation Centres	IEP	Portuguese Electronic Institute
Technology Transfer and Valorisation Centres	ARCP	Association Network of Competencies in Polymers
Technology Transfer and Valorisation Centres	LNEG	National Laboratory for Energy and Geology
Other R&D Infrastructures	ALGORITMI	ALGORITMI Research Centre
Other R&D Infrastructures	ISISE	Institute for Sustainability and Innovation in Engineering Structures
Other R&D Infrastructures	TERM Tech	TERM Tech Technological Centre - University of Minho
Colabs	ARCP	Association Network for Competence in Polymers
Colabs	BUILTCoLAB	Collaborative Laboratory for the Built Environment of the Future
Colabs	DTx	Collaborative Laboratory for Digital Transformation
Colabs	NET4C02	Network for a Sustainable C02 Economy
Colabs	VGCoLAB	Vasco da Gama CoLAB-Energy Storage
Digital Innovation Hubs	-	PRODUTECH DIH
Digital Innovation Hubs	-	DIGITALbuilt
Competitiveness Clusters	-	AEC Cluster - Architecture, Engineering & Construction
Competitiveness Clusters	-	Engineering & Tooling Cluster
Competitiveness Clusters	-	PRODUTECH Production Technologies Cluster
Competitiveness Clusters	-	TICE.PT
Business Associations	AIMMAP	Association of Portuguese Metal-Mechanic and Related Industries and Metalworkers
Business Associations	APCOR	APCOR - Portuguese Cork Association

Annex 2

Delimitation of the main sectors of activity from the Portuguese Classification of Economic Activities (CAE Rev. 3) in the field of "Industrialisation and Advanced Manufacturing Systems"

For the definition of the main economic activities included in the priority domain "Industrialisation and Advanced Manufacturing Systems", the sectoral delimitation established for the production technologies sector by the PRODUTECH Cluster is taken as a reference. This sector includes **manufacturers of machinery and equipment (including producers of components, subsystems and support applications), software companies for industry, engineering and industrial consulting companies, systems integrators and other services and products aimed at industry** (*lato sensu*, i.e. including utilities, construction and the primary sector). It also includes machine installers, system and equipment repair, maintenance and reconversion companies and support services. It interacts downstream with various sectors of manufacturing industry (and that, by definition, use production technologies), and upstream with manufacturers of raw materials, e.g. base metals, plastic products, and other intermediate goods (and that, by definition, are also, like the sector itself, users of production technologies).

Delimitation of the priority domain in terms of the Portuguese Classification of Economic Activities (CAE Rev. 3):

— **Hard nucleus:**
  • 281 - Manufacture of general-purpose machinery and equipment
  • 282 - Manufacture of other general-purpose machinery
  • 283 - Manufacture of machinery and tractors for agriculture, livestock and forestry
  • 284 - Manufacture of machine tools
  • 289 - Manufacture of other special-purpose machinery
— **Expanded Core:**
  • 2529 - Manufacture of other metal tanks and containers
  • 253 - Manufacture of steam generators
  • 25732 - Mechanical tool manufacturing
  • 25733 - Manufacture of sintered parts
  • 25734 - Manufacture of metal moulds
  • 2651 - Manufacture of instruments and appliances for measuring, checking and navigating
  • 2711 - Manufacture of electric motors, generators and transformers
  • 3312 - Repair and maintenance of machinery and equipment
  • 332 - Installation of industrial machinery and equipment
  • 4614 - Agents involved in the sale of machinery, industrial equipment, ships and aircraft
  • 4661 - Wholesale of agricultural machinery and equipment
  • 4662 - Wholesale of machine tools
  • 4663 - Wholesale of machinery for mining, construction and civil engineering
  • 4664 - Wholesale of machinery for the textile industry, sewing machines and knitting machines
  • 5829 - Editing of other software
  • 6201 - Computer programming activities
  • 7112 - Engineering activities and related techniques
  • 7120 - Technical testing and analysis activities
  • 749 - Other professional, scientific and technical activities n.e.c.

It was mentioned that the production technologies sector is diffuse and broad, making it especially difficult to analyse it and, in particular, to quantitatively approximate its dimension and relevance, given the known limitations of primary information sources.

(Sources: "Augusto Mateus & Associados (2017). Estudo para a PRODUTECH "Fileira das tecnologias de produção em Portugal - Atualização do diagnóstico e aprofundamento estratégico""; "Ministério da Economia e Cluster PRODUTECH (2019). Cluster PRODUTECH - Tecnologias de Produção. Pacto Setorial para a Competitividade e Internacionalização. Estratégia anexa ao pacto setorial para a competitividade e internacionalização")

3.

Priority domain characterisation

Agro-Environmental and Food Systems

3.1. Resources and Assets

The "Agro-Environmental and Food Systems" domain seeks to explore the potential for regional economic valorisation resulting from the combination of scientific resources and assets, natural and symbolic resources and assets and business bases, namely food industries, agriculture and livestock production, forestry, forest-based industries, among others, capable of promoting an agro-food and forestry sector with greater added value, in a manner compatible with the preservation and management of resources such as water, forests and ecosystems, and to contribute to a greater valorisation of endogenous resources as an opportunity to increase territorial competitiveness.

Within the scope of the exercise to assess the existence of critical mass in this priority domain, it is important to analyse the technological resources and assets to be integrated by the main business bases of the agro-environmental and food-related sectors. The non-technological resources and assets that by their nature are inimitable and non-transferable will also be characterised, namely the territory-intensive assets and resources. In a first point, the stock of human capital with advanced skills by main areas of education and training is characterised through the indicator "Number of graduates in higher education by areas of education and training", already used in the preparation of RIS3 NORTE 2020, with accumulated values from the academic years 2008/2009 to 2017/2018.

Based on the established methodology, the education and training areas considered to have the greatest potential for the achievement of the rationale defined for this domain are the following[23]:

- **"Agriculture"**: such as "Agriculture, forestry and fishing", "Crop and animal production", "Floriculture and gardening", "Forestry and hunting", "Fisheries" and "Veterinary science";

- **"Sciences, mathematics and computer science"**: such as "Life sciences", "Biology and biochemistry", "Environmental sciences", "Computer sciences", "Physics", "Chemistry", "Earth sciences", "Physical sciences, Computer and IT sciences";

- **"Services":** such as "Environmental protection", "Environmental protection technology", "Natural environments and wildlife" and "Public health services";

- **"Engineering, manufacturing and construction":** such as "Metallurgy and metalworking", "Electricity and energy", "Electronics and automation", "Chemical process technology", "Food industries" and "Materials (wood, cork, paper, plastic, glass and other industries)";

- **"Social sciences, commerce and law"**: as "Commerce".

Between 2008 and 2018, 61 012 students graduated in these training areas in Norte Region, distributed by the different types of courses, namely, professional higher technical courses, bachelor's degrees, master's degrees and doctorates. Of this total, during this period, 2 305 obtained a doctoral degree and 30 429 obtained a master's degree. In terms of education and training areas, the number of graduates in the following areas stands out: (i) "Agriculture, Forestry, Fisheries and Veterinary Sciences": with 2 549 graduates in "Veterinary Sciences" and 1 505 in "Agricultural and Animal Production"; (ii) "Sciences, Mathematics and IT": with 7 337 graduates in "Biology and Biochemistry", 4 470 in "Computer Sciences" and 1 683 in "Earth Sciences"; (iii) "Environmental Protection": with 1 337 graduates in "Environmental protection technology" and 640 in "Public health services"; (iv) "Manufacturing ": with 1 458 graduates in "Food industries" and 973 graduates in "Materials (wood, cork, paper, plastic, glass and other industries)"; (v) "Engineering and related techniques": with 15 986 graduates in "Electronics and automation", 7 331 in "Metallurgy and metalworking", 6 671 in "Technology of chemical processes", 4 011 in "Engineering and related techniques - programmes not classified in another training area" and 1 632 in "Electricity and energy". This information is systematised in the following figure.

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[23]   The exercise of identifying the most relevant education and training areas for this domain took into consideration: (i) the revised rationales in the new domains of smart specialisation of S3 NORTE 2027; (ii) the responses to the surveys carried out to the Regional Platforms of Smart Specialisation for the review of S3 NORTE 2027, (iii) the international demand trends and corresponding R&D&I strategies and policies for the priority domains of S3 NORTE 2027 and (iv) the basic resources and assets that are included in RIS3 NORTE 2020.

Figure 13 • Number of Graduates by Education and Training Areas in Norte Region, cumulative value
from 2008/2009 to 2017/2018

Source: DGEEC

It is also important to characterise the regional scientific production, namely the publications by scientific and technological areas considered most relevant to the achievement of the rationale of the priority domain "Agro-Environmental and Food Systems". This analysis is carried out based on the indicator "Number of publications indexed in the Web of Science by scientific area", a variable already used in the preparation of RIS3 NORTE 2020, using the cumulative values from 2008 to 2018.

Taking into account the defined methodology, the most relevant scientific and technological areas for this domain in terms of publications[24] are: (i) "Agricultural Sciences": with 1 511 publications in "Agriculture, Forestry and Fisheries" and 2 820 publications in "Other Agricultural Sciences"; (ii) "Exact and Natural Sciences": with 9 739 publications in "Biological Sciences", with 7 579 publications in "Chemistry", 5 411 publications in "Computer and Information Sciences" and 3 947 publications in "Earth and Environmental Sciences"; and (iii) "Engineering Sciences and Technology": with 4 517 publications in "Materials Engineering", 4 202 publications in "Electrical, Electronic and Computer Engineering", 2 414 publications in "Environmental Engineering", 2 414 publications in "Mechanical Engineering" and 5 008 publications in "Other Engineering Sciences and Technologies". This information is systematised in the following figure.

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[24] The exercise of identifying the most relevant scientific and technological domains for this domain took into account: (i) revised rationales in the new smart specialisation domains of S3 NORTE 2027; (ii) responses to surveys carried out to the Regional Smart Specialisation Platforms for the review of S3 NORTE 2027, (iii) international demand trends and corresponding R&D&I strategies and policies for the priority domains of S3 NORTE 2027 and (iv) the resources and assets of base contained in RIS3 NORTE 2020.
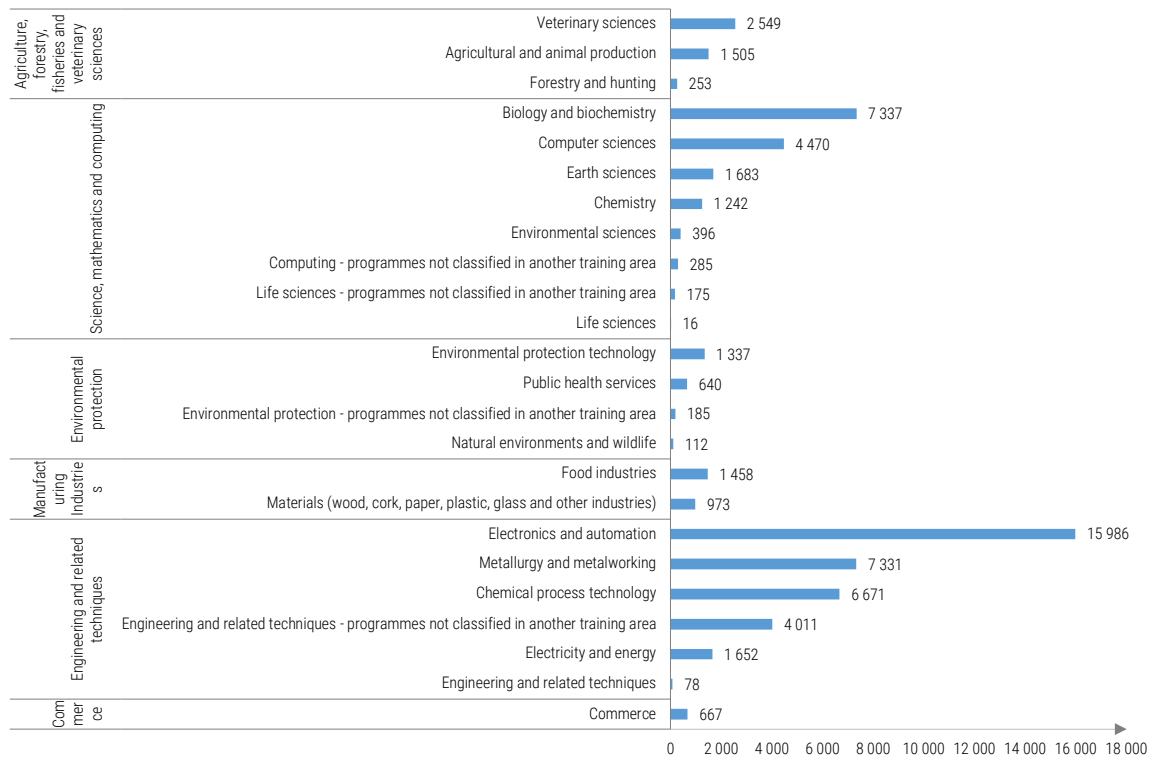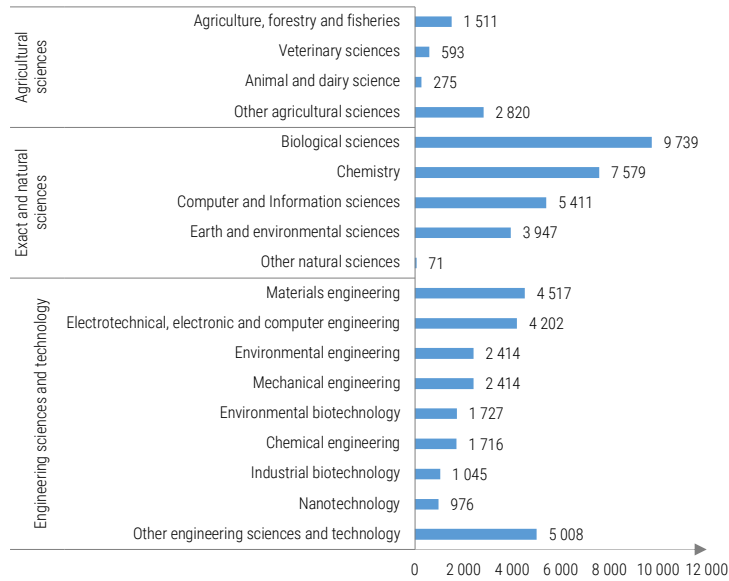
Figure 14 • Number of Publications by Scientific and Technological Areas in Norte Region,
cumulative value from 2008 to 2018
Source: DGEEC

A fundamental element of the characterisation of scientific and technological resources is also related to the identification of the installed capacity in the region in terms of non-business R&I scientific and technological infrastructures that are part of the regional scientific and technological system. Based on the established methodology, 65 Research and Technological Infrastructures were identified in this priority domain that fall within its areas of intervention (see Annex 1). The following table shows the main areas of intervention of this type of entity within this priority domain.

Table 7 • Main intervention areas of the Research and Technological Infrastructures within the
domain "Agro-Environmental and Food Systems"

Type of Institution	Main areas of intervention
Research Infrastructures	Biotechnology, biology, chemistry, biochemistry, chemical engineering, microbiology, molecular biology, food safety, food, nutrition, health, veterinary and animal sciences, plant health, environment, climate change, earth sciences, environmental sciences, marine sciences, water, soil, ecosystems, biodiversity, ecology, territory horticulture, genetics, genomics, energy, biomass, biorefinery, circular economy, systems engineering, information systems, sensors, automation, digitalisation, robotics, precision agriculture, water management, advanced agro-industrial processing systems, mechanical engineering, materials engineering, nanotechnology, bioengineering, bioproducts.
Technological Infrastructures	Biotechnology, biology, food quality and safety, animal by-products, materials, bioeconomy, bioproducts, circular economy, biodiversity, environment, water resources, soil, water, landscape, waste valorisation, forestry, mountain, ecosystem management, health and well-being, vines, wine, cork, meat, energy, biorefineries, biomass, biofuels, systems engineering, information technologies, robotics, nanotechnology.

In the case of the "Agro-Environmental and Food Systems" domain, the characterisation of non-technological resources and assets implies in a first point the synthetic analysis of the territory surface characterisation in terms of agriculture, forestry, energy, water, and protected areas. The mapping of land use classes allows a general reading of the use of territorial resources and macro landscapes that reflect the diversity of Norte Region and its sub-regions, as presented in the figure below.
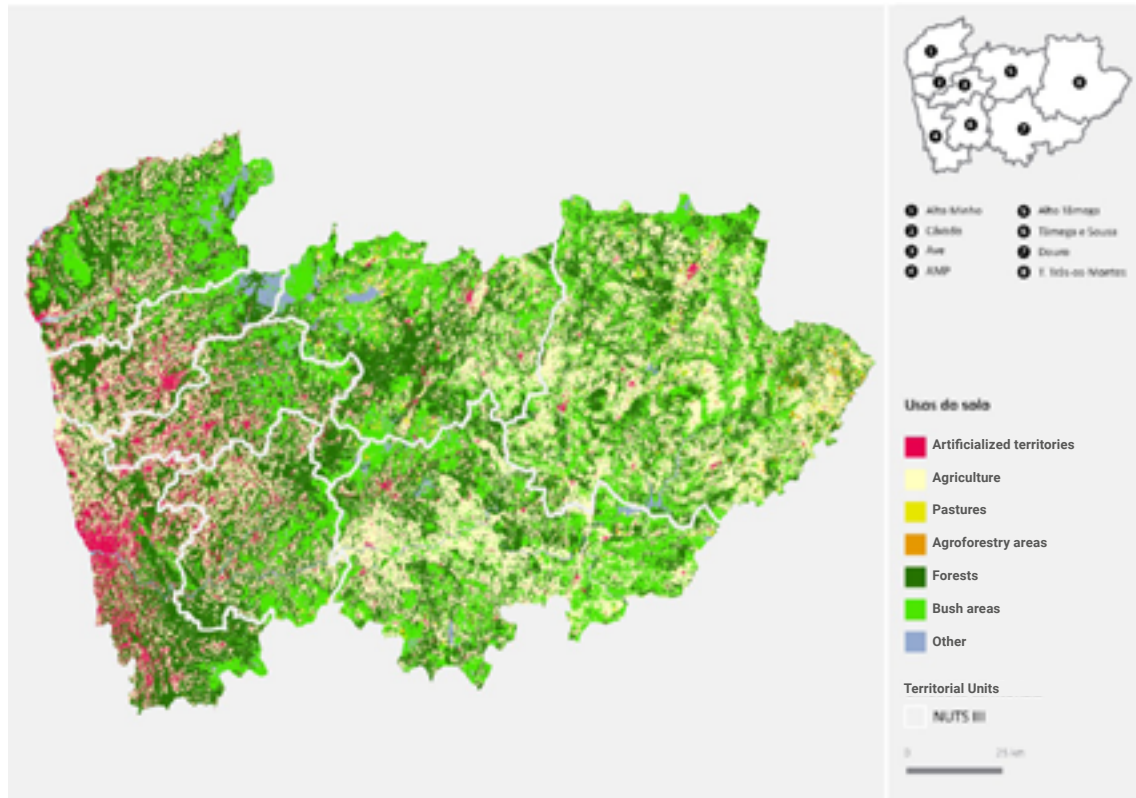
Figure 15 • Land use and land cover in 2018
Source: COS 2018, DGT

The used agricultural surface of Norte Region is of 663 341 ha and represents about 30% of its territory and 16.7% of the national total, being 70% concentrated in the interior territory, corresponding to the Agricultural Region of Trás-os-Montes that englobes the NUTS III Terras de Trás-os-Montes, Alto Tâmega and Douro[25].

The value of agricultural production in Norte[26] amounts to 1 615 million euros, representing 22.7% of the national total (continental), with 71% of vegetable production (of which 38.1% is fruit, 33.5% wine and 22.4% vegetables and horticultural products) and 29% to animal production (of which 50.2% milk and 23.1% cattle). In terms of production volume of the main regional crops[27] associated with agricultural production, the most important are, with more than 50% of national production, the PDO liqueur wine (96%), chestnuts (88%), kiwi (80%), rye (72%), fodder corn (60%) and olive trees (53%). Below 50%, but still with strong representative-ness when compared to the national production, is the PDO wine (48.5%), the apple (42%), the table olive (41%) and the cherry (40%).

As regards regional food products associated to this area with PDO/PGI/TSG[28] classification, not including wines, goat meat (100%, unique in the country), sausage products (96.5%), honey (54%), pastry products (43%), olive oil (29%) - in particular extra virgin olive oil (36.5%) - and beef (31%) stand out with the greatest relative importance in the total national production[29] (in volume). This representation changes when the production value is taken into account, with goat meat (100%), sausage products (80%), beef (48%), honey (39%), olive oil (24%) and sheep meat (21%) standing out. In the regional context, sausage products (42%), beef (31%) and olive oil (16.5%) are more relevant.

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[25]   Instituto Nacional de Estatística (2021)

[26]   Instituto Nacional de Estatística (2020)

[27]   Instituto Nacional de Estatística (2019)

[28]   PDO - Protected Designation of Origin; PGI - Protected Geographical Indication; TSG - Traditional Speciality Guaranteed.

[29]   Direção Geral de Agricultura e Desenvolvimento Rural (2019)

The forested area in Norte Region constitutes about 37% of its territory and about 18% of the national total[30]. Regional forestry production represents about 30% of national production and is mainly made up of maritime pine (26%), eucalyptus (25%), oak (10%) and chestnut (7%). Biomass not only from forestry waste, but also from agriculture, livestock, and the agri-food industry, also stands out as an important energy resource in Norte in terms of bioenergy, contributing to the sustainable development of forestry, agriculture and livestock activity.

A significant percentage of the territory corresponds to core areas for the conservation of nature and biodiversity which include the Peneda-Gerês National Park (only in this category), Natural Parks, Protected Landscapes of National and Local Interest, Sites of Community Interest (SCI) and Special Protection Areas (SPA) integrated into the Natura 2000 Network, to which is added the Alto Douro Wine Region, World Heritage Site, according to UNESCO classification. In the case of Norte Region, there is also: the Biosphere Reserves classified by UNESCO, Gerês/Xurês and Meseta Ibérica, and the classification of Barroso, as a GIAHS/SIPAM site, by the Food and Agriculture Organisation (FAO) of the United Nations (UN)[31].

Regarding the main water resources, fundamental to the activities related to this domain, Norte Region is characterised by 10 hydrographic basins, namely, Lima, Âncora, Minho, Neiva, Cávado, Leça, Ave, Douro, Tâmega and Vouga, belonging to the hydrographic regions of Minho and Lima (HR 1), Cávado, Ave and Leça (HR 2), Douro (HR 3) and, albeit marginally, Vouga, Mondego and Lis (HR 4), which are responsible for the existence of good water availability, especially on the coast. There are 69 public water reservoirs of public service, 65% of which in the interior, corresponding to the NUTS II Alto Tâmega, Terras de Trás-os-Montes and Douro[32]. In terms of hydro-agricultural exploitation there are 16 stations of which 15 are inland[33].

3.2 Business Bases

For the definition of the main economic activities included in this domain, the sectors that constitute the major areas of this domain and that are considered in its rationale[34/35] are, namely: (i) Agriculture and animal production; (ii) Food industry; (iii) Beverages industry; (iv) Forestry; (v) Wood and cork industry; (vi) Pulp and paper industry; (vii) Packaging and (viii) Water and Waste Management. The following figures show the turnover, personnel in service and in the main sectors of activities included in the domain "Agro-Environmental and Food Systems".

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[30]   Instituto Nacional de Estatística (2019)

[31]   Comissão de Coordenação e Desenvolvimento Regional do Norte (2020)

[32]   Instituto da Conservação da Natureza e das Florestas (2018)

[33]   Direção Geral de Agricultura e Desenvolvimento Rural (2021)

[34]   Instituto Nacional de Estatística (2019); Associação para a competitividade da indústria florestal (2013); Instituto Nacional de Estatística (2007)

[35]   Annex 2 contains the delimitation of the main sectors of activity in terms of the Statistic Classification of Economic Activities (CAE Rev. 3) included in the priority domain "Agro-Environmental and Food Systems".
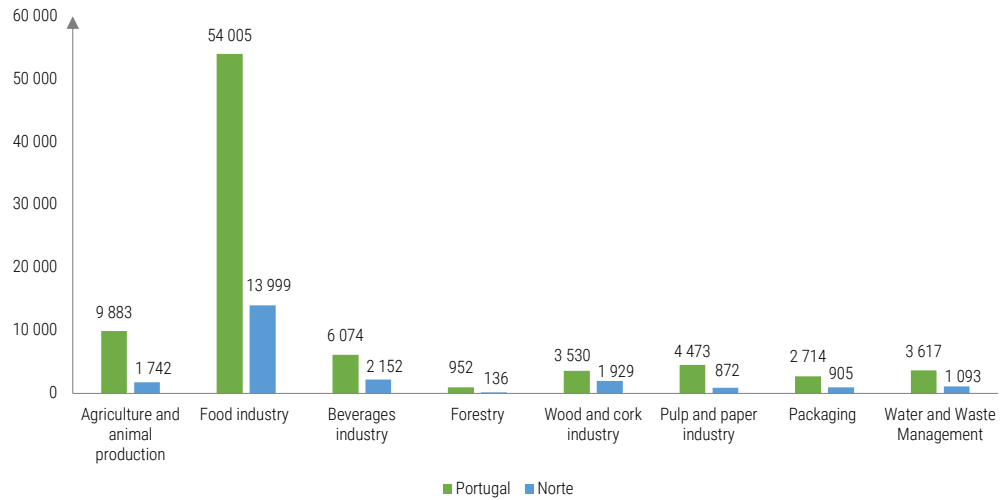
Figure 16 • Turnover in the main sectors included in the domain "Agro-Environmental and Food Systems", Portugal and Norte Region, million euros, 2019

Source: INE, Sistema de contas integradas das empresas
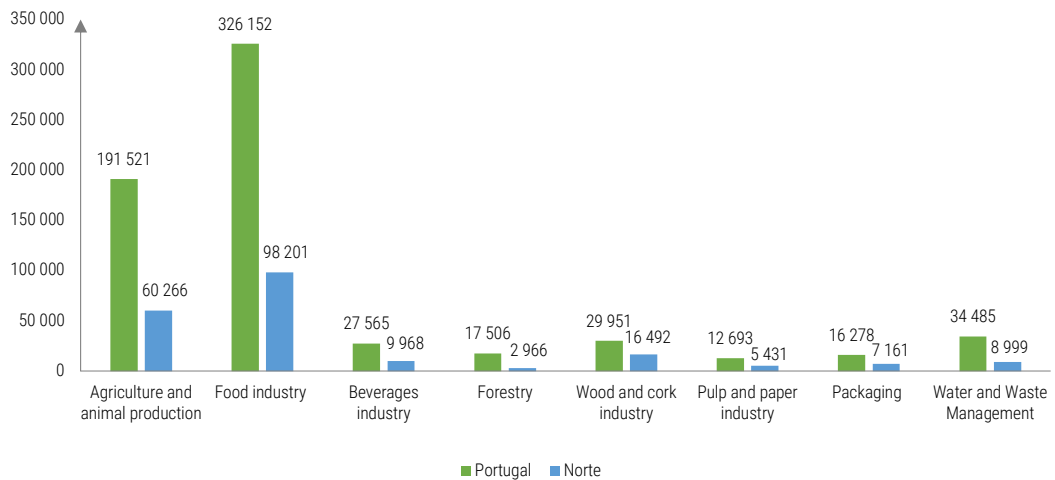
Figure 17 • Personnel employed in the main sectors included in the domain "Agro-Environmental and Food Systems", Portugal and Norte Region, million euros, 2019

Source: INE, Sistema de contas integradas das empresas

Overall, the turnover of the sectors of activity considered in this priority domain amounted in the Norte Region in 2019 to around 22 827 million euros, employing around 210 000 people, representing 27% and 32% respectively, of the national total.

The food industries and commerce have a very relevant economic expression in Norte, with a turnover of approximately 14 000 million euros and around 100 000 people employed, representing 61% and 47%, respectively, in this domain. These values correspond respectively to 26% and 30% of the national total for these industries, in 2019. As for the beverage industry, it represents 2 152 million euros of turnover and nearly 10 000 people in service, and its importance at national level reaches 35% in these two indicators. In third place comes the sector of agriculture and animal production with a turnover of 1 742 million euros in Norte Region but in second place with regard to personnel in service accounting for more than 60 000 workers.

The sectors associated to the forestry sector, namely forestry, wood and cork industry and pulp and paper industry, have a turnover value of 2 937 million euros with 24 889 people employed. In this sector, the wood and cork industry stand out, both in terms of turnover and personnel employed, representing 55% of the national total for these indicators. The packaging sector, although residual, has a very particular relevance in this area due to its articulation with the remaining sectors, being fundamental for product valorisation and innovation.

The water and waste management sector represents almost 1 100 million euros of turnover with about 9 000 people at its service. The need for more efficient management of water and waste is crucial to meet the need to develop and enhance the agro-food sector, including forestry, agriculture, livestock and food processing, in order to promote agriculture that generates greater added value.

In terms of international trade, the sectors of activity considered in this priority domain represent 15.4% of the region's total exports[36]. The food industry and commerce sectors are responsible for 31% of the total exports of the domain and the wood and cork industries 30%, being the sectors that revealed the highest export capacity, followed by the pulp and paper industries with 11%, the packaging sector with 10%. The remaining sectors, agriculture and animal production, forestry and water and waste management, have a very residual expression in this variable.

Based on the methodology established in the analytical framework for the definition of priority domains of smart specialisation, it is also important to consider in the characterisation of the business base of this priority domain the competitiveness clusters and sectorial business associations operating in Norte Region (Cf. Annex 1). The following table presents the main areas of intervention of the competitiveness clusters and sectoral business associations within this priority domain.

Table 8 • Main intervention areas of the Competitiveness Clusters and Business Associations within the domain "Agro-Environmental and Food Systems"

Type of Institution	Main areas of intervention
Competitiveness Clusters and Business Associations	Agro-food, wine, vineyards, cork, forest, canned fish.

3.3 Advanced Users and Trends

In the priority domain "Agro-Environmental and Food Systems" a prospective analysis[37] was carried out to identify the main medium and long-term global trends that shape intermediate and final demand, allowing for the assessment of the regional potential in the construction of competitive advantages and the improvement of the level of insertion in international value chains. The schematic and conceptual dimension of this identification process must consider the interaction of the different trends among themselves, enhancing the effect of each one and of the whole. These trends are structured into the following five topics:

a) **Precision agriculture** - transformation of the current chemical-mechanical model of agricultural development, ensuring greater efficiency of intermediate inputs and reduction of nutrients in the environment (especially nitrogen and phosphorus), resulting from their excessive use and not being fully absorbed by plants, which are also a major source of air, soil and water pollution;

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[36] Source: Data of companies' exports obtained from the Iberinform database. Does not include the referring values to individual companies.

[37] Relevant bibliography consulted: Comissão de Coordenação e Desenvolvimento Regional do Norte (2014), Comissão Europeia (2015, 2017, 2018, 2019, 2020), Estado português (2017, 2018, 2019, 2020), Fundação para a Ciência e Tecnologia (2019a, 2019b), Monteiro, Meira, Santos, Leite, Guimarães & Gomes (2019), Santos (2013).

b) **Agriculture and ecological transition** - reproduction in agricultural activity of ecological processes resulting from successive adaptations of natural ecosystems (predation, parasitism, symbiosis, etc.) as a way not only to improve the efficiency of production factors, particularly energy-intensive ones, but also to reduce the environmental footprint and atmospheric emissions, preserve biodiversity and improve the process of adaptation to climate change;

c) **Livestock and atmospheric emissions** - the need to reduce greenhouse gas (GHG) emissions from agriculture, not only of carbon dioxide but also of methane and nitrous oxide, overwhelmingly originating from intensive livestock farming, which occupies most arable land with possible alternative sustainable uses, based on the cereal-soy-cattle complex, the consumption of critical raw materials and the excessive use of antimicrobial agents;

d) **Ecosystem services and sustainable agri-forestry-pastoral activities** - the growing importance of species and their genome and of ecosystem services as production factors in different sectors of activity, and investment in natural capital, including in the restoration of carbon-rich habitats and climate compatible agriculture, is fundamental to innovation and economic and social progress;

e) **Healthy and sustainable food** - the importance of food models compatible with the biophysical limits of the planet and the needs of the population, while ensuring traceability, food safety, quality and resilience, reducing obesity, the prevalence of diseases related to unbalanced diet of health care costs and waste, and manufacturing, processing, packaging and transport processes compatible with the circular economy paradigm and reduction of greenhouse gas (GHG) emissions, promoting waste reduction and its valorisation throughout the food chain.

The R&D&I strategies and public policies associated with this priority domain cannot be found dissociated from the global trends structured into the five topics mentioned in the previous point and are not and cannot be mutually exclusive. Resulting from the analysis of different documents from national and international organisations, the R&D&I strategies and public policies for this domain are the following:

a) **Precision agriculture** - development of digitalisation technologies, geographical information systems, digitalisation of the territory, sensing, automation or robotisation, microsatellites for e.g. forest growth monitoring, which increase the economic efficiency of intermediate inputs (the relationship between the level of use of inputs and the level of production), such as fertilisers, plant protection products, water or energy, through their use in the most appropriate quantity, time and location;

b) **Agriculture and ecological transition** - widespread application of integrated protection (and the concept of economic level of attack); use of pollination services, biotic pest and disease control, mycorrhizae (to improve water and nutrient uptake), symbiotic synthesis of atmospheric nitrogen; maintenance of land on permanent fallow or in rotation, involving annual and multi-annual crops and legumes; eradication of invasive species; practices that improve the levels of organic matter in soils and carbon sequestration; use of techniques that control metabolism and produce anti-microbial substances;

c) **Livestock and atmospheric emissions** - improving animal husbandry techniques and the quality of pasture and forage; reducing dependence on critical raw materials and developing sustainable, innovative additives through cultured vegetable proteins, seafood, such as algae, and bio-economy by-products; improving indigenous breeds and extensification of livestock production; meeting standards of animal welfare and the collection, treatment, recycling and reuse of effluent; reducing the veterinary application of antimicrobials;

d) **Ecosystem services and sustainable agro-forestry-pastoral activities** - articulation of the productive function of woody material of the forest with its conservation and protection functions (of water resources, erosion, biodiversity, etc.), carbon storage and sequestration, production of biofuels and biomaterials; reconversion of abandoned territories into biodiverse landscape elements, namely buffer strips, fallow land, non-productive trees, terraced walls; mapping of ecosystems and monitoring of their produced goods and services; combating forest and ecosystem pests; development and application of new technologies to fight forest fires;

e) **Healthy and sustainable food** - smart labelling, packaging and materials, reusable and recyclable, that improve food safety and public health and reduce waste; promotion of safe and functional food, involving actions such as product traceability, post-harvest techniques, nutritional quality, bioactive substances, risk assessment and management, minimal processing technologies; use of by-products

in the context of the circular economy paradigm; promotion of the Mediterranean and Atlantic diet, with increased consumption of protein of plant origin and sustainable fish farming; more sustainable processing or transformation technologies for new foods or improvement of traditional foods promoting their authenticity (e.g. Protected Designations of Origin (PDO) and Protected Geographical Indications (PGI); use of food industry by-products in bioproducts with high added value.

The following table presents the association between the trends identified in the domain "Agro-Environmental and Food Systems" and the "societal challenges" that constitute heavy trends of structural change in the economy and society and that present a transversal character to different priority domains. This analysis allows the conclusion that this priority domain is aligned with structural transformation trends such as demographic, energy-environmental transition, circular economy, digital transformation, and industry 4.0. This conclusion thus shows that, despite the sectoral and thematic specificities of this priority domain, there are common elements in the trends and policies to other priority domains of smart specialisation that promote an interpenetration of areas, which will increasingly exist in various enterprises, institutions, and economic activities.

Table 9 • Association[1] between trends identified in the domain "Agro-Environmental and Food Systems" and "societal challenges"

Trends	Aging		Energy Efficiency		Decarbonisation		Circular Economy		Digitalisation		Industry 4.0	
	D	I	D	I	D	I	D	I	D	I	D	I
a) Precision agriculture			●			●		●	●		●	
b) Agriculture and ecological transition			●		●		●					
c) Livestock and atmospheric emissions			●		●			●				
d) Ecosystem services and sustainable agro-forestry-pastoral activities						●	●					
e) Healthy and sustainable food	●					●		●				

[1] Direct (D) or indirect (I) association

3.4 Rationale

In the case of the "Agro-Environmental and Food Systems" core priority domain, the aim is to explore the potential for regional economic valorisation resulting from the combination of scientific resources and assets with natural and symbolic resources and assets. Considering the productive dimension of Norte, anchored in agricultural and animal production activities and in the agro-food industry, the strategic positioning should target more sophisticated market segments and explore the valorisation potential associated with symbolic knowledge, in line with the trends of increasing appreciation of the origin, tradition and authenticity of products. On the other hand, the cross-fertilisation of the regional multi-sector business base gains relevance, aligning it thematically and boosting cross-innovation and the diversification of the sources of income of local populations.
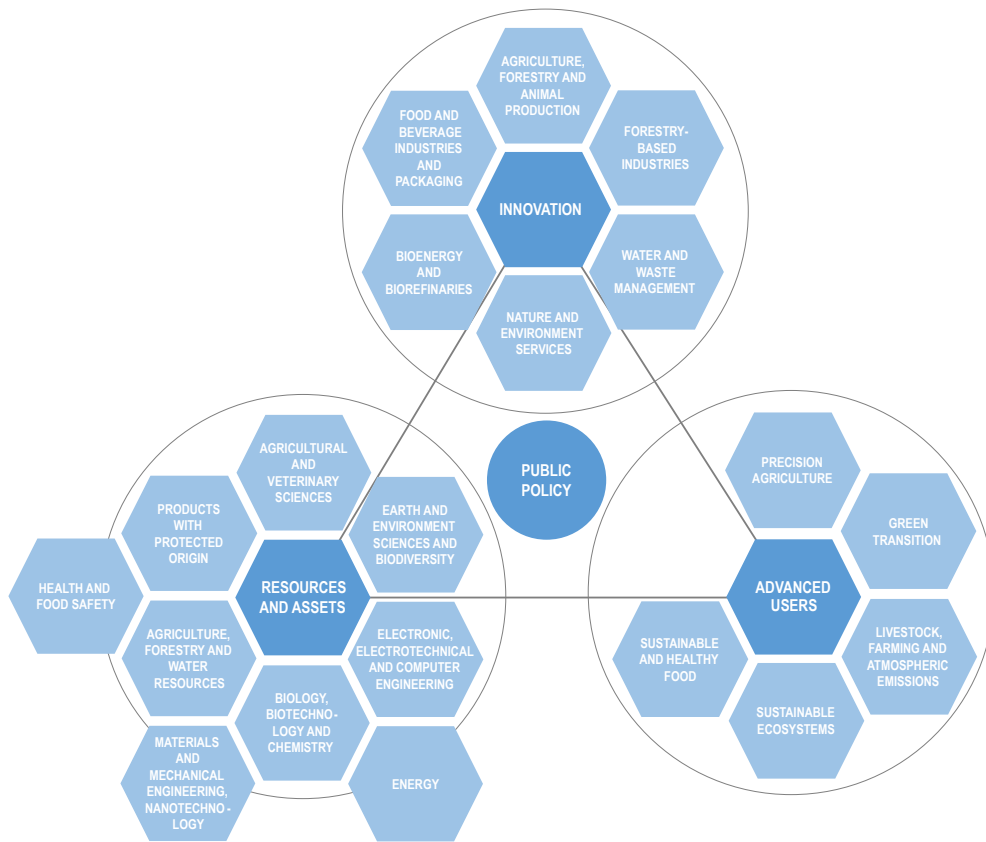
Figure 18 • Analytical framework of the domain "Agro-Environmental and Food Systems"

In terms of policy rationale, the domain "Agro-Environmental and Food Systems" aims to articulate the strong regional agricultural potential, namely in high added value products (wine, olive oil, chestnuts, Protected Designations of Origin (PDO) and Protected Geographical Indications (PGI), etc.), with scientific and technological skills (oenology, engineering, biology, biotechnology, ICT, robotics, etc.) and business (food industries, agriculture and animal production, forestry, forest-based industries, etc.), capable of promoting an agro-food and forestry sector with greater added value, in a way that is compatible with the preservation and management of resources, such as water, forests and ecosystems, and contributing to a greater valorisation of endogenous resources as an opportunity to increase territorial competitiveness.

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Annex 1

List of the non-business entities of the scientific and technological system identified in the priority domain "Agro-Environmental and Food Systems"[38]

Typology	Acronym	Name
R&D Units	CBQF	Centre of Biotechnology and Fine Chemistry (CBQF)
R&D Units	CEB-UM	Centre of Biological Engineering from University of Minho (CEB-UM)
R&D Units	CECA	Centre for Animal Science Studies (CECA)
R&D Units	CIIMAR	Interdisciplinary Centre for Marine and Environmental Research (CIIMAR)
R&D Units	CIMO	Mountain Research Centre (CIMO)
R&D Units	CIQUP	Chemistry Research Centre of Porto University (CIQUP)
R&D Units	GreenUPorto	Sustainable Agro-Food Production Research Centre (GreenUPorto)
R&D Units	InBIO	Research Network on Biodiversity and Evolutionary Biology (InBIO)
R&D Units	LEPABE	Laboratory for Process, Environmental, Biotechnological and Energy Engineering (LEPABE)
R&D Units	LSRE-LCM	Separation and Reaction Processes Laboratory - Laboratory for Catalysis and Materials (LSRE-LCM)
R&D Units	REQUIMTE	Associate Laboratory for Green Chemistry - Clean Technologies and Processes (REQUIMTE)
R&D Units	UCIBIO	Unit for Applied Biomolecular Sciences (UCIBIO)
R&D Units	CBMA	Centre for Molecular and Environmental Biology (CBMA)
R&D Units	CECAV	Centre for Animal and Veterinary Science (CECAV)
R&D Units	CITAB	Centre for Agro-environmental and Biological Research and Technology (CITAB)
R&D Units	CQVR	Chemistry Centre - Vila Real (CQVR)
R&D Units	INESC TEC	INESC TEC - INESC Technology and Science (INESC TEC)
R&D Units	MEtRICs	Centre for Mechanical Engineering and Resource Sustainability (MEtRICs)
R&D Units	CETRAD	Centre for Transdisciplinary Studies for Development (CETRAD)
R&D Units	CISAS	Centre for Research and Development in Agro-Food Systems and Sustainability (CISAS)
R&D Units	proMetheus	Research Unit in Materials, Energy and Environment for Sustainability (proMetheus)
Associated Labs.	SusTEC	Associate Laboratory for Sustainability and Technology in Inland Regions
Associated Labs.	InBIO	Research Network on Biodiversity and Evolutionary Biology (InBIO)
Associated Labs.	LAQV/ REQUIMTE	Associate Laboratory for Green Chemistry - Clean Technologies and Processes
Associated Labs.	ALICE	ALICE - Associated Laboratory for Innovation in Chemical Engineering

[38] The identification of the entities was based on the analysis of a synthetic characterisation of each institution obtained, namely through consultation of various ANI publications, FCT evaluation reports and the entities' websites. It should be noted that the mere identification of a given infrastructure in each domain is not enough to guarantee its framework in S3 NORTE 2027 for the purposes of support for financing from EU funds. Similarly, the non-inclusion of a given infrastructure may not prevent access to such support and funding, depending always on the project that will be presented.

Typology	Acronym	Name
Associated Labs.	INESC TEC	INESC TEC - Institute for Systems Engineering and Computers, Technology and Science (INESC TEC)
Associated Labs.	AL4TECH	Associated Laboratory in Bio/Chemical/Micro-Nano/Electromechanical Technology
Associated Labs.	IMS	Institute for Molecular Sciences
Associated Labs.	CBQF	Centre for Biotechnology and Fine Chemistry
Associated Labs.	CIMAR LA	Marine and Environmental Research Centre
Associated Labs.	Inov4Agro	Institute for Innovation, Empowerment and Sustainability in Agro-Food Production
Associated Labs.	AL4AnimalS	Associate Laboratory for Animal and Veterinary Science
State Labs.	IPMA	Portuguese Sea and Atmosphere Institute
State Labs	INIAV	National Institute for Agricultural and Veterinary Research
State Labs	LNEG	National Energy and Geology Laboratory
R&D Infraest. RNIE	BBRI	Biomass and Bioenergy Research Infrastructure
R&D Infraest. RNIE	C4G	Geosciences Collaboratory
R&D Infraest. RNIE	CECOLAB	National Infrastructure Network for the Circular Economy
R&D Infraest. RNIE	FHP - AWAM	CECOLAB Association - Collaborative Laboratory
R&D Infraest. RNIE	FOOD-CHAIN-PT	Towards Circular Economy
R&D Infraest. RNIE	GenomePortugal	Research Network on Precision Agriculture, Water Management and Advanced Agro-Industrial Processing Systems
R&D Infraest. RNIE	Micro&Nano-Fabs@PT	Fraunhofer Portugal Research Center for Agriculture and Water Management
R&D Infraest. RNIE	PORBIOTA	International Food Chain Alliance Network
R&D Infraest. RNIE	PRISC	International Food Chain Alliance - Portugal
R&D Infraest. RNIE	Pt-OPEN-SCREEN	National Facility for Genome Sequencing and Analysis
R&D Infraest. RNIE	PtmBRCN/MIRRI-PT	National Facility for Genome Sequencing and Analysis
R&D Infraest. RNIE	PTNMR	Network of Micro and Nanofabrication Research Facilities
Technology Centres	CTCOR	Portuguese E-Infrastructure for Information and Research in Biodiversity
Technology Transfer and Valorisation Centres	CVR	National Infrastructure for Scientific Collections
Technology Transfer and Valorisation Centres	INESC TEC	National Infrastructure for Chemical Biology and Genetics
Technology Transfer and Valorisation Centres	INL	National Infrastructure for Chemical Biology and Genetics
Technology Transfer and Valorisation Centres	BLC3	Portuguese microBiological Resources Center Network
Technology Transfer and Valorisation Centres	AQUAVALOR	Portuguese microBiological Resources Center Network / Microbial Resource Research Infrastructure - Portugal
Technology Transfer and Valorisation Centres	EBRI	National Nuclear Magnetic Resonance Network

Typology	Acronym	Name
Technology Transfer and Valorisation Centres	INIAV	Cork Technological Centre
Technology Transfer and Valorisation Centres	LNEG	Centre for Waste Valorisation
Technology Transfer and Valorisation Centres	TECMEAT	Institute for Systems Engineering and Computers, Technology and Science
Other R&D Infrastructures	ICIBio	International Iberian Nanotechnology Laboratory
Other R&D Facilities	LabPaisagem	Technology and Innovation Campus
Colabs	AQUAVALOR	Water Technology Transfer and Valorisation Centre
Colabs	BIOREF (ProBloreflnery)	EBRI - European Bioproducts Research Institute
Colabs	COLAB VINES&WINES	INIAV - National Institute for Agricultural and Veterinary Research
Colabs	CoLab4Food	National Energy and Geology Laboratory
Colabs	ForestWise	Graphical Collaborative Laboratory for Integrated Forest and Fire Management
Colabs	MORE	Mountains Research Collaborative Laboratory
Competitiveness Clusters	-	Vine and Wine Cluster
Competitiveness Clusters	-	Portuguese AgroFood Cluster
Business Associations	AEVP	AEVP - Association of Port Wine Companies
Business Associations	ANICP	ANICP - National Association of Canned Fish Producers
Business Associations	APCOR	APCOR - Portuguese Cork Association
Business Associations	FORESTIS	Forestis - Portuguese Forestry Association

Annex 2

Delimitation of the main sectors of activity from the Portuguese Classification of Economic Activities (CAE Rev. 3) of the priority domain "Agro-Environmental and Food Systems"

For the definition of the main economic activities that integrate this domain, the sectors that constitute the great areas of this domain and that are considered in its rationale are namely:

– **Agriculture and livestock**
– **Food industry**
– **Manufacture of beverages**
– **Forestry**
– **Wood and cork industry**
– **Pulp and paper industry**
– **Packaging**
– **Water and Waste Management**

Delimitation of the priority domain in terms of the Portuguese Classification of Economic Activities (CAE Rev. 3):

(i) **Agriculture and animal production**
- 011 - Temporary crops
- 012 - Permanent crops
- 013 - Growing of vegetative propagation material
- 014 - Animal production
- 015 - Mixed farming
- 016 - Support activities to agriculture and post-harvest crop activities
- 4611 - Agents involved in the sale of agricultural raw materials, live animals, textile raw materials and semi-finished goods
- 462 - Wholesale of agricultural raw materials and live animals
- 47761 - Retail sale of flowers, plants, seeds and fertilizers in specialised shops

(ii) **Food industries and commerce**
- 101 - Slaughtering animals, preparation and preserving of meat and meat products
- 102 - Preparation and preserving of fish, crustaceans and molluscs
- 103 - Processing and preserving of fruit and vegetables
- 104 - Animal and vegetable oils and fats production
- 105 - Manufacture of dairy products
- 106 - Processing of cereals and leguminous plants; manufacture of starches and starch products
- 107 - Manufacture of bakery and farinaceous products
- 108 - Manufacture of other food products
- 109 - Manufacture of animal feeds
- 4617 - Agents involved in the sale of food, beverages and tobacco
- 4631 - Wholesale of fruit and vegetables
- 4632 - Wholesale of meat and meat products
- 4633 - Wholesale of dairy products, eggs and edible oils and fats
- 4634 - Wholesale of alcoholic and other beverages
- 4636 - Wholesale of sugar and chocolate and sugar confectionery
- 4637 - Wholesale of coffee, tea, cocoa and spices
- 4638 - Wholesale of other food
- 4639 - Non-specialised wholesale of food, beverages and tobacco
- 4711 - Retail sale in non-specialised shops with food, beverages or tobacco predominating
- 4721 - Retail sale of fruit and vegetables in specialised shops
- 4722 - Retail sale of meat and meat products in specialised shops
- 4723 - Retail sale of fish, crustaceans and molluscs in specialised shops
- 4724 - Retail sale of bread, cakes, flour confectionery and sugar confectionery in specialised shops
- 4729 - Retail sale of other food products in specialised shops

Note: In the analysis of food industries, the statistics referring to PDO/PGI/TGIs products will also be considered

(iii) **Beverage Industry**
- 110 - Beverage Industry
- 4634 - Wholesale of beverages
- 4725 - Retail sale of beverages in specialised shops

(iv) **<u>Forestry</u>**
- 021 - Silviculture and other forestry activities
- 022 - Logging
- 023 - Extraction of cork, resin and gathering of other forest products except timber
- 024 - Service activities incidental to forestry and logging

(v) **<u>Wood and cork industries</u>**
- 161 - Sawmilling, planning and impregnation of wood
- 162 - Manufacture of wooden products, cork, straw and plaiting materials, except furniture

(vi) **<u>Pulp and paper industries</u>**
- 171 - Manufacture of pulp, paper and paperboard
- 172 - Manufacture of corrugated paper and paperboard and of articles of paper and paperboard

(vii) **<u>Packaging</u>**
- 16240 - Manufacture of wooden containers
- 1721 - Manufacture of corrugated paper and paperboard and of containers of paper and paperboard
- 22220 - Manufacture of plastic packaging
- 23131 - Manufacture of glass packaging
- 2592 - Manufacture of light metal packaging

(viii) **<u>Water and Waste Management</u>**
- 360 - Water collection, treatment and supply
- 370 - Collection, purification and treatment of waste water
- 381 - Waste collection
- 382 - Waste treatment and disposal
- 383 - Recovery of materials
- 390 - Decontamination and similar activities

Note: Furniture manufacturing is considered in the domain "Creativity, Fashion and Habitats", in particular in the Habitat sector.

(Sources: "INE (2019). Estatísticas Agrícolas - 2018"; "AIFF (2013). Estudo prospetivo para o setor florestal"; "INE (2007). Classificação Portuguesa das Atividades Económicas Rev.3")

4.

Priority domain characterisation

Sustainable Mobility and Energy Transition

4.1. Resources and Assets

The aim of the "Sustainable Mobility and Energy Transition" domain is to take advantage of the scientific and technological competences installed to promote the upgrading of the automotive components and systems industries in the context of global value chains, as well as to provide greater added value to other mobility industries and their infrastructures, ensuring a more competitive and sustainable mobility system.

As part of the exercise to assess the existence of critical mass in this priority domain, it is important to analyse the resources and technological assets to be integrated by the main business bases of the automotive, aeronautics and space, railways, shipbuilding, motorbikes and bicycles, transport and logistics, construction of transport infrastructures and energy networks and energy production, transport, distribution, and trade sectors. A first point characterises the stock of human capital with advanced skills by main areas of education and training through the indicator "Number of graduates in higher education by areas of education and training", already used in the preparation of RIS3 NORTE 2020, with cumulative values of the academic years from 2008/2009 to 2017/2018.

Based on the established methodology, the education and training areas considered to have the greatest potential for the achievement of the rationale defined for this domain are the following[39]:

- **"Engineering and related techniques"** such as "Metallurgy and metalworking", "Electricity and energy", "Electronics and automation", "Chemical process technology", "Construction and repair of motor vehicles";

- **"Science, mathematics and computing"** such as "Life sciences", "Biology and biochemistry", "Environmental sciences", "Physics", "Earth sciences" and "Computer sciences";

- **"Manufacturing industries"** such as "Materials (wood, cork, paper, plastic, glass and other industries)" and "Extractive industries";

- **"Architecture and construction"**, such as "Architecture and urbanism" and "Building and civil engineering";

- **"Transport Services"**;

- **"Social sciences, commerce and law"** as "Commerce".

Between 2009 and 2018, 69 367 students graduated in these training areas in Norte Region, distributed across the different types of courses, namely, professional higher technical courses, bachelor's degrees, master's degrees and doctorates. Of this total, during this period, 2 434 obtained a doctoral degree and 25 139 obtained a master's degree. In terms of education and training areas, the number of graduates in the following areas stands out: (i) "Engineering and related techniques": with 15 986 graduates in "Electronics and automation", 6 671 in "Chemical process technology", 7 331 in "Metallurgy and metalworking" and 1 652 graduates in "Electricity and energy"; (ii) "Sciences, mathematics and computing": with 4 470 in "Computer sciences" and 7 337 in "Biology and biochemistry"; (iii) "Manufacturing": with 246 graduates in "Textile, clothing, footwear and leather industries", 973 in "Materials (wood, cork, paper, plastic, glass and other industries)" and 471 in "Extractive industries"; (iv) "Architecture and construction": with 8 827 graduates in "Civil construction and civil engineering" and 7 168 in "Architecture and urbanism"; and (v) "Social sciences, commerce and law": with 667 graduates in "Commerce". This information is systematised in the following figure.

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[39] The exercise of identifying the most relevant education and training areas for this domain took into consideration: (i) the revised rationales in the new domains of smart specialisation of S3 NORTE 2027; (ii) the responses to the surveys carried out to the Regional Platforms of Smart Specialisation for the review of S3 NORTE 2027, (iii) the international demand trends and corresponding R&D&I strategies and policies for the priority domains of S3 NORTE 2027 and (iv) the basic resources and assets that are included in RIS3 NORTE 2020.

Figure 19 • Number of Graduates by Education and Training Areas in Norte Region, cumulative value
from 2008/2009 to 2017/2018
Source: DGEEC

It is also important to characterise the regional scientific production, namely the publications by scientific and technological areas considered most relevant for the achievement of the rationale of the priority domain "Sustainable Mobility and Energy Transition". This analysis is carried out based on the indicator "Number of publications indexed in the Web of Science by scientific area", a variable already used in the preparation of RIS3 NORTE 2020, using the cumulative values from 2008 to 2018.

Taking into account the defined methodology, the scientific and technological fields that stand out in this area in terms of publications[40] are: (i) in the area of "Engineering Sciences and Technologies": "Materials Engineering" with 4 517 publications, "Electrical, Electronic and Computer Engineering" with 4 202 publications, "Mechanical Engineering" with 2 414 publications, "Environmental Engineering" with 2 414 publications and "Civil Engineering" with 1 592 publications; and (ii) in the area of "Exact and Natural Sciences": "Chemistry", with 7 579 publications, "Physics", with 5 843 publications, "Computer and Information Sciences", with 5 411 publications, and "Earth and Environmental Sciences", with 3 947 publications. This information is systematised in the following figure.

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[40]   The exercise of identifying the most relevant scientific and technological areas for this domain took into account: (i) revised rationales in the new smart specialisation domains of S3 NORTE 2027; (ii) responses to surveys carried out to the Regional Smart Specialisation Platforms for the review of S3 NORTE 2027, (iii) international demand trends and corresponding R&D&I strategies and policies for the priority domains of S3 NORTE 2027 and (iv) the resources and assets of base contained in RIS3 NORTE 2020.
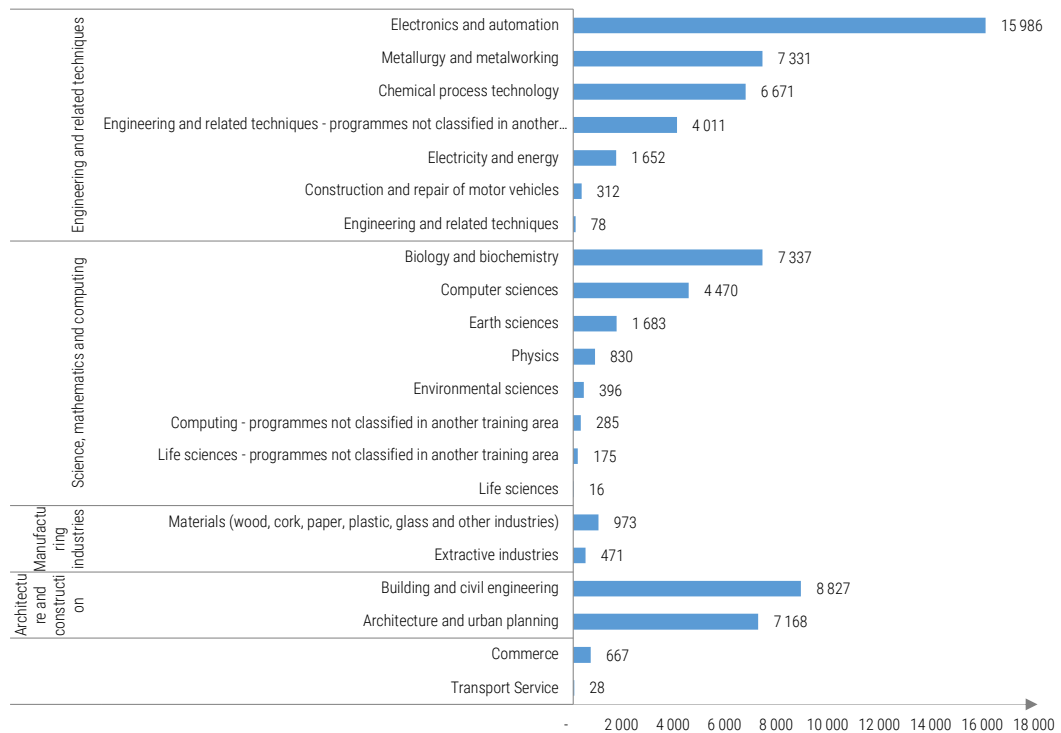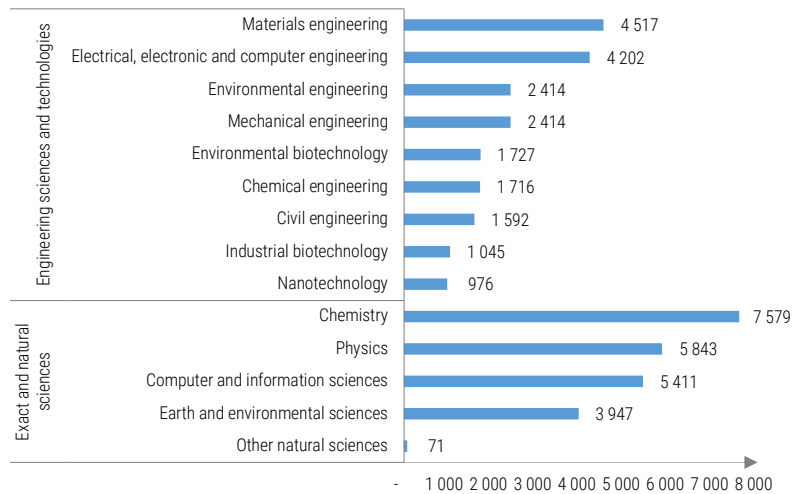
Figure 20 • Number of Publications by Scientific and Technological Areas in Norte Region,
cumulative value from 2008 to 2018
Source: DGEEC

A fundamental element of the characterisation of scientific and technological resources is also related to the identification of the installed capacity in the region in terms of non-business R&I scientific and technological infrastructures that are part of the regional scientific and technological system. Based on the established methodology, 51 R&D Institutions and Infrastructures and Technological Centres and Interfaces were identified in this priority domain that fall within its areas of intervention (see Annex 1). The following table presents the main areas of intervention of this typology of entities within this priority domain.

Table 10 • Main intervention areas of R&D Institutions and Infrastructures and Technological
Centres and Interfaces within the "Sustainable Mobility and Energy Transition" domain

Type of Institution	Main areas of intervention
R&D Institutions and Infrastructures	Materials, systems and computer engineering, artificial intelligence, computer and information sciences, mechanical engineering, chemistry, energy, environment, digital, engineering structures, architecture and urbanism, structures and buildings, nanotechnology, biotechnology, connectivity, aeronautics, transport, networks and electric vehicles, bioenergy.
Technological Centres and Interfaces	Mechanical engineering and industrial management, technical textiles, nanotechnology and technical, functional and intelligent materials, metalworking, waste valorisation, systems and computer engineering, nanotechnology, polymers, design, energy and geology, chemistry, materials engineering, biosustainability, engineering structures, architecture, engineering and construction, digitalisation, automation and robotics.

4.2 Business Bases

The "Sustainable Mobility and Energy Transition" domain thus encompasses a heterogeneous set of activities aiming at harnessing the installed scientific and technological competences (in the areas of production technologies, materials, digital technologies, biotechnology, etc.) to promote the upgrade of the components' and systems' automotive industries (from the production of moulds and tools to the assembly of complex systems) in the context of global value chains, as well as to provide higher added value in other mobility industries and their infrastructures (such as aeronautics, railways, maritime transport, urban mobility, logistics, energy, space, etc.).

For the definition of the main economic activities that integrate this domain, the sectors that constitute its major areas of activity are considered[41/42], namely: (i) Automotive, (ii) Aeronautics and Space, (iii) Railway, (iv) Shipbuilding, (v) Motorcycles and Bicycles, (vi) Transport and Storage, (vii) Construction of Transport and Energy Networks infrastructures and (viii) Energy production, transport, distribution and trade. The following figure shows the turnover in the main sectors of activity included in the domain "Sustainable Mobility and Energy Transition".
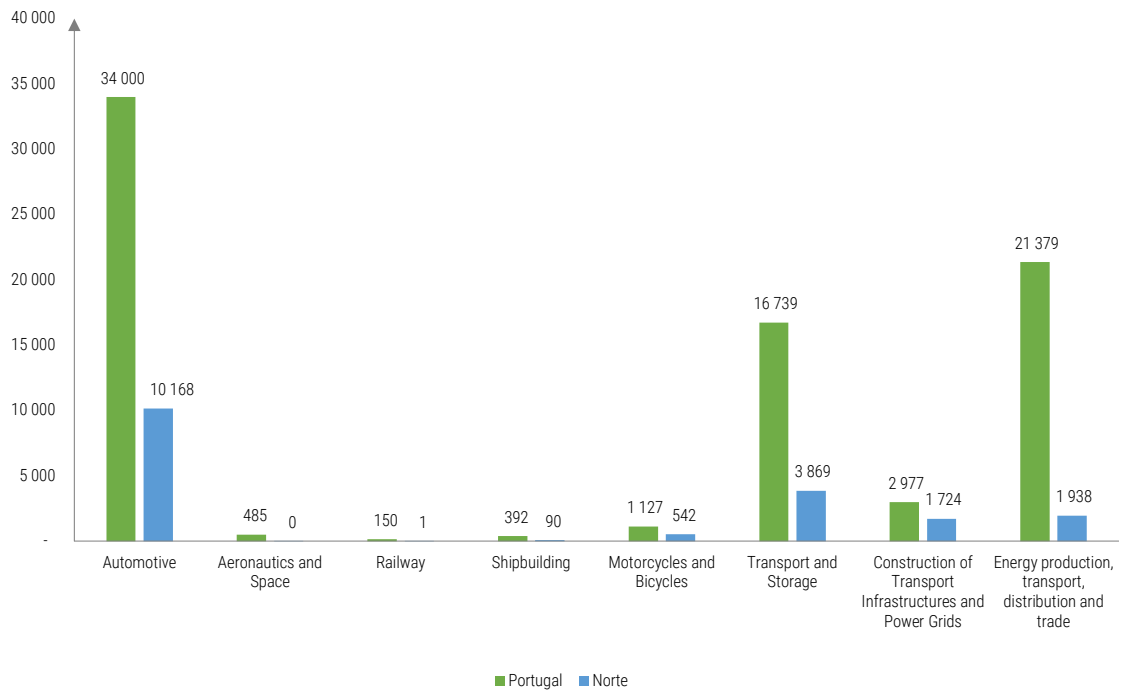
Figure 21 • Turnover in the main sectors included in the domain "Sustainable Mobility and Energy Transition", Portugal and Norte Region, million euros, 2019

Source: INE, Sistema de contas integradas das empresas

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[41] Relevant bibliography consulted: Direção-Geral das Atividades Económicas (2018) e Instituto Nacional de Estatística (2007)

[42] Annex 2 contains the delimitation of the main sectors of activity in terms of the Portuguese Classification of Economic Activities (CAE Rev. 3) included in the priority domain "Sustainable Mobility and Energy Transition".
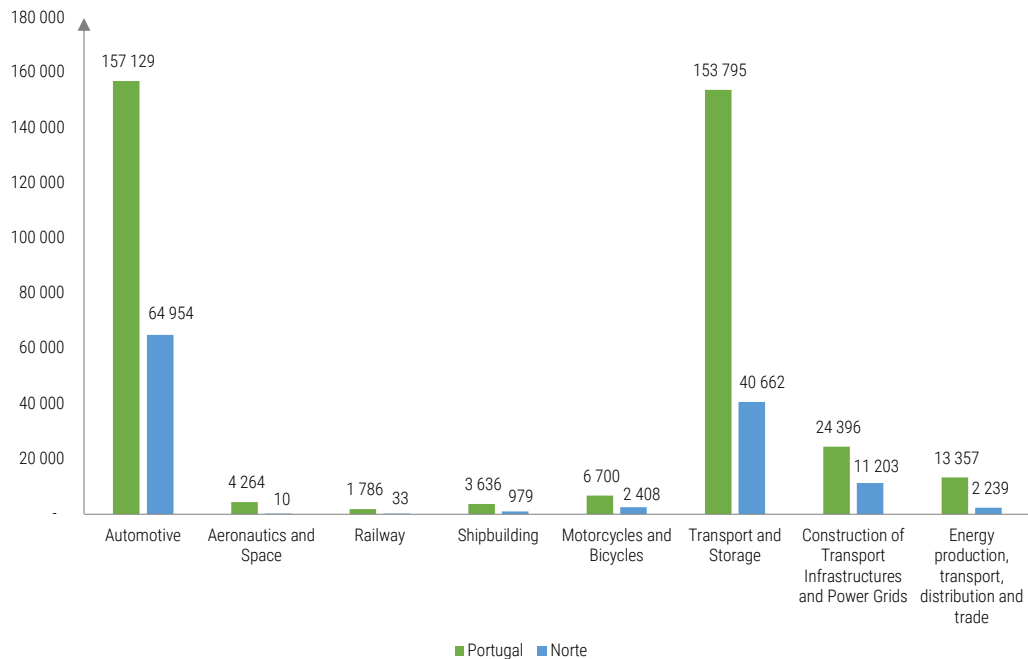
Figure 22 • Personnel employed in the main sectors included in the domain "Sustainable Mobility and Energy Transition", Portugal and Norte Region, Number, 2019

Source: INE, Sistema de contas integradas das empresas

The automotive sector has a very relevant economic expression in Norte Region, with a turnover of 10 168 million euros and almost 65 000 people employed. These figures correspond respectively to 30% and 41% of the national total for this sector in 2019. The transport and storage sector comes in second place with 3 869 million euros in turnover and more than 40 000 people employed, corresponding to 23% and 26% of the national total, respectively. Highlight, also, for the sector of construction of transport infrastructures and energy networks, where Norte has a weight of 58% in the national total in relation to turnover (1 724 million euros) and 46% in relation to staff in service (11 203 people employed).

The energy production, transport, distribution and trade sector represents close to 2 000 million euros of turnover and 2 239 people employed in Norte Region. In the bicycle and motorbike sector, Norte represents 48% and 36% of the national total in relation to turnover and personnel employed, with a total of 542 million euros and 2 408 people employed. Shipbuilding represents 90 million euros of turnover and almost 1 000 people employed in Norte Region. The economic activities associated with aeronautics and space and railways have a very reduced expression in Norte, both in terms of turnover and personnel.

At the level of international trade, the value of exports[43] of the sectors of activity included in the domain of "Sustainable Mobility and Energy Transition" was more than 5 700 million euros in 2019, representing 22% of total exports from Norte. Within this domain, exports from the automotive sector stand out, with 65% of the total, followed by the transport and storage sector, with 17%, and the construction of transport infrastructure and energy networks, with 15%.

Based on the established methodology, it is also important to consider in the characterisation of the business base the competitiveness clusters and sectoral business associations operating in Norte. The following table shows the areas of intervention of the competitiveness clusters and sectoral associations within this priority domain.

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[43] Source: Data of companies' exports obtained from the Iberinform database. Does not include the referring values to individual companies.

Table 11 • Main intervention areas of the Competitiveness Clusters and Business Associations
within the domain "Sustainable Mobility and Energy Transition".

Type of Institution	Main areas of intervention
Competitiveness Clusters and Business Associations	Automotive, aeronautics, space, defence, railways, architecture, engineering, construction, smart urban solutions, chemistry, design, engineering, prototyping, mould making, tooling, new materials, production technologies, ICT&E.

4.3 Advanced Users and Trends

In the priority domain "Sustainable Mobility and Energy Transition" a prospective analysis was carried out[44] to identify the main global medium and long term trends that shape the intermediate and final demand, allowing the assessment of the regional potential in the construction of competitive advantages and the improvement of the insertion level in international value chains. The schematic and conceptual dimension of this identification process must consider the interaction of the different trends among themselves, enhancing the effect of each one and of the whole. These trends are structured into the following five topics:

a) **Decarbonisation** - reducing the use of oil and other fossil fuels and increasing the use of (more) clean and renewable energy sources, such as electricity, hydrogen, fuel cells or biofuels, as well as the use of new materials (bio-materials and smart materials), improving the energy balance and circularity of production processes and developing aerodynamics to reduce greenhouse gas (GHG) emissions, in particular carbon dioxide emissions, and thereby reduce transport's effect on climate change;

b) **Mobility as a service** - new business model with a change from the paradigm of possession by ownership to possession by use, with less use of individual transport and growth of integrated, shared and multimodal mobility services (car, soft modes, rail, etc.), based on digital technologies of tailored transport supply, together with the increased digitalisation also of logistics and supply chains and the need to reconcile the improvement of mobility of people and goods with the efficiency of vehicles and reverse logistics;

c) **Smart vehicles and infrastructures** - increased automation and connectivity of and between vehicles and their infrastructure (such as road signs, traffic lights, dynamic speed limits, indication of parked vehicles or obstacles to movement) and different modes of transport and their integration and interoperability within the overall transport system, associating networks of electric recharging and refuelling of less polluting fuels, of specialised parking areas and of digital support (5G), with greater importance of user experience or emotional design in the interaction between people and vehicles, central in the future of drive-free use.

d) **Internationalisation, economy and mobility** - reducing the ecological footprint of international transport, implying sustainable aeronautics (with reduced GHG emissions), safe (for passengers and in the management of airspace and ground logistics), reliable (in time and punctuality) alongside the development of railways for distances of less than 1 000 Km, as a means of transport with greater potential energy efficiency and thus better dissociating traffic growth and respective environmental impacts and greater relevance of health and hygiene issues, namely in shared vehicles;

44   Relevant bibliography consulted: Comissão de Coordenação e Desenvolvimento Regional do Norte (2014), Monteiro, Meira, Santos, Leite, Guimarães & Gomes (2019), Comissão Europeia (2011, 2015a, 2015b, 2017, 2018a, 2018b, 2019, 2020), Estado português (2017, 2018, 2019a, 2019b, 2019c), Fundação para a Ciência e Tecnologia (2019a, 2019b, 2019c), European Construction, Built Environment and Energy Efficient Buildings Technology Platform (2018), High Level Group on the Competitiveness and Sustainable Growth of the Automotive Industry in the European Union. European Commission (2017), Alonso Raposo et al (2019), ERTRAC (2018), Deloitte (2019), McKinsey & Company (2016), PricewaterhouseCoopers (2018), Deloitte Consultores, S.A. (2018), High Level Group on Aviation Research. European Commission (2011), Advisory Council for Aviation Research and Innovation in Europe (2017), Aerospace and Defence Industries Association of Europe (2018a, 2018b), SESAR Joint Undertaking (2016), European Rail Research Advisory Council (2017, 2019), Shift2Rail, Joint Undertaking (2018), Portugal Space (2019), European Investment Bank (2019).

e) **Space economy** - significant growth rate of the space economy, nearly twice that of the world economy, using skills and technologies at the frontier of knowledge, transferable to other application areas, such as aeronautics and transport in general, in energy networks and mobility infrastructures, augmented satellite navigation systems meteorological services, remote, assisted, autonomous and connected transportation and driving, monitoring of space assets and debris, and traffic management, space software and hardware, and development of systems and components for space vehicles (propulsion, transportation, exploration, control) and ground services solutions, etc.

The R&D&I strategies and public policies associated with this priority domain cannot be dissociated from the global trends structured into the five topics mentioned in the previous point, and are not, nor can they be, mutually exclusive. Resulting from the analysis of different documents from national and international organisations, the R&D&I strategies and public policies for this domain are the following:

a) **Decarbonisation** - development, in most cases of components, of (i) electric vehicles, plug-in hybrid electric vehicles and fuel cell electric vehicles; (ii) hydrogen, biodiesel and bioethanol vehicles for heavy duty passenger and freight transport; (iii) battery autonomy, durability and recharging speed; (iv) concentrated and decentralised storage solutions (including chemical, electrochemical, electrical, mechanical and thermal storage); and (v) reuse, remanufacturing and recycling (second life) in the context of the circular economy paradigm;

b) **Mobility as a service** - technological synergies between transport modes; maintenance and rehabilitation of infrastructure for transport integration, interoperability and intermodality; multimodal mobility, including planning, pricing and payment; new business models, driven by fleet purchasing for tailor-made (collective) mobility; tailor-made vehicle sharing on demand, irrespective of location and (occasional) solidarity and citizens' initiatives;

c) **Smart vehicles and infrastructures** - merging physical and digital vehicle conception, manufacturing and operation; automation of some or all vehicle driving functions in real time in road traffic; technologies for communication of vehicles with each other (Car2Car) and with the transport infrastructure (Car2X) to optimise and secure traffic flows; networking of vehicle occupants with the outside world, allowing communication, work or access to multimedia content; business models progressively more based on software and application upgrades than on hardware and vehicle exchange; complementary approaches, whose combined use will increase the level of safety and functionality, such as artificial vision devices and vehicle sensing; Car2X interaction; high-precision satellite information; Car2Car interaction; vehicle cognitive capabilities; complementary services provided by the vehicle to its users;

d) **Internationalisation, economy and mobility** - air traffic management and logistics systems (commercial aviation, unmanned aircraft, vertical mobility, military aircraft, etc.); non-intrusive security and screening processes without interruptions and delays; new aircraft configurations and propulsion systems (hybrid, electric, etc.); widespread use of drones; smart materials and structures; advanced aerodynamics and flight mechanics; widespread electrification of rail networks; energy recovery by rolling stock and use of renewable energy sources; smart, connected and autonomous rolling stock;

e) **Space economy** - development of satellite launch vehicles and facilities; new generation of satellites, following the miniaturisation trend (mini, micro and nano satellites); satellite services (communication, earth observation, navigation and integrated applications) for different users (agriculture, forestry, environment, commercial, civilian and military); development of hardware and software for mission control centres; telemetry and telecommand systems; GNSS (Global Navigation Satellite System) receivers and communication terminals; manned and robotic exploration vehicles, involving probes and orbiters.

The following table presents the association between the trends identified in the domain "Sustainable Mobility and Energy Transition" and the "societal challenges" that constitute heavy trends of structural change in the economy and society and that present a transversal character to different priority domains. This analysis allows the conclusion that this priority domain is aligned with structural transformation trends such as demographic, energy-environmental transition, circular economy, digital transformation, and Industry 4.0. This conclusion thus reveals that, despite the sectoral and thematic specificities of this priority domain, there are common elements in the trends and policies to other priority domains of smart specialisation that promote an interpenetration of areas, which will increasingly exist in various enterprises, institutions, and economic activities.

Table 12 • Association[1] between trends identified in the domain "Sustainable Mobility and Energy Transition" and "societal challenges"

Trends	Aging		Energy Efficiency		Decarbonisa-tion		Circular Economy		Digitalisa-tion		Industry 4.0	
	D	I	D	I	D	I	D	I	D	I	D	I
a) Decarbonisation			•		•		•					
b) Mobility as a service			•			•		•		•		•
c) Smart vehicles and infrastructure	•								•		•	
d) Internationalisation, economy and mobility			•		•			•				
e) Space economy										•		•

[1] Direct (D) or indirect (I) association

4.4 Rationale

From the domain "Sustainable Mobility and Energy Transition" it is intended to take advantage of the scientific and technological competences installed to promote the upgrade of the components' and systems' automotive industries in the context of global value chains, as well as to provide greater added value in other mobility industries and their infrastructures ensuring a more competitive and sustainable mobility system. The following figure presents the analytical framework of the priority domain "Sustainable Mobility and Energy Transition".
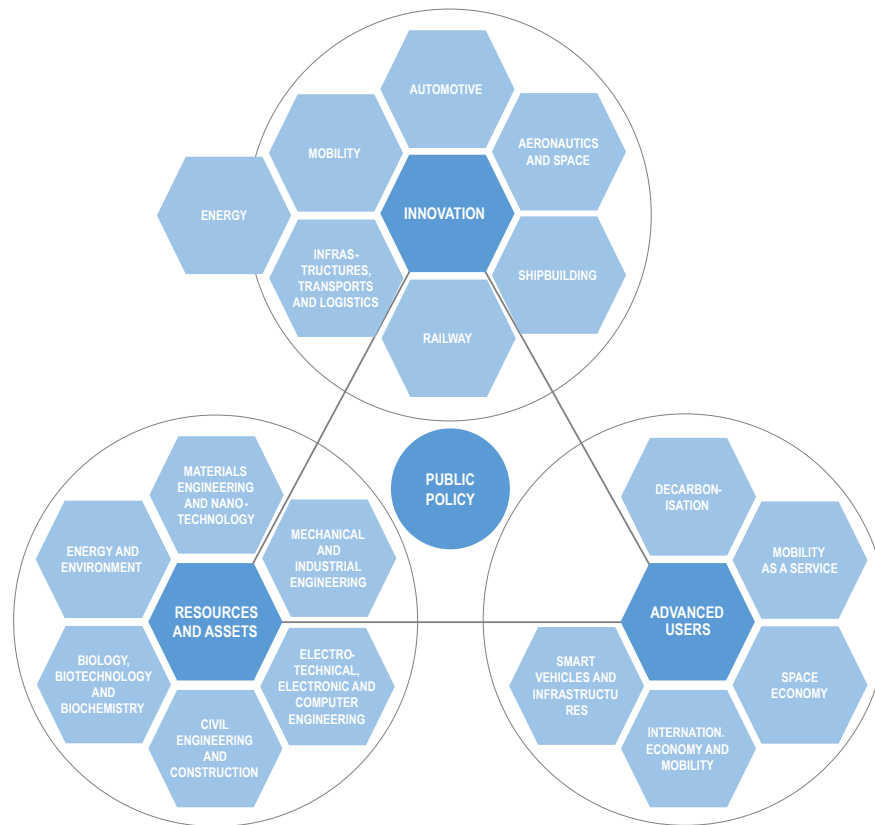
Figure 23 • Analytical framework of the domain "Sustainable Mobility and Energy Transition"

In terms of the policy rationale, the "Sustainable Mobility and Energy Transition" domain thus aims at harnessing the installed scientific and technological competences (in the areas of production technologies, materials, digital technologies, biotechnology, etc.) to promote the upgrade of the components' and systems' automotive industries (from the production of moulds and tools to the assembly of complex systems) in the context of global value chains, as well as to provide higher added value in other mobility industries and their infrastructures (aeronautics, railways, maritime transport, urban mobility, logistics, energy, space, etc.), ensuring a more competitive and sustainable mobility system, in a context of decarbonisation of the economy, energy transition, digitalisation and new mobility concepts.

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Annex 1

List of the non-business entities of the scientific and technological system identified in the priority domain "Sustainable Mobility and Energy Transition"[45].

Typology	Acronym	Name
R&D Units	CEFT	Centre for Transport Phenomena Studies
R&D Units	CITTA	Centre for Territory, Transport and Environment Research
R&D Units	CMEMS-Uminho	Electromechanical Microsystems Research Unit
R&D Units	ISISE	Institute for Sustainability and Innovation in Engineering Structures
R&D Units	LAETA	Associated Laboratory for Energy, Transport and Aeronautics
R&D Units	UACC	Artificial Intelligence and Computer Science Laboratory
R&D Units	ALGORITMI	ALGORITMI Research Centre
R&D Units	CONSTRUCT	R&D Institute for Structures and Constructions
R&D Units	INESC TEC	INESC TEC - INESC Technology and Science
R&D Units	IPC	Institute for Polymers and Composites
R&D Units	METRICs	Centre for Mechanical Engineering and Resource Sustainability
R&D Units	SYSTEC	Centre for Systems and Technologies
R&D Units	CICGE	Geospatial Sciences Research Centre
R&D Units	CTAC	Centre for Territory, Environment and Construction
Associated Labs.	LAETA	Associate Laboratory for Energy, Transport and Aerospace
Associated Labs.	INESC TEC	Institute for Systems and Computer Engineering, Technology and Science
Associated Labs.	ARISE	Advanced Manufacturing and Intelligent Systems
Associated Labs.	LIP	Laboratory for Instrumentation and Experimental Particle Physics
Associated Labs.	LASI	Associated Laboratory for Intelligent Systems
State Labs.	LNEG	National Energy and Geology Laboratory
R&D Infraest. RNIE	BBRI	Biomass and Bioenergy Research Infrastructure
R&D Infraest. RNIE	ENgAGE SKA	Sustainable E-science: Capacity Building and Smart Growth
R&D Infraest. RNIE	Micro&NanoFabs@PT	ENAbling Green E-science for Square Kilometer Array
R&D Infraest. RNIE	SGEVL	Network of Micro and Nanofabrication Research Facilities
R&D Infraest. RNIE	WindScanner.PT	Smart Electric Grids and Electric Vehicles Laboratory
Technology Centres	CATIM	WindScanner Portugal
Technology Centres	CITEVE	Technological Support Centre for Metalomechanic Industry
Technology Transfer and Valorisation Centres	CCG/ZGDV	Transport Phenomena Study Center
Technology Transfer and Valorisation Centres	CEIIA	Research Center for Territory, Transport and Environment
Technology Transfer and Valorisation Centres	CeNTItvc	Electromechanical Microsystems Research Unit
Technology Transfer and Valorisation Centres	INEGI	Institute for Sustainability and Innovation in Engineering Structures

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[45] The identification of the entities was based on the analysis of a synthetic characterisation of each institution obtained, namely through consultation of various ANI publications, FCT evaluation reports and the entities' websites. It should be noted that the mere identification of a given infrastructure in a given domain is not enough to guarantee its framework in S3 NORTE 2027 for the purposes of support for financing from EU funds. Similarly, the non-inclusion of a given infrastructure may not prevent access to such support and funding, depending always on the project that will be presented.

Typology	Acronym	Name
Technology Transfer and Valorisation Centres	INESC TEC	Associate Laboratory of Energy, Transport and Aeronautics
Technology Transfer and Valorisation Centres	INL	International Iberian Nanotechnology Laboratory
Technology Transfer and Valorisation Centres	ISQ	Welding and Quality Institute
Technology Transfer and Valorisation Centres	PIEP	Association for Polymers Engineering Innovation Pole
Technology Transfer and Valorisation Centres	ARCP	Association Network of Competencies in Polymers
Technology Transfer and Valorisation Centres	CITN Mahalingam	N. Mahalingam Innovation and Technology Centre
Technology Transfer and Valorisation Centres	LNEG	National Laboratory for Energy and Geology
Other R&D Infrastructures	ALGORITMI	ALGORITMI Research Centre
Other R&D Infrastructures	FIBRENAMICS	FIBRENAMICS - University of Minho
Other R&D Infrastructures	ISISE	Institute for Sustainability and Innovation in Engineering Structures
Colabs	ARCP	Association Network for Competencies in Polymers
Colabs	BIOREF (ProBlore-flnery)	Research and Innovation in Biorefineries
Colabs	BUILTCoLAB	Collaborative Laboratory for the Built Environment of the Future
Colabs	Ceiia S2uL	Collaborative Laboratory for Urban Sustainability
Colabs	NET4C02	Network for a Sustainable C02 Economy
Colabs	Rail Colab	RAIL CoLAB - Collaborative Laboratory for the Modernisation of the Railway System
Digital Innovation Hubs	-	DIH 4 Global Automotive
Digital Innovation Hubs	-	DIGITALbuilt
Digital Innovation Hubs	-	DIH4ClimateNeutrality
Digital Innovation Hubs	-	PRODUTECH DIH
Competitiveness Clusters	-	AED Cluster - Portuguese Association for Aeronautics, Space and Defence Industries Cluster
Competitiveness Clusters	-	AEC Cluster - Architecture, Engineering and Construction
Competitiveness Clusters	-	Automotive Cluster Portugal
Competitiveness Clusters	-	Petrochemistry, Industrial Chemistry and Refining Cluster
Competitiveness Clusters	-	Portuguese Railway Platform Cluster
Competitiveness Clusters	-	Smart Cities Portugal Cluster
Competitiveness Clusters	-	Engineering & Tooling Cluster
Competitiveness Clusters	-	PRODUTECH Production Technologies Pole
Competitiveness Clusters	-	TICE.PT
Business associations	AFIA	Association of Manufacturers for the Automotive Industry

Annex 2

Delimitation of the main sectors of activity based on the Portuguese Classification of Economic Activities (CAE Rev. 3) - "Sustainable Mobility and Energy Transition"

For the definition of the main economic activities that integrate this domain, the sectors that constitute the great areas of this domain and that are considered in its rationale are, namely:

– **Automobile**
– **Aeronautics and Space**
– **Railways**
– **Shipbuilding**
– **Motorbikes and Bicycles**
– **Transport and Logistics**
– **Construction of transport infrastructures and energy networks**
– **Energy production, transport, distribution and trade**

Delimitation of the priority domain in terms of the Portuguese Classification of Economic Activities (CAE Rev. 3):

(i) <u>**Automobile**</u>

  • 29100 - Manufacture of motor vehicles
  • 29200 - Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers
  • 29310 - Manufacture of electrical and electronic equipment for motor vehicles
  • 29320 - Manufacture of other parts and accessories for motor vehicles
  • 22111 - Manufacture of tyres and tubes
  • 22112 - Rebuilding of tyres
  • 27200 - Manufacture of accumulators and batteries
  • 25734 - Manufacture of metal moulds
  • 45110 - Sale of motor vehicles
  • 45190 - Sale of other motor vehicles
  • 45200 - Maintenance and repair of motor vehicles
  • 45310 - Wholesale of motor vehicle parts and accessories
  • 45320 - Retail trade of motor vehicle parts and accessories

Note: In addition to the manufacturing CAE indicated in the DGAE study, the CAEs for tyre manufacturing and battery manufacturing were added, as well as for trade. The CAE metal mould manufacturing was also considered considering that 75% of production is directed to the automotive sector (cf. DGAE (2018). Mould Industries Synopsis).

(Source: "Direção-Geral das Atividades Económicas (2018). A Indústria Automóvel na Economia Portuguesa ")

(ii) <u>**Aeronautics and Space**</u>

  • 30300 - Manufacture of aircraft, spacecraft and related equipment
  • 33160 - Repair and maintenance of aircraft and spacecraft
  • 51220 - Space transport

(Source: No national studies were found indicating the CAE that constitute the aeronautics and space industry sector. In this case, the document "INE (2007). Classificação Portuguesa das Atividades Económicas Rev.3" was used and the CAE of industry and repair that include in their designation the word "aircraft", "space vehicles", "space transportation" and "satellites" were searched.)

(iii) <u>**Railway**</u>

  • 302 - Manufacture of railway locomotives and rolling stock
  • 3317 - Repair and maintenance of other transport equipment (including: locomotives; wagons and other railway equipment)

(Source: No national studies were found indicating the CAE that include the railway sector. In this case, the document "INE (2007). Classificação Portuguesa das Atividades Económicas Rev.3" was used and the CAE of industry and repair that include in their designation the word "railways" were researched.)

(iv) <u>**Shipbuilding**</u>

  • 3011 - Construction of ships and floating structures, except pleasure and sporting boats
  • 3012 - Building of pleasure and sporting boats
  • 3315 - Repair and maintenance of ships and boats

(Source: "Direção-Geral de Política do Mar (2019). Observatório Economia Azul")

(v) **Motorbikes and Bicycles**
- 3091 - Manufacture of motorbikes
- 3092 - Manufacture of bicycles and invalid carriages
- 45401 - Wholesale and retail trade of motorbikes and related parts and accessories
- 45402 - Maintenance and repair of motorbikes and related parts and accessories

Source: "INE (2007). Classificação Portuguesa das Atividades Económicas Rev.3"

(vi) **Transport and Storage**
- 491 - Interurban passenger transport by rail
- 492 - Freight transport by rail
- 493 - Other passenger land transport
- 494 - Road freight transport and removal activities
- 501 - Sea and coastal passenger water transport
- 502 - Sea and coastal freight water transport
- 503 - Inland passenger water transport
- 504 - Inland freight waterway transport
- 511 - Passenger transport by air
- 512 - Air freight and space transport
- 52 - Warehousing and support activities for transportation (including handling)

(Source: "Banco de Portugal (2017). Análise das empresas do setor dos transportes" and "INE (2007). Classificação Portuguesa das Atividades Económicas Rev.3")

(vii) **Construction of transport infrastructure and energy networks**
- 4211 - Construction of roads and airfields
- 4212 - Construction work for railways
- 4213 - Bridge and tunnel construction
- 4291 - Water engineering
- 4222 - Construction of electricity transmission and distribution networks, and telecommunications networks

(viii) **Energy production, transmission, distribution and trade**
- 351 - Electricity production, transmission, distribution and trade
- 352 - Gas production; distribution of gaseous fuels through pipelines; pipeline gas trading 353 - Production and distribution of steam, hot and cold water and cold air through pipelines; ice making

(Source: "INE (2007). Classificação Portuguesa das Atividades Económicas Rev.3")

5.

Priority domain characterisation

Health and Life Sciences

5.1. Resources and Assets

The "Health and Life Sciences" domain aims to articulate research and health care provision activities with the significant regional business base specialised in the production of goods and services related to these activities, namely pharmaceuticals, medical devices, ICT, health care services, personal protective equipment, health and well-being tourism, social support and physical activity, cosmetics, among others.

As part of the exercise to assess the existence of critical mass in this priority domain, it is important to analyse the resources and technological assets to be integrated by the main business bases of the health sector. The first point characterises the stock of human capital with advanced skills by main areas of education and training through the indicator "Number of graduates in higher education by areas of education and training", already used in the preparation of RIS3 NORTE 2020, with accumulated values for the academic years 2008/2009 to 2017/2018.

Based on the established methodology, the education and training areas considered to have the greatest potential for the achievement of the rationale defined for this domain are the following[46]:

- **"Health and Social Protection":** such as "Health", "Medicine", "Nursing", "Dental sciences", "Diagnostic and therapeutic technologies", "Therapy and rehabilitation", "Pharmaceutical sciences", "Social services", "Child and youth services", "Social work and guidance";

- **"Science, mathematics and computing"**: such as "Life sciences", "Biology and biochemistry", "Chemistry" and "Computer sciences";

- **"Veterinary Sciences";**

- **"Public health services";**

- **"Social sciences, commerce and law":** such as "Psychology" and "Commerce";

- **"Engineering and related techniques"** such as "Electronics and automation" and "Chemical process technology".

Between 2009 and 2018, 108 188 students graduated in these training areas in Norte Region, distributed across different types of courses, namely, professional higher technical courses, bachelor's degrees, master's degrees, and doctorates. Of this total, during this period, 3 346 obtained a doctoral degree and 34 210 obtained a master's degree. In terms of education and training areas, the number of graduates in the following areas stands out: (i) "Health and Social Protection" with 12 885 graduates in "Nursing", 7 608 graduates in "Medicine", 7 084 in "Therapy and Rehabilitation", 6 358 in "Pharmaceutical Sciences", 5 629 in "Social Work and Guidance", 4 897 graduates in "Dental Sciences" and 4 897 in "Diagnostic and Therapeutic Technologies"; (ii) "Sciences, Mathematics and Informatics" with 7 337 graduates in "Biology and biochemistry" and 4 470 in "Computer Sciences"; (iii) "Veterinary Sciences" with 2 549 graduates; (iv) "Public Health Services" with 640 graduates; (v) "Social Sciences, Commerce and Law" with 10 482 graduates in "Psychology"; and (vi) "Engineering and related techniques" with 15 986 graduates in "Electronics and automation" and 6 671 in "Chemical process technology". This information is systematised in the following figure.

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46   The exercise of identifying the most relevant education and training areas for this domain took into consideration: (i) the revised rationales in the new domains of smart specialisation of S3 NORTE 2027; (ii) the responses to the surveys carried out to the Regional Platforms of Smart Specialisation for the review of S3 NORTE 2027, (iii) the international demand trends and corresponding R&D&I strategies and policies for the priority domains of S3 NORTE 2027 and (iv) the basic resources and assets that are included in RIS3 NORTE 2020.
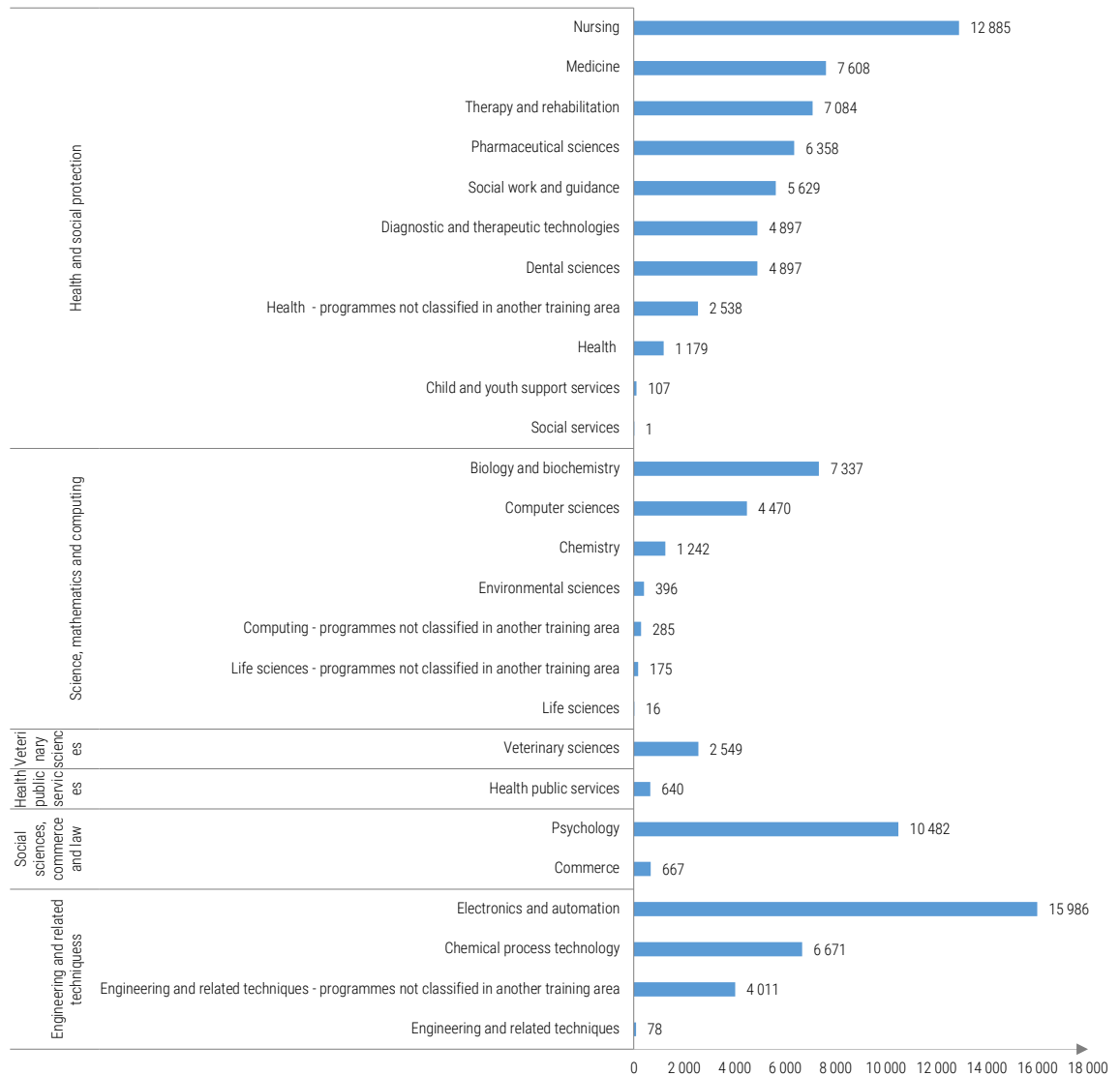
Figure 24 • Number of Graduates by Education and Training Areas in Norte Region, cumulative value
from 2008/2009 to 2017/2018
Source: DGEEC

It is also important to characterise the regional scientific production, namely the publications by scientific and technological areas considered most relevant to the achievement of the rationale of the priority domain "Health and Life Sciences". This analysis is carried out based on the indicator "Number of publications indexed in the Web of Science by scientific area", a variable already used in the preparation of RIS3 NORTE 2020, using the cumulative values from 2008 to 2018.

Taking into account the defined methodology, the most relevant scientific and technological areas for this domain in terms of publications[47] are: (i) "Medical Sciences and Health": "Clinical Medicine" with 9 628 publications, "Basic Medicine" with 5 186 publications and "Health Sciences" with 4 480 publications; (ii) "Social Sciences": "Psychology" with 1 723 publications; (iii) "Exact and Natural Sciences": "Biological Sciences" with 9 739 publications, "Chemistry" with 7 579 publications, "Physics" with 5 843 publications and "Computer and

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[47]   The exercise of identifying the most relevant scientific and technological areas for this domain took into account: (i) revised rationales in the new smart specialisation domains of S3 NORTE 2027; (ii) responses to surveys carried out to the Regional Smart Specialisation Platforms for the review of S3 NORTE 2027; (iii) international demand trends and corresponding R&D&I strategies and policies for the priority domains of S3 NORTE 2027 and (iv) the resources and assets of base contained in RIS3 NORTE 2020.

Information Sciences" with 5 411 publications; (iv) "Veterinary Sciences" with 593 publications; (v) "Engineering Sciences and Technologies": "Materials Engineering" with 4 517 publications, "Electrical Engineering, Electronics and Computing" with 4 202 publications, "Environmental Engineering" with 2 414 publications and "Medical Engineering" with 1 808 publications. This information is systematised in the following figure.
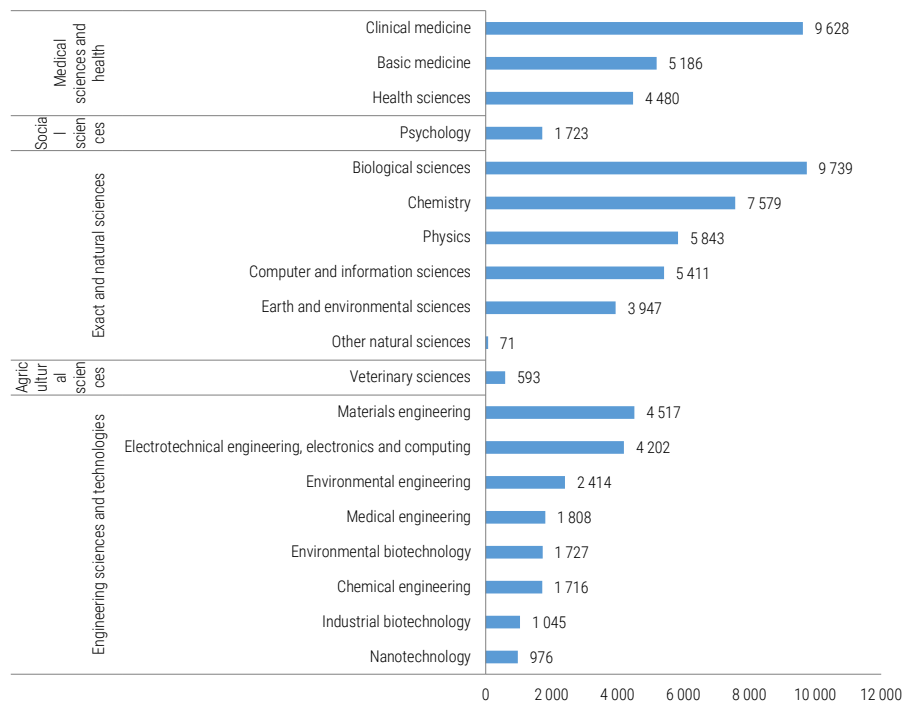
Figure 25 • Number of Publications by Scientific and Technological Areas in Norte Region, cumulative value from 2008 to 2018

Source: DGEEC

A fundamental element of the characterisation of scientific and technological resources is also related to the identification of the installed capacity in the region in terms of non-business R&I scientific and technological infrastructures that are part of the regional scientific and technological system. Based on the established methodology, 75 R&D Institutions and Infrastructures and Technological Centres and Interfaces were identified in this priority domain that fall within its areas of intervention (see Annex 1). The following table shows the main areas of intervention of this typology of institutions within this priority domain.

Table 13 • Main intervention areas of R&D Institutions and Infrastructures and Technological Centres and Interfaces within the domain "Health and Life Sciences".

Type of Institution	Main areas of intervention
R&D Institutions and Infrastructures	Health sciences, pharmaceutical sciences, biomedicine, bioengineering, biotechnology, oncology, neurology, psychology, epidemiology, cardiovascular diseases, public health, biological sciences, genetics, molecular biology, chemistry, materials engineering, nanotechnology, photonics, biomaterials, tissue engineering, regenerative medicine, veterinary sciences, information systems, systems and computer engineering, artificial intelligence, health services, rehabilitation, physical activity, sport.
Technological Centres and Interfaces	Health sciences, health technologies, biotechnology, biomedicine, regenerative medicine, materials engineering, nanotechnology, public health, cosmetics, computer science, information science, electrical engineering, electronics and informatics, information systems, systems engineering, information and communication technologies, electronics and instrumentation, automation and robotics, mechanical engineering, digitalisation.

It is also important to highlight non-technological resources and assets, that is, endogenous resources and assets, specific to the territories and that can support business innovation in this priority domain. Specifically, water is highlighted as one of these resources and in two ways. On the one hand, the extensive coastline of Norte Region boosts the development of health and well-being activities associated with thalassotherapy and treatments that make use of marine environmental and biological resources. On the other hand, and with a distinctive character, mineral and thermal waters constitute a relevant natural resource that can be boosted within the scope of preventive medicine, in articulation with tourism activities and the export of health services. Norte has 20 thermal spas dispersed throughout the territory (1 in Terras de Trás-os-Montes, 2 in Alto Minho, Ave, AMPorto and Douro, 3 in Cávado and Tâmega e Sousa and 5 in Alto Tâmega)[48], representing about 40% of the total national supply. These resources and assets present an important possibility of valorisation, whether considering the aging population and the bet on preventive medicine, whether considering the availability of a health system and tourism infrastructures.

5.2 Business Bases

The area of "Health and Life Sciences" encompasses a diverse set of activities aimed at consolidating the dynamics of articulation between research and business, seeking to develop new products and services capable of responding to current challenges, such as demographic aging, digitalisation, and chronic diseases.

To define the main economic activities in this domain, the sectors that constitute its main areas of activity were considered[49/50], namely: (i) Pharmaceuticals; (ii) Medical Devices; (iii) Health Services; (iv) Social Support and (v) Cosmetics. The following figures show the turnover and personnel in service in the main sectors of activity included in the domain "Health and Life Sciences".
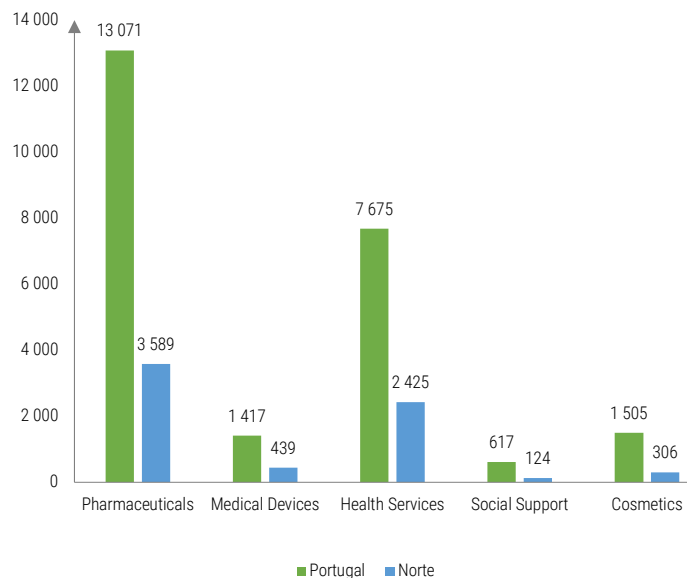
Figure 26 • Turnover in the main sectors included in the domain "Health and Life Sciences",
Portugal and Norte Region, million euros, 2019

Source: INE, Sistema de contas integradas das empresas

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[48]   Termas Norte de Portugal (2016)

[49]   Relevant bibliography consulted: INE (2011); Porto Business School (2013); Ministério da Economia e Health Cluster Portugal (2019)

[50]   Annex 2 contains the delimitation of the main sectors of activity in terms of the Portuguese Classification of Economic Activities (CAE Rev. 3) included in the priority domain "Health and Life Sciences".
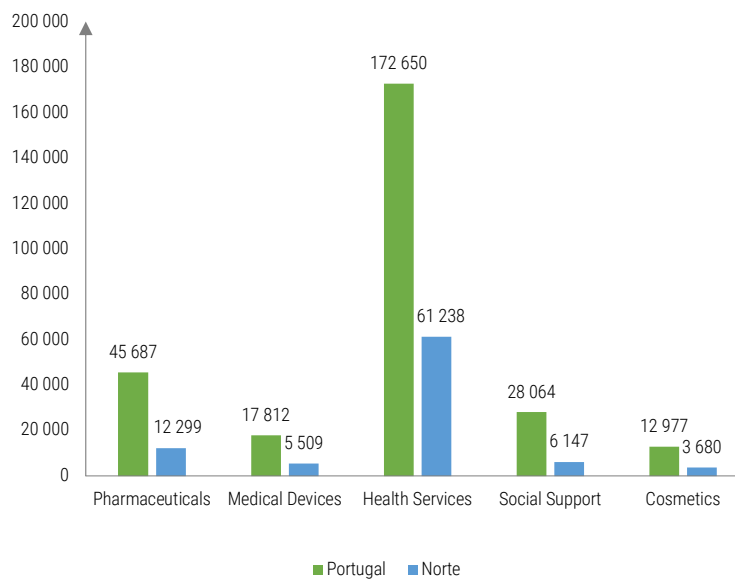
Figure 27 • Personnel employed in the main sectors included in the domain "Health and Life Sciences", Portugal and Norte Region, Number, 2019

Source: INE, Sistema de contas integradas das empresas

In Norte Region, "Health and Life Sciences" achieved in 2019 a turnover of nearly 7 000 million euros and almost 90 000 people in service. These figures correspond respectively to 28% and 32% of the national total. In terms of turnover, the pharmaceutical sector (manufacturing and trade) stands out with 3 589 million euros, followed by healthcare provision with 2 425 million euros, the medical devices sector (manufacturing and trade) with 439 million euros and cosmetics (manufacturing and trade) with 306 million euros. In terms of personnel, the healthcare services sector stands out with 61 238 people employed, followed by pharmaceuticals with 12 299 people, social support with 6 147 people, medical devices with 5 509 people and cosmetics with 3 680 employed persons.

In terms of international trade, the value of exports[51] in 2019 in "Health and Life Sciences" was around 428 million euros, 49% concentrated in the pharmaceutical sector, followed by the cosmetics sector with 32% and medical devices with 14%. Although exports from this domain only represent 1.6% of Norte's total, it should be noted that 82% correspond to R&D-intensive economic activities classified by the OECD[52] as high and medium-high R&D intensity. This is thus one of the priority domains of S3 NORTE 2027 with the greatest potential for R&D intensity and, therefore, for contributing to increasing R&D expenditure in Norte Region.

Based on the established methodology, it is also important to consider in the characterisation of the business base of this priority domain the competitiveness clusters and sectoral business associations operating in Norte. The following table presents the main areas of intervention of the competitiveness clusters framed within this priority domain.

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[51]   Data of companies' exports obtained from the Iberinform database. Does not include the referring values to individual companies.

[52]   Galindo-Rueda, F. and F. Verger (2016)

Table 14 • Main intervention areas of the Competitiveness Clusters and Business Associations
within the domain "Health and Life Sciences"

Type of Institution	Main areas of intervention
Competitiveness cluster	Health Cluster Portugal (pharmaceutical/biotechnology, medical devices, consumables and hospital and laboratory equipment, ICT&E for health, health activities and transversal services)[53]

5.3 Advanced Users and Trends

In the "Health and Life Sciences" priority domain, a prospective analysis was carried out[54] to identify the main medium and long-term global trends. The schematic and conceptual dimension of this identification process should consider the interaction of the different trends among themselves, enhancing the effect of each one and of the whole. These trends are structured into the following five topics:

a) **Active and healthy aging** - increasing life expectancy and the need to ensure autonomy, quality of life and well-being for as long as possible;

b) **Chronic diseases** - prevalence of oncological, cardiovascular and degenerative diseases and diseases resulting from unhealthy lifestyles (such as obesity and diabetes);

c) **Medicine and advanced technologies** - development of new therapeutic solutions and treatments from R&D in the areas of biomedicine, biotechnology and biochemistry, associated with information analysis and construction of predictive models and data platforms;

d) **Personalised medicine** - greater focus on the patient, with access to information, participation in decision-making, permanent surveillance and monitoring, early diagnosis, use of electronic data records;

e) **Sustainability and resilience of health systems** - increase in quantity and quality (differentiation, specialisation, etc.) of health services and consequently of private and, above all, public costs and their financing needs, together with the need for a permanent installed capacity to respond to health events and occurrences to protect people and their social and economic life.

In this context of trends, the concept and respective technologies for One Health, which consists of the integrated approach planet-plants-animals-humans in the area of health, in particular epidemiology, also gain relevance. The R&D&I strategies and public policies associated with this priority domain cannot be dissociated from the global trends structured into the five topics mentioned in the previous point, and are not and cannot be mutually exclusive. Resulting from the analysis of different documents from national and international organisations, the R&D&I strategies and public policies for this domain are as follows:

a) **Active and healthy aging** - promoting physical activity, leisure, sport and involvement in social activities and enhancing the socialisation of the (more) elderly; provision of health care such as rapid response to warning signs or remote monitoring to enhance community aging;

b) **Chronic diseases** - promotion of healthy eating and lifestyle habits (such as physical activity and sport); improvement of screening and early diagnosis processes; permanent monitoring; increased provision of long-term and palliative care;

c) **Medicine and advanced technologies** - development of new therapeutic solutions, involving areas such as biological medicines, vaccines and their components; regenerative medicine and tissue engineering, gene therapies or bioinformatics; incorporation of advanced technologies in the development of medical devices;

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[53] Health Cluster Portugal (2019)

[54] Relevant bibliography consulted: Comissão de Coordenação e Desenvolvimento Regional do Norte (2014), Monteiro, Meira, Santos, Leite, Guimarães & Gomes (2019), Comissão Europeia (2018), Fundação para a Ciência e Tecnologia (2019), Boston Consulting Group (2019), Health Cluster Portugal (2019).

d) **Personalised medicine** - validation and introduction of new biomarkers for diagnosis, monitoring, prognosis and therapeutic decision; development of representative models for each type of disease and its aetiology; sharing of electronic patient records, customisation of services and fast and convenient access; personalised genetics; human microbiome research; digital medicine (telemedicine, preventive and continuous monitoring);

e) **Sustainability and resilience of health systems** - the efficiency of services and the cost-effectiveness of treatments provide incentives for innovation, through, inter alia, telemedicine and remote diagnosis (such as imaging), evaluation of the effectiveness of technologies, interventions, systems, programmes and policies, training in health literacy of the population, one health, use of mobile applications and simple-to-use medical devices or personal protective equipment, along with the development of health risk prevention and management plans and intervention in infrastructures and equipment to strengthen action in extreme situations.

The following table shows the association between the trends identified in the domain of "Health and Life Sciences" and the "societal challenges" that constitute heavy trends of structural change in the economy and society and that are transversal to different priority domains. This analysis allows the conclusion that this priority domain is aligned with structural transformation trends such as demographic, digital transformation and Industry 4.0. This conclusion thus reveals that, despite the sectoral and thematic specificities of this priority domain, there are common elements in the trends and policies to other priority domains of smart specialisation that promote an interpenetration of areas, which will increasingly exist in various enterprises, institutions and economic activities.

Table 15 • Association[1] between trends identified in the domain "Health and Life Sciences" and "societal challenges"

Trends	Aging		Energy Efficiency		Decarbonisation		Circular Economy		Digitalisation		Industry 4.0	
	D	I	D	I	D	I	D	I	D	I	D	I
a) Active and healthy aging	●											
b) Chronic diseases		●										
c) Medicine and advanced technologies									●		●	
d) Personalised medicine									●			
e) Sustainability and resilience of health systems		●							●			

[1] Direct (D) or indirect (I) association

5.4 Rationale

The "Health and Life Sciences" domain aims to articulate research and health care provision activities with the significant regional business base specialised in the production of goods and services related to these activities. Recognizing the growing importance of this sector and taking advantage of the business base present in Norte Region, this domain aims to stimulate innovation based on knowledge. The following figure shows the referential analysis of the priority domain "Health and Life Sciences".
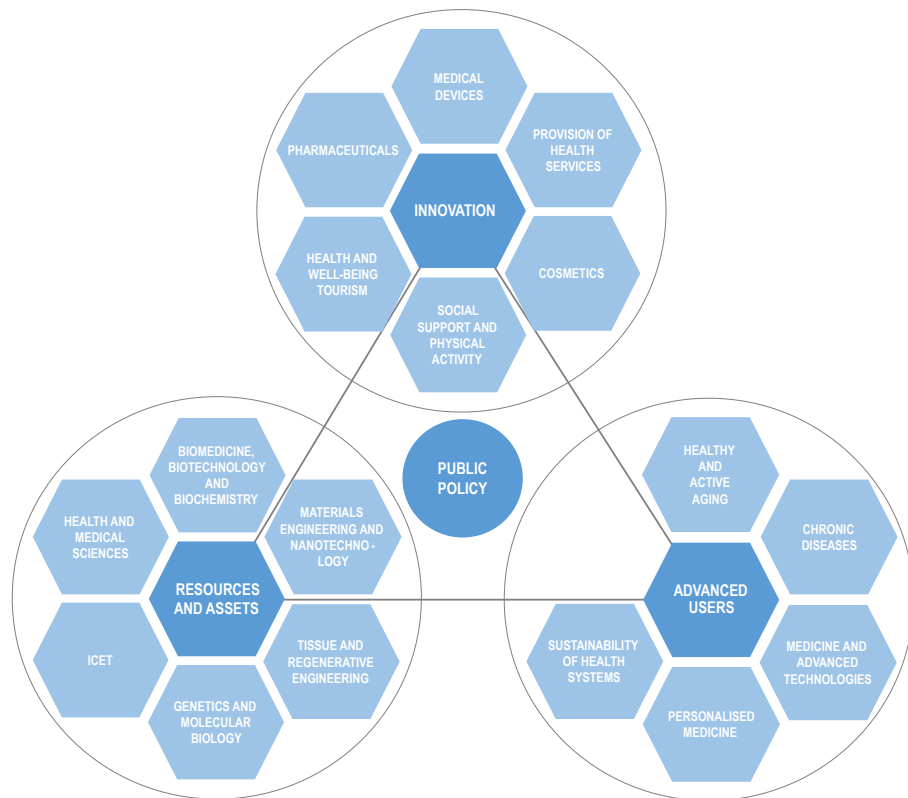
Figure 28 • Analytical framework of the domain "Health and Life Sciences".

In terms of policy rationale, the domain of "Health and Life Sciences" aims to promote the consolidation of articulation dynamics between research at regional level (namely, in the areas of tissue engineering and regenerative medicine, cancer, neurosciences, development of surgical techniques, etc.) and companies in the health industry and services in the broad sense (pharmaceuticals, medical devices, ICT, health services, personal protective equipment, health and wellness tourism, social support and physical activity, cosmetics, etc.), driving the development of new products and services capable of responding to current challenges (aging population, chronic diseases, pandemics or digital transformation), and contributing to the sustainability and resilience of the health system.

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Annex 1

List of non-corporate entities of the scientific and technological system identified in the priority domain "Health and Life Sciences"[55]

Typology	Acronym	Name
R&D Units	CBQF	Centre of Biotechnology and Fine Chemistry
R&D Units	CEB-UM	Centre of Biological Engineering from the University of Minho
R&D Units	CIIMAR	Interdisciplinary Centre for Marine and Environmental Research
R&D Units	CI-IPOP	Research Centre of the Portuguese Oncology Institute of Porto
R&D Units	CIPsi	Research Centre in Psychology
R&D Units	CIQUP	Chemistry Research Centre of the University of Porto
R&D Units	CMEMS-Uminho	Research Unit in Electromechanical Microsystems
R&D Units	EPIUnit	Research Unit in Epidemiology - Institute of Public Health of the University of Porto
R&D Units	i3S	Institute for Research and Innovation in Health
R&D Units	IFIMUP	Institute for Advanced Materials Physics, Nanotechnology and Photonics - University of Porto
R&D Units	InBIO	Research Network on Biodiversity and Evolutionary Biology
R&D Units	REQUIMTE	Associated Laboratory for Green Chemistry - Clean Technologies and Processes
R&D Units	UCIBIO	Applied Biomolecular Sciences Unit
R&D Units	UnIC	Cardiovascular Research and Development Unit
R&D Units	2Ai	Applied Artificial Intelligence Laboratory
R&D Units	CIAFEL	Physical Activity, Health and Leisure Research Centre
R&D Units	CIDESD	Sports, Health and Human Development Research Centre
R&D Units	CINTESIS	Research Centre in Health Technologies and Services
R&D Units	CPUP	Psychology Centre of the University of Porto
R&D Units	ICVS/3Bs-LA	Associate Laboratory, Institute of Life and Health Sciences / Research Group on Biomaterials, Biodegradables and Biomimetics
R&D Units	INESC TEC	Institute for Systems and Computer Engineering, Technology and Science
R&D Units	UMIB	Multidisciplinary Biomedical Research Unit
R&D Units	CIFI2D	Centre for Research, Training, Innovation and Intervention in Sports
R&D Units	CIR	Rehabilitation Research Centre
R&D Units	MedinUP	Pharmacological Research and Medicinal Innovation Centre
Associated Labs.	InBIO	Research Network on Biodiversity and Evolutionary Biology

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[55] The identification of the entities was based on the analysis of a synthetic characterisation of each institution obtained, namely through consultation of various ANI publications, FCT evaluation reports and the entities' websites. It should be noted that the mere identification of a given infrastructure in each domain is not enough to guarantee its framework in S3 NORTE 2027 for the purposes of support for financing from EU funds. Similarly, the non-inclusion of a given infrastructure may not prevent access to such support and funding, depending always on the project that will be presented.

Typology	Acronym	Name
Associated Labs.	ICVS/3B's	ICVS/3B's - Associated Laboratory, Institute of Life and Health Sciences / Research Group on Biomaterials, Biodegradables and Biomimetics
Associated Labs.	i3S	Institute for Research and Innovation in Health
Associated Labs.	REQUIMTE	Associate Laboratory for Green Chemistry - Clean Technologies and Processes
Associated Labs.	INESC TEC	Institute for Systems Engineering and Computers, Technology and Science
Associated Labs.	AL4TECH	Associate Laboratory in Bio/Chemistry/Micro-Nano/Electromechanical Technology
Associated Labs.	i4HB	Institute for Health and Bioeconomy
Associated Labs.	RISE	Health Research Network: from Laboratory to Community Health
Associated Labs.	ITR	Laboratory for Integrative and Translational Research in Population Health
Associated Labs.	LASI	Associated Laboratory for Intelligent Systems
State Labs.	INSA	National Institute of Health Dr. Ricardo Jorge
State Labs.	LNMLCF	National Institute for Legal Medicine and Forensic Sciences
Clinical Academic Centres	-	Clinical Academic Clinical Centre Braga (2CA-Braga)
Clinical Academic Centres	-	Clinical Academic Centre ICBAS - CHP
Clinical Academic Centres	-	University Medical Centre FMUP - CHSJ
Clinical Academic Centres	-	Clinical Academic Center Egas Moniz
Clinical Academic Centres	-	Clinical Academic Centre of Trás-os-Montes and Alto Douro
R&D Infrastr. RNIE	BIOBANCO.PT	National Biobanks Network
R&D Infrastr. RNIE	BioData	National Biobanks Infrastructure
R&D Infrastr. RNIE	CRYO-EM-PT	BioData.pt - Portuguese Biological Data Network
R&D Infrastr. RNIE	Genome-Portugal	BioData.pt	ELIXIR PT - Portuguese Distributed Infrastructure for Biological Data
R&D Infrastr. RNIE	Micro&NanoFabs@PT	National Network of Advanced Electron Microscopy for Health and Life Sciences
R&D Infrastr. RNIE	NECL	National Advanced Electron Microscopy Network for Health and Life Sciences
R&D Infrastr. RNIE	PPBI	National Laboratory for Genome Sequencing and Analysis
R&D Infrastr. RNIE	ProtoTera	National Facility for Genome Sequencing and Analysis
R&D Infrastr. RNIE	PtCAC	Network of Micro and Nanofabrication Research Facilities
R&D Infrastr. RNIE	Pt-OPEN-SCREEN	Network of Extreme Conditions Laboratories
R&D Infrastr. RNIE	PtCRIN	PPBI - Portuguese Platform of BioImaging
R&D Infrastr. RNIE	PtmBRCN/MIRRI-PT	Portuguese Platform of BioImaging
R&D Infrastr. RNIE	PTNMR	Network of Advanced Cancer Therapies
R&D Infrastr. RNIE	RNCCC	The Portuguese Network of Infrastructures for Proton Therapy and Advanced Technologies for Cancer Prevention and Treatment
R&D Infrastr. RNIE	RNEM	National Network of Clinical Academic Centres

Typology	Acronym	Name
R&D Infrastr. RNIE	TERM RES-Hub	National Infrastructure for Chemical Biology and Genetics
R&D Infrastr. RNIE	TRIS-HCP	National Infrastructure for Chemical Biology and Genetics
Technology Centres	CITEVE	Portuguese Clinical Research Infrastructure Network
Technology Transfer and Valorisation Centres	AQUAVAL-OR	Portuguese Clinical Research Infrastructure Network
Technology Transfer and Valorisation Centres	CCG/ZGDV	Portuguese microBiological Resources Center Network
Technology Transfer and Valorisation Centres	CeNTItvc	Portuguese microBiological Resources Center Network / Microbial Resource Research Infrastructure - Portugal
Technology Transfer and Valorisation Centres	INEGI	National Nuclear Magnetic Resonance Network
Technology Transfer and Valorisation Centres	INESC TEC	Institute for Systems Engineering and Computers, Technology and Science
Technology Transfer and Valorisation Centres	INL	International Iberian Nanotechnology Laboratory
Technology Transfer and Valorisation Centres	2CA-Braga	Academic Clinical Centre
Technology Transfer and Valorisation Centres	EBRI	European Bioproducts Research Institute
Technology Transfer and Valorisation Centres	ISPUP	Institute of Public Health of the University of Porto
Other R&D Infrastructures	IINFACTS	Research and Advanced Training Institute in Health Sciences and Technologies - CESPU
Other R&D Infrastructures	TERM Tech	Technology Centre TERM Tech - University of Minho
Colabs	4LifeLab	Collaborative Laboratory in Knowledge and Technology for a Better Health
Colabs	AQUAVAL-OR	Water Technology Transfer and Valorisation Centre
Colabs	ProChlld	ProChild Colab Against Poverty and Social Exclusion
Digital Innovation Hubs	-	DigiHealthPT
Competitiveness Clusters	-	Health Cluster Portugal

Annex 2

Delimitation of the main sectors of activity from the Portuguese Classification of Economic Activities (CAE Rev. 3) in the domain of "Health and Life Sciences"

For the definition of the main economic activities that integrate this domain, the sectors that constitute the great areas of this domain and that are considered in its rationale are namely:

− **Pharmaceuticals**
− **Medical Devices**
− **Health Services**
− **Social Support**
− **Cosmetics**

Delimitation of the priority domain in terms of the Portuguese Classification of Economic Activities (CAE Rev. 3):

(i) **Pharmaceuticals**
- 211 - Manufacture of basic pharmaceutical products
- 212 - Manufacture of pharmaceutical preparations
- 4646 - Wholesale of pharmaceutical goods
- 47730 - Retail sale of pharmaceutical products in specialised shops

(ii) **Medical Devices**
- 266 - Manufacture of radiation, electromedical and electrotherapeutic equipment
- 325 - Manufacture of medical and surgical instruments and supplies
- 47740 - Retail sale of medical and orthopaedic goods in specialised shops
- 47782 - Retail sale of optical, photographic, cinematographic and precision instruments in specialised shops

(iii) **Health Services**
- 861 - Activities of inpatient care facilities
- 862 - Medical and dental practice activities
- 869 - Other human health activities

(iv) **Social Support**
- 871 - Activities of integrated long-term care facilities, with accommodation
- 872 - Residential care activities for mental retardation, mental health and substance abuse
- 873 - Residential care activities for the elderly and disabled
- 879 - Other social work activities with accommodation
- 881 - Social work activities without accommodation for the elderly and disabled
- 889 - Other social work activities without accommodation

(v) **Cosmetics**
- 2042 - Manufacture of perfumes and toilet preparations
- 4645 - Wholesale of perfume and cosmetics
- 4775 - Retail sale of cosmetics and toiletries in specialised shops

(Sources: "INE (2011). Conta Satélite da Saúde"; "Porto Business School (2013). Estudo para o HCP "O setor da saúde: da racionalização à excelência" "; "Ministério da Economia e Health Cluster Portugal (2019). Health Cluster Portugal. Pacto Setorial para a Competitividade e Internacionalização. Estratégia anexa ao pacto setorial para a competitividade e internacionalização")

6.

Priority domain characterisation

Tourism Services and Territorial Assets

6.1. Resources and Assets

The purpose of the "Tourism Services and Territorial Assets" domain is to value territory-intensive resources by taking advantage of scientific and technological capacities and the relevant tourism supply, with the aim of boosting tourism services and improving the integration of tourism in different cultural, modern and traditional contexts, as a way of broadening the territorial base to promote regional competitiveness.

As part of the exercise to assess the existence of critical mass in this priority domain, it is important to analyse the technological resources and assets to be integrated by the main business bases in this area. The non-technological resources and assets that by their nature are inimitable and non-transferable will also be characterised, namely the territory-intensive assets and resources. The first point characterises the stock of human capital with advanced skills by main areas of education and training through the indicator "Number of graduates in higher education by areas of education and training" already used in the preparation of RIS3 NORTE 2020, with accumulated values for the academic years from 2008/2009 to 2017/2018.

Based on the established methodology, the education and training areas considered to have the greatest potential for the achievement of the rationale defined for this domain are the following[56]:

a) **"Services":** such as "Transport services", "Personal services", "Sport", "Tourism and leisure" and "Hotel and restaurant services";

b) **"Arts and Humanities":** such as "History and Archeology", "Foreign Languages and Literature", "Performing Arts", "Crafts" and "Audiovisuals and Media Production";

c) **"Social sciences, commerce and law":** such as "Commerce" and "Marketing and advertising";

d) **"Science, mathematics and computing":** such as "Computer Science" and "Environmental Science";

e) **"Engineering, manufacturing and construction":** as "Architecture and urbanism";

f) **"Health and social protection":** as "Therapy and rehabilitation".

Between 2009 and 2018, 48 005 students graduated in these training areas in Norte Region, distributed by the different types of courses, namely, professional higher technical courses, bachelor's degrees, master's degrees and doctorates. Of this total, during this period, 1 026 obtained a doctoral degree and 10 642 obtained a master's degree. In terms of education and training areas, the number of graduates in the following areas stands out: (i) "Services" with 8 083 graduates in "Sport" and 3 437 in "Tourism and Leisure"; (ii) "Arts and Humanities" with 5 102 graduates in "Audiovisuals and Media Production" and 2 245 in "Performing Arts"; (iii) "Social Sciences, Commerce and Law" with 4 223 graduates in "Marketing and advertising"; (iv) "Sciences, mathematics and computing" with 4 470 graduates in "Computer sciences"; (v) "Engineering, manufacturing and construction" with 7 168 graduates in "Architecture and urban planning"; and (vi) "Health and social protection": with 7 084 graduates in "Therapy and rehabilitation". This information is systematised in the following figure.

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[56] The exercise of identifying the most relevant education and training areas for this domain took into consideration: (i) the revised rationales in the new domains of smart specialisation of S3 NORTE 2027, (ii) the responses to the surveys carried out to the Regional Platforms of Smart Specialisation for the review of S3 NORTE 2027, (iii) the international demand trends and corresponding R&D&I strategies and policies for the priority domains of S3 NORTE 2027 and (iv) the basic resources and assets that are included in RIS3 NORTE 2020.

Figure 29 • Number of Graduates by Education and Training Areas in Norte Region, cumulative value
from 2008/2009 to 2017/2018

Source: DGEEC

It is also important to characterise the regional scientific production, namely the publications by scientific and technological areas considered most relevant to the achievement of the rationale of the priority domain "Tourism Services and Territorial Assets". This analysis is carried out based on the indicator "Number of publications indexed in the Web of Science by scientific area", a variable already used in the preparation of RIS3 NORTE 2020, using the cumulative values from 2008 to 2018.

Taking into account the defined methodology, the most relevant scientific and technological areas for this domain in terms of publications[57] are "Computer and Information Sciences" with 5 411 publications, "Earth and Environmental Sciences" with 3 947 publications and "Environmental Engineering" with 2 414 publications. This information is systematised in the following figure.

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[57] The exercise of identifying the most relevant scientific and technological domains for this domain took into account: (i) revised rationales in the new smart specialisation domains of S3 NORTE 2027, (ii) responses to surveys carried out to the Regional Smart Specialisation Platforms for the review of S3 NORTE 2027, (iii) international demand trends and corresponding R&D&I strategies and policies for the priority domains of S3 NORTE 2027 and (iv) the resources and assets of base contained in RIS3 NORTE 2020.
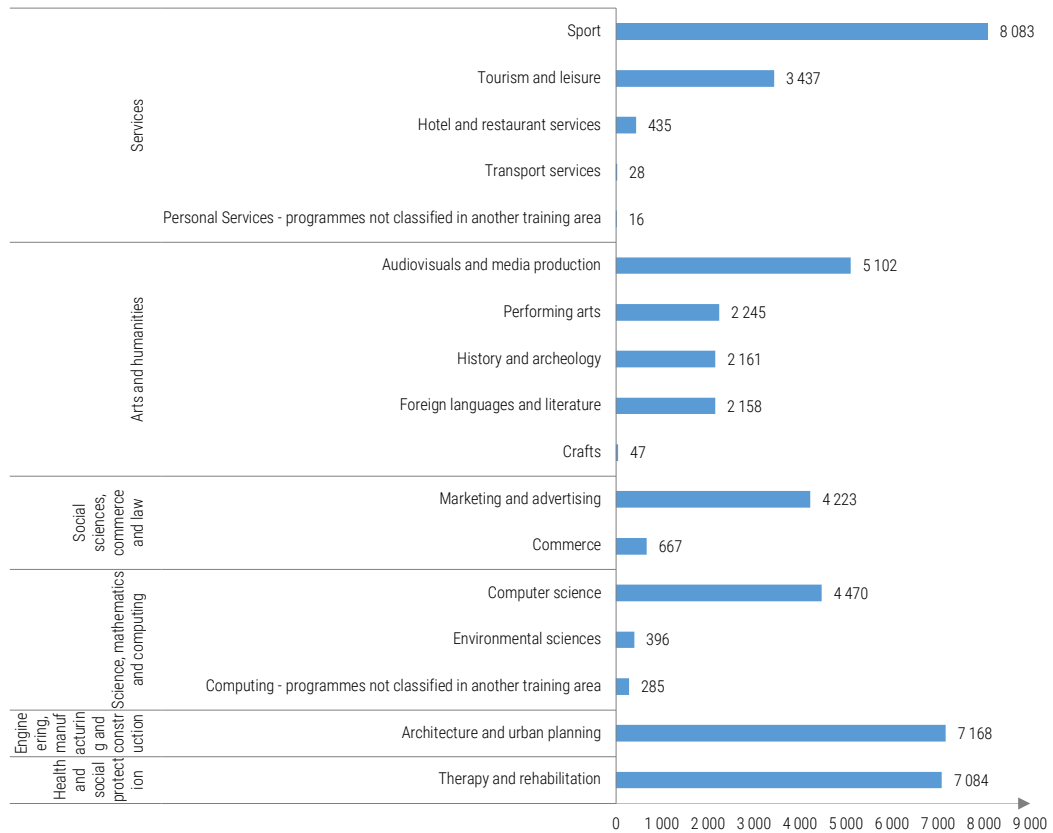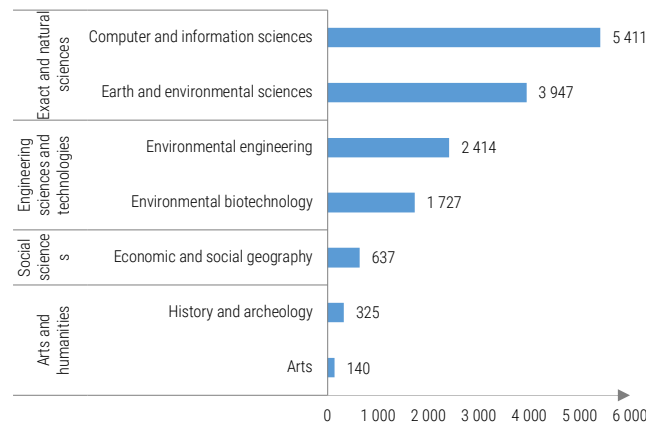
Figure 30 • Number of Publications by Scientific and Technological Areas in Norte Region,
cumulative value from 2008 to 2018
Source: DGEEC

A fundamental element of the characterisation of scientific and technological resources is also related to the identification of the installed capacity in the region in terms of non-business R&I scientific and technological infrastructures that integrate the regional scientific and technological system. Based on the established methodology, 10 Research and Technological Infrastructures were identified in this priority domain that fall within its areas of intervention (see Annex 1). The following table shows the main areas of intervention of this type of entity within this priority domain.

Table 16 • Main intervention areas of Research and Technological Infrastructures within the domain
"Tourism Services and Territorial Assets"

Type of Institution	Main areas of intervention
Research Infrastructures	Tourism, earth and environmental sciences, economic and social geography, history and archeology, computer and information sciences, cultural heritage, arts, digital.
Technological Infrastructures	Tourism, computer sciences, information sciences, health sciences, digitalisation, cultural heritage, water technology, mountain.

In the case of the domain "Tourism Services and Territorial Assets" it is also important to characterize the non-technological resources and assets that by their nature are inimitable and non-transferable. Thus, the main tourism resources of the region will be characterised, namely, cultural resources and heritage (physical and material), natural resources, creative resources and endogenous resources.

Cultural resources[58] include UNESCO World Heritage, classified cultural heritage networks and routes and intangible heritage. In Norte, the Alto Douro Wine Region, the Prehistoric Sites of Côa Valley Rock Art, the Historic Centre of Oporto, the Historic Centre of Guimarães and the Bom Jesus do Monte Sanctuary in Braga are part of the UNESCO World Heritage list. Based on the classified immovable heritage, there are structured networks and itineraries on different themes, such as the Cathedrals Route, the Route of the Romanesque in the Norte Region of Portugal, Religious Heritage, the Monasteries Network, the Castles and Fortresses Network, the Norte Region of Portugal Baroque and the Fortresses Network.

In terms of intangible cultural heritage it is worth highlighting the Caminhos de Santiago as a cultural itinerary. In Norte Region, there are also three entries on the list of the National Inventory of Intangible Cultural Heritage, namely, one from Tâmega e Sousa, Entre-os-Rios (Endoenças de Entre-os-Rios), one from Douro, Vila Real (Bisalhães black pottery manufacturing process) and one from Terras de Trás-os-Montes, Macedo

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58   Autoridade de Gestão do NORTE 2020 (2015)

de Cavaleiros (Carnival of Podence), the last two also being on the UNESCO list of Intangible Heritage[59]. Norte Region concentrates the largest number of national monuments (275) and buildings of public interest (993), plus 108 buildings of municipal interest. Overall, the region concentrates 30% of Portugal's cultural real estate. The special protection areas of the Alto Douro Wine Region and the Prehistoric Sites of Rock Art of the Côa River Valley are also the largest protected areas of cultural heritage in the country.
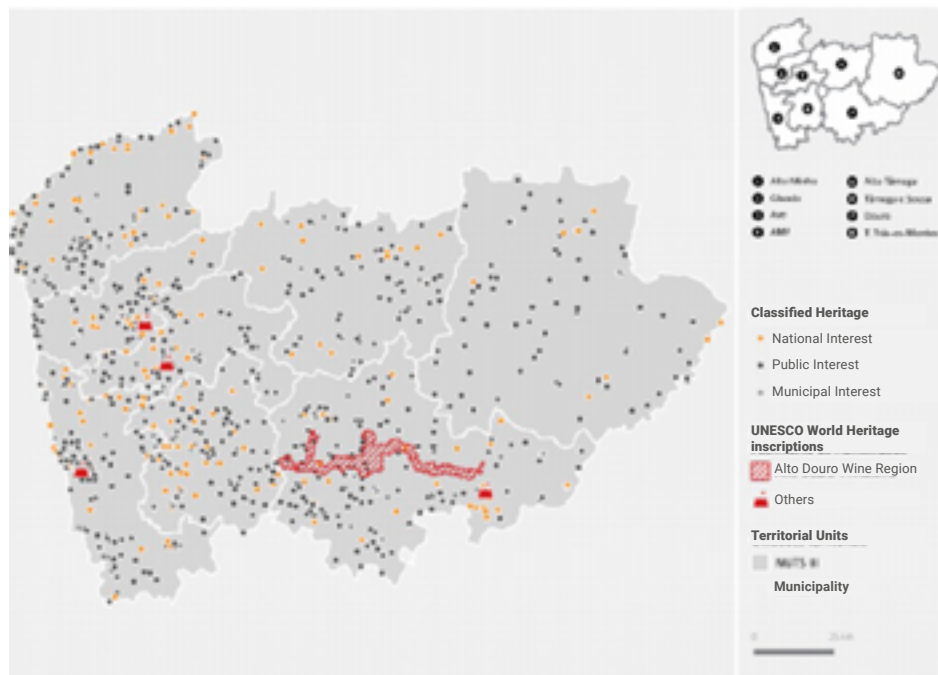
Figure 31 • Classified Cultural Property in 2020
Source: DGPC[60]

It is also worth highlighting the considerable range of cultural and creative resources that Norte has available to affirm the cosmopolitanism of the main regional urban centres and the tourist attraction through relevant and symbolic infrastructures, cultural agendas and events that are differentiating and can be important tourist attraction points, namely the Serralves Museum of Contemporary Art, Casa da Música, Theatro Circo, Vila Flor Cultural Centre, Côa Museum, etc.

Natural resources[61] include natural parks, protected landscapes of national and local interest, sites of community interest, special protection areas integrated in the natura 2000 network and UNESCO world geoparks. In Norte is located the only National Park in Portugal - the National Park of Peneda-Gerês, and 4 Natural Parks (i) the Alvão Nature Park, (ii) the Douro Internacional Nature Park, (iii) the Litoral Norte Nature Park and (iv) the Montesinho Nature Park, several Protected Landscapes of national and local interest, 19 Sites of Community Interest and 6 Special Protection Areas integrated in the Natura 2000 Network (Estuaries of the Minho and Coura River; Serra do Gerês; Montesinho and Nogueira; Rivers Sabor and Maçãs; International Douro and Águeda Valley) and 2 geoparks classified by UNESCO (Arouca and Terras de Cavaleiros). These resources are particularly important for the development of leisure and sport activities in the context of Nature Tourism, namely rafting, kayaking, hiking, climbing, birdwatching, etc. It is also worth mentioning the several thermal stations spread in the region, such as Termas de Pedras Salgadas, Caldelas, São Vicente, Taipas, Chaves and Caldas da Saúde and Caldas de Aregos, which play a fundamental role in preventive medicine and Health and Well-being Tourism.

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[59]   http://www.patrimoniocultural.gov.pt/pt/patrimonio/patrimonio-imovel/pesquisa-do-patrimonio/

[60]   Informação de 2020 disponibilizada pela Direção-Geral do Património Cultural (DGPC)

[61]   www.icnf.pt
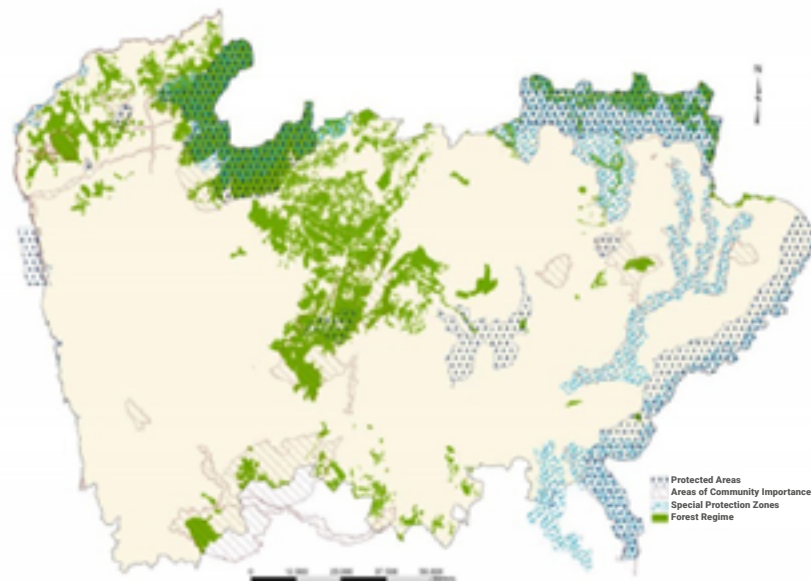
Figure 32 • Natura 2000 network
Source: ICNF[62]

Norte Region has also important natural resources associated with the sea, rivers and reservoirs that can be used to develop nautical tourism, such as sailing, surfing, canoeing, among others, as well as cruise ship tourism. The combination of sun and sea makes it possible to provide beaches of recognised quality which are important for coastal tourism, as well as health and wellness tourism associated with the therapeutic properties of the sea.

Finally, it is important to highlight the endogenous resources, namely gastronomy, wines, authenticity, popular culture, and the hospitality of Norte, which will enable the region's tourism development to be boosted. In this field, the Collective Efficiency Strategies (EEC) associated to the Programmes for the Economic Enhancement of Endogenous Resources (PROVERE) stand out. These programmes aim to promote the competitiveness of low-density territories and the economic valorisation of endogenous resources of regional scope, with a capacity for differentiation. Under these programmes, public investments are financed (for the enhancement of territorial resources, through infrastructures to support tourism visitation or experience, or for the rehabilitation of cultural and natural heritage) and business projects, particularly linked to the supply of hotels and restaurants, tourist entertainment companies and businesses related to the agro-food sector, heritage and crafts.

In Norte Region, five PROVERE Collective Efficiency Strategies are formally recognised, aimed at the economic valorisation of endogenous resources, tending to be inimitable, namely:

• **"Minho Innovation" (NUTS III Alto Minho, Cávado and Ave):** The traditional landscape of Minho, strongly humanised, resulting from a combination of natural elements, such as the National Park of Peneda-Gerês or the Cabreira Mountains, and traditional agricultural practices, such as irrigation, maize cultivation, extensive livestock systems, *bouça*, *ao alto* ("to the top") and *enforcado* ("hanging") vines;

• **"Aquanatur" (NUTS III Alto Tâmega):** The water as an agglutinating element in the culture and local identity, in the agricultural and industrial productions and in the touristic dynamics (of health and well-being, as the thermal springs);

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[62] http://www2.icnf.pt/portal/pn/biodiversidade/rn2000/resource/doc/rn-pt/mapa-zpe-2016-11-15.pdf

- **"Terras de Trás-os-Montes" (NUTS III Trás-os-Montes):** Itinerancies and tourist routes associated with the Terra Fria Route, the Terra Quente Route and different thematic routes related to many of its traditional productions (from chestnuts to cherries, from native breeds to olive oil, for example);

- **"Douro 2020" (NUTS III Douro):** Douro and the classification of the Alto Douro Wine Region as a UNESCO World Heritage Site, in its intangible and identity dimension, but also in its productive and landscape dimension, aimed at enhancing the value of local productions, as in the case of vines and wine, but also in tourism (in wine tourism or cultural and landscape touring) or in other traditional agricultural and agro-industrial activities, such as nuts, olive oil, fruit or gastronomy;

- **"Tourism for all" (NUTS III Tâmega e Sousa and AMPorto, only the territories of low density - Municipalities of Arouca and Vale de Cambra):** Heritage elements (Romanesque Route) and landscape elements (Douro Verde), standing out as an anchor product, the nature tourism and, as complementary products, the cultural tourism, the gastronomic tourism, the wine tourism and the health and well-being tourism.

Smart specialisation must be based on regional potential in resources and assets with inimitable and non-transferable characteristics, on which globally competitive goods and services can be developed. These endogenous resources and assets are therefore strategic for boosting the priority domain associated with "Tourism Services and Territorial Assets".

6.2 Business Bases

The domain "Tourism Services and Territorial Assets" encompasses a heterogeneous set of activities that aim to valorise territory-intensive resources, namely cultural resources, natural resources, creative resources and endogenous resources.

For the definition of the main economic activities included in this domain, the sectors that constitute its main areas of activity[63/64] are, namely: (i) Accommodation, (ii) Restaurants, (iii) Travel agencies, tour operators and tourist guides, and (iv) Tourism, recreational and cultural activities. The following figures show the turnover and staff employed in the main sectors of activity included in the domain "Tourism Services and Territorial Assets".

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[63]   Relevant bibliography consulted: Instituto Nacional de Estatística (2019) e Instituto Nacional de Estatística (2007)

[64]   Annex 2 contains the delimitation of the main sectors of activity in terms of the Portuguese Classification of Economic Activities (CAE Rev. 3) included in the priority domain "Tourism Services and Territorial Assets".
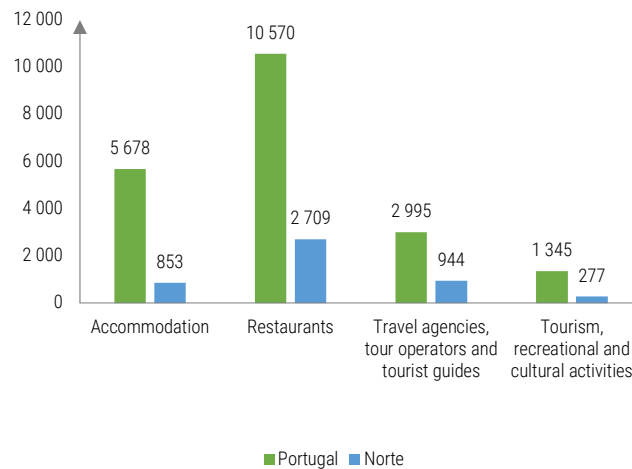
Figure 33 • Turnover in the main sectors included in the domain "Tourism Services and Territorial Assets", Portugal and Norte Region, million euros, 2019

Source: INE, Sistema de contas integradas das empresas
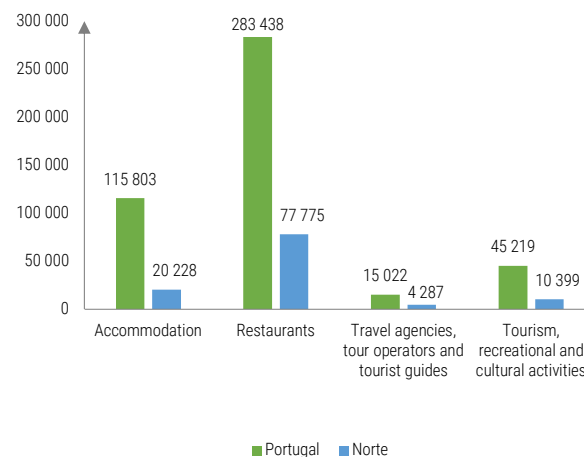
Figure 34 • Personnel employed in the main sectors included in the domain "Tourism Services and Territorial Assets", Portugal and Norte Region, Number, 2019

Source: INE, Sistema de contas integradas das empresas

The sector with the greatest weight in tourism is the restaurant sector, which has a turnover value of 2 709 million euros with 77 775 people employed. These values correspond respectively to 27% and 25% of the national total for this sector in 2019. The Accommodation sector also has a relevant economic expression in Norte, with a turnover of close to 853 million euros and almost 20 228 people employed. These values correspond respectively to 15% and 17% of the national total for this sector in 2019. Travel agencies, tour operators and tour guides have a turnover of 944 million euros and 4 287 people employed (respectively 32% and 29% of the national total). The activities of tourist entertainment, recreation and culture is the sector with less expression in tourism with a turnover of 227 million euros but represent 10 399 persons employed (respectively 21% and 25% of the national total).

In terms of tourist accommodation supply, Norte Region had, in 2020, 1 420 tourist accommodation units and 62 229 beds, corresponding respectively to 27.4% and 18.1% of the total supply of the country. Of these lodgings, highlight to the 535 units and 8 314 beds of the units of rural tourism and housing that represent the largest regional concentration, with, respectively, 38.9% of the total number of units of this type in the country and 35.5% of the total number of beds. In what concerns the regional dispersion, 30.1% of the tourist accommodation is located in Porto Metropolitan Area, 17.2% in Alto-Minho, 12% in Cávado and 11.6% in

Douro. If we analyse the accommodation capacity of these establishments, the distribution by sub-regional areas is 48.1%, 11.1%, 11.8% and 7.4%, respectively. The units of rural tourism and housing have, however, a different dispersion in the territory: 26.5% (21.2% of the beds) are located in Alto-Minho, 17.8% (20% of the beds) in Douro, 12.1% (14.9% of the beds) in Tâmega and Sousa and 12% in Ave (11.8% of the beds)[65]. The territorial distribution in terms of tourist accommodation supply (number of establishments and accommodation capacity) can be observed in the following maps.
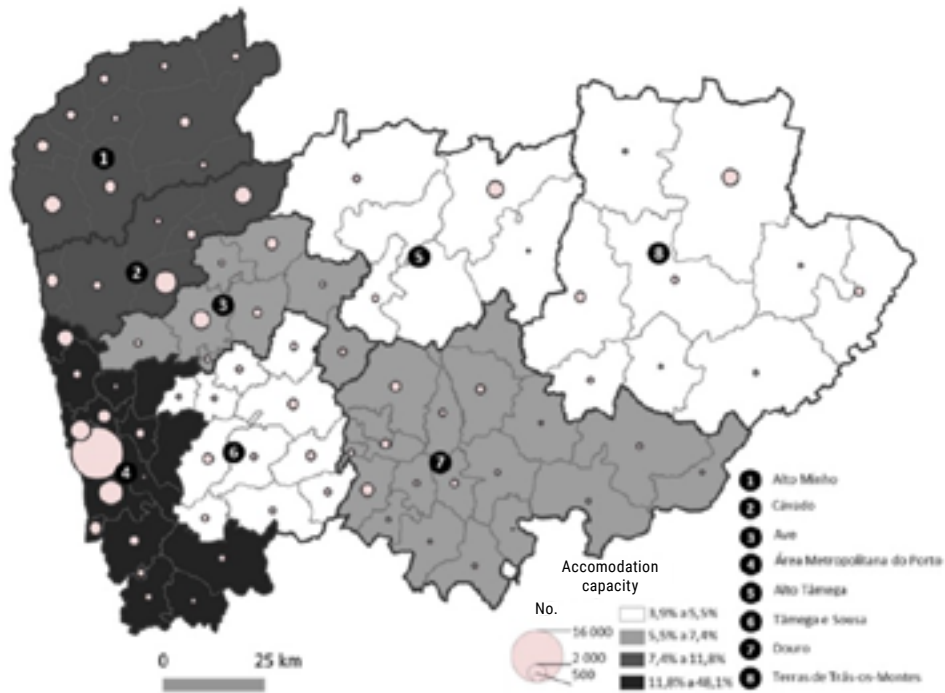
Figure 35 • Accommodation capacity (No.) in tourist accommodation establishments by geographical location, 2020

Source: INE, Inquérito à permanência de hóspedes na hotelaria e outros alojamentos

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[65]   Instituto Nacional de Estatística (2021). Inquérito à permanência de hóspedes na hotelaria e outros alojamentos.
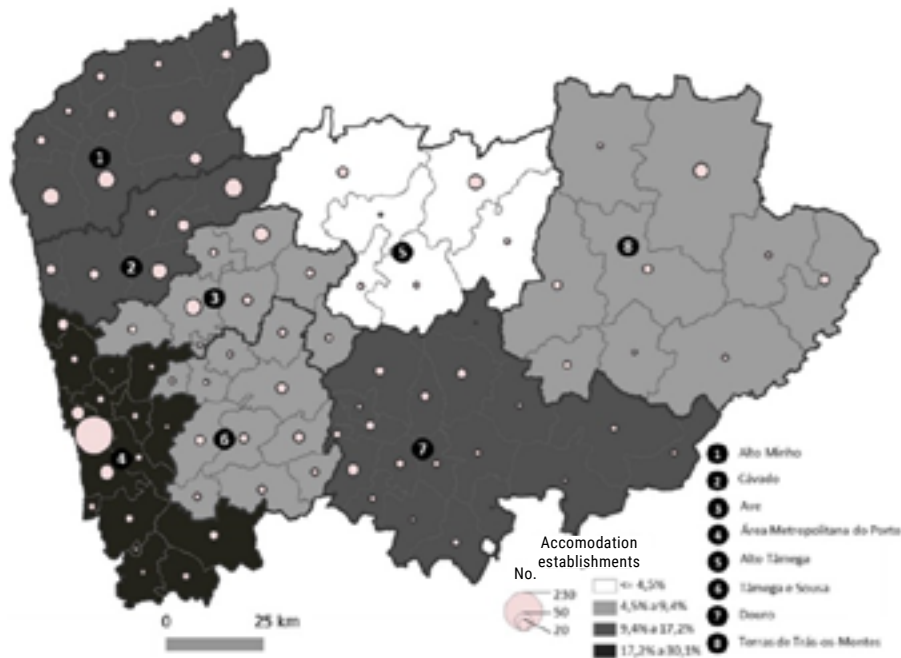
Figure 36 • Tourist accommodation establishments (No.) by Geographic localisation, 2020
Source: INE, Inquérito à permanência de hóspedes na hotelaria e outros alojamentos,

In 2019, 10 810 712 overnight stays were recorded in Norte Region, which is equivalent to 642 934.64 euros in total income. Of the total number of overnight stays, 60% correspond to non-resident overnight stays.

Based on the established methodology, it is also important to consider in the characterisation of the business base of this priority domain the competitiveness clusters and sectoral business associations operating in Norte. The following table presents the main areas of intervention of the competitiveness clusters and sectoral business associations within this priority domain.

Table 17 • Main intervention areas of the Competitiveness Clusters and Business Associations
within the "Tourism Services and Territorial Assets" domain

Type of Institution	Main areas of intervention
Competitiveness Clusters and Business Associations	Tourism, ICT, hotel, catering and beverages, tourist entertainment, travel agencies and operators, digitalisation, thermal tourism, agro-tourism and rural tourism

6.3 Advanced Users and Trends

In the priority domain "Tourism Services and Territorial Assets" a prospective analysis was carried out[66] to identify the main global medium and long-term trends that shape the intermediate and final demand, allowing the assessment of the regional potential in the construction of competitive advantages and the improvement of the insertion degree in international value chains. The schematic and conceptual dimension of this identification process must consider the interaction of the different trends among themselves, enhancing the effect of each one and of the whole. These trends are structured into the following five topics:

[66]   Relevant bibliography consulted: Comissão de Coordenação e Desenvolvimento Regional do Norte (2008, 2014), Monteiro, R., Meira, R. Santos, P., Leite, V., Guimarães, C. & Gomes, J. (2019); Fundação para a Ciência e Tecnologia (2019a, 2019b); Organisation for Economic Co-operation and Development (2017, 2019); Turismo de Portugal (2017, 2015); World Tourism Organisation (2019)

a) **Aging populations and tourism** - increase in life expectancy in the main issuing countries and a significant increase in the market segment dedicated to senior tourism, involving tourists with time and resources available for long stays but demanding in terms of the quality of service related to safety (people and goods), logistics, health and medical support or qualified and (permanently) available support;

b) **Work, family organisation and tourism** - reduction in the size of households, postponement of the birth of the first child, growing number of single-parent families and very active working lives with little time available for long stays, implying a propensity for frequent tourism and leisure weekends and short breaks, often as a complement to travel or professional networking exercises;

c) **Sustainability, authenticity and tourism** - growing importance attributed to the environment, local history and cultural heritage, healthy living and social justice by successive generations (namely millennials and generation Z), who are more informed and independent in their choices and consumption, making prior assessments of destinations and products, preferring flexible itineraries and seeking experiences with authenticity that promote learning and self-realisation;

d) **Digitalisation and tourism** - progressive disintermediation of the sector and of the reservations and increasing the use of platforms, mobile applications (namely integrated ticketing and payment systems) and, in general, the Internet to promote, market and share information and experiences, along with the virtualisation and availability of other content before, during and after visiting different destinations;

e) **Mobility, environment and tourism** - increased mobility of people, resulting in particular from the rising income of the middle classes in emerging countries and the improved cost/benefit ratio of air travel, and consequent congestion of transport infrastructures, increased carbon footprint of the economy and increased risk of exceeding the tourism carrying capacity of the more popular or ecologically vulnerable destinations.

The R&D&I strategies and public policies associated with this priority domain cannot be found dissociated from the global trends structured into the five topics mentioned in the previous point, and are not and cannot be mutually exclusive. Resulting from the analysis of different documents from national and international organisations, the R&D&I strategies and public policies for this domain are the following:

a) **Cultural heritage and tourism** - promotion of networks and routes of classified cultural heritage in different themes, such as: (i) Romanesque; (ii) monasteries; (iii) cathedrals; (iv) religious heritage; (v) castles and fortresses; (vi) Baroque; (vii) fortified settlements; promotion of UNESCO World Heritage: (i) Alto Douro Vinhateiro; (ii) Prehistoric Sites of Côa Valley Rock Art; (iii) Historic Centre of Porto; (iv) Historic Centre of Guimarães; (v) Bom Jesus do Monte Sanctuary; (vi) consolidation of the Way of St. James (Caminho de Santiago) as a cultural itinerary; (vii) enhancement of intangible cultural heritage, namely inscribed on the respective UNESCO list;

b) **Natural resources and tourism** - promotion of nature conservation and biodiversity areas, encompassing the only National Park, 4 Nature Parks, several Protected Landscapes of national and local interest, 19 Sites of Community Interest and 6 Special Protection Areas integrated in the Natura 2000 Network and 2 geoparks classified by UNESCO, for leisure and sport activities in the context of Nature Tourism (rafting, kayaking, hiking, climbing, birdwatching, etc.); enhancement of the different thermal spas in the context of preventive medicine and Health and Well-being Tourism;

c) **Creativity, creation and tourism** - development of cultural and creative industries, namely performing arts, music, film and video, publishing, to affirm the cosmopolitanism of the main regional urban centres and tourism animation, through the construction of dense cultural agendas of activities and events, taking advantage of relevant and symbolic infrastructures (Serralves Museum of Contemporary Art, Casa da Música, Theatro Circo, Vila Flor Cultural Centre, Côa Museum, etc.);

d) **Local development and tourism** - development of local and sub-regional tourism promotion and entertainment strategies, namely in low density territories, taking advantage of local accommodation, the natural and built heritage, the landscape, the practices, traditions and festivities, endogenous products and resources (gastronomy, wines, etc.), the connection of oenology with signature cuisine and cultural contexts, as a way of boosting demand not only for the production but also for the associated services, placing local agents closer to the final consumers and downstream of the respective value chains;

e) **Business plans and tourism** - development of business plans with more autonomous and adjustable distribution channels, allowing the construction of diversified tourism packages according to consumer preferences, less dependent on intermediation and increasingly resorting to the use of online platforms for prior assessment of destinations, products, price, service quality and own construction of flexible itineraries according to their needs and enjoyment desires.

The following table presents the association between the trends identified in the domain "Tourism Services and Territorial Assets" and the "societal challenges" that constitute heavy trends of structural change in the economy and society and that present a transversal character to different priority domains. This analysis allows the conclusion that this priority domain is aligned with structural transformation trends such as demographic challenges, energy-environmental transition and digital transformation. This conclusion thus shows that, despite the sectoral and thematic specificities of this priority domain, there are common elements in the trends and policies to other priority domains of smart specialisation that promote an interpenetration of areas, which will increasingly exist in various enterprises, institutions and economic activities.

Table 18 • Association[1] between trends identified in the domain "Tourism Services and Territorial Assets" and "societal challenges"

Trends	Aging		Energy Efficiency		Decarbonisation		Circular Economy		Digitalisation		Industry 4.0	
	D	I	D	I	D	I	D	I	D	I	D	I
a) Aging populations and tourism	●											
b) Work, family organisation and tourism												
c) Sustainability, authenticity and tourism							●					
d) Digitalisation and tourism									●			
e) Mobility, environment and tourism			●	●						●		

[1] Direct (D) or indirect (I) association

6.4 Rationale

The aim of the "Tourism Services and Territorial Assets" priority domain is to enhance intensive territorial resources by taking advantage of the scientific and technological capacities and the relevant tourism supply, with the aim of boosting tourism services and improving the integration of tourism in different cultural, modern, and traditional contexts, as a way to broaden the territorial base and promote regional competitiveness. The following figure shows the referential analysis of the priority domain "Tourism Services and Territorial Assets".
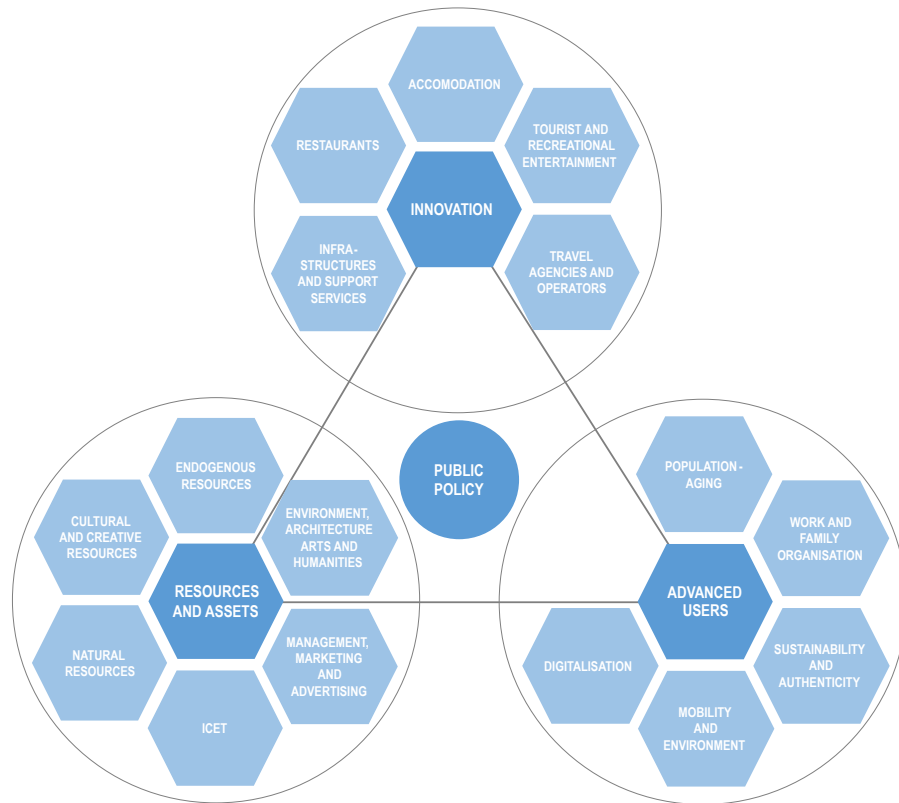
Figure 37 • Analytical framework of the domain "Tourism Services and Territorial Assets"

In terms of policy rationale, the "Tourism Services and Territorial Assets" domain thus aims to enhance territory-intensive resources, namely cultural resources (UNESCO world heritage, classified cultural heritage networks and routes, intangible heritage, etc.), natural resources (national park, natural parks, protected landscapes of national and local interest, sites of community interest, special protection areas integrated into the natura 2000 network, UNESCO world geoparks, etc.), creative resources (relevant and symbolic infrastructures, cultural agendas, events, etc.) and endogenous resources (gastronomy, wines, authenticity, etc.), taking advantage of scientific and technological capacities (namely, in the areas of management, marketing, arts, digital technologies, etc.) and the relevant tourism supply (accommodation, catering, tourist entertainment, etc.), with the aim of boosting tourism services and better integrating tourism into different cultural, modern and traditional contexts, as a way of broadening the territorial base for promoting regional competitiveness.

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Annex 1

List of non-corporate entities of the scientific and technological system identified in the priority domain "Tourism Services and Territorial Assets"[67]

Typology	Acronym	Name
R&D Units	Lab2PT	Landscape, Heritage and Territory Laboratory
R&D Units	CETRAD	Centre for Transdisciplinary Studies for Development
R&D Units	REMIT	Research in Economics, Management and Information Technology
R&D Units	UNIAG	Applied Management Research Unit
Associated Labs.	IN2PAST	Associate Laboratory for Research and Innovation in Heritage, Arts, Sustainability and Territory
R&D Infraest. RNIE	CCD	Digital Creativity Centre
Technology Transfer and Valorisation Centres	AQUAVAL-OR	Water Technology Transfer and Enhancement Centre
Colabs	AQUAVAL-OR	Water Technology Transfer and Valorisation Centre
Colabs	MORE	Research Mountains Collaborative Laboratory
Digital Innovation Poles	-	InnovTourism
Competitiveness Clusters	-	Tourism Cluster
Competitiveness Clusters	-	TICE.PT
Business Associations	AHP	Hotel Association of Portugal
Business Associations	AHRESP	Portuguese Restaurant and Similar Hospitality Association
Business Associations	APAVT	Portuguese Association of Travel Agencies and Tourism
Business Associations	NEST	NEST - Centre of Innovation in Tourism Association
Business Associations	ATPN	Porto and Norte Tourism Association
Business Associations	ATP	Portuguese Thermal Baths Association
Business Associations	TURIHAB	Association of Housing Tourism

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67   The identification of the entities was based on the analysis of a synthetic characterisation of each institution obtained, namely through consultation of various ANI publications, FCT evaluation reports and the entities' websites. It should be noted that the mere identification of a given infrastructure in each domain is not enough to guarantee its framework in S3 NORTE 2027 for the purposes of support for financing from EU funds. Similarly, the non-inclusion of a given infrastructure may not prevent access to such support and funding, depending always on the project that will be presented.

Annex 2

Delimitation of the main sectors of activity from the Portuguese Classification of Economic Activities (CAE Rev. 3) in the "Tourism Services and Territorial Assets" domain

For the definition of the main economic activities that integrate this domain, the sectors that constitute the great areas of this domain and that are considered in its rationale are, namely:

− **Accommodation**
− **Restaurants**
− **Travel agencies, tour operators and tour guides**
− **Tourist entertainment, recreational and cultural activities**

Delimitation of the priority domain in terms of the Portuguese Classification of Economic Activities (CAE Rev. 3):

(i) **Accommodation**
  • 55 - Accommodation

(ii) **Restaurants**
  • 56 - Catering and similar

(iii) **Travel agencies, tour operators and tour guides**
  • 79 - Travel agencies, tour operators, other reservation services and related activities

(vi) **Tourism, recreation and cultural activities**
  • 86905 - Thermal activities
  • 90 - Theatre, music, dance and other artistic and literary activities
  • 91 - Libraries, archives, museums and other cultural activities
  • 93210 - Activities of amusement parks and theme parks
  • 93291 - Bullfighting activities
  • 93292 - Marinas activities
  • 93293 - Organisation of tourist entertainment activities
  • 93294 - Other amusement and recreation activities n.e.c.
  • 96040 - Physical well-being activities

(Sources: "INE (2019). Conta Satélite do Turismo 2016-2018"; "INE (2007). Classificação Portuguesa das Atividades Económicas Rev.3")

7.

Priority domain characterisation

Sea Resources and Economy

7.1. Resources and Assets

The aim of the "Sea Resources and Economy" domain is to create, expand and foster economic activities associated to the sea, seeking to valorise its specific resources, integrating its multiple activities, from the more traditional ones (fishing and the processing and commercialisation of fish, the naval industry, ports, maritime transport and logistics), to the more recent ones associated to the European strategy for blue growth (aquaculture, coastal tourism, marine biotechnology, ocean energy and the exploitation of marine mineral resources).

As part of the exercise to assess the existence of critical mass in this priority domain, it is important to analyse the technological resources and assets to be integrated by the main business bases of the sectors associated to the economy of the sea. Non-technological resources and assets that by their nature are inimitable and non-transferable, namely territory-intensive assets and resources, will also be characterised. The first point characterises the stock of human capital with advanced skills by main areas of education and training through the indicator "Number of graduates in higher education by areas of education and training", already used in the preparation of RIS3 NORTE 2020, with accumulated values for the academic years from 2008/2009 to 2017/2018.

Based on the established methodology, the education and training areas considered to have the greatest potential for the achievement of the rationale defined for this domain are the following[68]:

- **"Engineering, manufacturing and construction":** such as "Metallurgy and metalworking", "Electricity and energy", "Electronics and automation", "Chemical process technologies", "Construction and repair of motor vehicles" and "Building and civil engineering";

- **"Science, mathematics and computing"**: such as "Life sciences", "Physics" and "Computing";

- **"Agriculture":** as "Fisheries" and "Veterinary Sciences";

- **"Services":** such as "Transport services", "Environmental protection technologies" and "Natural environments and wildlife";

- **"Social sciences, commerce and law"**: as the "Commerce".

Between 2008 and 2018, 67 479 students graduated in these training areas in Norte Region, distributed by the different types of courses, namely, professional higher technical course, bachelor's degree, master's degree and doctorate. Of this total, during this period, 2 640 obtained a doctoral degree and 23 361 obtained a master's degree. In terms of education and training areas, the number of graduates in the following areas stands out: (i) "Sciences, mathematics and computing": with 4 470 graduates in "Computer Sciences" and 7 337 in "Biology and biochemistry"; (ii) "Engineering and related techniques": with 15 986 graduates in "Electronics and automation", 6 671 in "Technology of chemical processes" and 7 331 in "Metallurgy and metalworking"; (iii) "Manufacturing industries": 973 graduates in "Materials (wood, cork, paper, plastic, glass and other industries)"; (iv) "Veterinary sciences", with 2 549 graduates; (v) "Architecture and construction": with 8 827 graduates in "Building and civil engineering"; (vi) "Transport services and environmental protection": with 1 337 graduates in "Environmental protection technology". This information is systematised in the following figure.

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[68]   The exercise of identifying the most relevant education and training areas for this domain took into consideration: (i) the revised rationales in the new domains of smart specialisation of S3 NORTE 2027, (ii) the responses to the surveys carried out to the Regional Platforms of Smart Specialisation for the review of S3 NORTE 2027, (iii) the international demand trends and corresponding R&D&I strategies and policies for the priority domains of S3 NORTE 2027 and (iv) the basic resources and assets that are included in RIS3 NORTE 2020.
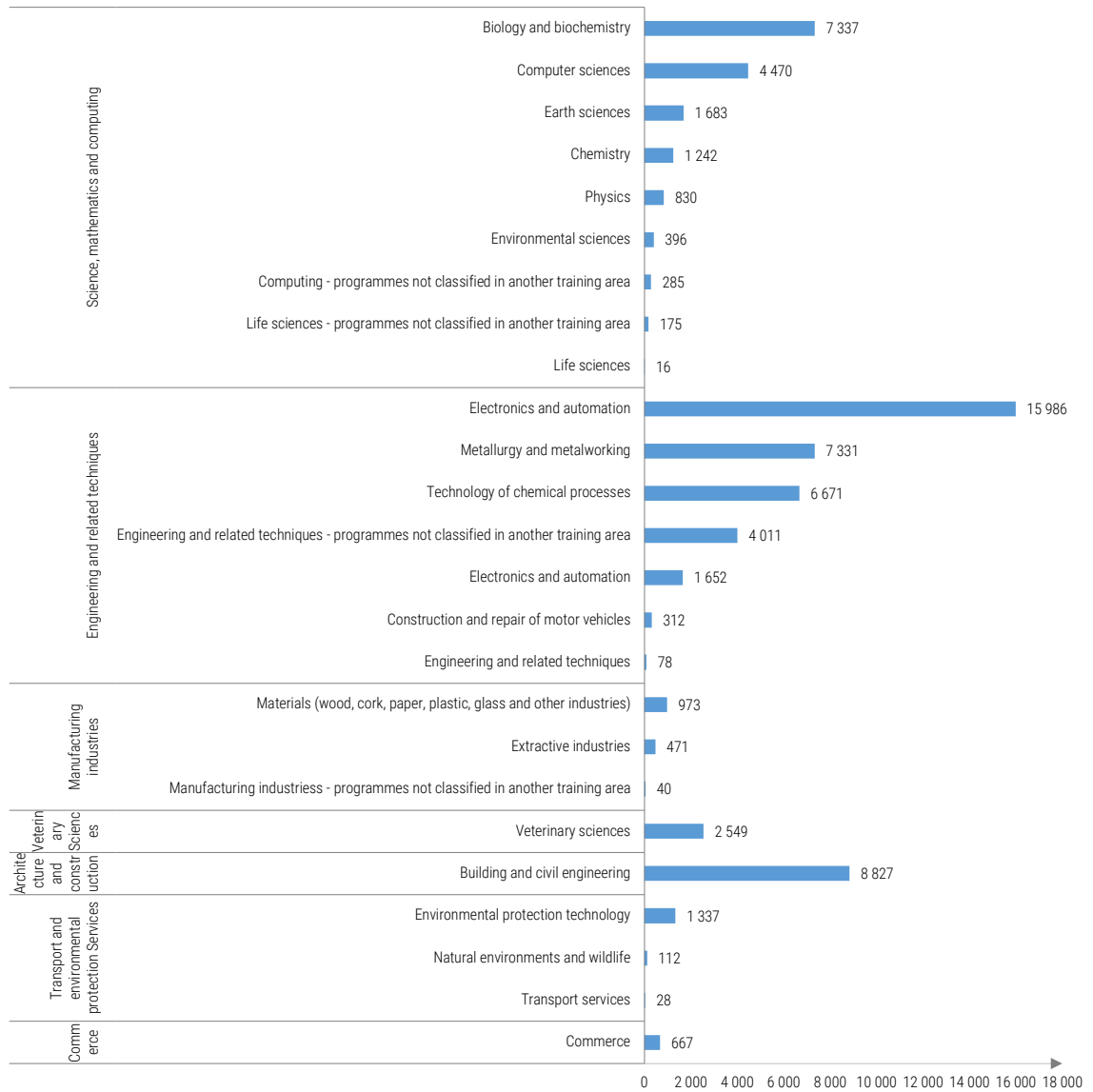
Figure 38 • Number of Graduates by Education and Training Areas in Norte Region, cumulative value
from 2008/2009 to 2017/2018
Source: DGEEC

It is also important to characterise the regional scientific production, namely the publications by scientific and technological areas considered most relevant to the achievement of the rationale of the priority domain "Sea Resources and Economy". This analysis is carried out based on the indicator "Number of publications indexed in the Web of Science by scientific area", a variable already used in the preparation of RIS3 NORTE 2020, using the cumulative values from 2008 to 2018.

Taking into account the defined methodology, the most relevant scientific and technological areas for this domain in terms of publications[69] are: (i) in the area of "Exact and natural sciences": 9 739 publications in "Biological sciences", 7 579 publications in "Chemistry", 5 843 publications in "Physics", 5 411 publications in "Computing and information sciences" and 3 947 publications in "Earth and Environmental Sciences"; (ii) in "Engineering Sciences and Technology": 5 008 publications in "Other Engineering Sciences and

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[69]　The exercise of identifying the most relevant scientific and technological domains for this domain took into account: (i) revised rationales in the new smart specialisation domains of S3 NORTE 2027, (ii) responses to surveys carried out to the Regional Smart Specialisation Platforms for the review of S3 NORTE 2027, (iii) international demand trends and corresponding R&D&I strategies and policies for the priority domains of S3 NORTE 2027 and (iv) the resources and assets of base contained in RIS3 NORTE 2020.

Technologies", 4 517 publications in "Materials Engineering" and 4 202 publications in "Electrical, Electronic and Computer Engineering"; (iii) in "Agricultural Sciences": 1 511 publications in "Agriculture, Forestry and Fisheries" and 595 in "Veterinary Sciences". This information is systematised in the following figure.
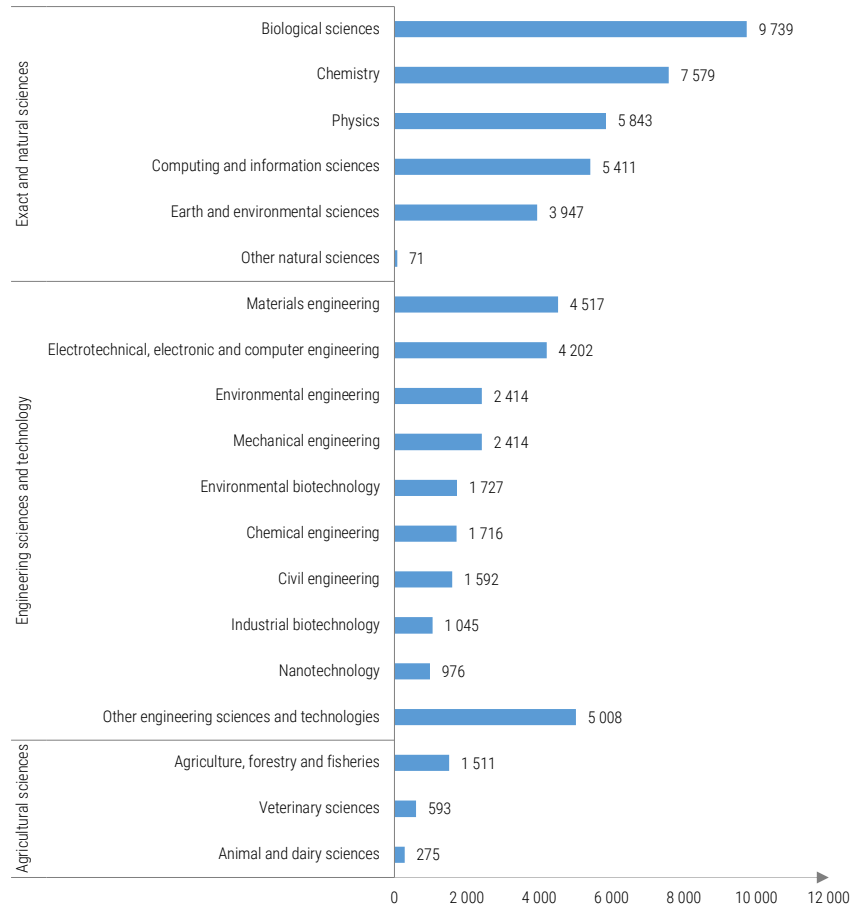
Figure 39 • Number of Publications by Scientific and Technological Areas in Norte Region, cumulative value from 2008 to 2018
Source: DGEEC

A fundamental element of the characterisation of scientific and technological resources is also related to the identification of the installed capacity in the region in terms of non-business R&I scientific and technological infrastructures that integrate the regional scientific and technological system. Based on the established methodology, 37 Research and Technological Infrastructures were identified in this priority domain that fall within its areas of intervention (see Annex 1). The following table shows the main areas of intervention of the R&D Institutions and Infrastructures and Technological Centres and Interfaces within this priority domain.

Table 19 • Main intervention areas of Research and Technological Infrastructures within the domain
"Sea Resources and Economy"

Type of Institution	Main areas of intervention
Research Infrastructures	Marine sciences, environmental sciences, energy, bioenergy, biomass, blue biotechnology, aquaculture, ocean resources, food and nutrition, aquatic biodiversity, ecology, conservation, aquatic ecosystems, geology and hydrogeology, chemistry, biological sciences, biochemistry, biology, bioengineering, materials engineering, biomaterials, mechanical engineering, robotics, automation, telecommunications, sensors, intelligent systems, electrical engineering, electronics and informatics, construction technologies, engineering structures, health sciences and pharmaceutical sciences.
Technological Infrastructures	Metalworking, marine structures and platforms, robotics, automation, intelligent systems, electrical engineering, electronics and IT, mechanical engineering, industrial engineering, renewable energies, geology, climate, life sciences, biotechnology, aquaculture, engineering structures, engineering, and construction.

Secondly, it is important to characterise non-technological resources, i.e. natural resources associated with the sea where the region stands out, such as energy resources. One of the main resources identified concerns wind and wave resources, allowing for the opportunity to develop the production of electricity at sea. In effect, the most intense renewable energy resource at sea in Portugal is located in the region. The bathymetric characteristics of the Portuguese coast mean that the most appropriate wind technology for implementation at sea is floating wind, still under development, or even floating photovoltaic plants[70], still under study. In terms of offshore wind, the infrastructures that are being created off the coast of Viana do Castelo stand out in Norte Region, and whose investment has already begun, with the aim of reaching, in a first phase, 200 MW of new capacity, of which 25 MW are already allocated to the Windfloat project[71].

The sea is also the place where in the medium/long term algae may be cultivated for biofuel production through a technology still under development. Taking into account the Industrial Strategy for Ocean Renewable Energies[72], it may be opportune to focus on this typology, not only on the development of technologies, but also on the associated value chains, with an economic impact on the region[73]. The blue bioeconomy includes the biotechnological exploitation of non-traditional living marine resources, all the commercial applications derived from their biomass and also the waste and by-product flows that can be generated from their processing. This group of marine organisms includes macroalgae, micro-organisms and invertebrates[74].

Norte Region also has important natural resources associated with the sea that can be used to develop nautical tourism, such as sailing, surfing, canoeing, among others, as well as cruise ship tourism. The combination of sun and sea makes it possible to provide beaches of recognised quality that are important for coastal tourism, as well as health and wellness tourism associated with the therapeutic properties of the sea. In this field of valorisation of endogenous resources associated with the sea, the role of territorial approaches is highlighted, materialised in local development strategies, promoted by local coastal action groups.

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[70]　Contribution Direção-Geral de Energia e Geologia

[71]　Estado Português (2020)

[72]　Estado Português (2017a)

[73]　Contribution Direção-Geral de Energia e Geologia

[74]　Estado Português (2021)

7.2 Business Bases

The domain "Sea Resources and Economy" thus encompasses a set of economic activities aimed at harnessing and exploiting the resources of the sea, primarily through its energy and economic potential. For the definition of the main economic activities that integrate this domain, the sectors that constitute the great areas of this domain and for which statistical data[75/76] is available are, namely: (i) Fishing, marine aquaculture, transformation and commercialisation of their products; (ii) Naval construction, maintenance and repair; (iii) Ports, transport and logistics; (iv) Recreation, sports and tourism; and (v) Non-living marine resources. The following figures show the turnover and personnel employed in the main sectors of activities included in the "Marine Economy and Resources" domain.

Figure 40 • Turnover in the main sectors included in the domain "Sea Resources and Economy",
Portugal and Norte Region, million euros, 2019
Source: INE, Sistema de contas integradas das empresas,

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[75]   Relevant bibliography consulted: Direção-Geral de Política do Mar (2019) e Fórum Oceano (2020)

[76]   Annex 2 contains the delimitation of the main sectors of activity in terms of the Statistic Classification of Economic Activities (CAE Rev. 3) included in the priority domain "Sea Resources and Economy".

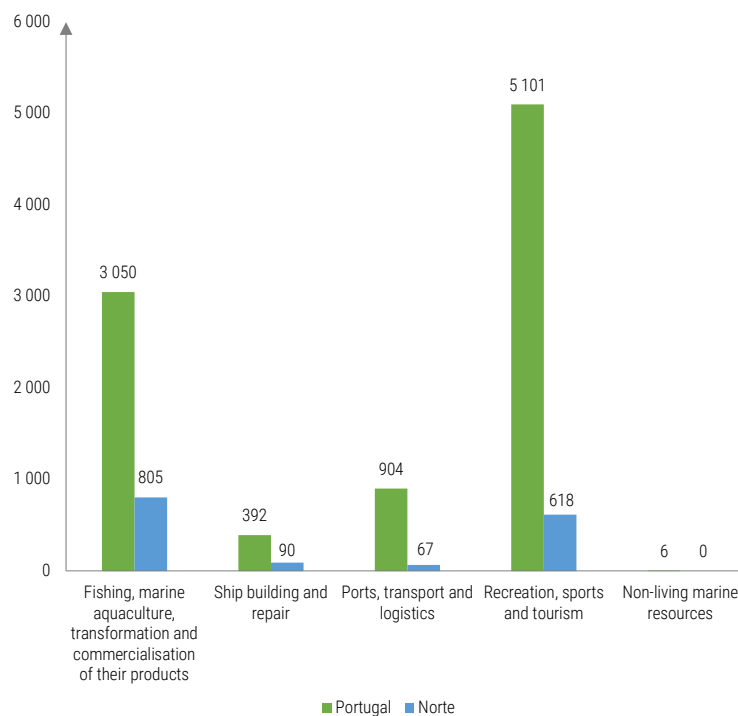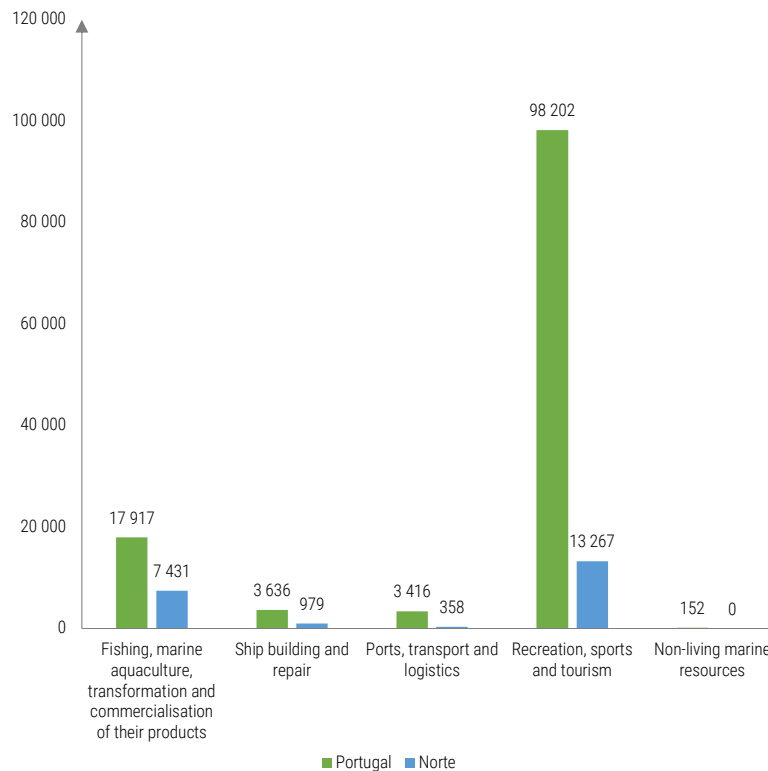Figure 41 • Personnel employed in the main sectors included in the domain "Sea Resources and Economy", Portugal and Norte Region, million euros, 2019

Source: INE, Sistema de contas integradas das empresas,

The economic activities related to the sea in Norte reach a turnover of nearly 1 584 million euros and 21 414 people employed, representing at national level 17% and 17.4%, respectively, in 2019. The "Recreation, sports and tourism" activities stand out, which at a regional level record a turnover of 618 million euros and more than 13 267 people employed, representing 39% and 62% respectively in this field. However, its importance in the national context does not exceed 12% of the turnover and 13.5% of the employed personnel. These figures correspond exclusively to the activity related to coastal accommodation (municipalities with a coastal border), since for the activities related to marinas no statistics are available at the scale of Norte Region.

The fishing and marine aquaculture sectors, processing and marketing of their products, represent a turnover of 809 million euros and employ 7 431 people, representing, at the regional level, 51% and 34.7% respectively, in this field. The importance of the region in the national context in these activities is 27% in terms of turnover and 41.5% in terms of employed personnel. In the set of these activities, marketing is the most important, representing 61% of the turnover and 33% of the people employed, followed by processing with 27% of the turnover and 28% of the personnel employed, fishing with 11.5% of the total turnover and 38% of the employed personnel, with aquaculture representing a very residual expression of 0.5% of the turnover and 1% of the people employed.

The activities related to shipbuilding, maintenance and repair and ports, transport, and logistics, appear with a smaller expression compared to the above sectors, although their development is essential to strengthen the competitiveness of activities related to this area. The shipbuilding, maintenance and repair sector represents 90 million euros of turnover and almost 1 000 people employed and the ports, transport and logistics sector reaches 67 million euros and about 350 people employed. The existence in Norte Region of port infrastructures that are essential to the internationalisation of the regional economy, such as the commercial port of Leixões, the port of Viana do Castelo and the Douro waterway[77], stands out. In Portugal, activities related to non-living marine resources concern the exploitation of sea salt, and there is no exploitation of this resource in Norte Region.

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[77]   Comissão de Coordenação e Desenvolvimento Regional do Norte (2020)

Based on the established methodology, it is also important to consider in the characterisation of the business base of this priority domain the competitiveness clusters and sectoral business associations operating in Norte Region. The following table presents the main areas of intervention of the competitiveness clusters and sectoral business associations within this priority domain.

Table 20 • Main intervention areas of the Competitiveness Clusters and Business Associations
within the domain "Sea Resources and Economy"

Type of Institution	Main areas of intervention
Competitiveness Clusters and Business Associations	Fisheries, aquaculture and fish industry, naval industry, ports, logistics and maritime transport, recreational boating, maritime services, energy, engineering and construction, production technologies, digitalisation, metallurgy and metalworking.

7.3 Advanced Users and Trends

In the priority domain "Sea Resources and Economy"[78] a prospective analysis was carried out to identify the main medium and long term global trends that shape intermediate and final demand, allowing for the assessment of the regional potential in the construction of competitive advantages and the improvement of the level of insertion in international value chains. The schematic and conceptual dimension of this identification process must consider the interaction of the different trends among themselves, enhancing the effect of each one and of the whole. These trends are structured into the following five topics:

a) **Blue energy** - significant growth in offshore wind energy production and the respective installed capacities and market shares (global and renewable), although more moderate as regards other sources such as tidal and wave energy, due to the development and maturity of current technological solutions, tidal power plants and wave turbines, respectively;

b) **Aquaculture** - growth in offshore aquaculture fish production at a rate higher than that of the world population and of animal protein consumption, being the fastest growing food production sector of animal origin and thus contributing not only to improving human nutrition but also to the sustainability of fish stocks in the oceans;

c) **Maritime, Coastal and Cruise Tourism** - growth in activities that help combat the traditional seasonality of demand, such as cruise shipping, in association with shipbuilding, water sports (sailing, surfing, etc.) and green tourism (observation of marine species and diving), and reduction of the carbon footprint and, in general, the environmental impact of (traditional) coastal tourism;

d) **Marine Mineral Resources** - potential exploration and production of minerals from the ocean beds, including cobalt, copper and zinc, and, depending on technological development and market evolution, of minerals dissolved in seawater such as boron, lithium and potassium, in a foreseeable global context of increased demand and prices of non-energy raw materials and possible extension of the continental shelf;

e) **Blue Biotechnolog**y - potential development and production of new drugs from research and development associated with the knowledge of marine organisms, such as some recent successes (Zovirax, Acyclovir and Yondelis), as well as products for the cosmetics, industrial biomaterials and food sectors, resulting from the production of metabolites and primary compounds, such as polymers, sugars, lipids and proteins.

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[78]   Comissão de Coordenação e Desenvolvimento Regional do Norte (2014), Comissão Europeia (2012, 2015, 2018, 2019, 2020), Direção-Geral de Política do Mar (2014), Estado português (2017b, 2020, 2019), European Commission (2019), Fundação para a Ciência e Tecnologia (2019a, 2019b), Monteiro, Meira, Santos, Leite, Guimarães & Gomes (2019), Organisation for Economic Cooperation and Development (2016).

The R&D&I strategies and public policies associated with this priority domain cannot be found dissociated from the global trends structured into the five topics mentioned in the previous point, and are not and cannot be mutually exclusive. Resulting from the analysis of different documents from national and international organisations, the R&D&I strategies and public policies for this domain are the following:

a) **Blue Energy** - development of technologies to respond to challenges associated with the use of wind turbines in open sea (offshore), such as transport and anchoring structures, monitoring systems, mechanical wear, new materials, grid connections or maintenance operations, and selection and commercial optimisation of different technologies available in the experimental phase for the use of wave and tidal energy;

b) **Aquaculture** - differentiation of supply and investment in the production of juveniles and species suited to the Portuguese coast; development of structures for open sea aquaculture in the particular conditions of the continental shelf; automation of aquaculture units, using remote and real-time monitoring through life support analysis equipment and physical-chemical (water) and biological (organisms) parameters;

c) **Maritime, Coastal and Cruise Tourism** - development of (i) new tourism concepts and products associated with recreational boating and top-level sports at sea, (ii) maritime transport solutions to support tourism in riverside areas, and (iii) new technologies to monitor pollution and its pathways and biological and ecosystem effects, and for recycling and new material uses for such waste;

d) **Marine Mineral Resources** - mapping of marine mineral resources and possible associated critical and reserve areas, such as sensitive ecosystems; development of technology for exploration and exploitation of marine minerals; assessment of the sea's potential for reducing risks from climate change and possible practical solutions for carbon sequestration;

e) **Blue Biotechnology** - development of technologies for the commercialisation of marine bioactive compounds for the pharmaceutical, nutraceutical and cosmetic industries, as well as for the production of biofuels; promotion of pre-commercial initiatives of bioactive compounds through processing technologies and metabolite separation; knowledge of the diversity of marine organisms and their biochemical processes and ecosystems; sustainable production of bioactive compounds from their genetic resources.

The following table shows the association between the trends identified in the domain of "Sea Resources and Economy" and the "societal challenges" that constitute major trends of structural change in the economy and society and that are transversal to different priority domains. This analysis allows the conclusion that this priority domain is aligned with structural transformation trends such as energy efficiency, decarbonisation, digitalisation, and industrialisation. This conclusion thus reveals that, despite the sectoral and thematic specificities of this priority domain, there are common elements in the trends and policies to other priority domains of smart specialisation that promote an interpenetration of areas, which will increasingly exist in various enterprises, institutions, and economic activities.

Table 21 • Association[1] between trends identified in the domain "Sea Resources and Economy" and "societal challenges"

Trends	Aging		Energy Efficiency		Decarbonisation		Circular Economy		Digitalisation		Industry 4.0	
	D	I	D	I	D	I	D	I	D	I	D	I
a) Blue Energy			●		●							
b) Aquaculture						●		●				
c) Maritime, Coastal and Cruise Tourism					●							
d) Marine Mineral Resources									●			
e) Blue Biotechnology									●			●

[1] Direct (D) or indirect (I) association

7.4 Rationale

In the case of the emerging priority domain "Sea Resources and Economy", the aim is to create, expand and foster economic activities associated with the sea, seeking to enhance its specific resources. The economy of the sea includes multiple activities, from the most traditional, such as fishing and the processing and marketing of fish, the naval industry, ports, maritime transport, and logistics, to those, more recent, that are associated with the European strategy for blue growth, such as aquaculture, coastal tourism, marine biotechnology, ocean energy and the exploitation of marine mineral resources. It is this diversity that constitutes the economy of the sea, although it is the latter activities, related to the exploration of new activities associated with the economic valorisation of the resources of the sea, that are the focus of this priority domain of S3 NORTE 2027. The following figure shows the referential analysis of the priority domain "Sea Resources and Economy".
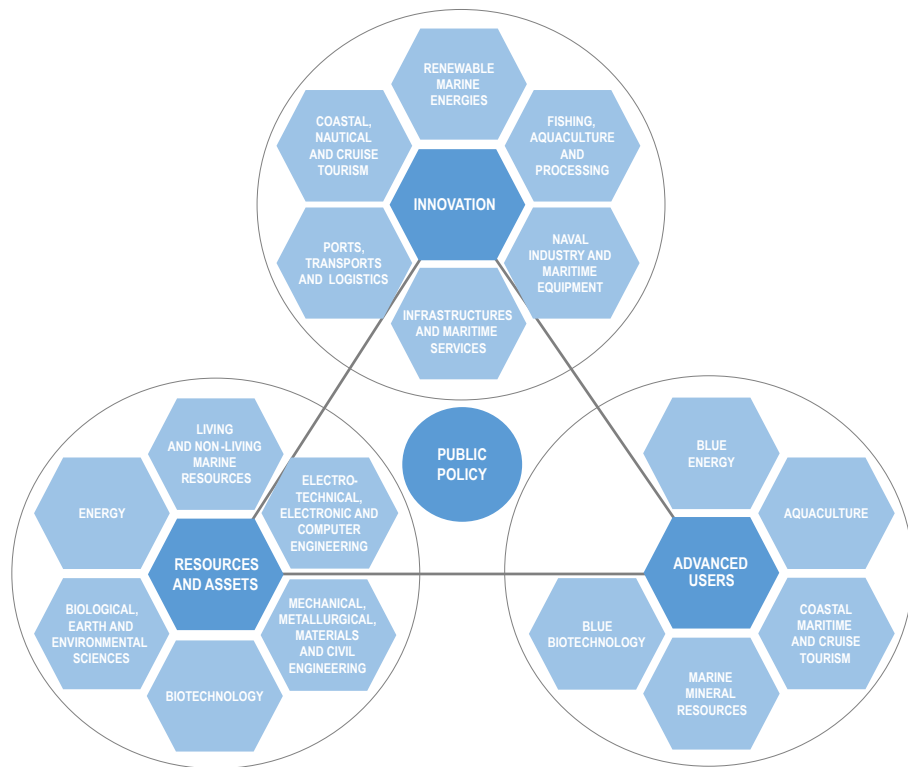
Figure 42 • Analytical framework of the domain "Sea Resources and Economy"

In terms of policy rationale, the "Sea Resources and Economy" domain thus intends to promote the establishment of articulation relations between applied engineering (civil, mechanical, naval, robotics, biotechnology, energy, computer science, materials), sea resources (living marine resources, non-living marine resources and services of marine and coastal ecosystems) and economic activities that value them (renewable marine energy, coastal, nautical and cruise tourism, naval industry, biotechnology, aquaculture, maritime equipment, infrastructures, etc.), favouring the creation of a set of synergies that enhance the creation of value and employment generation of activities related to the economy of the sea, preserving and promoting the sustainable use of marine resources.

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Annex 1

List of non-corporate entities of the scientific and technological system identified in the priority domain "Sea Resources and Economy"[79]

Typology	Acronym	Name
R&D Units	CIIMAR	Interdisciplinary Centre for Marine and Environmental Research (CIIMAR)
R&D Units	InBIO	Research Network on Biodiversity and Evolutionary Biology (InBIO)
R&D Units	ISISE	Institute for Sustainability and Innovation in Engineering Structures (ISISE)
R&D Units	REQUIMTE	Associate Laboratory for Green Chemistry - Clean Technologies and Processes (REQUIMTE)
R&D Units	UCIBIO	Unit for Applied Biomolecular Sciences (UCIBIO)
R&D Units	CBMA	Centre for Molecular and Environmental Biology (CBMA)
R&D Units	CONSTRUCT	R&D Institute for Structures and Constructions (CONSTRUCT)
R&D Units	ICVS/3Bs- LA	Associated Laboratory, Institute of Life and Health Sciences / Research Group on Biomaterials, Biodegradables and Biomimetics (ICVS/3Bs - LA)
R&D Units	INESC TEC	INESC TEC - INESC Technology and Science (INESC TEC)
R&D Units	SYSTEC	Systems and Technologies Centre (SYSTEC)
Associated Labs.	InBIO	Biodiversity and Evolutionary Biology Research Network (InBIO)
Associated Labs.	ICVS/3B´s	ICVS/3B's - Associated Laboratory, Institute of Life and Health Sciences / Research Group on Biomaterials, Biodegradables and Biomimetics
Associated Labs.	LAQV/ REQUIMTE	Associated Laboratory for Green Chemistry - Clean Technologies and Processes
Associated Labs.	INESC TEC	INESC TEC - Institute for Systems Engineering and Computers, Technology and Science (INESC TEC)
Associated Labs.	AL4TECH	Associated Laboratory in Bio/Chemical/Micro-Nano/Electromechanical Technology
Associated Labs.	ARI-NET	Network of Infrastructures in Aquatic Research
Associated Labs.	CIMAR LA	Marine and Environmental Research Centre
Associated Labs.	ARISE	Advanced Manufacturing and Intelligent Systems
State Labs.	IPMA	Portuguese Sea and Atmosphere Institute
State Labs.	LNEG	National Laboratory for Energy and Geology
R&D Infraest.RNIE	AIR Centre	AIR Centre (Atlantic International Research Centre)
R&D Infraest.RNIE	BBRI	Biomass and Bioenergy Research Infrastructure
R&D Infraest.RNIE	C4G	Geosciences Collaboratory
R&D Infraest.RNIE	EMBRC.PT	European Marine Biological Resources Centre Portugal

[79] The identification of the entities was based on the analysis of a synthetic characterisation of each institution obtained, namely through consultation of various ANI publications, FCT evaluation reports and the entities' websites. It should be noted that the mere identification of a given infrastructure in each domain is not enough to guarantee its framework in S3 NORTE 2027 for the purposes of support for financing from EU funds. Similarly, the non-inclusion of a given infrastructure may not prevent access to such support and funding, depending always on the project that will be presented.

Typology	Acronym	Name
R&D Infraest.RNIE	EMSO- PORTU-GAL	European Multidisciplinary Seafloor and Water
R&D Infraest.RNIE	TEC4SEA	Column Observatory - Portugal
Technology Centres	CATIM	Modular platform for research, testing and validation of technologies supporting a sustainable marine economy
Technology Transfer and Valorisation Centres	CEIIA	Technological Support Centre for the Metal-Mechanical Industry
Technology Transfer and Valorisation Centres	INEGI	Engineering and Development Centre (Association)
Technology Transfer and Valorisation Centres	INESC TEC	Institute for Systems and Computer Engineering, Technology and Science
Technology Transfer and Valorisation Centres	LNEG	National Energy and Geology Laboratory
Other R&D Infrastructures	CVTMar	CVTMar - Centre for the Valorisation of Technology based on Marine Resources - University of Minho
Other R&D Infrastructures	ICIBio	Institute of Science and Innovation for Bio-Sustainability - University of Minho
Other R&D Infrastructures	ISISE	Institute for Sustainability and Innovation in Engineering Structures (ISISE)
Colabs	Atlantic	Collaborative Laboratory for the Atlantic
Colabs	B2E	Collaborative Laboratory for the Blue Bioeconomy
Digital Innovation Hubs	-	Portugal Blue Digital Hub
Competitiveness Clusters	-	AEC Cluster - Architecture, Engineering and Construction
Competitiveness Clusters	-	Portuguese Sea Cluster
Business Associations	AIMMAP	AIMMAP - Association of Metallurgical and Metalworking Industries and alike of Portugal

Annex 2

"Sea Resources and Economy" - Delimitation of the main sectors of activity based on the Portuguese Classification of Economic Activities (CAE Rev. 3)

For the definition of the main economic activities that integrate this domain, the sectors that constitute the great areas of this domain and that are considered in its rationale are, namely:

— **Fishing, marine aquaculture, processing and marketing of their products**
— **Shipbuilding, maintenance and repair**
— **Ports, transport and logistics**
— **Recreation, sport and tourism**
— **Non-living marine resources**

Delimitation of the priority domain in terms of the Portuguese Classification of Economic Activities (CAE Rev. 3):

(i) **Fishing, marine aquaculture, processing and marketing of their products**
   - 0311 - Sea fishing, gathering of seaweed and other marine products
   - 032 - Aquaculture (Note: the 3-digit CAE was used since the 4-digit CAE has statistical secrecy, namely CAE 0321 - Saltwater aquaculture and 0322 - Freshwater aquaculture)
   - 1020 - Preparation and preservation of fish, crustaceans and molluscs
   - 10913 - Manufacture of feed for aquaculture
   - 46381 - Wholesale of fish, crustaceans and molluscs
   - 4723 - Retail sale of fish, crustaceans and molluscs in specialised shops

(ii) **Shipbuilding, maintenance and repair**
   - 3011 - Construction of ships and floating structures, except pleasure and sporting boats
   - 3012 - Building of pleasure and sporting boats
   - 3315 - Repair and maintenance of ships and boats

(iii) **Ports, transport and logistics**
   - 501 - Sea and coastal passenger water transport
   - 502 - Sea and coastal freight water transport
   - 5222 - Support activities for water transport
   - 7734 - Hire of water transport equipment

(vi) **Recreation, sport and tourism**
   - 93292 - Harbour activities (marinas)
   - 55 - Accommodation (municipalities with a coastal border)

(v) **Non-living marine resources**
   - 08931 - Sea salt extraction

(Sources: "Direção-Geral de Política do Mar (2019). Observatório Economia Azul 2019"; "Fórum Oceano (2020). Desafios do Mar 2030")

8.

Priority domain characterisation

Technologies, State, Economy and Society

8.1. Resources and Assets

From the domain "Technologies, State, Economy and Society", the aim is to promote the accumulated skills in science, technology, engineering and mathematics aiming at the digital transformation of the economy and society as a process based on a set of digital technologies. Thus, it is intended to ensure the integration of digital technologies in businesses, the use of internet services, the promotion of digital skills, the provision of connectivity infrastructures and mobile services and the development of digital public services and open and networked administration.

As part of the exercise to assess the existence of critical mass in this priority domain, it is important to analyse the resources and technological assets to be integrated by the main business bases included in this area, which aims at the digital transformation of the economy and society. In a first point, the stock of human capital with advanced skills by main areas of education and training is characterised through the indicator "Number of graduates in higher education by areas of education and training", cumulative value from 2008/2009 to 2017/2018, already used in the preparation of RIS3 NORTE 2020.

Based on the established methodology, the education and training areas considered to have the greatest potential for the achievement of the rationale defined for this domain are the following[80]:

- **"Science, mathematics and computing":** such as "Mathematics and statistics", "Computing", "Physical sciences" and "Life sciences";

- **"Engineering, manufacturing and construction":** such as "Engineering and related techniques", "Manufacturing industries" and "Architecture and construction";

- **"Social sciences, business and law":** such as "Social and behavioural sciences", "Information and journalism", "Business sciences" and "Law";

- **"Arts and humanities":** as "Humanities" and "Arts";

- **"Education":** such as "Teacher/trainer training" and "Education Sciences".

Between 2008 and 2018, 180 072 students graduated in these training areas in Norte Region, distributed by the different types of courses, namely, professional higher technical course, bachelor's degree, master's degree, and doctorate. Of this total, during this period, 5 016 obtained a doctoral degree and 57 233 obtained a master's degree. In terms of education and training areas, the number of graduates in the following areas stands out: (i) "Sciences, mathematics and computing": with 4 755 in "Computing", 1 055 in "Mathematics and statistics", 3 755 in "Physical sciences" and 7 924 in "Life sciences"; (ii) "Engineering, manufacturing industries and construction": with 36 041 in "Engineering and related techniques", 3 188 in "Manufacturing" and 15 995 in "Architecture and Construction"; (iii) "Social Sciences, Business and Law": with 21 504 in "Social and Behavioural Sciences", 30 426 in "Business Sciences", 4 532 in "Information and Journalism" and 10 635 in "Law"; (iv) "Arts and Humanities": with 13 955 in "Arts" and 7 925 in "Humanities"; and (v) "Education" with 18 382 in "Teacher/Trainer Training" and "Education Sciences". This information is systematised in the following graph.

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[80]   The exercise of identifying the most relevant education and training areas for this domain took into consideration: (i) the revised rationales in the new domains of smart specialisation of S3 NORTE 2027, (ii) the responses to the surveys carried out to the Regional Platforms of Smart Specialisation for the review of S3 NORTE 2027, (iii) the international demand trends and corresponding R&D&I strategies and policies for the priority domains of S3 NORTE 2027 and (iv) the basic resources and assets that are included in RIS3 NORTE 2020.

Science, mathematics and computing

Biology and biochemistry	7 337
Computer sciences	4 470
Earth sciences	1 683
Chemistry	1 242
Mathematics	848
Physics	830
Environmental sciences	396
Other	683

Engineering, manufacturing and construction

Electronics and automation	15 986
Building and civil engineering	8 827
Metallurgy and metalworking	7 331
Architecture and urban planning	7 168
Chemical process technology	6 671
Engineering and related techniques - programmes not classified in another…	4 011
Electricity and energy	1 652
Food industries	1 458
Materials (wood, cork, paper, plastic, glass and other industries)	973
Other	1 147

Social sciences, commerce and law

Management and administration	15 401
Law	10 635
Psychology	10 482
Accountancy and taxation	6 534
Economics	6 222
Marketing and advertising	4 223
Information and journalism	3 843
Sociology and other studies	3 550
Finance, banking and insurance	1 676
Political sciences and citizenship	1 250
Other	3 281

Arts and humanities

Audiovisual and media production	5 102
Design	4 310
Performing arts	2 245
Fine arts	2 165
History and archeology	2 161
Foreign languages and literature	2 158
Humanities - programmes not classified in another training area	1 687
Other	2 052

Education

Education sciences	5 448
Teachers training in elementary education (1st and 2nd Cycles)	4 851
Teachers training in special education	2 608
Teachers ant trainers training in technological areas	2 498
Training of kindergarten teachers	1 527
Other	1 450

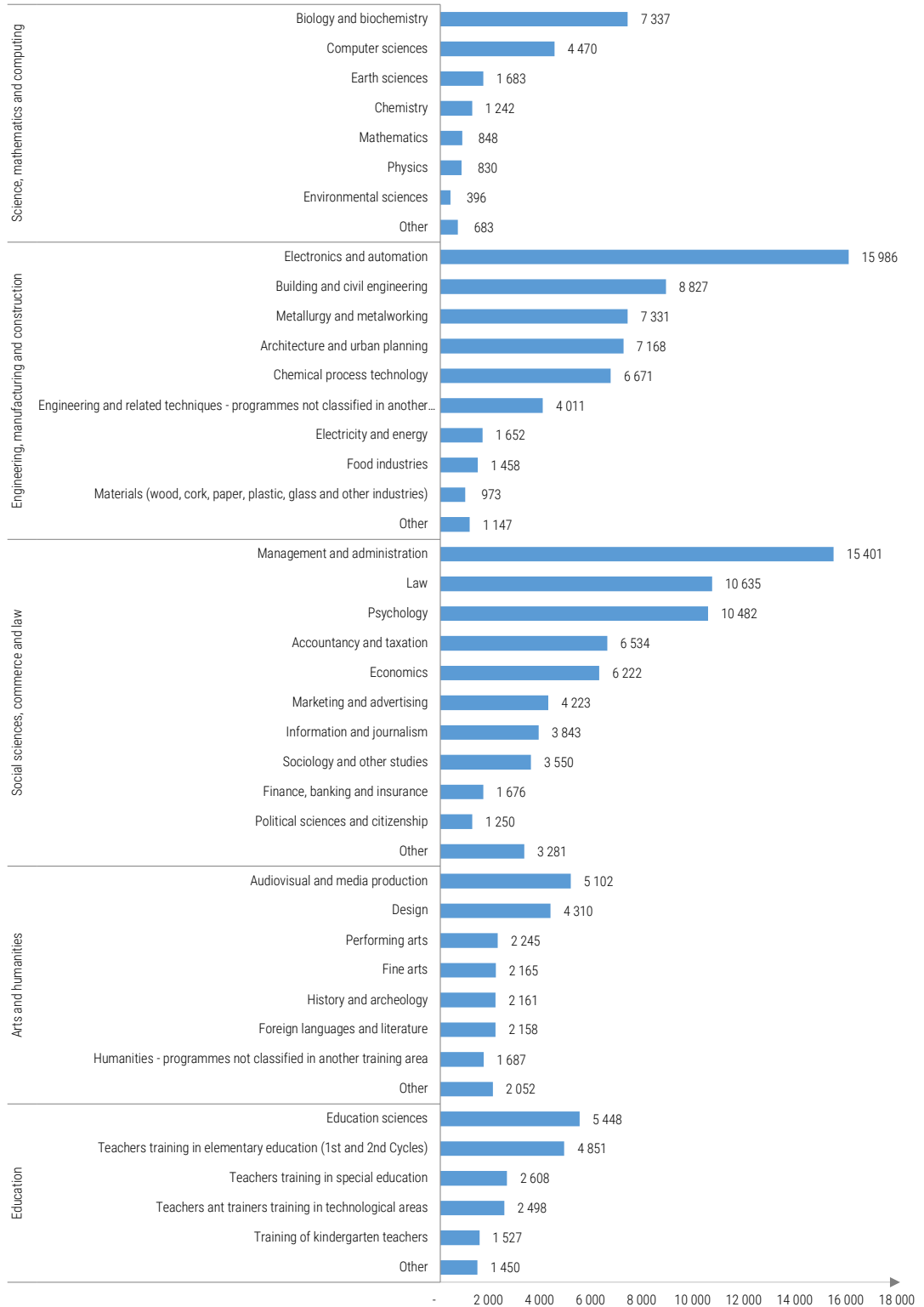- 2 000 4 000 6 000 8 000 10 000 12 000 14 000 16 000 18 000

Figure 43 • Number of Graduates by Education and Training Areas in Norte Region, cumulative value
from 2008/2009 to 2017/2018
Source: DGEEC

It is also important to characterise the regional scientific production, namely the publications by scientific and technological areas considered most relevant for the achievement of the rationale of the priority domain "Technologies, State, Economy and Society". This analysis is carried out based on the indicator "Number of publications indexed in the Web of Science by scientific area", cumulative value from 2008 to 2018, already used in the preparation of RIS3 NORTE 2020.

Taking into account the defined methodology, the most relevant scientific and technological areas for this domain in terms of publications[81] are: (i) "Engineering Sciences and Technology": with 5 008 publications in "Other Engineering Sciences and Technologies", 4 517 publications in "Materials Engineering", 4 202 publications in "Electrical, Electronic and Computer Engineering", 2 414 publications in "Mechanical Engineering" and 2 414 publications in "Environmental Engineering"; (ii) "Exact and Natural Sciences": 5 411 publications in "Computer and Information Sciences", 3 947 publications in "Earth and Environmental Sciences" and 1 901 in "Mathematics"; (iii) "Social Sciences": 1 819 publications in "Economics and Management", 1 723 in "Psychology" and 1 200 in "Education Sciences". This information is systematised in the following figure.

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[81] The exercise of identifying the most relevant scientific and technological domains for this domain took into account: (i) revised rationales in the new smart specialisation domains of S3 NORTE 2027, (ii) responses to surveys carried out to the Regional Smart Specialisation Platforms for the review of S3 NORTE 2027, (iii) international demand trends and corresponding R&D&I strategies and policies for the priority domains of S3 NORTE 2027 and (iv) the resources and assets of base contained in RIS3 NORTE 2020.
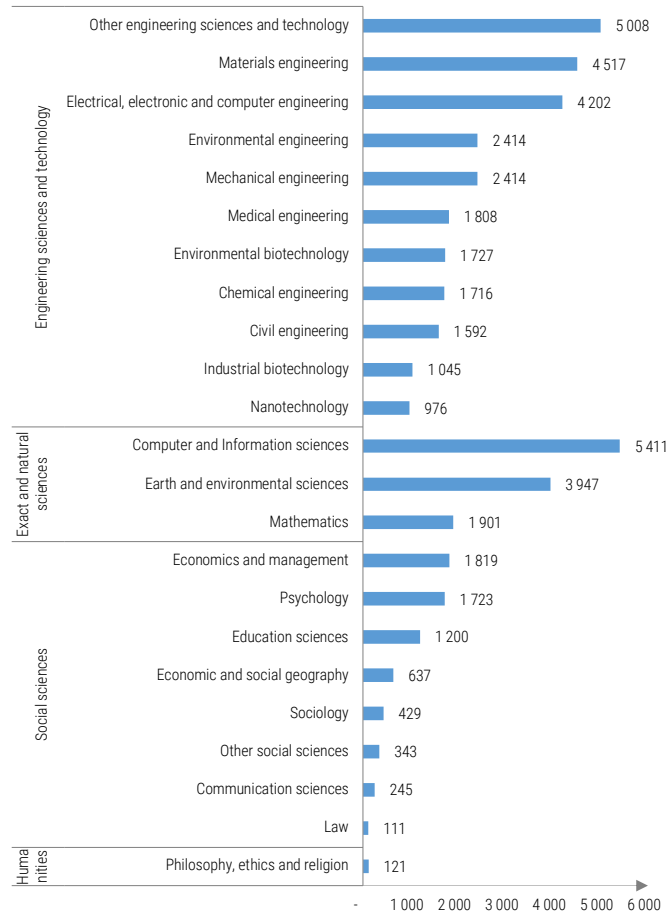
Figure 44 • Number of Publications by Scientific and Technological Areas in Norte Region, cumulative value from 2008 to 2018

Source: DGEEC

A fundamental element of the characterisation of scientific and technological resources is also related to the identification of the installed capacity in the region in terms of non-business R&I scientific and technological infrastructures that are part of the regional scientific and technological system. Based on the established methodology, 56 R&D Institutions and Infrastructures and Technological Centres and Interfaces were identified in this priority domain that fall within its areas of intervention (see Annex 1). The following table presents the main areas of intervention of this typology of entities within this priority domain.

Table 22 • Main intervention areas of R&D Institutions and Infrastructures and Technological Centres and Interfaces within the "Technologies, State, Economy and Society" domain

Type of Institution	Main areas of intervention
R&D Institutions and Infrastructures	Computer science, information science, electrical engineering, electronics and computing, engineering and smart computing, artificial intelligence, computer science, information technologies, communications and electronics, systems engineering, intelligent systems, advanced computing, communication sciences, mathematics, statistics, education sciences, psychology, humanities, sociology, political science, ethics, justice, law, philosophy, economics, finance, management, accounting, taxation, society and territory.
Technological Centres and Interfaces	Computer and information sciences, electrical engineering, electronics and computer science, artificial intelligence and decision support, digitalisation, information technologies, communications and electronics, computer graphics, systems engineering, advanced computing, digital economy, information systems, smart urban ecosystems, cyber-security, and cyber-physical systems.

8.2 Business Bases

The domain "Technologies, State, Economy and Society" thus encompasses a heterogeneous set of activities aiming at the digital transformation of the economy and society as a process based on a set of digital technologies (internet of things, next generation wireless networks [5G], cloud computing, data analysis, artificial intelligence, cybersecurity or high-performance computing).

For the definition of the main economic activities that integrate this domain, the sectors that constitute its great areas of activity are considered, namely, those that integrate the concept of companies with information and communication technologies (ICT) activities[82/83]. In this analysis, these enterprises are divided into 4 groups: (i) Manufacture of ICT equipment, which includes "Manufacture of electronic components and boards", "Manufacture of computers and peripheral equipment", "Manufacture of communication equipment" and "Manufacture of radio and television receivers and similar consumer goods"; (ii) ICT consulting and programming, which includes "Computer programming and consultancy, and related activities", "Software publishing" and "Computer and communication equipment activities"; (iii) ICT equipment trading and repair, which includes "Wholesale of information and communication technology equipment", "Retail sale of information and communication technology equipment in specialised shops" and "Repair of computers and communication equipment"; and (iv) Telecommunications.

The following figures show the turnover and staff employed of the "Information and communication technology businesses" included in the domain "Technology, State, Economy and Society".
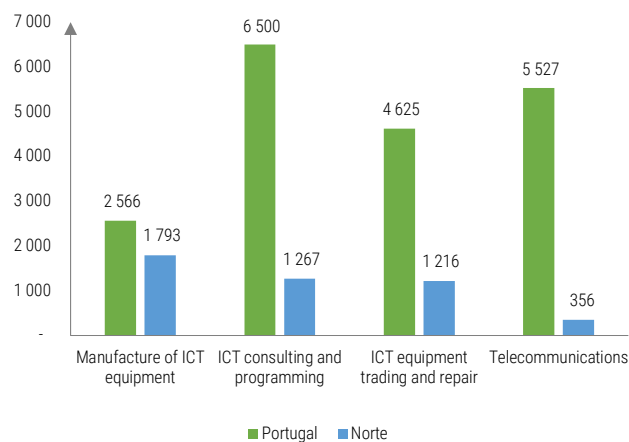

Figure 45 • Turnover in the main sectors included in the domain "Technologies, State, Economy and Society", Portugal and Norte Region, million euros, 2019

Source: INE, Sistema de contas integradas das empresas

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82   Relevant bibliography consulted: Instituto Nacional de Estatística (2018) e Instituto Nacional de Estatística (2007)

83   Annex 2 contains the delimitation of the main sectors of activity in terms of the Portuguese Classification of Economic Activities (CAE Rev. 3) included in the priority domain "Technologies, State, Economy and Society".
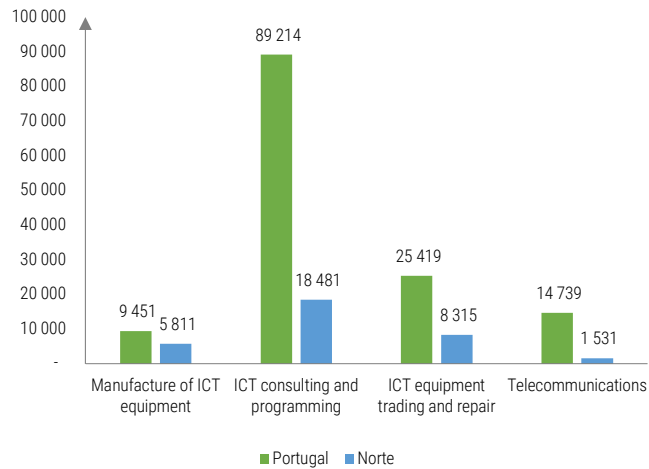
Figure 46 • Personnel employed in the main sectors included in the domain "Technologies, State, Economy and Society", Portugal and Norte Region, Number, 2019

Source: INE, Sistema de contas integradas das empresas

The "companies with information and communication technology (ICT) activities" represented a total of 5 023 million euros of turnover and 34 138 employees in Norte Region, representing 26% and 25% of the national total, respectively. The ICT equipment manufacturing activities stand out in terms of turnover which, in Norte, represent 39% of the total turnover and 17% of the personnel employed in this area, with 1 793 million euros and 5 811 people employed as a whole. ICT consulting and programming activities also stand out in the region, with 18 481 employees and 1 267 million euros of turnover, representing 54% and 27%, respectively, of the total in this domain. The ICT equipment trading and repair activities come in third place with 1 216 million euros of turnover but have a greater weight in terms of personnel employed with 8 315 employees.

In terms of international trade, the value of exports of the sectors included in the domain of "Technologies, State, Economy and Society" was more than 1 200 million euros in 2019, representing 5% of total exports from Norte. Within this domain, the exports of the sector of consulting and computer programming and related activities stand out, with 34% of the total, while the sectors of manufacturing of radio and television receivers and similar consumer goods, with 18%, and data processing activities, hosting of information and related activities and web portals, with 15%, are also noteworthy.

Based on the established methodology, it is also important to consider, in the characterisation of the business base, the competitiveness clusters and sectoral business associations operating in Norte. The following table presents the main areas of intervention of the competitiveness clusters and sectoral associations within this priority domain.

Table 23 • Main intervention areas of the Competitiveness Clusters and Business Associations within the domain "Technology, State, Economy and Society"

Type of Institution	Main areas of intervention
Competitiveness Clusters and Business Associations	Information, communication and electronic technologies, digital economy, smart urban solutions, e-government.

In terms of digital transition analysis, it is important to highlight the results of the 2020 Digital Economy and Society Index[84], in which Portugal ranks 19th among the 28 EU Member States. The country registers a poor performance according to European standards in terms of human capital and use of Internet services. In terms of connectivity, Portugal has fallen one place compared to last year's ranking, but has an overall score above average. The indicator which registered the biggest drop is digital technology in enterprises, where Portugal moved from 11th to 16th place, and is now below the EU average. In digital public services, Portugal continues to perform well, being one of the EU countries with the best results in this domain, despite having fallen one place compared to the previous year's classification. The following chart shows Portugal's results in the 2020 Digital Economy and Society Index.
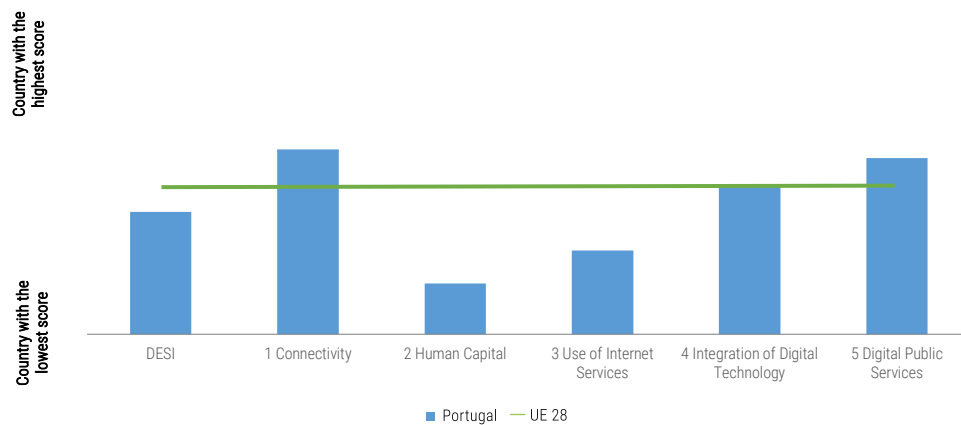

Figure 47 • 2020 Digital Economy and Society Index
Source: European Commission

It is therefore important to also analyse the information society indicators available on a regional scale. As regards the information society indicators in households in Norte Region, it can be seen that households with at least one person aged between 16 and 74 with access to a computer reach 68.3%, those with an Internet connection 76.7% and those with a broadband Internet connection 73.7%. In these indicators, Norte Region is below the national values which are, respectively, 71.5%, 79.4% and 76.9%. This situation is reproduced with regard to "Individuals aged between 16 and 74 using computers", which are 60.4% in the region and 66.8% in Portugal, while "Individuals aged between 16 and 74 using the Internet" are 69.2% in Norte and 74.7% in Portugal.

In terms of information society indicators in municipal councils, it can be seen that Norte Region has higher indicators than Portugal regarding the use of e-commerce, public consultation processes made available on the website and the completion and submission of online forms, as shown in the following table.

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[84]   Comissão Europeia (2020c)

Table 24 • Information society indicators in municipalitites, 2018

Indicator	Portugal	Norte
Internet connection	100	100
Internet connection via broadband	100	100
Internet presence	100	100
Use of e-commerce	58.4	59.3
Public consultation processes made available on website	93.2	94.2
Completion and submission of online forms	63.6	70.9

Source: INE, 2019 - Anuário Estatístico da Região Norte 2018

The digital transition constitutes one of the essential instruments of the country's development strategy, with widespread and affordable broadband internet access being one of the means of promoting a more relational society, based on knowledge and information. In 2018, Norte Region recorded a number of broadband internet accesses of about 1.2 million, equivalent to 32% of the national total. Compared to 2011, when the number of accesses was around 660 000, there is an increase of 79%.

When the rate for broadband Internet service at a fixed location per 100 inhabitants is analysed, it can be seen that Norte has an access rate of 33%, lower than the national average (37%). On the other hand, the analysis of the following figure, where this rate is represented per municipality, shows the existence of a remarkable territorial heterogeneity, in particular a coastal-interior dichotomy.

Figura 48 • Broadband internet access at a fixed location (number) and per 100 inhabitants (%) in 2018
Source: Autoridade Nacional de Comunicações (ANACOM), Inquérito às Telecomunicações

The patterns previously identified may also be explained by factors such as socioeconomic inequalities, the age level of the population, among others. According to the 2020 Digital Economy and Society Index report, Portugal's greatest difficulty lies in the "human capital" indicator, in relation to which the country still has a long way to go.

On the other hand, according to ANACOM's 2020 report[85], Norte Region has good 2G coverage and adequate 3G and 4G coverage, with different performances between different types of urban areas and between operators. Specifically, there is a worse performance in predominantly rural areas, with significant levels of non-existent coverage in 3G and 4G. As this technology is essential for cohesion and competitiveness, it will be important in the future to resolve these constraints.

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[85] Available in: https://anacom.pt/render.jsp?contentId=1528021.

In light of the above, it is necessary to improve internet connectivity and coverage levels, as well as combat digital illiteracy, promoting greater inclusion of the population and greater digitalisation of companies.

8.3 Advanced Users and Trends

In the priority domain "Technology, State, Economy and Society", a prospective analysis[86] was carried out to identify the main global medium and long term trends that shape the intermediate and final demand, allowing to assess the regional potential in the promotion of accumulated competences in science, technology, engineering and mathematics for the digital transformation of the economy and society. The schematic and conceptual dimension of this identification process should consider the interaction of the different trends among themselves, enhancing the effect of each one and of their set. These trends are structured in the following five topics:

a) **Global connectivity, digital infrastructures and mobile services** - Internet as a good of merit, that is, the generalisation of its access in good conditions of security, reliability and performance is a fundamental element for equal opportunities in learning and knowledge, personal and professional development, economic activity, socialisation and, in general, in the exercise of citizenship, respecting civic and political rights of citizens regardless of their place of residence and work and their economic and social condition;

b) **Digital as an ecosystem of (related) technologies** - digital transformation as a process based on a set of interdependent technologies whose developments reinforce each other, amplifying their economic and social effects, which implies a permanent effort of investment in research and development, of adaptation of institutions, both public and private, to change as a new normal and of accumulation of human capital in relevant scientific and technological areas;

c) **Inclusion, empowerment, skills and the labour market** - growing need for labour force with digital skills and the need for an adequate response in the various levels of education and vocational training and retraining of workers, together with the profound (and disruptive) process of creation and destruction of jobs and the emergence of new forms of labour relations, enhanced by automation and the breakdown of work into specific tasks and remote and occasional work, namely on platforms, with unconventional professional statuses and greater (potential) income polarisation between people, regions and countries;

d) **Digital as a market** - tendency towards the hegemony of the digital market in service areas (such as financial services) or in the distribution of dematerialised goods (music, cinema, video, books, newspapers, etc.) and towards its growing importance in the remaining markets, resulting from combined effects such as: existence of network economies (economies of scale on the demand side); reduction of costs and of the cost of additional units (marginal costs); reduction of transaction costs (costs of transactions per se and resulting from market frictions, such as distance or asymmetric information);

e) **Digital public services and open and networked administration** - providing services to citizens and businesses preferably (and by definition) electronically, through interoperable and increasingly unified points of contact, ensuring: sharing and re-use of data between institutions and users; digital inclusion and accessibility, including for target groups such as the elderly and people with disabilities; smart and connected territories, in areas such as transport, energy, education, health or culture; legal, regulatory and IT security framework for the protection of personal data and privacy and cybersecurity.

[86]   Bibliografia relevante consultada: Comissão de Coordenação e Desenvolvimento Regional do Norte (2014), Monteiro, Meira, Santos, Leite, Guimarães & Gomes (2019), Fundação para a Ciência e Tecnologia (2019e), Estado português (2017b, 2018c, 2019c, 2019e, 2020b), Comissão Europeia (2015b, 2016, 2018c, 2018b, 2018a, 2020b, 2020d), European Commission - Directorate-General for Research and Innovation. European Commission (2020), High-Level Expert Group on Artificial Intelligence (AI HLEG). European Commission (2019), Urban Agenda for EU. Digital Transition (2018), ESPON (2017), Eurofound (2018), Gonzalez Vazquez et al (2019), Organisation for Economic Co-operation and Development (2019a, 2019b), European Parliamentary Research Service. European Parliament (2019), High-Level Expert Group on the Impact of the Digital Transformation on EU Labour Markets. European Commission (2019), DG CONNECT. European Commission (2020a, 2020b).

The R&D&I strategies and public policies associated with this priority domain cannot be dissociated from the global trends structured into the five topics mentioned in the previous point, and are not, nor can they be, mutually exclusive. Resulting from the analysis of different documents from national and international organisations, the R&D&I strategies and public policies for this domain are the following:

a) **Global connectivity, digital infrastructures and mobile services** - provision of broadband infrastructures (fixed and mobile), with networks enabling higher access and data transfer speeds (Very High Capacity Networks or VHCN, Fibre to the Premises or FTTP, Data Over Cable Service Interface Specification or DOCSIS and 5G technology), enabling widespread use by families and companies, in rural or urban territories, in a competitive and permanently regulated market context that ensures the lowest possible prices so that they do not become factors of exclusion;

b) **Digital as a (related) technology ecosystem** - permanent public and private R&D investment in the technology cluster: internet of things, next-generation wireless networks (5G), from edge to cloud computing, big data analytics, artificial intelligence, cybersecurity or high-performance computing (HPC); support for advanced training in the sciences, technologies, engineering and mathematics; attracting FDI in ICT, taking advantage of business process outsourcing (BPO) and, above all, knowledge process outsourcing (KPO) trends, such as software factories and engineering centres, for fixing and accumulating human capital.

c) **Inclusion, empowerment, skills and the labour market** - transversal integration of digital technologies in the different curricular areas of basic and secondary education; broadening the training supply of higher education institutions (increasing the number of students) to meet the digital skills needs of companies; training and re-qualification actions for assets (to adapt to the digital change in course) and for inclusion and digital literacy; regulation of new labour relations, ensuring adequate conditions and professional status according to the type of work and its intensity and frequency; analysis of changes in employment and work concepts and development of policies to mitigate the social impact of those changes;

d) **Digital as a market** - promoting e-commerce, both between companies along the supply chains (B2B) and online sales (B2C); dematerialisation and digitalisation of services and goods and making them available online; development of applications and platforms for online interaction and provision of services or improvement of their provision; digital marketing and respective strategies, involving fusion between the cyber-physical, analogue and retail; market regulation, boosting competition and investment and reducing inefficiencies due to excessive concentration or abuse of dominant position;

e) **Digital public services and open and networked administration** - increasing users of online services and the provision of pre-completed forms and open data; expanding telemedicine, electronic prescriptions and the exchange of medical data; production and distribution of multimedia content on platforms to support distance learning; development of applications and platforms for traffic management, public transport and energy (smart grids) in cities; promotion of living labs in territories with characteristics of agglomeration and density of interactions; reconversion of processes to the digital universe and training and empowerment of workers.

It is also important to mention that in the context of the crisis caused by the Covid-19 pandemic, concepts and respective technologies gained relevance, such as the low touch economy[87], characterised by less interactions between people and with no or low contact with equipment and surfaces, by health and safety protection, by new consumer behaviours and by (permanent) changes in some sectors.

The following table presents the association between the trends identified in the domain "Technologies, State, Economy and Society" and the "societal challenges" that constitute heavy trends of structural change in the economy and society and that present a transversal character to different priority domains. This analysis allows the conclusion that this priority domain is aligned with structural transformation trends such as digital transformation and Industry 4.0. This conclusion thus reveals that despite the sectoral and thematic specificities of this priority domain, there are common elements in the trends and policies to other priority domains of smart specialisation that promote an interpenetration of areas, which will increasingly exist in various enterprises, institutions, and economic activities.

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[87]   Board of Innovation (2020)

Table 25 • Association[1] between trends identified in the domain "Technologies, State, Economy and Society" and "societal challenges"

Trends	Aging		Energy Efficiency		Decarbonisa-tion		Circular Economy		Digitalisa-tion		Industry 4.0	
	D	I	D	I	D	I	D	I	D	I	D	I
(a) Global connectivity, digital infrastructures and mobile services									●			
b) Digital as a (related) technology ecosystem				●		●		●	●		●	
c) Inclusion, empowerment, skills and the labour market				●		●		●	●		●	
d) Digital as a market				●		●		●	●		●	
e) Digital public services and open and networked administration		●							●			

[1] Direct (D) or indirect (I) association

8.4. Rationale

The aim of the domain "Technologies, State, Economy and Society" is to promote the accumulated skills in science, technology, engineering, and mathematics for the digital transformation of the economy and society as a process based on a set of digital technologies. Thus, it is intended to ensure the integration of digital technologies in businesses, the use of Internet services, the promotion of digital skills, the provision of connectivity infrastructures and mobile services and the development of digital public services and open and networked administration. The following figure presents the analytical framework of the priority domain "Technologies, State, Economy and Society".
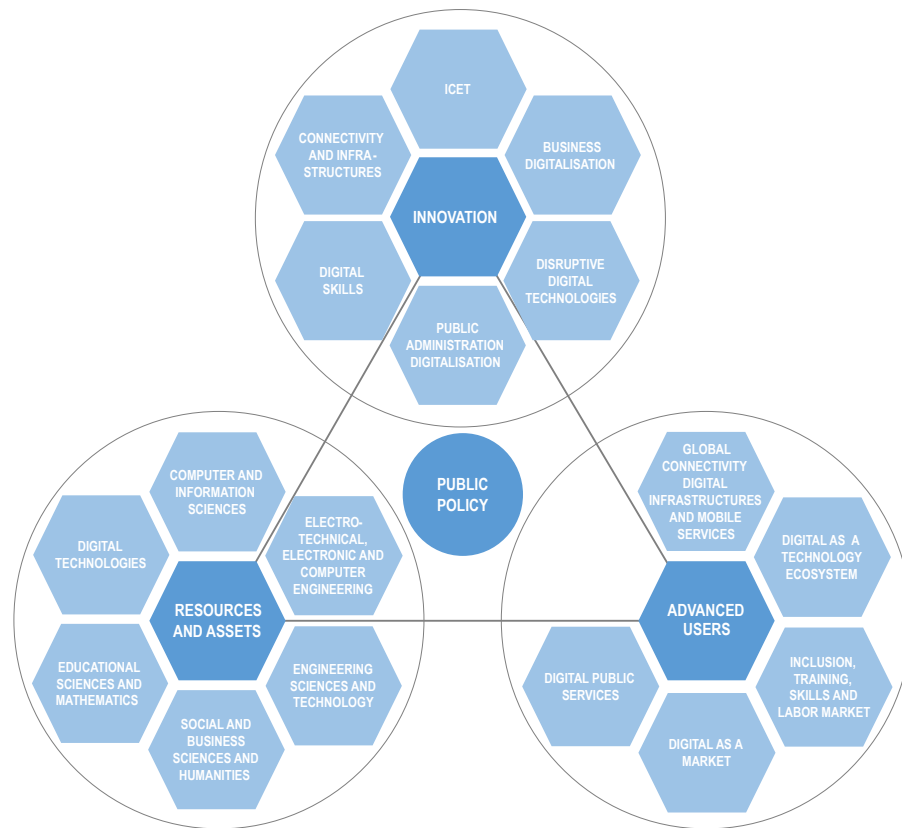
Figure 49 • Analytical framework of the domain "Technologies, State, Economy and Society"

In terms of the policy rationale, the domain "Technologies, State, Economy and Society" aims to promote the accumulated competences in science, technology, engineering and mathematics for the digital transformation of the economy and society as a process based on a set of digital technologies (internet of things, next generation wireless networks [5G], cloud computing data analytics, artificial intelligence, cybersecurity or high performance computing) ensuring the integration of digital technologies in businesses, the use of internet services, the promotion of digital skills, the provision of connectivity infrastructures and mobile services and the development of digital public services and open and networked administration.

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Annex 1

List of non-corporate entities of the scientific and technological system identified in the priority domain "Technology, State, Economy and Society"[88]

Typology	Acronym	Name
R&D Units	CECS	Centre for Communication and Society Studies
R&D Units	CICP	Political Science Research Centre
R&D Units	CIIE - U.Porto	Centre for Educational Research and Intervention
R&D Units	CIPES	Centre for Research into Higher Education Policies
R&D Units	CIPsi	Research Centre for Psychology
R&D Units	CISTER	Research Centre for Embedded and Real-Time Computing Systems
R&D Units	CMUP	Mathematics Centre of the University of Porto
R&D Units	GECAD	Research Group on Engineering and Intelligent Computing for Innovation and Development
R&D Units	UACC	Laboratory of Artificial Intelligence and Computer Science
R&D Units	CITAR	Arts Science and Technology Research Centre (UCP)
R&D Units	ALGORIT-MI	ALGORITMI Research Centre
R&D Units	cef.up	Economics and Finance Centre of the University of Porto
R&D Units	CEGE	Centre for Economics and Management Studies
R&D Units	CEHUM	Centre for Humanistic Studies
R&D Units	CEID-CRC-FL	Centre for Legal Studies and Research
R&D Units	CEPS	Centre for Ethics, Politics and Society
R&D Units	CICF	Research Centre for Accounting and Taxation
R&D Units	CIEC-UM	Research Centre for Child Studies
R&D Units	CIEd	Research Centre for Education
R&D Units	CMAT	The Mathematics Centre of the University of Minho
R&D Units	CPUP	Psychology Centre of the University of Porto
R&D Units	IF	Institute of Philosophy
R&D Units	INESC TEC	Institute for Systems and Computer Engineering, Technology and Science
R&D Units	IS-UP	Institute of Sociology of the University of Porto
R&D Units	JusGov	Research Centre for Justice and Governance
R&D Units	NIPE	Centre for Research into Economic and Business Policies
R&D Units	CEFH	Centre for Philosophical and Humanistic Studies
R&D Units	CEOS.PP	Centre for Organisational and Social Studies at the Polytechnic of Porto
R&D Units	CETRAD	Centre for Transdisciplinary Studies for Development

[88] The identification of the entities was based on the analysis of a synthetic characterisation of each institution obtained, namely through consultation of various ANI publications, FCT evaluation reports and the entities' websites. It should be noted that the mere identification of a given infrastructure in each domain is not enough to guarantee its framework in S3 NORTE 2027 for the purposes of support for financing from EU funds. Similarly, the non-inclusion of a given infrastructure may not prevent access to such support and funding, depending always on the project that will be presented.

Typology	Acronym	Name
R&D Units	CIEB	Centre for Research in Basic Education
R&D Units	CIICESI	Centre for Innovation and Research in Business Science and Information Systems
R&D Units	CIJE	Legal and Economic Research Centre
R&D Units	GILT	Games, Interaction & Learning Technologies
R&D Units	IJP	Portucalense Legal Institute
R&D Units	inED	Centre for Research and Innovation in Education
R&D Units	REMIT	REMIT - Research in Economics, Management and Information Technology
R&D Units	UNIAG	Management Applied Research Unit
Associated Labs.	IT	Institute of Telecommunications
Associated Labs.	INESC TEC	Institute for Systems and Computer Engineering, Technology and Science
Associated Labs.	LASI	Associate Laboratory for Intelligent Systems
R&D Infraest. RNIE	Datalab	Social Sciences Data Laboratory
R&D Infraest. RNIE	RNCA	National Advanced Computing Network
R&D Infraest. RNIE	CCD	Centre for Digital Creativity
Technology Transfer and Valorisation Centres	CCG/ZGDV	Association Centre for Computer Graphics
Technology Transfer and Valorisation Centres	INESC TEC	Institute for Systems and Computer Engineering, Technology and Science
Technology Transfer and Valorisation Centres	INCD	National Distributed Computing Infrastructure
Other R&D Infrastructures	ALGORIT-MI	ALGORITMI Research Centre
Colabs	DTx	Collaborative Laboratory for Digital Transformation
Colabs	Ceiia S2uL	Collaborative Laboratory for Urban Sustainability
Colabs	VORTEX	COLAB in Cyber-Fiscal Systems and Cyber Security
Digital Innovation Hubs	-	AI4PA Portugal - Artificial Intelligence & Data Science for Public Administration Portugal Innovation Hub
Digital Innovation Hubs	-	ATTRACT DIH
Digital Innovation Hubs	-	C-Hub: Cybersecurity DIH
Digital Innovation Hubs	-	CONNECT5
Digital Innovation Hubs	-	Defence4Tech Hub
Digital Innovation Hubs	-	DIH4ClimateNeutrality
Competitiveness Clusters	-	TICE.PT
Competitiveness Clusters	-	Cluster Smart Cities Portugal
Business Associations	ACEPI	Digital Economy Association
Business Associations	APDC	Portuguese Association for the Development of Communications

Annex 2

Delimitation of the main sectors of activity from the Portuguese Classification of Economic Activities (CAE Rev. 3) in the priority domain "Technologies, State, Economy and Society"

For the definition of the main economic activities that integrate this domain, the sectors that constitute the great areas of this domain and that are considered in its rationale are, namely:

- **Information society in households**
- **Information society in municipalities**
- **Companies with information and communication technology (ICT) activities**

Main indicators to be used in the analysis of the business base of this domain:

a) **Information society indicators in households**
- - Proportion of households with at least one person aged between 16 and 74 with access to a computer
- - Proportion of households with at least one person aged 16 to 74 with an internet connection
- - Proportion of households with at least one person aged 16 to 74 with a broadband internet connection
- - Proportion of individuals aged 16 to 74 using computers
- - Proportion of individuals aged 16 to 74 using the Internet

b) **Information Society Indicators in Municipalities**
- Proportion of Municipalitites with an Internet connection
- Proportion of Municipalitites with Broadband Internet Connection
- Proportion of Municipalities with an Internet presence
- Proportion of Municipalitities with use of e-commerce
- Proportion of Municipalities with public consultation processes made available on the Internet site
- Proportion of Municipalities with Online completion and submission of forms

c) **Companies, turnover and staff employed in companies with information and communication technology (ICT) activities**

The scope of economic activity considered for the calculation of the ICT sector comprises companies classified under the following codes of the CAE Rev. 3:
- 261 - Manufacture of components and boards, electronic
- 262 - Manufacture of computers and peripheral equipment
- 263 - Manufacture of communication equipment
- 264 - Manufacture of radio and television receivers and similar consumer goods
- 268 - Manufacture of magnetic and optical media
- 465 - Wholesale of information and communication technology equipment
- 474 - Retail sale of information and communication technologies equipment in specialised shops
- 582 - Software publishing
- 61 - Telecommunications
- 62 - Computer programming, consultancy and related activities
- 631 - Data processing, hosting and related activities; web portals
- 951 - Repair of computers and communication equipment

(Source: "INE (2018). Anuário Estatístico Região Norte"; "INE (2007). Classificação Portuguesa das Atividades Económicas Rev.3")

Priority Domains
Characterisation

S3NORTE

2027

NORTE REGION SMART
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