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The contribution of higher education institutions to innovation ecosystems

*Innovative practices from
Higher Education for Smart
Specialisation*

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Abstract

This technical report presents the results of a cross-case analysis of the eleven case studies conducted under the Higher Education for Smart Specialisation project during the period 2016-2020. The analysis identifies key themes and innovative practice examples from across case studies, developing a structured typology of innovative practices for higher education engagement in innovation ecosystems in the context of the design and implementation of Smart Specialisation Strategies (S3). More concretely, it contributes to identify:

- (i) The contribution of innovative practices to their regional innovation ecosystems and the design and implementation of S3.
- (ii) The key features of these practices that have made possible the transformative role of higher education in their regional innovation system, with particular attention to how they integrate education, research and innovation.

Executive summary

This report capitalises on the findings of eleven case studies undertaken under the Higher Education for Smart Specialisation (HESS) project during the period 2016–2020, identifying and proposing a structured typology of innovative practices of higher education (HE) engagement in innovation ecosystems in the context of Smart Specialisation Strategies (S3). The objective of the report is to examine:

- (i) The contribution of innovative practices to their regional innovation ecosystems and the design and implementation of S3.
- (ii) The key features of these practices that have made possible the transformative role of higher education institutions (HEIs) in their regional innovation system, with particular attention to how they integrate education, research and innovation.

The heterogeneity of the cases made it difficult to draw transversal lessons. The case study regions are not only heterogeneous in their development level, but they also present substantial differences in the nature of the S3 governance process or HEI system, the selected S3 priorities, the design of the participatory process or the innovation policy mix. Following the categories used for the European Regional Development Fund's (ERDF) regional classification, seven of the regions are classified as less developed (Eastern Macedonia and Thrace, Lithuania, Lubelskie, North Central Bulgaria, North East Romania, Portugal and Puglia), two as transition (Centre-Val-de Loire and Northern Netherlands) and two as more developed (Lower Austria and Navarre).

A cross-case analysis has been used as methodological approach, using a series of questions to identify innovative practices in each of the HESS case studies and guide analysis of them to facilitate deeper understanding. The practices identified in the case studies are compared and discussed through a matrix analysis, proposing a structured typology of innovative practices and key features. A summary table is presented as a source of inspiration and learning by other EU Member States and regions promoting knowledge triangle integration in innovation ecosystems.

The analysis identified sixteen categories of innovative practices grouped around four broad dimensions: 1) Governance of S3 and HEI system, 2) Engagement of HEIs in innovation systems, 3) Skills development and training function of HEIs, 4) Connecting HEIs and S3 externally to learn from and with others.

The main conclusion of the cross-case analysis is the importance of place-specific context for policy design and implementation. The cases highlight great diversity of practice in terms of leveraging ERDF funding, which in some cases is heavily oriented towards HEIs and in other cases less so. They also point to the importance of complementary national and regional initiatives to effectively engage HEIs. Moreover, while in general it could be observed that in less developed regions HEIs can assume an even greater role in the animation of innovation dynamics, through access to relevant funding streams, they are also confronted with bigger challenges. Indeed, to be effective recipients of funding that can generate S3-relevant knowledge, provide S3-relevant education and training, knowledge-intensive services and infrastructure, and bridge local knowledge with S3-relevant external sources, HEIs must overcome various internal and external limitations. Nevertheless, the case reports indicate that HEI-oriented funding instruments can be a first important step to engage HEIs in S3 and their wider innovation ecosystem. In more developed territories, on the other hand, while funding was also important, other more sophisticated practices like co-funding and HEIs participating in the development of funding streams come into play.

The first dimension 'S3 and HEI Governance' relates to the involvement of HEIs in the governance of the S3 process and to the governance of the HEI system itself, which affects the capacity of HEIs to engage in the S3 process. Innovative practice categories under this dimension found in the cases are: (i) Leadership of HEIs in the design and implementation of S3; (ii) Participation of HEIs in S3 governance bodies; (iii) S3 stakeholder representation in HEI governing bodies; and (iv) HEI institutional capacity, coordination and multilevel governance.

The second dimension 'S3 Implementation through HEIs roles in the regional innovation system' moves beyond involvement in S3 governance to include innovative practices that support S3 implementation through the different roles that HEIs play on a day-to-day basis in regional innovation systems. From the cases, the following innovative practices were identified: (i) HE engagement with business; (ii) Connecting SMEs and entrepreneurs to S3; (iii) HEIs engagement with intermediate institutions; and (iv) Mechanisms for embedding HEIs in the innovation ecosystem.

The third dimension 'Regional upgrading through skills development and alignment' singles out the core human capital function of HEIs, strongly reflected in all the HESS case studies, from the broader roles played in S3 implementation. It is composed of the following innovative practices: (i) Explicit focus on human capital built

into S3; (ii) Specific initiatives to meet companies' skills needs; (iii) Industrial doctorate programmes; and (iv) Linking HEIs and VET systems.

The final dimension 'Learning with and from others' captures innovative practices related to the cross-border, inter-regional or international connectivity of HEIs as a route to supporting the implementation of S3 by facilitating processes of learning with and from others. The three innovative practices identified are the following: (i) Cross-border initiatives and international collaboration; (ii) The HESS case-study, and (iii) EU funded programmes and instruments.

In terms of funding mechanisms to engage HEIs in S3, the analysis highlights the importance of synergies between national and regional funding to adequately address the challenges of higher education to impact their innovation ecosystems. The capacity of certain regions to integrate synergies of funding into the design of the instruments is an interesting way of overcoming the challenges for beneficiaries to do this at the project level. However, there is a tendency to copy instruments that have worked in different regional contexts instead of developing tailored ones. Moreover, the instruments targeting HEI engagement in S3 could explore complementarities within funding instruments, to provide a more consistent and long-term support to boost innovation ecosystems. The report concludes that there is a potential to use regional funds for targeted collaborations with other regions in similar S3 priority areas to address common challenges in human capital and skills development, as well as to design instruments targeting specific HEIs (VET, applied research) and encouraging intra-regional higher education collaborations that could lead to interesting results in terms of the contribution of HEIs to S3.

1 Introduction

Cohesion Policy is the main investment policy of the European Union to strengthen economic, social and territorial cohesion, supporting Member States and regions in job creation, business competitiveness, economic growth, sustainable development and improving quality of life. One of the funds to deliver Cohesion Policy is the European Regional Development Fund (ERDF) that aims to strengthen economic, social and territorial cohesion in the European Union.

Smart Specialisation Strategies (S3) were launched for the first time in the period 2014-2020 to achieve Cohesion Policy objectives. This is a place-based approach for targeted use of European Regional Development Fund for research and innovation in priority areas selected by each EU region and Member State through wide stakeholder engagement. Among the key institutions contributing to S3 implementation are higher education institutions. However their full potential has still not been harnessed in many EU Member States and regions in terms of the impact in their regional innovation ecosystems. The contribution of higher education to education, research and innovation and engagement with the territory is key to achieve the objectives of S3, and we need to understand the challenges they are facing to increase impact in their territories.

This report is part of the Higher Education for Smart Specialisation (HESS) project, that has been managed by the Joint Research Centre and the DG for Education, Youth, Sport and Culture of the European Commission since 2016. The objective of HESS is to analyse how higher education can be better integrated into S3 policy mixes and how the role of higher education institutions (HEIs) in regional economic development can be strengthened.

The project has produced scientific evidence for policymaking connecting EU cohesion, higher education and research and innovation policies. Implemented in four consecutive phases, the first three phases (2016- 2021) of the project focused on conducting action-research case studies in selected EU Member States and regions, collecting evidence of how HEIs are contributing to S3 implementation in different geographical contexts, and the main challenges they face. Phase four will capitalize on the previous work, reinforcing coordination with key EU initiatives such as the European Institute of Innovation and Technology (EIT) to promote higher education entrepreneurship and innovation contributing to S3.

This report capitalises on the findings of 11 case studies undertaken under HESS project during the period 2016-2021. All HESS case studies were developed adopting principles of 'action research', meaning they were carried out with and for the local and/or regional authorities and HEIs in the different regions in which the cases were developed. Out of the 11 cases, 2 of them took place at the national level, namely Lithuania and Portugal. This report presents the results of a cross-case analysis designed to identify key themes and innovative practice examples from across the 11 case studies. As such it develops a structured typology of innovative practices for higher education engagement in innovation ecosystems in the context of the design and implementation of S3. It examines:

- (i) The contribution of those practices to their regional innovation ecosystems and the design and implementation of S3.
- (ii) The key features of these practices that have made possible the transformative role of higher education in their regional innovation system, with particular attention on how they integrate education, research and innovation.

The analysis presents four main limitations that need to be taken into account. First, the heterogeneity of the case study regions with some being less developed, others in transition and others in an advanced development stage, makes the task of comparing innovative practices challenging since the innovation ecosystem and S3 contexts are very different. Second, while the sample of eleven case studies provide a good representation of less advanced, transition and advanced regions, the place-based character of S3 and the different policy context of each region should be taken into account for more general considerations. Third, the case studies were developed in different moments in time during the period 2016-2021, therefore some of them were at the early stages of the S3 implementation while others were at the very end of the programming period. For instance, in the cases that were more advanced in the programming period, the policy mixes and funding programmes are more sophisticated and tailored to the regional context. Fourth, despite the fact that the HESS project has the common aim of boosting HEIs impact in S3, the action-research method followed in the case studies allowed for tailored research objectives to address specific regional challenges. The different research objectives also made it challenging to compare innovative practices and details of each practice across cases.

The report is structured as follows. In section 2 we briefly explain the methodology employed to analyse the cases. This is followed by an overview of the key findings of the cross-case analysis and the presentation of a

structured typology to organise the innovative practices uncovered. These practices are then set out in further detail and illustrated with examples from the HESS cases. The final section summarises and concludes.

2 Methodology

The 11 case studies were developed between 2016 and 2021 by different authors. While they all employed an action research methodology with common elements – typically including exploratory meetings, in-depth interviews, desk research and participatory workshops or focus groups – they have resulted in reports that are heterogeneous in their structure and the specific themes analysed. The case study reports can be found in the reference list, and they were conducted for the territories set out in Table 1.

Table 1. Overview of Higher Education for Smart Specialisation case studies (2016-2021)

2017	2018	2019	2020	2021
1. Navarre, Spain 2. North-East Romania	3. Centre-Val-de Loire, France 4. North Central Bulgaria 5. Puglia, Italy		6. Lithuania 7. Lubelskie, Poland	8. Eastern Macedonia and Thrace 9. Lower Austria 10. Northern Netherlands 11. Portugal

The method used to identify and analyse innovative practices from these cases was cross-case analysis. This allows researchers to deepen understanding and explanation of a particular phenomenon or general condition (Yin, 2003; Thomas, 2011). The cross-case analysis was guided by the following questions:

- What innovative practices on higher education engagement can be found in the case studies? What was their contribution to the regional innovation ecosystem and the design and implementation of Smart Specialisation?
 - What key features of those practices has made possible the transformative role of higher education in their regional innovation system?
 - How do the innovative practices identified across the cases fit within the thematic areas of the Knowledge and Innovation Communities (KIC) promoted by the European Institute of Innovation and Technology (EIT) and integrate the knowledge triangle?

To undertake the cross-case analysis it was necessary to first conduct within case analyses according to the above questions. The research team examined each case, capturing the answers to the questions in a table. Tables were then compared and discussed, producing one revised table per case. The innovative practices identified, and their key features were then displayed in a matrix that allowed the research team to work across the cases systematically (Miles & Huberman, 1994) to ultimately develop a structured typology of innovative practices.

3 Overview of key findings from cross-case analysis

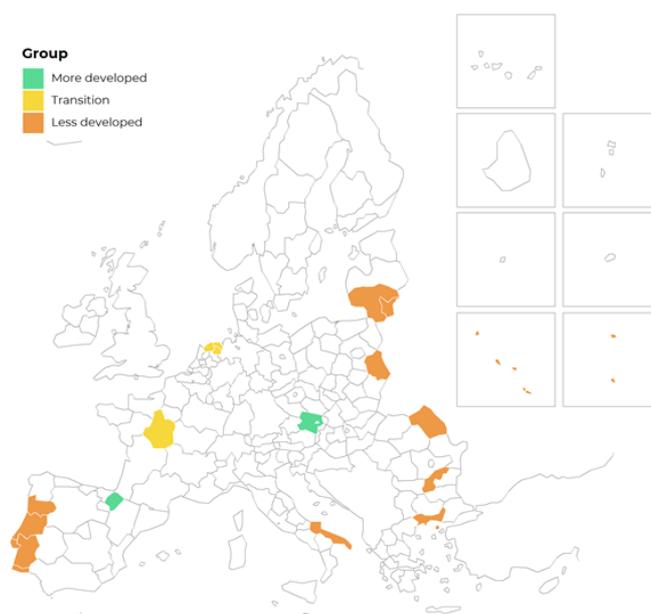
The heterogeneity in the HESS case studies analysed reflects a combination of the action research approach employed in the project and the large differences in context across the eleven cases. In this regard it is in line with the broad acceptance in contemporary regional economic development literature of the importance of place-specific context for policy design and implementation (Todtling and Trippl, 2005; Coenen et al, 2016).

The 'action research' methodology adopted in HESS case studies mobilised key actors of the innovation ecosystem in each study region, with the Joint Research Centre facilitating an iterative process of joint reflection and knowledge generation by local actors. The methodology applied the characteristics defined for action-research of: dealing with real world problems; incorporating change as an integral part of research; developing research as a cyclical process in the form of feedback loops of findings that generate possibilities for change; and establishing the crucial role of practitioners the research process (Denscombe, 2010) and of 'action research for territorial development' that works at the intersection of action research and regional innovation systems (Karlsen and Larrea, 2014).

The process led to the identification of key challenges in each region related to higher education engagement in S3 and the impact in the innovation system. It also involved defining research questions of interest for each case study and reflecting, discussing and reaching agreements between key stakeholders on the actions needed to increase the impact of higher education in the territory. Ultimately, the action-research method applied by the Joint Research Centre has reinforced the partnerships between higher education and regional authorities in charge of S3, and a shared strategic long-term higher education agenda in S3.

At a general level, differences in context are reflected in the broadly defined level of development of the regions analysed. Following the categories used for the European Regional Development Fund's (ERDF) eligibility criteria, Map 1 highlights that seven of the cases can be classified as less developed (Eastern Macedonia and Thrace, Lithuania, Lubelskie, North Central Bulgaria, North East Romania, Portugal and Puglia), two as transition (Centre-Val-de Loire and Northern Netherlands) and two as more developed (Lower Austria and Navarre). However, beyond these fairly crude categories there are substantial differences in aspects such as the nature of multilevel governance of the S3 process (e.g. degree of centralisation), the nature of the HEI system (e.g. degree of centralisation, types of institutions), the specifics of the S3 itself (e.g. priorities), the design of the entrepreneurial discovery process (EDP) (e.g. top-down or bottom-up, types of actors involved, role of intermediaries), and the broader innovation policy mix (e.g. types of policies, their links to the S3). The HESS action research methodology, which was built around a reflective process that mobilises actors, therefore inherently brought different dimensions to the fore in each of these different contexts.

Figure 1. HESS case regions and countries



Note: Portugal and Lithuania are characterised as less developed because at least 50% of their constituent regions fall into this category.

While this heterogeneity of context made it challenging to identify very clear-cut innovative practices with general application, a detailed cross-case analysis revealed sixteen categories of innovative practices into which specific examples from the cases could be placed. In turn, it was possible to group these sixteen categories into four broad dimensions, as set out in Table 2, recognising that several of the practices cut across these dimensions. Firstly, there were practices related to governance, either of the S3 itself or of the HEI system. Secondly, there were practices related to the engagement of HEIs in their regional innovation systems that support the ongoing implementation of S3. However, from these engagement practices related to the innovation system, we separated out into a third dimension those practices related specifically to the skills development or training function of HEIs. The final dimension contains categories of innovative practices relating to the process of connecting HEIs and S3s externally, to learn from and with others.

While the HESS case studies have not focused on specific thematic areas aligned with the EIT Knowledge and Innovation Communities (KIC), most of the good practices identified are highly relevant for the EIT Strategic Innovation Agenda 2021-2027. The engagement of HEI's in Smart Specialisation demands new roles, governance and institutional leadership conducive to increased entrepreneurial and innovative capacity. It demands as well, a strong engagement of HEIs in their regional innovation ecosystem, with the capacity to strengthen the links with industry, business, public administrations and citizens for a new way of defining a shared vision innovation agenda.

The innovative practices have been organised according to categories under the four dimensions, underlining the relevance of the categories for the EIT Strategic Innovation Agenda 2021-2027, as shown in the following table.

Table 2. Structured typology of innovative practices for HEI engagement in S3

Dimension	Innovative practice category	Relevance for EIT Strategic Innovation Agenda 2021-2027
S3 and HEI Governance	<ul style="list-style-type: none"> • Leadership of HEIs in design and implementation of S3 • Participation of HEIs in S3 governance bodies • S3 stakeholder representation in HEI governing bodies • HEI institutional capacity, coordination and multilevel governance 	<ul style="list-style-type: none"> • Systemic institutional change and integration of HEIs in innovation ecosystems • Strengthening the innovation and entrepreneurial capacity of HEIs
S3 Implementation through HEIs roles in regional innovation system	<ul style="list-style-type: none"> • HEI engagement with business • Connecting small and medium size enterprises (SMEs) and entrepreneurs to S3 • HEIs engagement with intermediate institutions • Mechanisms for embedding HEIs in innovation ecosystems 	<ul style="list-style-type: none"> • Strengthen the links between HEIs and their local and regional ecosystems • Strengthen HEIs integration in innovation ecosystems
Regional upgrading through skills development and alignment	<ul style="list-style-type: none"> • Explicit focus on human capital built into S3 • Specific initiatives to meet companies' skills needs • Industrial doctorate programmes • Linking higher education (HEI) and vocational education (VET) systems 	<ul style="list-style-type: none"> • Integration of higher education, research and innovation with an emphasis on entrepreneurial talent, business creation and innovation skills. • Involvement of other actors in the knowledge triangle
Learning with and from others	<ul style="list-style-type: none"> • Cross-border initiatives and International collaboration • Intra-regional HEIs collaborations • HESS study 	<ul style="list-style-type: none"> • Impact beyond the KIC partners • Reinforcing the innovation capacity of Member States and regions

	<ul style="list-style-type: none">• EU funded programmes	<ul style="list-style-type: none">• Increase complementarity and synergies between the EIT activities and national and regional funding programmes and priorities
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4 Innovative practices for higher education engagement in S3

In this section we explore in further detail the innovative practices uncovered for HEI engagement in regional innovation ecosystems and the design and implementation of S3, illustrating each of the categories with specific examples from the HESS cases.

4.1 S3 and HEI Governance

This first dimension includes innovative practices related to the involvement of HEIs in the governance of the S3 process and to the governance of the HEI system itself, which affects the capacity of HEIs to engage in the S3 process.

4.1.1 Leadership of HEIs in design and implementation of S3

When HEIs play a leadership role, they can contribute significantly to both the design and implementation of S3. First, as active participants in the Entrepreneurial Discovery Process (EDP), they can identify potentially strong fields for science-business cooperation and create partnerships and mobilise actors around a vision. For instance, HEIs in Eastern Macedonia and Thrace performed a bibliometric analysis of scientific publications by regional HEIs, providing an analysis of Strengths, Weaknesses, Opportunities and Threats (SWOT) for an informed priority selection and elaboration of their S3 action plan. They can also play a very important role in the identification and refinement of priorities.

Among the key features identified supporting the transformative roles of HEIs in S3 design are: (i) senior level participation in S3 direction; (ii) faculty level participation in S3 dynamics; (iii) selection of S3 priorities reflecting HEIs strengths in research and teaching; and (iv) formal recognition of HEIs' leadership. Navarre, for instance, stands out as a region in which HEIs participated in both the working groups and decision-making bodies. They have also set up Thematic Chairs within universities, linking HEIs to specific S3 priorities. In Lubelskie, HEIs' leadership role in the process was explicitly recognised in formal S3 documents. However, one of the challenges that emerges, even when HEIs have had an active participation in the S3 design process, is maintaining their influence during the implementation process and beyond, as shown by the Lithuanian case.

When HEIs play a leading role during the implementation phase, they can also contribute to the process in a number of significant ways: (i) providing information to other actors, particularly companies, about possibilities for collaborative projects in the S3 priorities; (ii) training for competences within S3 measures, particularly skills for the implementation of different R&I activities; (iii) providing regional infrastructures that add value and transfer knowledge, such as incubators, intensive knowledge services and science technology parks; and (iv) by leading projects under priority areas. As the case of Northern Netherlands shows, HEIs can also be active in shaping funding streams, drawing down subsidies, providing co-funding and leveraging and maximising impact of expenditures on the regional knowledge economy.

4.1.2 Participation of HEIs in S3 governing bodies

HEIs' participation in S3 governing bodies is an important category of S3 and HEI governance. HEIs can help develop policy and inform funding decisions in the S3 framework, provide feedback on the mix of policies, propose updates, revisions and, where relevant, funding. They also have an important role to play in S3 monitoring and evaluating activities. The aforementioned contributions are based on a number of key features: (i) an explicit recognition of HEIs and research centres as major actors in the governance structure; (ii) their full involvement in the S3 specialisation domains; (iii) the participation of academic representatives in evaluation and advisory roles. Examples that illustrate these key features are the Academic Task Force set up in North East Romania that provides academics with evaluation and advisory roles within the S3; or the S3 monitoring system designed by HEIs in Portugal. Lower Austria offers a fine example of the recognition given to HEIs as major actors in the S3 governance structure: the regional S3 is jointly coordinated by the Department for Economy, Tourism and Technology and the Department of Science and Research Policy. Central-Val de Loire's DEV'Up regional economic development agency, that combines research and innovation and economic development, has helped to provide consensus and raise awareness of S3, including among the academic community.

4.1.3 S3 stakeholder representation in HEI governing bodies

Another important category within the first dimension of the typology of innovative practices for HEI engagement in S3 is stakeholder representation in HEI governing bodies. This can take the form of participation of representatives from business or other S3 stakeholders in HEIs' governing boards, which contributes to favourable quadruple helix development. Key features of this practice include consulting local businesses when preparing and updating curricula to meet labour market needs, and joint organization of internships and practical lectures. For example, in the Centre for Entrepreneurship at Ruse University in North Central Bulgaria, business representatives can set assignments or dissertation topics related to their companies' needs. The Public University of Navarre (UPNA) 'Foro Social' establishes a regular dialogue between research professors and companies and University of Navarre (UNAV) engages alumni to capture emerging market needs and trends for the definition of new curricula or adapting existing ones. The Energy Academy Europe promoted by the University of Groningen and the Hanze University of Applied Sciences bringing business, students, partners and networks together to facilitate acceleration of the energy transition.

4.1.4 HEI institutional capacity, coordination and multilevel governance

HEI systems with strong institutional capacity can contribute especially effectively to analysing the research needs of the region, driving HEI collaboration projects and coordinating HEI efforts within the S3 framework. This category of practices highlights the importance of regional HEI and Science, Technology and Innovation (STI) coordination bodies, together with regional plans for HE Research and Innovation. For example, the Research, Innovation and Technology Coordination Council (CORIT) and the Community of Universities and Education institutions (COMUE) bodies in Centre Val de Loire are interesting examples of R&I policy coordination as regards the contribution of HEIs to regional development, integrating education in a sustainable way in the S3 governance. While CORIT has a large representation of enterprises that focus on specific themes in small working groups, COMUE is a decision-making body, a community of universities and education institutions with monthly meetings at the highest level. Lubelskie's Association of HEIs is another example of HEI coordination, becoming a starting point to identify areas for future cooperation, leading to, for example, the establishment of an Innovation Incubator Programme II 2.0 on commercialisation of research and development (R&D). The incipient "University of the North" of Northern Netherlands is setting the path to coordinate and pool higher education capabilities of the region with a long-term shared vision and strategy to contribute to the innovation ecosystem.

Multilevel governance is important for S3 strategies (Estensoro & Larrea, 2019) to ensure that national, regional, and local strategies are integrated in a coordinated way, and indeed this is highlighted as a key challenge in the Portuguese case. National S3s can emphasize the key role that local universities play in the innovation ecosystems of the region and include priorities related to the need to develop academic curricula in collaboration with local businesses. A key feature here is feedback from HEIs, so that national priorities reflect their local strengths. For example, Gabrovo University in North Central Bulgaria was consulted during the development of the top-down national strategy and the feedback provided was crucial to include the field of Mechatronics as a key priority area for the North Central region. Another key feature is the role played by municipal authorities. North Central Bulgaria also offers an example of a municipal government that contributes to stimulate dialogue and collaboration among stakeholders through the "Ruse Free City Spirit" and the Knowledge Fund aimed at projects related to the priority fields of the city. In Lower Austria the strategy process to develop the new national research and innovation strategy brings together different stakeholders, at different levels, including HEIs. The Netherlands Top Sector programme at national level has exerted a very strong steering effect on HEIs with long-standing clusters in the region, which together with the proliferation of innovation funds at the provincial level are increasing complexity of the innovation funding landscape with a potential risk of over-specialisation and provincial specialisation.

4.2 S3 implementation through HEIs role in regional innovation ecosystems

While overlapping in some regards with the first dimension, this second dimension moves beyond involvement in S3 governance to include innovative practices that support S3 implementation through the different roles that HEIs play on a day-to-day basis in regional innovation systems. It focuses on roles related to engagement in the regional innovation ecosystem in general, with the human capital function of HEIs in S3 implementation the more specific focus of a separate dimension.

4.2.1 HEI engagement with business

HEI engagement with business can contribute to S3 implementation by improving the relevance and alignment of research and study programmes to S3 needs. A key innovative practice in this dimension is the establishment of knowledge transfer partnerships between HEIs and industry. Their existence contributes to generate new dynamics in the EDP through collaborations in highly innovative projects with potential impact on regional development. Key features of these knowledge transfer partnerships are: (i) clustering of many research groups around an interdisciplinary topic linked to the territory and (ii) operating as well-designed funding instruments that integrate HEIs into the S3. These key features integrate the knowledge triangle by promoting strong interactions between regional stakeholders and national/international actors. Centre Val de Loire's Ambition Recherche Développement (ARD 2020) is an example of successful knowledge transfer partnerships. However, room for improvement was identified in terms of involving students and graduates to a much greater extent, thereby ensuring that the S3 priorities can count on highly skilled human capital. Indeed, further key features of HEI engagement with business overlap with the third dimension of regional upgrading through skills alignment and include: (i) student placements and co-design of courses; (ii) local actors agreeing to play the role of mentors, tutors and professional councillors; and (iii) interdisciplinary courses on entrepreneurship and business management. For example, Cuza University's Faculty of Economic and Business Administration in North East Romania is working on this, recognizing the importance of building partnerships with other HEIs to cater for the needs of different sectors.

4.2.2 Connecting SMEs and entrepreneurs to S3

HEIs can play a very important role in developing research and innovation agendas that are sufficiently dense to form the basis of regional specialisation. Key features in this innovative practice are: (i) informal networks to access SMEs through alumni networks to help build organisational proximity to facilitate subsequent collaboration; (ii) building connections between firms and HEIs through student projects, also involving vocational training; (iii) follow-up activities with innovating SMEs that had a useful low-intensity interaction with HEIs; (iv) strong animators and local policy support; role of universities' of applied science to continue activities after the life of the project; (v) shared research agendas facilitated by HEIs participating in high level discussions with large companies and lower level discussions with SMEs around applied research and student projects; (vi) sustained research directions between HEIs and SMEs building up to larger activities; and (vii) HEIs leveraging of expert innovators by ensuring that their use of ERDF funds created spill-overs for smaller firms. The Water campus example in the Northern Netherlands case is an example of the latter, while the 'innovation workplace' concept is an example of a first low-intensity interaction with small and SMEs that was later followed up. Its Living labs are an example of larger activities resulting from sustained research directions between HEIs and SMEs.

4.2.3 HEIs engagement with intermediate institutions

Intermediate institutions, such as clusters, technopoles and knowledge communities, among other, are key actors in innovation ecosystems. HEIs engagement with intermediate institutions can contribute to S3 design and implementation and in general to the innovation ecosystem because those institutions are better able to integrate knowledge triangle actors in the region, connecting HEIs with business and civil society and bridge the gap between firms and academic institutions to overcome SMEs limited absorptive capacity.

A number of key features support HEIs transformative role when engaging with intermediate institutions. First, the existence of knowledge sharing spaces, such as the knowledge communities linked to clusters in Navarre, that have great potential to strengthen the integration of higher education and to foster closer collaboration between technology centres, universities and clusters. Second, enabling closer connections between university research groups and companies. Technopoles in Lower Austria are a great example of this. Established as technologically oriented business centres which continuously aim to expand the innovation absorption of businesses by making use of study and research institutions in the vicinity, they enable a close interlinkage between innovation and HE strategy. Third, supporting innovation in businesses through clusters, which can reach across different locations, bringing together companies and research groups in joint thematic innovation development. The House of Digitalization in Lower Austria brings together the logic of technopole site development with the thematic collaboration logic of clusters through a network to translate research expertise into business. Another interesting example can be found in Portugal, where 26 Collaborative Laboratories that consist of at least one company and one R&D unit associated to a HEI aim to create skilled and scientific jobs. Centre-Val de Loire's regional competitiveness clusters that promote R&D departments in local companies to support processes and organisational innovation in industry, as does its Ambition Recherche Développement

programme (ARD 2020) that has created sustainable partnerships between industry and researchers focused on the region's S3 priorities.

4.2.4 Mechanisms for embedding HEIs in innovation ecosystems

HEIs can more easily play an important role in S3 strategies when they are embedded in innovation ecosystems through adequate mechanisms. They can contribute to building up innovation ecosystems by intensifying contacts between innovators and knowledge producers and by building up new connections. They are also able to foster interdisciplinary research and contribute to regional upgrading through human capital development processes. Key features of this innovative practice include: (i) government departments to address the central role of HEIs, such as the dedicated department created in Lower Austria to help in the transition from an agriculturally dominated region into the knowledge economy; (ii) development of funding schemes for cooperation with HEIs, such as in the Northern Netherlands region, where the Dairy Campus in Leeuwarden and the potato starch research activities in Groningen are led by companies that have the resources and the funding to invest in building relationships with the university; (iii) active involvement in collective arrangements created to encourage collaboration with regional innovation ecosystems, such as like the Energy Valley and Living Labs in Northern Netherlands or the Regional Academic Centre at Ruse University in North Central Bulgaria, which has the role of integrating research and innovation activities with local business; and (iv) launching new areas of activity at the interface of different fields of science through interdisciplinarity, such as in Lubelskie, where the John Paul II Catholic University launched new areas of activity related to biotechnology or the introduction of socio-cultural aspects to the traditional process of technology development (i.e. involvement of social sciences in issues related to the development of autonomous cars or brain signal testing in devices for rehabilitation, research on self-motivation and healthy lifestyles).

National publicly funded and co-funded technology initiatives can also contribute to embed HEIs in the innovation ecosystem by addressing short-term exploitation of university research and covering the entire spectrum of applied research. A key feature in this regard is the capacity to bring together a critical mass of key research and technological development competences through cooperation between science and industry aligned with S3 priorities. The Competence Centres for Excellent Technologies (COMET) in the Lower Austria region illustrate how this comes about by linking university research and research training with many business partners in networks that combine access to joint infrastructure (testing facilities), competence development and collaborative pre-competitive research and technology development projects.

Finally, specific project calls can contribute to incentivise HEI engagement in S3 priority areas during implementation. Key features that support HEI engagement through project calls include the inclusion of S3 priority areas in the project calls' eligibility criteria and the existence of collaboration between HEIs and business through industrial PhDs and the development of R&D projects and university business programmes. These calls also contribute to integrating the knowledge triangle by boosting stronger engagement of universities within their territories, creating stronger links with business programmes. The Navarre region offers a good example of how those project calls are framed.

4.3 Regional upgrading through skills development and alignment

The core human capital function of HEIs and the roles that they play in the development and alignment of skills with the emerging needs of smart specialisation strategies are strongly reflected in the HESS case studies. Given their importance, this dimension of HEIs engagement in regional innovation systems is separated out from the broader roles played in S3 implementation reflected in the previous set of innovative practice examples.

4.3.1 Specific focus on human capital built into S3

A practice developed in several of the case regions to reflect the importance of education and training for the development of S3 is to explicitly establish a focus on human capital and skills within the S3. HEIs play a central role in these transversal measures, built around their explicit contribution through training of graduates and businesses and geared towards reinforcing links with the R&I system and enhancing responsiveness to the skills needs of companies for S3 implementation. In several cases this is operationalised by explicitly establishing transversal priorities related to human capital within the S3. For example, there are S3 priorities related to 'education and training' in Navarre, to 'human capital' in Centre-Val de Loire, and to 'the development of innovation competences among a new generation' in North East Romania. The Northern Netherlands S3 also

features a range of sophisticated mechanisms to support regional upgrading through human capital development processes, and human capital is identified as an emerging focus in the Lithuanian case.

From these cases a range of key features supporting the transformative roles of HEIs in S3 as regards human capital development can be identified. Within an overall objective of increasing the skills of the population to adapt to technological, economic and labour market changes in line with the S3, key features include: (i) strengthening overall collaboration between entrepreneurs, businesses and HEIs; (ii) identification of key regional challenges to guide HEI action relating to their training function; (iii) alignment of curricula with S3 priorities; (iii) collaboration to establish skills needs for specific areas such as new market development or training for innovation management; (iv) the development of various specific bridging initiatives such as targeted courses for CEOs and industrial doctorates, which are detailed further below in the other categories within this dimension, and (v) talent attraction and retention programmes to address gaps in the education system or brain drain negative outflows

4.3.2 Specific initiatives to meet companies' skills needs

The cases highlight a wide range of specific actions and/or incentives that are designed to encourage HEIs to better align their training activities with companies' skills needs in the context of S3, recognising that graduates provide a crucial vector of knowledge transfer for S3 implementation. For example, in the case of Centre-Val de Loire, there are several mechanisms in place to identify skills and competences demands, including regional observatories that collect data about graduates and company placements, leveraging of the national CAMPUS label to accompany companies from the HEI system in dealing with their skills needs, and the role of the development agency DEV'UP in bringing the needs of enterprises to the attention of the whole regional system. Several cases also highlight student placements and/or invited faculty from companies, both of which are mechanisms that can expose students to active learning in knowledge application contexts while supporting the overall alignment of training activities with companies' skills needs. It is also worth mentioning specifically the case of North East Romania, which both features mechanisms for engagement between HEIs and business around skills, and, along with the Navarre case, highlights the importance of developing a more nuanced understanding the overall process of graduate entry into labour markets for promoting the effective contribution of HEIs to the skills demands of S3. The Northern Netherlands HEIs are committed to expose students to "innovation workplace", with universities developing learning activities that expose students to activated learning in knowledge application contexts, connecting them to living labs and infrastructures contributing to S3 priorities.

4.3.3 Industrial doctorate programmes

The development of industrial doctorate programmes stands out as a specific action to support high-level skills development aligned with S3 priority areas and regional labour market needs that also serves to forge broader research and knowledge transfer connections between HEIs and business. In the Navarre case, industrial doctorates are cited "as one of the most effective instruments to foster cooperation, establish responsible partnerships, and catalyse a change in the "clash of cultures" between universities and other agents (especially university-business interaction)" (Campillo et al., 2017: 43). They feature most strongly in the Puglia case, where the characteristics of 'innovative industrial doctorates' are subject to significant analysis, and they are mentioned in the Lubelskie case in terms of industrial PhDs being conducted by the Life Science University are in the Lithuanian case in terms of an industrial PhD scheme that was providing funding for a few projects but had not yet gained momentum. Key features of such programmes include their multidisciplinary and transversal skills development, the significant time spent by doctoral students in a company (6-18 months), the involvement of companies in the definition of learning paths, and new learning approaches requiring strict linkage with external stakeholders.

4.3.4 Linking HEIs and VET system

The final category of innovative practices highlighted in this dimension concerns attempts to actively work on linking the activities of HEIs with the Vocational Education and Training (VET) system. Practices in many of the cases allude to the importance of VET for the implementation of S3 and the importance of an integrated approach with the HEI system (for example, the regional observatories in the case of Centre-Val de Loire). This is important to ensure a holistic and applied approach to human capital creation and technological capabilities that is aligned with the S3 through engagement with the private sector. In this regard, the Puglia case includes a detailed analysis of the roles played by their high technology schools (Istituti Tecnici Superiori), which are established as Foundations, owned/governed by enterprises, HEIs, local authorities, organisations from the education and training system, trade unions, social partners, and credit institutions. They have a flexible

structure that provides greater ability to interface with businesses, and facilitates curricula designed in collaboration with the local private sector and with an explicit focus on technological development and employability. The Northern Netherlands has also impressive experiences of joint collaborations between universities, universities of applied sciences and vocational education and training colleges. They share locations where students and researchers collaborate with SMEs on applied research and development. Regional vocational colleges have developed as well their own applied research function (practoraten) to support innovation in regional SMEs and are helping them to better absorb knowledge from HEIs.

4.4 Learning with and from others

This final dimension captures innovative practices identified throughout the cases that relate to the inter-regional or international connectivity of HEIs as a route to supporting the implementation of S3 by facilitating processes of learning with and from others.

4.4.1 Cross-border initiatives and international collaboration

Cross-border initiatives are important because they foster an evolution from university-university collaborations, particularly focused in collaboration among research groups, towards the collaboration with the larger research and innovation ecosystem. This practice features strongly in the Navarre region, that has joined a number of cross-border initiatives over the years, such as the Euroregion Aquitaine-Euskadi and the Working Community of the Pyrenees. Navarre is also a member of three European Territorial Cooperation Programmes: Cross border cooperation Spain-France (POCTEFA), the Interregional Cooperation Programme Atlantic Area (Interreg Atlantic) and Interregional Cooperation Programme South Area (Interreg Sudoe). Most importantly, and directly within the S3 context, Navarre is one of the partnering regions of the Vanguard Initiative and S3 Thematic Platforms, driven by a strong political commitment of the partner regions to use their S3 to boost new growth through bottom-up entrepreneurial innovation and industrial renewal in European priority areas. North Central Bulgaria is also part of number of networks and associations which bring together partners from the Danube Region. Specifically, under the Danube Transnational Programme, Ruse University worked on enhancing cooperation between academic institutions and businesses at the local level.

Leveraging international collaboration more generally is another practice that contributes to the innovation ecosystem and S3 design and implementation by helping universities to learn from others already engaged in collaboration processes with territorial stakeholders and local businesses. For instance, in North East Romania, HEIs endorsed the teaching philosophy embedded in EU programmes such as ERASMUS+ funding programme¹ (e.g. Knowledge Alliances), based on international collaboration and interaction with other stakeholders in developing teaching programmes and are also making efforts to increase international supervision of masters and PhD theses.

4.4.2 Intra-regional HEIs collaborations

The collaborations between higher education within the same region varies considerably among the case study regions. The UNAV and UPNA universities in Navarre region with occasional collaborations in the past or the Northern Netherlands with advanced collaborations among some of the institutions in the region. The 'ARD 2020 Biomédicament' in Centre- Val de Loire financed under the Ambition Recherche & Développement 2020' programme is a good example of initiatives to support systematic collaborations between higher education for the region to become a reference ecosystem in biomedicine research. It brings multidisciplinary expertise present in the region from different research organisations, from the University of Tours, University of Orléans, national research centres (INSERM², CNRS³, INRA⁴), Labex excellence laboratories and other research institutes in the region.

¹ <https://erasmus-plus.ec.europa.eu/>

² INSERM- French National Institute of Health and Medical Research

³ CNRS- French National Centre for Scientific Research

⁴ INRA- French National Institute for Agricultural Research

4.4.3 HESS Study

The HESS study process, and in particular its action-research based methodology that mobilises actors in joint reflection processes, stands out in many of the cases as an important innovative practice that is contributing to the regions' ecosystems and S3 design and implementation in a number of ways. Contributions from the HESS case study could be found particularly in the regions that can be classified as less developed according to the ERDF eligibility criteria, like Eastern Macedonia and Thrace, North East Romania and Lithuania. While in Eastern Macedonia and Thrace the HESS study identified a centre for life-long learning and business incubators in Democritus University of Thrace (DUTH) as having potential to foster stakeholder cooperation to address regional needs, in North East Romania the HESS contributed to involve academic representatives in S3 monitoring and evaluation. Also in transition regions like Northern Netherlands, the HESS study was reported to have had an important contribution by improving regional partnerships between HEIs and public authorities managing S3 and ESI Funds.

Key features found in the cases that support such contributions are: (i) building communities of practice formed by academics and regional development practitioners working to develop a shared vision of the region (ii) building capacities and partnerships as a first step to continue collaborations between public authorities involved in S3 implementation and HE; (iii) offering the opportunity to reintroduce the transformative role of HE and public research organisations in shaping placed-based development strategies; (iv) boosting engagement of HEIs through more coordinated response of their three missions; (v) understanding main challenges to active engagement in S3 and potential actions; (vi) understanding the role that HEIs can play in connecting SMEs to collaborative innovation processes; (vii) understanding actions that HEIs can take to address changing labour market demand and skills-jobs mismatches; and (viii) fostering stakeholder cooperation to address real challenges.

4.4.4 EU Funded programmes

Finally, EU funded programmes are an innovative practice that provide important foundations for learning with and for others. EU funded programmes are reported to contribute to strengthen innovation and ecosystems and to S3 design and implementation by upgrading curricula, modernizing management systems, capacity building for lecturers and creation and strengthening of Technology Transfer Offices and Centres within universities. They also provide incentives and mechanisms for partnerships between universities, and businesses including joint development of curricula and programmes and offering targeted scholarships for students. The European Structural and Investments Funds, European Social Fund and European Regional Development Fund, ERASMUS+, Interreg and Horizon 2020 are among the programmes highlighted in almost all cases.

5 Funding mechanisms for integrating HEIs and S3

Following the identification and discussion of 16 categories of innovative practices in the previous two Sections, we now turn to a brief review of an important transversal dimension regarding the funding mechanisms leveraged to integrate HEIs within S3. While the cases all refer to the use of European funding through the ERDF and other structural funding programmes at European level, this Section focuses on the case-specific initiatives that can be identified across the 11 case studies. Specifically, it makes a case-by-case review of funding schemes relevant for HEIs that are closely related to the S3 or that have a more general impact on the ways in which HEIs contribute to their innovation ecosystems.

5.1 Navarre, Spain

The Government of Navarre has made important efforts to promote specific instruments that boost the engagement of universities with its S3 priorities in ESIF funded calls, in calls funded by the regional administration budget and in calls promoted by the Spanish Government. Under ESIF (2014-2020), calls for funding R&I projects or institutions included S3 priority areas as eligibility criteria. For example, the instruments launched by the regional government to strengthen links between universities, industry and other innovation actors included a “Call for Industrial PhD” to support the development of doctoral studies by universities in partnership with local companies. Another interesting example is the “Call for technology centres and research institutions to develop R&D projects”, which supports collaborative projects implemented by partnerships of research institutions and business to align research with high industrial and market potential. Both calls include alignment to the S3 priority areas as eligibility criteria. Furthermore, the Spanish Science, Technology and Innovation Plan (PCTI) set up new “strategic” calls to support pluri-annual R&D project consortia devoted to specific S3 priority lines. The Government of Navarre has also leveraged national funding schemes aimed at fostering engagement of universities within their territories, such as the Campus of International Excellence programme launched by the Spanish Ministry of Education.

5.2 North-East Romania

Both S3 and higher education, research and innovation policies are pursued at the national level in Romania, posing significant constraints on the implementation of the regional strategies. The National Strategy on Tertiary Education aims at boosting the engagement of HEIs with the economic sector and is implemented through the Administrative Capacity Operational Programme (OP), the Human Capital OP and the Regional OP. The National Research Development and Innovation Strategy (2014-2020) established a vision of building a strong innovation ecosystem to allow Romanian firms to upgrade in global value chains. It supported S3 through a mix of instruments intended to apply to a broad range of activities considered relevant to the improvement of Romania’s competitiveness. Relevant implementing tools were OP Competitiveness (Priority Axis 1); OP Human Capital (Priority Axis 6 – Education and competencies); OP Regional Development (Priority Axis 1 – Promoting technological transfer); and OP Rural Development. However, above all the case shows that actors governing S3 still need to understand whether these sources of funding can support HEIs in their S3 implementation efforts.

5.3 Centre-Val de Loire, France

The existing S3 policy mix in Centre-Val de Loire has successfully involved the main universities, especially in partnerships with industry for knowledge transfer, through a programme named Ambition Recherche Development (ARD) that combines ERDF funding and State funding. The ARD partnerships are mainly focused on knowledge transfer based on research and aim to contribute to the emergence of several world-class research and development hubs and clusters. Complementary co-funded instruments include LE STUDIUM, an agency supported by the region during its initial stages and now benefiting from the European funding of Marie Skłodowska-Curie COFUND programme⁵, which works to hire highly skilled and experienced foreign researchers for the region. In terms of specific financial allocation from the ERDF, Axis 1 (A job-creating knowledge-based society) has been primarily concentrated in ‘Public Research’, ‘Technology Transfer and Cooperation between the University and local SMEs’, ‘Clusters and SMEs’ ‘Direct support to SMEs’ and ‘Entrepreneurship and Spin-offs’. In terms of OP expenditure, data available for 2014-2016 show that universities received 9.62% of total EU funding. Through ERASMUS a range of interesting experiences have been developed by regional stakeholders, including experimenting with recognizing VET competences gained in different contexts and the transfer of skills

⁵ <https://marie-sklodowska-curie-actions.ec.europa.eu/actions/cofund>

and innovation to deliver VET that supports the integration of social responsibility in enterprises. Finally, DEV'UP, the regional development agency coordinating the S3 process, led an INTERREG Project on the entrepreneurial discovery process in partnerships with 10 EU regions.

5.4 North Central Bulgaria

Bulgaria is a highly centralized country, and alongside a top-down approach to S3, regional and local authorities have no formal influence or jurisdiction over HEIs. In this context, EU funded OPs are the key funding source for the implementation of innovation, science and higher education policies. During the 2007-2013 programming period, under OP "Human Resources", universities received funding for upgrading curricula in line with the needs of the labour market, modernizing management systems and capacity building for lecturers. The OP "Competitiveness" also supported the creation and strengthening of Technology Transfer Offices and Technology Centres in different economic sectors, which were mainly established in HEIs, and funded projects supporting research institutions. However, HEIs were only able to access funding through eligible companies, limiting their participation and leading to the establishment of a separate OP specifically targeted at universities. Thus during the 2014-2020 programming period, the OP "Science and Education for Smart Growth" was established to specifically support science and education projects. However, its implementation was delayed due to mishandling of funds that led the European Commission to freeze all payments. The two most important calls for the universities have been the "Creation and Development of Centres of Excellence", and the "Creation and Development of Centres of Competence", but their implementation has been delayed substantially.

5.5 Puglia, Italy

The National OP on Research and Innovation for the programming period 2014-2020 and covering Italian less developed and transition regions outlined two main funding priorities: (1) investing in education, training and vocational training for skills and lifelong learning by developing education and training infrastructure; and (2) research, technological development and innovation. Within this programme, a new funding call on Industrial PhDs or "Innovative Industrial Doctorates" (IID) has been established. The aim was to promote a new vision of PhDs, especially in the South of Italy and in line with innovative doctoral and post-doctoral programmes already implemented in other European countries. Key characteristics of the IID, according to the first call for proposal in 2016, were alignment with the priority thematic areas of the National Smart Specialisation Strategy as well as with the regional labour market needs in terms of high skilled profiles. At the opposite end of the higher education spectrum, the funding of Higher Technical Institutes, a form of technology-based vocational education and training centre, also contributes to the regional innovation ecosystem. Finally, the region is also active in INTERREG programmes which directly contribute to relevant areas of the S3, such as the project "Grasping Innovation in Europe through a closer iNterAction between HEIs and SMEs". Its results have a great potential for smart specialisation areas of the region, whose economy is mostly based on SMEs in sectors like Agri-food and Tourism.

5.6 Lithuania

In Lithuania, research and innovation are wholly dependent on ERDF funding. In the 2007-2013 programming period a significant share of ESIF investments were targeted towards the development of R&I infrastructures in HEIs, justified given the needs of HEIs and the lack of investment in infrastructure in the preceding decade. However, to fully utilise the newly developed infrastructures, HEIs need funding to carry out R&I activities and to attract talent to lead cutting-edge research. More recent financial instruments dedicated to S3 implementation relate to priority measures 1 and 9 of the OP, encompassing the promotion of R&I activities and the reinforcement of human resources. The success in the implementation of the measures has been uneven. For example, the OP objective 1 measure "Joint research-business projects Intellect LT" was planned to be implemented jointly by two Ministries, but due to the lack of cooperation, uncertainties in the application of state aid rules and difficulties in joint management, the Ministry of the Economy and Innovation has implemented the measure alone, funding only SMEs as eligible applicants (HEIs can participate as partners). Moreover, approved contracts under some measures (eg. OP objective 1 measure "Promoting Commercialization and Transnationality of R&I Results") had not yet been signed due to unattractive funding conditions (small fixed grant amounts, unwillingness to engage in economic activities, etc.). In this context, the distribution of ESIF funds among HEIs has been uneven with seven universities receiving the bulk of the funding, 50% of which goes to Vilnius University. The activity of colleges is very low, receiving only 5% of ESIF funding for HEIs. More broadly, in Horizon 2020, 181 out of 217 projects funded were closely linked to S3 priorities, including HEIs, research institutes and businesses. Additionally, ERASMUS+ has enabled students from Lithuanian HEIs to

improve their knowledge by participating in mobility programmes and has greatly facilitated access to internship positions across Europe.

5.7 Lubelskie, Poland

HEIs and institutes from Lubelskie have benefited significantly from ESIF, with funding in the 2007-2013 enabling HEIs and institutes from Lubelskie to implement ambitious infrastructure projects. However, these investments have so far not contributed significantly to the number and value of R&I projects funded by the ESIF or Horizon 2020. While HEIs were very active in the design phase of the S3, during implementation most instruments supporting R&I activities (mainly the Lubelskie Regional OP for 2014-2020) are dedicated to entrepreneurs, so the role of HEIs in implementing the S3 (and especially the OP) is rather low. The Innovation Incubator programme II 2.0, a consortia of HEIs in the field of commercialisation of research is funded by the national OP for Smart Growth and HEIs from Lubelskie are engaged in the implementation of many educational projects funded by the OP Knowledge Education Development, which includes the following measures that can contribute to enhance their role in the innovation ecosystem: (i) Measure 3.1 – competences in HE: increasing the competences of persons participating in higher education to match the needs of the economy, labour market and the society; (ii) Measure 3.2 – doctoral studies: improving education quality and efficiency at PhD studies; (iii) Measure 3.3 – internationalisation of Polish HE: improving accessibility of international education programmes for Poles and foreigners participating in higher education; (iv) Measure 3.4 – management of HEIs: support for organisational changes and increasing the competences of higher education system staff; and (v) Measure 3.5 – complex programmes of HEIs: support for organisational changes and increasing the competences of higher education system staff.

5.8 Eastern Macedonia and Thrace

Most of the policy instruments available to the region for smart growth and for skills/training are designed and managed at the national level and are therefore not tailored to the regional needs and context. The severe fiscal limitations of the period between 2008 and 2018 affected all aspects of non-core HEI activities and infrastructure, including maintaining faculty and administrative posts that have remained vacant when staff retired. The regional S3 by design is heavily dependent on the national OPs and thus the policy instruments used apply mostly at the national level. From the institutional perspective, it seems that regional HEIs participated in the design of the S3 to make sure that the regional ESIF budget allocation would serve their urgent needs for infrastructure and facilities and maximise research project funding opportunities. The region could benefit from the design of more diverse and innovative funding instruments that consider the drivers of HEIs, match with S3 priorities and are complementary with the broader funding instruments landscape. Above all the case highlights that introducing a learning culture in the design and implementation of funding schemes, with a close cooperation with beneficiaries to understand what is working or could be improved would be very positive.

5.9 Lower Austria

Austria has a relatively low ESIF allocation, which in the 2014-2020 programming period has been used as co-financing for a single national OP. However, a well-developed system of multi-level governance has been put into place, with a specific department of the federal Ministry for Science, Research and the Economy being responsible for interacting with the states and distributing funds via intermediary regional bodies. ERDF measures that are designed to meet the regional S3 strategies are strongly co-financed with national and regional funds to multiply their leverage. In Lower Austria, the ERDF has supported the development and coordination of specific research and innovation sites (so-called technopoles), thematic clusters, digital platforms, incubators and start-up services, collaborative research and innovation project funding, as well as physical and research infrastructures. While providing only a small proportion of the overall ESIF regional investment, in comparison to agricultural funds, they have been instrumental in mobilising and developing such innovation support and have placed increasing emphasis on research capacity building. These efforts are combined with national instruments like the COMET Centres, federally funded applied research centres that develop key research and technological development competences through cooperation between science and industry.

5.10 Northern Netherlands

The Northern Netherlands is a relatively innovative economy, where HEIs and other publicly funded knowledge institutions play an important role. That is reflected in the extent to which HEIs have been involved in S3

implementation. There have been 93 funded projects to date under the four priority areas and 36 of those projects involved HEI participants, while 11 were directly led by HEIs and other regional knowledge institutions. Regional HEIs have been in close dialogue with the programme secretariat in the Regional interprovincial authority for the Northern Netherlands (SNN), and through their ongoing dialogue were active in shaping the creation of the funding streams. They have also been important in terms of the drawing down of subsidies, providing co-funding and maximising the impacts of these expenditures on the regional knowledge economy. This importance of HEIs was also evident in the previous programming period (2007-2013), when around 18% of total ERDF subsidies were provided to project consortia including HEIs, and around half that amount was provided to project consortia led by regional HEIs. Furthermore, infrastructure to support knowledge collaborations was also funded, such as the proeftuinen (living laboratories). The Human Capital Agenda is also specifically related to higher education, targeted at creating the skills necessary for the promotion of innovation. Although this only represents 2.4% of total ERDF expenditure in this period, all the funded projects to date include HEIs as partners, and three quarters are led by HEIs. Universities are likewise disproportionately represented in knowledge development projects, representing 15% of all program expenditure but with universities involved in 41% of project expenditure. One of the largest of these projects is Innofest, which funds key regional knowledge partners including HEIs to develop knowledge to be more directly applicable to non-innovative companies that nevertheless have a high innovative potential. In addition, the ERDF Managing Authority SNN has encouraged regional HEIs and other R&I stakeholders to co-create new funding streams, such as the Open Innovation instrument. The instrument encourages structural improvements of the innovation ecosystem through open innovation in collaboration between business, knowledge centres to increase SME innovation potential in emerging innovation areas with clear market potential that have a significant economic and societal impact. Finally, an additional instrument is provided by the REP fund from the Ministry of Economic Affairs, intended to provide a national and regional stream to complement European investments. Out of 12 projects, only one did not involve HEI partners. A number of these projects have related to specifically improving the regional innovation infrastructure around the clusters of strategic interest, most notably investments into Wetsus, the Energy Academy and the Dairy Campus.

5.11 Portugal

The national government has central responsibility for the governance and funding of the HE system in Portugal, and most funding for R&I is directly dependent on ESIF, which is administered at national level by the Thematic Programmes and at regional level through regional OPs. The case study research involved an analysis of approved ESIF co-financed projects and found: (i) Independently of their geographic location, HEIs have operations approved in various OPs; (ii) there were 1.537 projects approved involving HEIs, with the presence of 55 different HEI beneficiaries; (iii) the total eligible expenses for these projects was €645.278.423, of which €519.896.648 was from ESIF; (iv) there are large differences between HEIs in terms of the overall eligible expenses and total value of funds approved; (v) a number of HEIs stand out for having the highest number of projects and funds approved, namely the Universities of Aveiro, Porto, Minho and Coimbra; (vi) the highest number of projects approved was funded by the OP for Competitiveness and Internationalisation (COMPETE 2020); (vii) projects led by HEIs have predominantly been in the first investment priority of the thematic objective on research and innovation, which mostly involves knowledge generation, with only a small number of projects on knowledge transfer led by HEIs; (viii) a substantial amount of spending under thematic objective 10 has been linked to smart specialisation; (ix) the regional operational programmes with the most projects and funds approved were Lisbon, North and Centro. Another interesting finding is the large amount of ESIF spent on projects led by HEIs in the fields of 'education, training and lifelong learning' and 'human' in the Norte region when compared to other regional OPs. Many of these projects, such as technical and professional courses (TeSP) and doctorates, are linked to S3 priorities through eligibility and assessment criteria. This suggests that HEIs in Norte region are assuming a broader role in helping to implement S3 and would be a good candidate for future research.

6 Conclusions

The objective of the HESS project is to analyse how higher education can be better integrated into S3 policy mixes and how the role of higher education institutions in regional economic development can be strengthened. This report presents the results of a cross-case analysis based on the findings of 11 case studies developed by different authors between 2016 and 2021 under previous iterations of the HESS project. All HESS case studies were developed adopting principles of action research, meaning they were carried out with and for the local and/or regional authorities and HEIs in the different regions and countries in which the cases were developed.

A first important conclusion from the cross-case analysis is the importance of place-specific context for policy design and implementation, which is in line with contemporary regional economic development literature. While the heterogeneity of context made it challenging to identify very clear-cut innovative practices with general application, from the detailed analysis across cases a series of categories of innovative practice examples were identified. As a result, the report has developed a structured typology of 16 innovative practices for higher education engagement in innovation ecosystems in the context of the design and implementation of S3, grouped under four broad dimensions.

The heterogeneity of the cases is also strongly reflected in the analysis of the funding mechanisms leveraged to integrate HEIs within S3, from which it is difficult to draw transversal lessons. The cases highlight great diversity of practice in terms of leveraging ERDF funding, which in some cases is heavily oriented towards HEIs and in other cases less so. They also point to the importance of complementary national and regional initiatives to effectively engage HEIs. Moreover, while in general it could be observed that in less developed regions HEIs can assume an even greater role in the animation of innovation dynamics, through access to relevant funding streams, they are also confronted with bigger challenges. Indeed, to be effective recipients of funding that can generate S3-relevant knowledge, provide S3-relevant education and training, knowledge-intensive services and infrastructure, and bridge local knowledge with S3-relevant external sources, HEIs must overcome various internal and external limitations. Nevertheless, the case reports indicate that HEI-oriented funding instruments can be a first important step to engage HEIs in S3 and their wider innovation ecosystem. In more developed territories, on the other hand, while funding was also important, other more sophisticated practices like co-funding and HEIs participating in the development of funding streams come into play.

Returning to the categories of innovative practices themselves, the first dimension 'S3 and HEI Governance' includes innovative practices related to the involvement of HEIs in the governance of the S3 process and to the governance of the HEI system itself, which affects the capacity of HEIs to engage in the S3 process. Innovative practice categories under this dimension found in the cases are (i) Leadership of HEIs in the design and implementation of S3; (ii) Participation of HEIs in S3 governance bodies; (iii) S3 stakeholder representation in HEI governing bodies; and (iv) HEI institutional capacity, coordination and multilevel governance.

The second dimension 'S3 Implementation through HEIs roles in the regional innovation system' moves beyond involvement in S3 governance to include innovative practices that support S3 implementation through the different roles that HEIs play on a day-to-day basis in regional innovation systems. From the cases, the following innovative practices were identified: (i) HE engagement with business; (ii) Connecting SMEs and entrepreneurs to S3; (iii) HEIs engagement with intermediate institutions; and (iv) Mechanisms for embedding HEIs in the innovation ecosystem.

The third dimension 'Regional upgrading through skills development and alignment' singles out the core human capital function of HEIs, strongly reflected in all the HESS case studies, from the broader roles played in S3 implementation. It is composed of the following innovative practices: (i) Explicit focus on human capital built into S3; (ii) Specific initiatives to meet companies' skills needs; (iii) Industrial doctorate programmes; and (iv) Linking HEIs and VET systems.

The final dimension 'Learning with and from others' captures innovative practices related to the cross-border, inter-regional or international connectivity of HEIs as a route to supporting the implementation of S3 by facilitating processes of learning with and from others. The three innovative practices identified are the following: (i) Cross-border initiatives and international collaboration; (ii) The HESS case-study, and (iii) EU funded programmes and instruments.

In terms of the funding mechanisms leveraged to integrate HEIs within S3, the following findings emerge:

- i) The importance of synergies between national and regional funding to adequately address the challenges of higher education to impact their innovation ecosystems. The case studies from North-East Romania, North-Central Bulgaria or Eastern Macedonia and Thrace show that the specific challenges of less developed regions are not necessarily well addressed through a set of

common instruments at national level, and that higher education could have stronger impact on their regions and S3 with better tailored instruments. The capacity of certain regions to integrate synergies of funding from the design of the instruments is a really interesting way of overcoming the challenges for beneficiaries to do this at the project level. The Ambition Recherche Développement in Centre-Val de Loire or the Lower Austria ERDF measures co-financed with national and regional funds are inspiring examples of the use of funding synergies for HEIs to support S3.

- ii) The limited innovativeness of the funding mechanisms introduced to support HEIs contribution to S3 in general. The regions have tended to use rather classical instruments, such as university-business cooperation projects, research infrastructures or entrepreneurship support, and have tended to copycat instruments that have worked in different regional contexts instead of developing tailored instruments. The open innovation instrument, industrial doctorates or Le Studium agency to attract international talent constitute interesting practices exploring new ways of using regional funding to support S3.
- iii) The increasing coherence and complementarity of regional funding instruments to support HEIs contribution to S3. The case studies show that the use of ERDF to support research infrastructures has been quite common. However, in some cases investments in infrastructures are not adequately complemented with investments in R&I projects, policies to attract researchers or innovation managers, etc. The instruments targeting HEIs engagement in S3 should explore more carefully the complementarities within funding instruments, to provide a more consistent and long-term support to boost innovation ecosystems.
- iv) The limited leverage of cross-border and transnational cooperation instruments to boost innovation ecosystems. Analysis of the case studies shows that access to international networks and EU projects is limited in some of the regions and Member States. In other cases, the participation of HEIs in transnational projects is not adequately connected to the S3 process and priorities. All of the HESS case study regions were generally very aware of the EU funding programmes supporting higher education transnational collaborations, but only the most advanced ones are exploring the use of regional funds and cross-border instruments to boost their innovation ecosystems. There is potential to use regional funds for targeted collaborations with other regions in similar S3 priority areas of interest and for addressing common human capital and skills challenges.
- v) Potential to tailor instruments for specific higher education institutions. The case studies show that the national instruments for HEIs are highly competitive and usually the biggest and generalist universities are the ones that capture an important share of funding. The regional instruments targeting specific HEIs (VET, skills, applied research) or encouraging intra-regional higher education collaborations could lead to interesting results in terms of the contribution of HEIs to S3.

Finally, by way of summarising the key lessons from this cross-case analysis, Table 3 brings together the 16 innovative practice categories identified across the four broad dimensions and highlights their key features alongside their contribution to the integration of the knowledge triangle.

Table 3. Key features of innovative practices and support to knowledge triangle.

Dimension	Innovative practice category	Key features of innovative practice	Knowledge triangle integration
<p>S3 and HEI Governance</p>	<p>1. Leadership of HEIs in design and implementation of S3</p>	<p>(i) senior level participation in S3 direction (ii) faculty level participation in S3 dynamics (iii) selection of S3 priorities reflecting HEIs strengths in research and teaching (iv) formal recognition of HEIs' leadership</p>	<p>S3 Entrepreneurial Discovery Process and Governance bodies should engage quadruple helix actors, including business, research organisations, public administrations and citizens. The leadership effect of HEIs is key to mobilise quadruple helix actors, particularly in low capacity regions with weaker administrative capacity.</p>
	<p>2. Participation of HEIs in S3 governance bodies</p>	<p>(i) Explicit recognition of HEIs and research centres as major actors in S3 governance structure (ii) HEIs full involvement in the S3 specialisation domains (iii) Participation of academic representatives in evaluation and advisory roles</p>	
	<p>3. S3 stakeholder representation in HEI governing bodies</p>	<p>(i) Consulting local businesses when preparing (ii) Updating curricula to meet labour market needs (iii) Joint organization of internships and practical lectures</p>	
	<p>4. HEI institutional capacity, coordination and multilevel governance</p>	<p>(i) Importance of regional HEI and Science, Technology and Innovation (STI) coordination bodies mandate (ii) Coordination mechanism for HEIs in the region (iii) Place-based perspective in S3 coordination with national, local and provincial levels</p>	
	<p>5. HEI engagement with business</p>	<p>i) clustering of many research groups around an interdisciplinary topic linked to the territory (ii) operating as well-designed funding instruments that integrate HEIS into the S3</p>	

<p>S3 Implementation through HEIs roles in regional innovation system</p>	<p>6. Connecting SMEs and entrepreneurs to S3</p>	<p>(i) informal networks to access SMEs through alumni networks to help build organisational proximity to facilitate subsequent collaboration</p> <p>(ii) building connections between firms and HEIs through student projects, also involving vocational training</p> <p>(iii) follow-up activities with innovating SMEs that had a useful low-intensity interaction with HEIs</p> <p>(iv) strong animateurs and local policy support; role of universities of applied science to continue activities after the life of the project</p> <p>(v) shared research agendas facilitated by HEIs participating in high level discussions with large companies and lower level discussions with SMEs around applied research and student projects</p> <p>(vi) sustained research directions between HEIs and SMEs building up to larger activities</p> <p>(vii) HEIs leveraging of expert innovators by ensuring that their use of ERDF funds created spill-overs for smaller firms.</p>	<p>S3 participatory dynamics integrate the knowledge triangle by promoting strong interactions between regional stakeholders and national/international actors.</p> <p>Interactions should lead to a shared vision of the S3 priority areas for European Regional Development Funds investments for research and innovation, and a shared long-term innovation agenda for the region.</p>
	<p>7. HEIs engagement with intermediate institutions</p>	<p>(i) Existence of knowledge sharing spaces, such as the ones strengthening the integration of higher education and to foster closer collaboration between technology centres, universities and clusters. (ii) Enabling closer connections between university research groups and companies.</p> <p>(iii) Supporting innovation in businesses through clusters, which can reach across different locations, bringing together companies and research groups in joint thematic innovation development.</p>	
	<p>8. Mechanisms for embedding HEIs in innovation ecosystems</p>	<p>(i) Government departments to address the central role of HEIs</p> <p>(ii) Development of funding schemes for cooperation with HEIs</p>	

		<ul style="list-style-type: none"> (iii) Active involvement in collective arrangements created to encourage collaboration with regional innovation ecosystems (iv) Launching new areas of activity at the interface of different fields of science through interdisciplinarity (v) Capacity to bring together a critical mass of key research and technological development competences through cooperation between science and industry aligned with S3 priorities (vi) HEIs targeted funding instruments with S3 priority areas as eligible criteria or university-business collaboration programmes 	
Regional upgrading through skills development and alignment	9. Explicit focus on human capital built into S3	<ul style="list-style-type: none"> i) Strengthening entrepreneurs, businesses and HEIs collaborations (ii) Identification of key regional challenges to guide HEI action relating to their training function (iii) Alignment of curricula with S3 priorities (iii) Collaboration to establish skills needs for specific areas such as new market development or training for innovation management (iv) Developing bridging initiatives (v) Talent attraction and retention programmes 	<p>S3 brings together the education, research and innovation mission of HEIs in a more coherent and comprehensive way, ensuring the impact of HEIs in their territories.</p> <p>The European Regional Development Fund for 2021-2027 includes a specific objective to invest in 'Skills for smart specialisation, industrial transition and entrepreneurship'.</p>
	10. Specific initiatives to meet companies' skills needs	<ul style="list-style-type: none"> (i) Mechanisms to identify regional skills needs (ii) Students exposure to active learning (iii) Graduate labour market tracking system (iv) Connecting students to research infrastructures and living labs in S3 fields 	
	11. Industrial doctorate programmes	<ul style="list-style-type: none"> (i) Multidisciplinarity and transversal skills 	

		<p>(ii) Time spent by doctoral students in a company (6-18 months)</p> <p>(iii) Companies involvement in the definition of learning paths</p> <p>(iv) New learning approaches liaising with external stakeholders</p>	
	12. Linking HEIs and VET system	<p>(i) Importance of VET for S3 implementation and integrated vision of regional skills needs approach</p> <p>(ii) Human capital creation and technological capabilities aligned with the S3 through engagement with the private sector</p>	
Learning with and from others	13. Cross-border initiatives and International collaboration	(i) Contributes to the innovation ecosystem and S3 design and implementation by helping universities to learn from others already engaged in collaboration processes with territorial stakeholders and local businesses.	The collaboration across regional innovation ecosystems are helping address common European challenges, reinforcing EU value chains and bridge fragmentation, facilitating synergies between EU funding programmes and initiatives
	14. HEIs intra-regional collaborations	<p>(i) Connects higher education capacities in the region to better respond to regional challenges and needs</p> <p>(ii) Acknowledges the diverse ways in which higher education can contribute to their region, looking to complementarities</p>	
	15. HESS study	(i) Action-research methodology driven case studies characterised by actors willing to explore the capacities and challenges of the region, and co-create solutions through co-leadership approach	
	16. EU funded programmes	<p>(i) EU collaborations and networks as a way to learn from international players and other regional practices</p> <p>(ii) HEIs networks leveraging effect for regional players with less international exposure and experience</p>	

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List of abbreviations and definitions

ARD	Ambition Recherche Développement
CNRS	French National Centre for Scientific Research
COMET	Competence Centres for Excellent Technologies
COMUE	Community of universities and education institutions
CORIT	Research, Innovation and Technology Coordination Council
DEV'UP	Regional economic development agency of Centre-Val de Loire region
DUTH	Democritus University of Thrace
EDP	Entrepreneurial Discovery Process
EIT	European Institute of Innovation and Technology
ERDF	European Regional Development Funds
ESIF	European Structural and Investment Funds
ETCP	European Territorial Cooperation Programme
EU	European Union
HE	Higher Education
HEI	Higher Education Institution
HESS	Higher Education for Smart Specialisation
IID	Innovative Industrial Doctorates
INRA	French National Institute for Agricultural Research
INSERM	French National Institute of Health and Medical Research
INTERREG ATLANTIC	Interregional Cooperation Programme Atlantic Area
INTERREG SUDOE	Interregional Cooperation Programme South Area
ITS	Istituti Tecnici Superiori (high technology schools)
JRC	Joint Research Centre
KIC	Knowledge and Innovation Community
LabEx	French Laboratory of Excellence
OP	Operational Programme under EU Structural and Investment Funds
PCTI	Spanish Science, Technology and Innovation Plan
POCTEFA	Cross-border Cooperation Programme Spain-France
R&I	Research and Innovation
R&D	Research and Development
SME	Small and medium size enterprise
SNN	Regional interprovincial authority for the Northern Netherlands coordinating S3
S3	Smart Specialisation Strategy
STI	Science, Technology and Innovation
SWOT	Strengths, Weaknesses, Opportunities and Threats
UNAV	University of Navarre
UPNA	Public University of Navarre
VET	Vocational Education and Training

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