BEYOND 4.0

Regional report: entrepreneurial ecosystems in six European countries

D4.1 Analysis of incumbent and emerging ecosystems in Finland, Bulgaria, Spain, Germany, United Kingdom, and The Netherlands

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Document description

This report covers three research activities:

- *firstly, it describes fourteen cases of entrepreneurial ecosystems in eight regions in six EU countries, based upon desk research into quantitative indicators, interviews and workshops with actors from the respective ecosystems. In the description, we provide information about the elements of the ecosystems, the impact of digital transformation on the ecosystems and the social and economic outcomes of the ecosystems.*
- *Secondly, with this description, the report contributes to a novel perspective on the working of the entrepreneurial ecosystem by comparing the findings across ecosystems. The qualitative and comparative approach taken in this report provides additional information on how ecosystems operate and the role of the different elements.*
- *Thirdly, this report offers conclusions on the working of entrepreneurial ecosystems to be discussed broader within the BEYOND4.0 project. These discussions will be with relevant stakeholders. These workshop findings will be the basis and serve as input for policy advice for regional, national and supranational authorities.*

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Abbreviations

EE = entrepreneurial ecosystem

IEE = incumbent entrepreneurial ecosystem

IEEs = incumbent entrepreneurial ecosystems

EEE = emerging entrepreneurial ecosystem

EEEs = emerging entrepreneurial ecosystems

UU = University of Utrecht

ICT = Information and Communication Technology

BPO = Business Process Outsourcing

Summary

Objective

The objective of Work Package 4 (WP4) of the BEYOND4.0 project, "Inclusive Futures for Europe BEYOND the impacts of Industry 4.0 and Digital Disruption", is to develop a new understanding of the economic impact of the digital transformation on regions. It assesses how digital transformations impact regional ecosystems, economies and societies, now and in the future. Regions selected for analysis include: Salo, Oulu (Finland), Brainport Eindhoven (Netherlands), Sofia (Bulgaria), West-Midlands (United Kingdom), Rhine-Ruhr (Germany) and the Basque Country (Spain).

This report develops a research framework to answer these questions. This is done by relating the discussion on ecosystems to the scientific debate, deducting more specific research questions and hypotheses, relating the questions in a research framework, developing a sound methodology to answer these questions, and then presenting the results. The results form the basis to achieve this report's scientific and policy objectives.

The study is unique in several ways. It is an in-depth study looking into fourteen ecosystems in six countries. It combines quantitative and qualitative data and methods to understand how the performance in these ecosystems has changed over time and how they adapted to the digital transformation. It adds the perspective of how new entrepreneurial ecosystems can emerge. The study also relates the performance to our societies' digital transformation and inclusive results for employees in these ecosystems.

Expanding the theory on entrepreneurial ecosystems

The study uses the perspective of Stam & Spigel (2018) on the entrepreneurial ecosystem. These are seen as a ´set of interdependent actors and factors that are governed to enable productive entrepreneurship within a particular territory´. Entrepreneurship is a crucial driver of economic change, with main innovation, diffusion, and competition mechanisms. The impact of an ecosystem depends on context and type of entrepreneurship (ambitious vs necessity entrepreneurship). Formal institutions matter for how the ecosystem functions and what kind of output it produces (Stam, 2015).

Ten elements play a role in creating value through entrepreneurial activity: four framework conditions (formal institutions, culture, physical infrastructure & demand) and six systemic conditions (networks, leadership, finance, talent, knowledge & support services/intermediaries) (Stam, 2015). The analysis departs from the logic that elements in an ecosystem are substitutable, and there are many different possible pathways to a high-performing entrepreneurial ecosystem (Schrijvers, Stam and Bosma, 2021).

Schrijvers et al. (2021) have developed a Qualitative Comparative Analysis (QCA) of 273 regions in Europe with four main Entrepreneurial Ecosystem (EES) configurations that help as a reference point for this report. The performance of entrepreneurial ecosystems is measured with proxies for productive entrepreneurship (i.e. innovative start-ups and unicorn firms). Their findings indicate different configurations of successful entrepreneurial ecosystems. There is thus not one perfect configuration that all successful ecosystems exhibit (Schrijvers et al., 2021).

To this logic, we want to add the perspective of 'institutional voids' (Bendickson et al., 2021). If not all conditions may be needed for productive entrepreneurship, this raises the question of how certain ecosystems can generate high outputs without being all-around entrepreneurial ecosystems. Institutional voids are defined as weaknesses in or absence of institutional support (Bendickson et al., 2021). They arise "when the population, and thus the tax base decreases, leading to issues with unemployment, crime, and corruption" (117).

We expand the research on entrepreneurial ecosystems in several ways. The first is by looking more in-depth into the functioning of entrepreneurial ecosystems. BEYOND4.0 starts from several regional cases and applies a qualitative approach to understand the operation of these ecosystems in more detail and understand the impact of the digital transformation. Such an analysis allows for digging deeper into the significance of institutional voids and how regions overcome such voids (see Bendickson et al., 2021). As indicated, we make the distinction between incumbent and emerging ecosystems. As Hannigan (et al., 2021) indicate, actors in incumbent entrepreneurial ecosystems probably spend a lot of activity on organisational maintenance activities rather than on innovation and new knowledge creation. Incumbent ecosystems may be losing out on entrepreneurship. That is why it is necessary to look at emerging ecosystems. The BEYOND4.0 research addresses several emerging entrepreneurial ecosystems. Comparing these incumbent and emerging ecosystems provides a more robust understanding of the working elements in these different entrepreneurial ecosystems. The next addition is that we are looking at the impact of the digital transformation on the functioning of ecosystems. Digital technologies should not only be seen as a risk for ecosystems. They may also bring opportunities for knowledge spillovers within ecosystems to drive new economic growth. The entrepreneurial ecosystem model is used to understand what drives entrepreneurship at a regional or national level. Less understanding exists of how knowledge spillovers enable entrepreneurial activity and industry emergence. We add to the entrepreneurial ecosystem approach the knowledge spillover theory of entrepreneurship. BEYOND4.0 is focused on knowledge spillovers and how they drive innovations and the adoption of new ideas (Audretsch, Keilbach, Lehmann, 2005). The regional proximity of companies, knowledge institutions and other stakeholders help share knowledge to deal with all kinds of challenges (Qian, 2018). To understand this transfer, we develop a specific taxonomy of three kinds of knowledge transfer within an ecosystem: from education to companies, from companies to companies, and from public institutions to companies. A last addition of BEYOND4.0 is that we are looking at inclusive growth outcomes. The question is how value creation is distributed within a region. How does this distribution contribute to the sustainability of an ecosystem in the longer term? Do the ecosystems value 'inclusive innovation', and what kind of dynamic is prevalent in how actors operate to achieve this inclusiveness (Bramwell, 2021)?

This expanded framework is included in Figure 1.

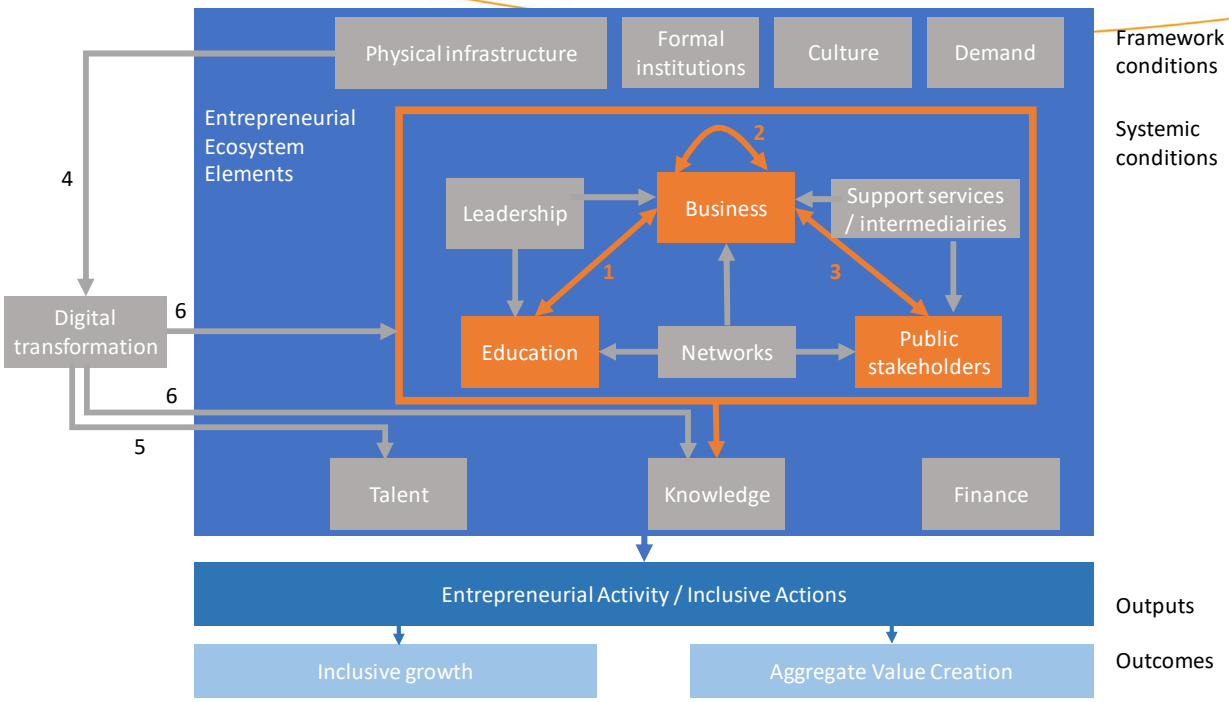

Figure 1. The expanded framework of the entrepreneurial ecosystem and its elements, based on Stam (2015)

The model of Stam (2015) has been redrafted by this study. At the core of the entrepreneurial ecosystem are the knowledge spillovers. The fact that knowledge spillovers exist and are stimulated at the regional level drives the success of specific regions and ecosystems. To understand the knowledge spillovers, three specific spillovers are in focus: between education and business (arrow 1), between businesses (arrow 2), and between business and public stakeholders (arrow 3). The figure allows integrating the information of the three systemic conditions of the Stam-model in these knowledge spillovers. We are interested in what degree such knowledge spillovers exist in entrepreneurial ecosystems and how successful these spillovers are. The 'knowledge' indicator, as measured by the Stam-model, measures the degree of success of these spillovers. The digital transformation affects the talent base in a region (arrow 5). This relationship requires specific analysis and will result from exploratory discussions with stakeholders in the ecosystems (Proeger & Runst, 2020). The digital transformation is also seen as a knowledge spillover for companies and regions. In the framework, these relationships (arrows 6) are explored in the discussions with stakeholders in the ecosystems.

This study focuses on two outputs: the impact of the digital transformation on entrepreneurial activity (does a shift to more digital sectors, business models, and products help in the rise of start-ups and new activity?); and, secondly, the impact on inclusive growth. For inclusive growth, the focus is first on the gender distribution in employment, second on the distributional effects of unemployment among educational groups, and lastly on how the growth of people at risk of poverty and social exclusion have developed themselves. These data have been calculated from the Eurostat

data. There is insufficient information about wage development for the regions and over time in the Regional Innovation Scoreboard (2021). Impacts such as polarisation cannot be checked. However, the case studies provide some data here and will be studied in WP8.

A regional comparative-analytical framework

This project connects the functioning of the entrepreneurial ecosystems as described by the Stam-model to the digital transformation and inclusive growth. We use a comparative methodology to develop understanding and require a comparative-analytical framework to understand our results. First, the entrepreneurial ecosystem is studied as a system. The study looks within a region for an industrial sector or business relevant to studying the digital transformation and its 'Industry 4.0' characteristics. The focus also needs to include how knowledge spillovers work between the three identified actors: education, public stakeholders and companies. For this purpose, the entrepreneurial ecosystem model is instrumental, as it distinguished ten rather tangible elements that determine its success (Stam and Van de Ven, 2019). The challenge herewith is to find meaningful data of all ten elements by which one can compare the different ecosystems across Europe.

Figure 2 illustrates which comparisons are conducted to answer the different research questions.

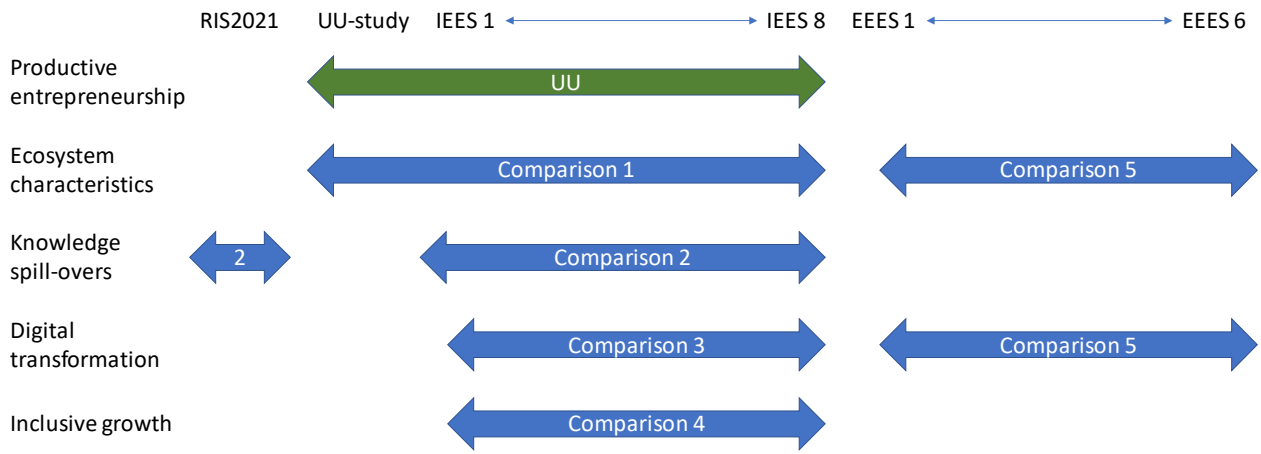

Figure 2. A regional comparative-analytical framework (UU = study by Mirella Schrijvers (2020))

The first comparison **(1)** is between the Schrijvers (et al., 2020)-study and in-depth case studies of incumbent ecosystems. This comparison allows us to understand how well the Stam-model explains what is happening within an ecosystem and which elements of the Stam-model may need further development? The comparison between incumbent entrepreneurial ecosystems, and next, between incumbent and emerging ecosystems, helps us develop a deeper understanding of the functioning and challenges of the ecosystems, given the digital transformation **(2)**. The second

comparison looks at the influence of the digital transformation on the IEEs **(3)**. First, we try to understand how the industrial networks saw themselves affected by the digital transformation. Are their business models under threat? Secondly, how does the IEEs tackle the threats and opportunities the digital transformation brings? The third comparison focuses on clarifying how the development of the IEEs can be seen as inclusive **(4)**. The focus is on work and human capital, social inclusion and distributional effects. The last comparison **(5)** is between the EEEs. We also refer to the Stam-model to describe the EEEs.

Selection of regions and cases

We conducted in-depth qualitative research into 'incumbent' and 'emerging' ecosystems in six countries: Finland, Bulgaria, Germany, the United Kingdom, Spain and the Netherlands. In total, we have studied eight different regions (namely two different (NUTS) regions in Finland and Germany) and fourteen ecosystems (six incumbent with two double cases, six emerging). The selection of regions has been made in a pragmatic way. The six research teams have been asked to select an incumbent and emerging entrepreneurial ecosystem in their respective countries, showing Industry 4.0 activities and confronted with digitalisation. The selection needed to follow the NUTS2 level and identify ecosystems that allow the assessment of the impact of the digital transformation. The actual selection is clarified further.

Table 1. BEYOND4.0 incumbent entrepreneurial ecosystems and description of major changes in the business ecosystem (source: regional reports, footnote 7)

Beyond4.0 region	Dominant business ecosystem	Change 2010-2022
Salo	Mobile technology	The Nokia business ecosystem collapsed in 2011. The region shows a strong decline. After 2018, Valmet started with battery production, using Industry 4.0 technologies (robotisation, IoT)
Oulu	Mobile technology; Wood Processing	The region experiences the replacement of Nokia business ecosystem by the emerging ICT ecosystems and incumbent wood processing. Both new sectors develop new avenues with Industry 4.0 technologies (IoT, informatisation).
Sofia	ICT sector	The continuous growth of ICT, branching out. This is not an industry sector, but the focus is on supplying industrial ICT solutions to the whole of Europe and North America. In this sense, they are driving Industry 4.0 efforts.
Duisburg	Steel sector	The sector experiences a steady decline of heavy steel, continuing restructuring. The new solutions lie in integrating digital solutions in the production systems.
Dortmund	Steel sector	The steel business ecosystem is not dominant anymore, new business ecosystems are on the rise.
Zuidoost Noord-Brabant	Advanced manufacturing	Advanced manufacturing has taken over the role as the dominant business ecosystem. This sector is at the core of the Dutch Smart Industry (or Industry 4.0).
Basque Country	Machine tool	This sector is also slowly declining, but still the most important business ecosystem in the region. The machine tool is representative of Industry 4.0 in Spain.
West Midlands	Car manufacturing	This is a slow declining sector, but still the most important business ecosystem in the region. Car manufacturing uses a great degree of robotisation and other Industry 4.0 technologies.

The 'emerging' ecosystems selected for this study are new industrial networks in development. They can also be reviving networks where new economic activities emerge or collapsed areas that revive. They are, per definition, not yet top-performers of productive entrepreneurship (anymore), as indicated for incumbent systems. We have selected the following networks.

Table 2. An overview of selected industrial networks that are aimed to support entrepreneurial ecosystems (source: regional reports, footnote 7)

Beyond4.0 region	Main aim of the EEEs
Finland: emerging Digital and Health EEEs (Salo & Oulu)	To help revive the region with new industrial growth networks.
Bulgaria: BPO EEEs (Sofia)	An extra industrial network, building on the IEE-strength
Basque country: Smart mobility EEEs	An extra industrial network, building on the IEE-strength
Germany: Logistics EEEs (Dortmund)	To help revive the region with new industrial growth networks.
United Kingdom: Digital Healthcare	A new industrial network to broaden the regional strengths, building on the national Health sector strength
Netherlands: Aerospace EEEs West North-Brabant	To support a region to make better use of existing public infrastructure and develop new industrial networks. Some actors are spin-offs of the older Fokker ecosystem.

Conclusions

The main objective of the study has been researched with the following three questions:

Question 1: How do regions successfully achieve inclusive economic growth, and which elements of the entrepreneurial ecosystems in these regions play a decisive role? How can ecosystems and regions respond and adapt based on the elements of the entrepreneurial ecosystem model? What does the distinction between incumbent and emerging entrepreneurial ecosystems bring?

This question has been broken down into several questions.

1. How entrepreneurial are the regions?

The selected incumbent ecosystems for this study spread across the entrepreneurial output index, with five ecosystems in the top quarter entrepreneurial output ranking. The diversity in case studies on the output side informs us about what works and how differences can be explained. The performance of Sofia ICT IEE is an outlier in the results. The reason for this is that the international and domestic investors in the ICT-sector, insulate themselves from the local environment. The international performance does not reflect the regional statistical information. Even after this study, it remains difficult to assess the regions' performance. The ecosystem of Salo performs still strongly in the entrepreneurial output data (see performance subgroup 'strong innovator +' (RIS: European Commission, 2021a), but in the knowledge spillover data, Salo has lower ratings for three core indicators. West Midlands, Noord-Brabant, Oulu, and the Basque Country perform strongly in each

output table. These cases constitute half of the IEEs sample, rendering a comparison not that relevant. We mainly learned more about was needed to be a leading ecosystem.

2. Which elements are driving the entrepreneurship of the incumbent entrepreneurial ecosystems? How can we evaluate the impact of institutional voids?

A first observation is that about one-third of the qualifications of the entrepreneurial conditions in the Schrijvers-study ((et al., forthcoming) differ from the results in this report. The discrepancies are the different scope of the studies (regional data is broader than the ecosystem perspective) and the different time perspectives. The case studies inform us about several conditions that have more impact on entrepreneurial activity than a statistical study can uncover. One main concern with the evaluation from the Stam-model is that successful ecosystems are more and more becoming 'settled' ecosystems. Actors in incumbent entrepreneurial ecosystems focus on organisational maintenance rather than new entrepreneurial activity (Hannigan et al., 2021). The entrepreneurial ecosystem model seems to be recognised by actors from the ecosystems as a useful tool for investigating and assessing these ecosystems.

Some elements in the functioning of the cases, however, are problematic. The **(regional) demand** element is considered irrelevant because most of the production generated in the ecosystem is not sold in the region. Furthermore, the elements of **Leadership** and **Services of intermediaries** are unclear to respondents, and it is not very easy to compare the findings on these elements across ecosystems.

Regarding the interplay between conditions that create success for the ecosystem, there is still a lot of work to be done. Considering the core conditions, most respondents address **Talent** as the main explanation for entrepreneurial success. Performance of the ecosystems can be explained to access to sufficient talent. A lack of talent translates into less entrepreneurial activity. Furthermore, the elements of **Formal institutions** and **Physical infrastructure** are considered 'necessary' (but not sufficient) conditions for the success of ecosystems. A well-functioning social network is often reported as the success (result) of the ecosystem, not as an 'input' element. We find mixed results for **Knowledge, Finance**, and **Entrepreneurship culture** elements. Most respondents characterise these elements as important resources for businesses, but often they consider them not as important as the element of Talent. For **Knowledge**, more in-depth insight into the knowledge spillovers that can be achieved is helpful to understand what drives entrepreneurial activity.

3. How do knowledge transfers occur in the IEEs?

The analysis shows that no region outperforms the others for innovation performance. Sofia shows a remarkable growth in R&D personnel and employment in knowledge-intensive sectors. They have caught up with the rest of Europe and are even in a leadership position. For **Sofia**, the main institutional voids are the connection between education and companies, and between companies. Here, the integration into the international (software) supply networks seem to help the sector perform. However, the many institutional voids do point to several economic risks the region runs. The ICT sector chooses to remain insulated from the political regime, but the growing social distance from the region may lead to major problems in the future. Also, without sufficient local support to develop its knowledge position, the sector remains at the mercy of the international conglomerates. The **two German regions** have similar outcome results, underperforming for all indicators except

for the employment in innovative SMEs. Investment in knowledge-intensive sectors is down, but innovative SMEs may counter-balance this. The dominance of the steel industry reduces the use of the different knowledge spillover mechanisms. Since most of (institutional) support seems directed towards the leading Steel IEE, companies can only rely on their direct collaboration to create entrepreneurial activity. The **Basque Country** has many employed in knowledge-intensive sectors and shows relatively high innovation expenditures. Public support drives most of the knowledge spillovers. Even if companies do drive several types of spillover, the guidance of major programmes is crucial to achieving the necessary new ideas. **Noord-Brabant** is seen as an innovation leader, but the figures show weaknesses for overall investments and innovative SMEs. Possibly, the cause is that there are so many possibilities to exchange ideas between leading innovators that SMEs cannot find their place. **Salo** has felt the impact of the closure of Nokia in the hardest way. The Salo region shows that several institutional voids have arisen. Only employment in innovative SMEs seems to help the region. **Oulu** has only experienced a decline in employment in knowledge-intensive activities or professions but sees high levels of R&D investment and action from innovative SMEs. Oulu shows the use of most of the knowledge spillovers. The same may be said of the **West Midlands**, with OEMs leading overall investment and innovation in the IEE and SMEs needing further investments and talent to strengthen their position in terms of digital transformation. The results also indicate that regions can suffer several institutional voids and still become top-performers on several indicators. Regions need to have a broad perspective on the outcome side too. It is not sufficient only to be a leader in patents etc., novel entrepreneurial activity among SMEs also needs to be developed. The figures show that there can never be a moment of rest for policymakers. Complacency in stimulating entrepreneurial activity can easily arise.

4. How do emerging entrepreneurial ecosystems perform?

The first question is if the emerging entrepreneurial ecosystem distinction is helpful. In the selection of emerging ecosystems, very different activities were selected. Only one of the ecosystems stood outside existing incumbent entrepreneurial ecosystems. The Dutch Aerospace cluster is looking for new paths forward, building on the remains of the demised Fokker aviation industry. The five other ecosystems are either spin-offs (Sofia BPO EEE, Basque Smart Mobility) or new ventures next to an IEEE (German Logistics EEE, Finnish Digital + Health EEE, UK Digital Health). This means that we have three different EEEs and that these differences affect the building and scale-up conditions for entrepreneurship.

From the comparison of the entrepreneurship conditions, it appears that the **Basque Smart Mobility EEEs** covers all conditions to operate as an incumbent EES. The initiative should be able to stimulate new entrepreneurial activity in the Basque Country. New products and services appear to function under major companies' umbrellas in the region. These companies reduce the risks for new products and services to launch, and work as knowledge spillover context to these new initiatives. The **Bulgarian BPO EEE** shows many of the same strengths of the Basque Smart Mobility EEE, but at the same time, the weaknesses of the ICT IEE it has sprung from. The EEE is embedded in much the same international company networks and lacks strong support from Sofia's knowledge and institutional networks. These facts help the sector arise, and at the same time, put it at risk. The support from international companies may disappear overnight. Insufficient knowledge support inside the region is needed to secure longer-term development. The **German Logistics EEE** has

successfully developed a broad set of initiatives and start-ups. The current success of the EEE arises from knowledge partnerships in which Fraunhofer IML plays an important role. The sector's future depends greatly on the ability to attract funding and sufficient high-skilled talent. The **Oulu Digital and Health EEE** case developed itself on the remains of Nokia. The advantage was the abundant supply of knowledge. Still, the EEE sees this systemic condition still as a risk for the future. The **Dutch Aerospace EEE** is quite different from the other cases. It would seem that the Dutch ministry of defence's support is an important help as a launching customer. From the discussions, this defence context is at the same time a barrier for growth. The interests of the different stakeholders still need to be aligned. The main issue remains with the EEEs themselves. The main actors are not aligned with the Aerospace cluster's direction. A lead company has been missing. Entrepreneurial activity has remained limited, mainly because of this lack of direction. The **United Kingdom Digital Health EEE** cases still have a lot of work to achieve a positive launching condition. R&D companies in the EEE are leading developments, but these are limited in terms of scope due to ICT infrastructure at the intermediary and consumer level. Nevertheless, national funding and report requirements are driving changes.

The comparison of the EEEs on the framework and systemic conditions shows more positive scores for conditions than was visible for the IEEs. This is, however, a misleading result, mainly because the performance of these EEEs cannot be fully evaluated. Only the future will tell if these evaluations are more wishful thinking or reality. The EEEs can use the EE-model to improve their situation, but overly optimistic evaluations should be countered by measuring the output side simultaneously. The entrepreneurial ecosystem model seems to be recognized by actors from the ecosystems as valuable for investigating and assessing these ecosystems. However, for emerging ecosystems, more elements are problematic. The core condition, Knowledge, is only well organised in two EEEs. The analysis of the knowledge spillovers shows different approaches used by the EEEs to find and develop new ideas. Finance is a complicated condition, mainly because these innovative sectors have difficulty in attracting sufficient private funding. Most of the networks rely on some kind of public funding. The element of (regional) Demand may be considered irrelevant in most regions, however, the public sector seems to be a leading customer in most cases. For the EEEs to use this support, they need to understand how to use such support. Locked into public sector logic is rarely helpful for entrepreneurial activity. Leadership and Services of intermediaries are seen as necessary conditions for very high productive entrepreneurship in the whole of Europe. Without clear Leadership, all the other elements of the Stam-model do not fall into the right place. The Services by intermediaries require more attention in all EEEs, and it would be helpful to have better tools to evaluate the quality of this support. Talent is only sufficiently present in the Basque and Bulgarian cases, mainly because they are part of the IEEs. Talent needs to be sufficiently present for an ecosystem even to consider launching. For the other four EES, this war on talent may not be an international issue but more war with incumbent IEEs for future growth opportunities.

Regarding the question of the right interplay between elements that create success (or lack thereof) for the ecosystem, there is still a lot of work to be done. Policymakers need to bank on a lot of elements to create successful EEEs. An easy recipe is not yet available.

Question 2: How do entrepreneurial ecosystems deal with the digital transformation?

For this question, the answers for the IEEs and EEEs need to be integrated. The differences between these ecosystems are also reflected in digital technologies. The IEEs are built on legacy ICT systems, and the digital transformation means integration of the legacy systems in the next software contexts. That is not an easy task. It also explains why digital transformation is a slow-moving process in these IEEs. The EEEs have been created to profit from the digital transformation opportunities. Digitalisation allows new products for Digital + Health, new last-mile solutions in the Logistics sector, new BPO-solutions and Smart Mobility. Digital technology is already a constituting element of the entrepreneurial ecosystem model. Regions need to be able to rely on digital sound infrastructure. Therefore, it is not a changing context but a necessary condition for entrepreneurship. This is acknowledged in all EEs and, therefore, not a factor that allows us to differentiate between cases. Digitalisation also appears in the Talent condition, since sufficient e-skills in a region are seen as a precondition for companies to absorb the opportunities of digitalisation. The digital literacy of the ecosystems shows a strong spread in practices. Sofia rates as very low as a digitally-minded region, which is in contradiction with the existence of the ICT IEEs. The other regions vary between medium positions to lead regions in the level of digital skills. This study adds two extra elements. The first is that the companies need to have adopted the digital technologies themselves. The second is that digitalisation needs to lead to new business models (Proeger & Runst, 2020). The response to question 2 addresses these two extra elements. These elements show how the EEs have picked up the digital transformation.

The environment and the 'stock' of skills in a region do not yet uncover what the digital transformation is doing to the companies in an ecosystem. The **presence of IT-specialists** is remarkedly different from the e-skills distribution in the population, as shown by the RIS2021 (European Commission, 2021a). Sofia shows an extremely low (normalised) score for digital skills in the population. On the other hand, their position for IT-specialists far exceeds the position of all other regions. It is clear that Sofia is an IT-intensive region, with a great number of IT specialists. However, these figures also confirm that Sofia's digital divide is quite pronounced. Digital technologies seem not to be common in the Bulgarian household. The reverse seems to be the case in the other regions. The number of IT-specialists is a better reflection of the need for high-level IT-knowledge. It does not reflect how digitalisation affects the business models in the EEs.

What we see is that companies in four of the ecosystems are driving the digitalisation in the world. What they do, forces other companies to change their practices. The mobile technology sector of Oulu, Brainport, the ICT IEE in Sofia and the digital health EEE in the West Midlands are major players in developing and application of digital technologies. The Basque machine tool IEE and the German Steel IEE see themselves as digital technologies consumers. In the Sofia, Dutch and Spanish cases, the new technologies allow attracting even more business to the region. In the UK, new technologies are attracting more businesses at a national level and limited infrastructure at the local level. The question is if these contexts are sufficient to deal with the digital transformation. Many of our respondents indicate that the digital transformation in the IEEs is still in its infancy in many respects and the current trends are just the beginning. The data and the discussions with stakeholders do not show that the regions are home to the new Amazon-type of companies. New digital business models are still rare in these IEEs. In addition, some respondents refer to a lack of action on behalf of the government (Bulgaria), some (Spain, Germany) report that stakeholders

show a sufficient level of awareness, but concrete action is sometimes lacking. In the IEEs, digitalisation is integrated into the production systems and service models, merely in a traditional way. The business models are not yet changing. The companies achieve extra efficiency, but mainly using the new technologies in the same way they have been doing with automation and mechanisation. Given sufficient digital infrastructure and high-level digital skills, more could be expected at the level of business models and technology adoption. More entrepreneurial possibilities should be possible with the technologies.

The contrast with the EEEs is striking. The digital transformation is the main driver of entrepreneurship in the EEEs. Digital technologies such as AI, IoT and Big Data analysis are crucial for start-ups and innovation efforts. For all EEEs, digital technologies are well present and used to develop new propositions and products except for the Dutch Aerospace cluster. For these five EEEs, the technologies are the reason to develop new business models.

These results explain why few of the stakeholders see digital technologies as a threat to current employment in the ecosystems. In the IEEs, a lot of employment opportunities arise for the companies to deal with changing their legacy systems. The EEEs require a constant stream of highly skilled talent to keep on growing. On the question of whether there may be future impacts on employment, the reactions of the stakeholders are more pessimistic. This pessimism does not inform concrete actions from the ecosystems. The digital transformation impacts both EEs as an enabler of change and more employment, but for very different reasons. Context does matter.

Question 3: How does the digital transformation affect new skills and competencies and employment and educational levels? What are the inclusive-growth related impacts of digital transformation at the ecosystem and regional level? What can be concluded about the regional strategies of economic development and inclusiveness in the studied emerging and incumbent ecosystem?

Well-developed entrepreneurial ecosystems generate more economic growth, and with economic growth arise better employment and life opportunities for the population in those regions. This requires that these opportunities are distributed in a fair and equal way. The analysis is limited to the IEEs: the issue with EEEs is that there is not really a comparison base: the organisations are mainly start-ups, and the life situation is not mapped in major statistics. For five of the EEs, the EEEs overlap with the IEEs. It is impossible to untangle results.

The comparison shows that all regions show rising employment and disappearing unemployment levels. This is not only because of better general economic conditions but also because of the performance of the IEEs in several of the cases. For at least three of the regions, the changes in employment and unemployment are related to the growth of the IEEs: the Finnish regions, Sofia ICT IEE and Brainport. The impact of the changes is different, mainly because of the different starting contexts. The Finnish cases had to absorb the closure of Nokia plants. Sofia has experienced mainly employment growth in the ICT cluster, and Brainport seems to have reached the limits of employment growth with personnel from the region, but even with finding the expert technical expertise at a global scale. Men and women have profited from both of these developments, with

some minor differences between regions. However, not all changes have been in the same direction.

More importantly, the shift towards more ICT- and technology/ knowledge-intensive work has profited men and women. The impacts have sometimes been in favour of women. For example, in the regional study on Oulu and Salo, the Finnish men experience higher unemployment rates than women. In the Brainport study, women have seen more growth in technology and knowledge-intensive jobs than men. What is striking is that unemployment growth mainly impacts the higher educated groups and more men. As far as technology has an impact, it seems to affect higher skilled personnel. Possibly, highly skilled jobs show higher turnover rates. The improved economic regional performance has mainly helped reduce the risk of poverty and social exclusion, even in the context of major events such as the break-up of Philips in the Netherlands, the downsizing of the Steel sector in Germany, and the closure of important areas Nokia plants. The growth generated by the IEEs has helped the regions to absorb these events. In this sense, entrepreneurial growth can be called inclusive. The fact that there is no clear group losing out on the labour market also allows us to qualify the growth as inclusive. The data miss a comparison with less performing regions, uncovering if the reverse result would be true: economic downturn correlated to more discrimination.

One question that remains unanswered is if the distribution of income between employers and employed has changed over the past decade. It is necessary to complete such information to evaluate inclusive growth fully. An analysis at the level of the separate companies (WP8) is needed to answer this question.

Discussion of results and future research

The set-up of this study was not aimed to provide a European representative perspective. Still, the spread over regions and the fact that the ecosystems cover different performance levels allow deducting several lessons at the EU level. Using the EE-perspective on inclusive growth and the digital transformation provides a better account of what is happening in the general economy than currently is tried with more technology deterministic approaches (Frey & Osborne, 2017; Nedelkoska & Quintini, 2018). The Stam-model has been very helpful in describing the reality of the different ecosystems. Stakeholders in these ecosystems acknowledged the model's usefulness in assessing their situation. The model requires a deeper analysis of the ecosystems provided with the qualitative ‘deep’ descriptions underlying this report and with a separate analysis of the knowledge spillovers. The ecosystem perspective allows understanding how the digital transformation affects companies and societies. The outcome is that technology is a useful tool for companies and actors to develop innovations and new business. However, integrating technology into company processes and business models requires serious investment by companies. The size of the investment makes the introduction of new technology slow and sticky. The advantage of the comparison at the ecosystem level is that experiences of separate companies or types of investments do not dominate the overall social change evaluated.

The material presented in the report reflects the situation in the ecosystems at the start of the COVID-19 crisis. Even if the pandemic affected the ecosystems, the focus in this report has not been

on the way the ecosystems have dealt with the crisis. Some more anecdotal information is included in Annexe 2.

The study has used a broad approach to inclusive impacts. The main missing indicator has been income distribution. Even if the results show that the transformation of the ecosystems, connected to the digital transformation, has not exacerbated societal or gender discriminations, these distributional impacts may be different. In the company case studies (WP8), more attention can be directed at inclusive wage impacts.

Policy recommendations

This report helps ecosystem stakeholders, regional, national and EU policymakers with four major policy recommendations.

What policy recommendations can be derived from the analysis for each region? Is the EE-model a sensible policy level?

The EE is not yet a relevant policy context. The results do show that entrepreneurial activity needs to be stimulated at the level of the ecosystems, which differs from the regional level. More and new business development requires connecting innovation development in knowledge institutes, in SMEs and between companies. To be able to do that, policymakers will require more information. Statistical data needs to be developed for policymakers to understand what is changing in their environments.

The EE-model shows the importance of a multi-pronged approach to stimulate entrepreneurial activity and inclusive results. The Stam-model insists that all conditions are necessary to achieve these results. The heterogeneity of results shows that multiple approaches are needed to stimulate the indicated outcomes. This also stresses that there are several ways to achieve more entrepreneurial activity. Policymakers need to learn what works and which risks exist with choices made from other cases.

The results show that policymakers will not have an easy choice between supporting IEEs with a lot of economic importance and stimulating new EEEs with uncertain futures. The lesson from the cases is that policymakers need to make anchor companies aware of their responsibility to their regions. Stimulating entrepreneurial activity should not be seen as a hobby or small-scale activity in such regions but as a main responsibility to share innovation among companies and other stakeholders. The example is Nokia in the period after 2008, when they supported the Oulu-region in offering patents for free and by supporting the local business community with a 'transition plan' for after the (probable) closure of the mobile phone factory.

Does the digital transformation change the game for ecosystems?

The digital transformation certainly is a game-changer for the ecosystems. The lesson is that within EEs, the take-up of technology and new (IT-driven) business models should be stimulated. Technology should not be seen as a risk for future employment but rather as a means for companies to survive in future markets. Moreover, technology offers opportunities for new products, more

efficient operations and new business models. This is the perspective that policymakers should promote.

The lesson is also that the digital transformation means something else for IEEs and EEEs. In IEEs, the legacy systems make it hard to adopt the newest technologies swiftly. However, these IEEs need to use the technologies to improve their survival rate. The EEEs live for the opportunities the digital transformation brings. Developing a healthy ecosystem context is important for (new) companies to upscale their uncovered opportunities. Companies need to understand and integrate the newest digital technologies. This requires more than just the availability of basic IT skills. The comparison between the skill levels for e-skills and IT skills shows how different results between EEs are. The attention of policymakers should be on developing more people with advanced IT-skills.

The digital transformation manages itself. This means that policymakers should not focus on dealing with technological transformation. Instead, the attention should be stimulating companies to invest more in the adoption of technology and the application of new business models.

What should policymakers at the regional use as a policy mix to support economic and social development?

This study has not been focused on differentiating approaches to inclusive social impacts. Consequently, we have little to say about which approach delivers more inclusive impacts to a region. The main recommendation is that stimulating entrepreneurial activity by improving the entrepreneurial quality of an ecosystem, has helped the selected regions provide more employment, reduce unemployment, and generate more equal outcomes. These outcomes are not the result of specific policy objectives in the region. More research will be needed to understand the benefits of specific entrepreneurial ecosystem approaches.

Is there a role for EU policymakers?

The ecosystem cases have shown EU interventions in different ways. The main activities that have been identified are specific funding for regions to stimulate entrepreneurship. Nearly all cases show the benefit of this support. More specific research is needed into the effectiveness of this support at the level of the ecosystems.

1. Introduction

1.1 Scientific and policy objectives of the study

The objective of Work Package 4 (WP4) of the BEYOND4.0 project, "Inclusive Futures for Europe BEYOND the impacts of Industry 4.0 and Digital Disruption", is to develop a new understanding of the economic impact of the digital transformation on regions. It assesses how digital transformations impact regional ecosystems, economies and societies, now and in the future. The social and economic impacts of six regions in Europe are analysed, building on possible future development paths as defined in WP2.1, which provides project coherence and a common framework for research. Stakeholders are approached to evaluate existing strategies and formulate future directions. Regions selected for analysis include: Salo, Oulu (Finland), Brainport Eindhoven (Netherlands), Sofia (Bulgaria), West-Midlands (United Kingdom), Rhine-Ruhr (Germany) and the Basque Country (Spain).
The main objectives of WP4 are to answer the following questions:

- What are the inclusive-growth related impacts of digital transformation at the ecosystem and regional level now and in the future?
- How can ecosystems and regions respond and adapt to future changes, and how can more inclusive-growth futures be achieved?
- Where could the EU help and support regions and regional ecosystems in adapting and changing course; what ingredients are needed for a suitable EU strategy at the regional level?

The first question is mainly a scientific one, and the second and third questions focus on the policy implications of the findings. For the first question, a set of sub-questions will be addressed:

- How do regions successfully achieve economic growth, and which elements of the entrepreneurial ecosystems in these regions play a decisive role? How can ecosystems and regions respond and adapt, based on the elements of the entrepreneurial ecosystem model? What does the distinction of the incumbent and emerging entrepreneurial ecosystems bring?
- How do entrepreneurial ecosystems deal with the digital transformation?
- How does the digital transformation affect new skills and competencies and employment and educational levels? What are the inclusive-growth related impacts of digital transformation at the ecosystem and regional level? What can be concluded about the regional strategies of economic development and inclusiveness in the studied emerging and incumbent ecosystem?
- How do incumbent and emerging entrepreneurial ecosystems differ from each other in remaining or becoming economically successful?

In this report, we develop a research framework to answer these questions. This is done by relating the discussion on ecosystems to the scientific debate; deducting more specific research questions and hypotheses, and relating the questions in a research framework; developing a sound methodology to answer these questions, and then presenting the results. The results form the basis to achieve this report' scientific and policy objectives.

1.2 Purpose and structure of this report

The purpose of this report is fourfold:

- First, it describes fourteen cases of entrepreneurial ecosystems in eight regions in six EU countries, based upon focused desk research into quantitative indicators, and interviews and workshops with actors from the respective ecosystems. In the description, we provide information about the elements of the ecosystems, the impact of digital transformation on the ecosystems and the social and economic outcomes of the ecosystems.
- Second, the report contributes to the literature on entrepreneurial ecosystems by qualitatively comparing the findings across different ecosystems with this description. The qualitative approach taken in this report provides additional information on how ecosystems operate and the role of the different elements. We used a direct comparison of the results.
- Third, this report offers the first conclusions on the working of entrepreneurial ecosystems discussed in a round of workshops in the BEYOND4.0 project. These conclusions will be discussed with relevant stakeholders. These workshop findings will be the basis for policy advice for regional, national and supranational authorities for a subsequent report on policy (D4.2). In this report, we research the present and past situation, and its findings provide input for upcoming activities within the BEYOND4.0 project (notably within Work Packages 4 and 8) to formulate recommendations for future policy changes and how more inclusive growth can be achieved.
- On an aggregate level, the report will be used to discuss how the EU could help and support regions and regional ecosystems in adapting and changing course.

The report is structured in the following way:

- First, we briefly describe the earlier theoretical and empirical research about the entrepreneurial ecosystem model that we apply to position our research efforts. We clarify our theoretical background and main concepts (Section 2).
- Our main research questions, research framework and hypotheses are discussed in Section 3.
- Section 4 develops the methodology of the study. Four types of comparison are clarified.

- Then, we introduce the fourteen ecosystems (Section 5).
- In Sections 6 to 9, our main results of the comparisons are shared.
- Our conclusions, discussion and policy recommendations follow in Section 10.
- There are two annexes: the first with the major comparative tables; the second with summaries of the different case studies.

1.3 A unique study

The uniqueness of this study lies in several characteristics:

- An in-depth study is conducted into ecosystems in six countries: the current research mainly provides information on one or two cases. Next, most of the studies are also quantitative, in this sense that they build on existing regional statistics and surveys. This study tries to understand the reality of these statistics and surveys by discussing research material with the actual actors in the ecosystems;
- A next unique characteristic of this study is that there is a focus on emerging entrepreneurial ecosystems. Most studies only focus on incumbent entrepreneurial ecosystems. We identify emerging ecosystems and compare them carefully to how incumbent systems perform. We understand from the literature that policymakers require a more appropriate set of tools to help new ecosystems arise and develop themselves (Hannigan et al., 2021);
- The third unique characteristic is that we not only focus on the entrepreneurship of the ecosystem and economic performance but that we relate the performance to the digital transformation our societies are confronted with. We also look at the performance from the perspective of inclusive results for employees in these ecosystems. In this study, inclusiveness is defined at the level of labour markets and societies. This will be different in our follow-up study (WP8 – Company strategies for leading economic and social performance), in which we then focus on employability at the level of companies;
- And the last unique characteristic of this study is that we dig deeper into the ecosystems by performing company case studies in each of the ecosystems we have identified. These case studies are performed in WP8. However, this WP8 will also address some of the research questions in WP4 from the perspective of these companies: how do companies operate and perform within entrepreneurial ecosystems?

2. Concepts and theoretical background

2.1 Theoretical background on entrepreneurial ecosystems

The starting point of this study is the Schumpeterian vision of **creative destruction** at the regional level. The creativeness lies in regions trying to develop new entrepreneurial actions to deal with their regions' ever-changing tides of economic activity. Schrijvers et al. (forthcoming) propose the concept of **entrepreneurial ecosystems** to describe this reality. The region is thus conceived as a collaboration of networks of organisations and actors to generate new knowledge, innovations in companies, and actions by policymakers and other actors. Bendickson et al. (2021) define "entrepreneurial ecosystem as the social and economic environment affecting local or regional entrepreneurship". Knowledge transfers at the regional level help develop networks' entrepreneurship. New ideas, innovation and creativity, are more strongly stimulated by these ecosystems. The question is then to understand if these entrepreneurial ecosystems can in some way be stimulated, created and further developed by policymakers (Schrijvers et al., forthcoming).

This report further assesses how **digital transformations** impact these regional ecosystems, economies and societies, now and in the future. Digital transformation is mainly seen as a risk for employment (Frey & Osborne, 2017) but may at the same time be a source for new developments.

The social and economic impacts of regions in six countries have been analysed using this entrepreneurial ecosystem concept. Regions selected for analysis are Salo and Oulu (Finland), Noord-Brabant (Netherlands), Sofia (Bulgaria), West-Midlands (United Kingdom), Rhine-Ruhr (Germany) and the Basque Country (Spain). These regions vary strongly from one another in terms of structural change, growth, and the way policymakers act (Schrijvers et al., forthcoming). What needs to be uncovered is how these regions deal with digital transformation and what this transformation delivers in socio-economic changes.

Stam & Spigel (2018) see an **entrepreneurial ecosystem** as a ´set of interdependent actors and factors that are governed so that they enable productive entrepreneurship within a particular territory´. Entrepreneurship is a crucial driver of economic change, with main innovation, diffusion, and competition mechanisms. The impact of an ecosystem depends on context and type of entrepreneurship (ambitious vs necessity entrepreneurship). Formal institutions matter for how the ecosystem functions and what kind of output it produces (Stam, 2015).

Figure 1 underneath provides a graphical representation of the entrepreneurial ecosystem model (EES) in which ten elements (four framework conditions: formal institutions, culture, physical infrastructure & demand and six systemic conditions: networks, leadership, finance, talent, knowledge & support services/intermediaries) play a role in creating value through entrepreneurial activity (Stam, 2015).

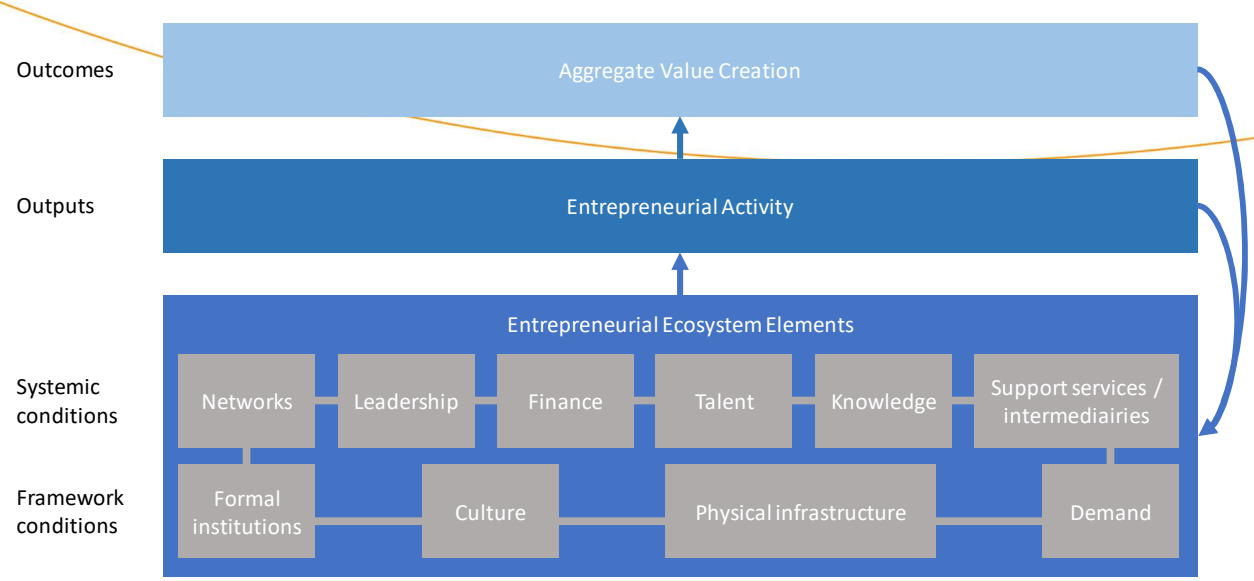

Figure 1. The entrepreneurial ecosystem and its elements, based on Stam (2015)

With the EES model, we can make two types of analysis. **If we reason that all ten elements are of (similar) importance, they should all be well developed.** We can look for statistical information for every variable and create an index-score, and based on that score, we can compare the ecosystems. The Entrepreneurial Ecosystem Index (EEI), for example, measures the degree to which in an ecosystem, the driving components of the ten elements compare to other ecosystems. Leendertse et al. (2021) have calculated a quantitative indicator for each of these components. They propose several EE-Indices for the EU and the Netherlands (Cloosterman et al., 2018; Leendertse et al., 2020).

To calculate the EEI, Leendertse (et al.) have first standardised the composite indicators they have calculated to ensure that all elements get similar weights in creating the index. The index calculation assumes that all ten elements are of equal importance in the ecosystem. Then, depending on the comparison, they either take the European or Dutch average of a component and determine how far the value of a specific ecosystem is from the EU or Dutch average. This component value is expressed as a number around 1, where 1 is the EU or Dutch average. Regions that perform better than the average receive a value above 1, regions that perform less receive a value below 1. One disadvantage of such an index approach is that all ten variables count to constitute a common score, but the real importance of each variable in practice in a particular region may be exaggerated or undervalued since for an ecosystem to be (economically) successful, not all ten elements might need to be strongly developed. However, the alternative, namely, to apply different weights for every variable, requires expert knowledge to determine each weight.

The second type of analysis departs from another logic. That logic argues that **elements are substitutable, and there are many different possible pathways** to a high-performing entrepreneurial ecosystem. And this is the pathway followed by Schrijvers, Stam and Bosma (2021), which we used as well in our analyses of the ecosystems.

Schrijvers et al. (2021) identify in their Qualitative Comparative Analysis (QCA) of 273 regions in Europe four main Entrepreneurial Ecosystem (EES) configurations. A QCA helps to understand the necessary conditions for a particular configuration, in our case, the pattern of elements constituting a successful entrepreneurial ecosystem. Such configurations are a specific combination of the ten elements of the entrepreneurial ecosystem model. Each of the four configurations is economically successful, but their combinations of ecosystem elements are not the same. This implies that there are several recipes for a high-performing ecosystem. The four successful empirically assessed patterns of EES all have high levels of entrepreneurship output: two of these were based on strong talent combined with either strong leadership or institutions. The other two configurations combined strong knowledge and intermediate services with either leadership or institutions. Schrijvers et al (2021) summarise these four configurations as a:

- Configuration 1: a combination of strong 'talent' with strong 'leadership';
- Configuration 2: a combination of strong 'talent' with strong 'institutions';
- Configuration 3: a combination of strong 'knowledge' and 'intermediate services' with strong 'leadership';
- Configuration 4: a combination of strong 'knowledge' and 'intermediate services' with strong 'institutions'.

To measure entrepreneurial ecosystems, Leendertse, Schrijvers and Stam (2021) divided Europe into 281 NUTS2 regions and reduced these to 273 regions on the basis of data quality and geographical overlap. Subsequently, for all ten elements of the EES model, they tried to define statistical indicators on the basis of existing data. The robustness of these indicators varied, which was explained by the diverging quality of the available data. As output measure, they defined productive entrepreneurship, which they operationalised with two measures: innovative start-ups (less than five years old) and unicorn firms (young private firms with a valuation of more than $1 billion). The most comprehensive database for innovative start-ups is the Crunchbase database, an online database that collects information on all promising new firms, mainly to inform potential investors who pay to access the data. The firms in Crunchbase were matched to NUTS2 regions with geocoding using the location of the company headquarters[1]. The analysis only includes firms founded in the last five years (in 2019), covering 2015-2019, and corrects the number of firms for population size. Data on unicorn firms' presence was also collected for all NUTS2 regions. This was used by Schrijvers et al. (2021) as an alternative output measure. The UU researchers performed two separate analyses to study differences in the configurations of high-performing ecosystems and very high-performing ecosystems, defined as regions being either in the top 25% or top 10% of entrepreneurship output in Europe. The performance of entrepreneurial ecosystems is measured with proxies for productive entrepreneurship (i.e. innovative start-ups and unicorn firms).

[1] See in Schrijvers et al, 2021: Crunchbase. (2019). Crunchbase; Crunchbase. (2020). Where does Crunchbase get their data? Retrieved June 27, 2020, from https://support.crunchbase.com/hc/en-us/articles/360009616013-Where-does-Crunchbase-get-their-data-

Their findings, concluding in the four QCA-solutions mentioned before, indicate different configurations of successful entrepreneurial ecosystems. High entrepreneurship outputs can be realized with a small variety of entrepreneurial ecosystem configurations. These varieties can be grouped into entrepreneurial ecosystems with strong human capital or knowledge combined with either strong leadership or strong formal institutions. When focusing on very high levels of entrepreneurship output, there is more convergence to an all-around entrepreneurial ecosystem with all ecosystem elements strongly developed. However, even in this small group of top 10% regions, there is still some variety in configurations, with some regions lacking strongly developed ecosystem elements. There is thus not one perfect configuration that all successful ecosystems exhibit. Nevertheless, the analysis of very high-performing ecosystems shows that just having a few ecosystem elements on a high level is not enough to become one of the top entrepreneurial regions in Europe (Schrijvers et al., 2021).

To this logic, we want to add **the perspective of 'institutional voids'** (Bendickson et al., 2021). If not all conditions may be needed for productive entrepreneurship, this raises the question of how certain ecosystems can generate high outputs without being all-around entrepreneurial ecosystems. Institutional voids are defined as weaknesses in or absence of institutional support (Bendickson et al., 2021). They arise when "when the population, and thus the tax base decreases, leading to issues with unemployment, crime, and corruption" (117).

Based on this research, we know that there are different pathways for successful ecosystem development, with policy recommendations that can be derived from these pathways. These pathways or configurations can be regarded as **ecosystem strategies for successful, productive entrepreneurship** and provide indications for policy options in a region. Relevant to observe is that the Schrijvers et al.-QCA-study is largely quantitative without enrichment of qualitative data. This is, of course, a major task for 273 cases. For the regions in our study, Schrijvers (2020) has provided a separate QCA-analysis, which we will discuss later.

2.2 The BEYOND4.0 research: expanding the framework

We expand the research on entrepreneurial ecosystems in several ways.

The first is by looking **more in-depth into the functioning of entrepreneurial ecosystems**. We use the same theoretical entrepreneurial ecosystem model of Stam as described above. However, the discussed and available research is spread between two extremes: at the one extreme, the studies are primarily quantitative, using regional and national statistics to understand the reality; and at the other extreme, mainly based on single (e.g., Bendickson et al., 2021; Centindamar et al., 2020) or two case studies (e.g., Lammers et al., 2021). **BEYOND4.0**, on the other hand, starts from several regional cases and applies a qualitative approach to understand the operation of these ecosystems in more detail and understand the impact of the digital transformation. Such an analysis allows for digging deeper into the significance of institutional voids and how regions overcome such voids (see Bendickson et al., 2021).

In addition, we make the **distinction between incumbent and emerging ecosystems**. The currently available studies focus mainly on incumbent ecosystems (Wurth, Stam & Spigel, 2021) and provide too little insight into the factors for new ecosystems to emerge and grow (or die) (Hannigan et al., 2021; Malecki, 2018). As Hannigan (et al.) indicate, actors in incumbent entrepreneurial ecosystems probably spend a lot of activity on organisational maintenance activities rather than on innovation and new knowledge creation. Incumbent ecosystems may be losing out on entrepreneurship. That is why it is necessary to look at emerging ecosystems. Emerging ecosystems may not rely on the same set of framework and systemic conditions as incumbent ecosystems. Institutional voids may plague the actors in such ecosystems. Depending on where the emerging ecosystem is located (within or outside an incumbent ecosystem), the development may be very different. The focus is on identifying which factors play a role, finding out which institutional voids may be present and how these elements play a role in knowledge spillovers and entrepreneurial activity (Bendickson et al., 2021). The BEYOND4.0 research addresses several emerging entrepreneurial ecosystems. Comparing these incumbent and emerging ecosystems provides a more robust understanding of the working elements in these different entrepreneurial ecosystems.

The next addition is that we are looking at the **impact of the digital transformation** on the functioning of ecosystems. Digital technologies may change the relationships between companies and stakeholders. They can be enablers of change. The cultural context may also shape the digital transformation itself, with trusting and engaging contexts allowing certain technologies to prevail (Candelo, Casalegno & Civera, 2021). Haarhaus et al. (2018) indicate that the understanding of how digitalisation influences the broader entrepreneurial landscape remains limited. Digital technologies should not only be seen as a risk for ecosystems. They may also bring opportunities for knowledge spillovers within ecosystems to drive new economic growth.

These core ideas of knowledge spillovers and institutional voids are missing in the entrepreneurial ecosystem approach. The entrepreneurial ecosystem model is used to understand what drives entrepreneurship at a regional or national level. It helps to understand how new companies arise and innovations come to the market. Schrijvers et al. (forthcoming) described the model focusing on all entrepreneurial ecosystem elements: Capital, Labour, and Knowledge. Capital and Labour are well-understood ecosystem elements. Less understanding exists of how Knowledge enables entrepreneurial activity and industry emergence (Audretsch et al., 2020; Jones & Ratten, 2021; Kang et al., 2021; Schrijvers et al., forthcoming). As explained, Leendertse et al. (2021) have developed entrepreneurial ecosystem metrics. Knowledge is operationalised by Leenderste et al. in two components: talent and new knowledge. The approach is focused on a 'stock of talent' or 'stock of new knowledge'. The indicator for the *stock of talent* is the prevalence of individuals with high levels of human capital (four separate indicators). For *new knowledge*, the intramural R&D expenditure is the main indicator. The 'stock approach' is certainly useful, but it still requires that the stocks of knowledge and talent are used in and by the entrepreneurial activity within an ecosystem. Suppose high levels of human capital were by themselves the main driver of entrepreneurial activity. In that case, we cannot explain why regions were able to generate high levels of entrepreneurial activity without having such high levels of human capital in the past. The secret of this activity may lie in the ability of such regions to achieve knowledge spillovers (Etxabe, 2019). We add to the entrepreneurial ecosystem approach the **knowledge spillover theory of entrepreneurship**. BEYOND4.0 is focused on knowledge spillovers and how they drive innovations and the adoption of

new ideas (Audretsch, Keilbach, Lehmann, 2005). The regional proximity of companies, knowledge institutions and other stakeholders help share knowledge to deal with all kinds of challenges (Qian, 2018). To understand this transfer, we develop a specific **taxonomy of three kinds of knowledge transfer** within an ecosystem: from education to companies, from companies to companies, and from public institutions to companies. Other types of knowledge transfer (for example, from arts to businesses) are possible, as demonstrated in Bendickson et al. (2021). It is important to understand that knowledge transfer is not only limited to the relationship between the education system and the business system.

A last addition of BEYOND4.0 is that we are **looking at inclusive growth outcomes**. Current ecosystem research covers mainly value creation and productivity results. The next question is how this value creation is distributed within a region. How does this distribution contribute to the sustainability of an ecosystem in the longer term? Do the ecosystems value 'inclusive innovation', and what kind of dynamic is prevalent in how actors operate to achieve this inclusiveness (Bramwell, 2021)? Inclusiveness and digital transformation can also be connected. Then, the perspective is to understand if actors in the ecosystem are trying to bridge the threats digital transformation delivers to skills shortages, skills profiles and entrepreneurship (Lebedeva, 2019). A series of studies is trying to shed light on how entrepreneurial ecosystems deal with **gender issues**. Women entrepreneurs are seen as an untapped resource (Cochran, 2021). However, gender divides exist in the access to resources and in the experiences of women relative to men entrepreneurs (Patterson, 2020; Motoyama et al., 2021). Further, inclusiveness is not only limited to gender issues. Indeed, in EU-policy documents, **other types of discrimination** should be addressed as for example, use of non-standard employment, employment of persons with disabilities, youth discrimination Inclusiveness is also defined as including social partners in the design and implementation of employment (EU COM(2021) 743 final).

With these additions, the actual interpretation framework is expanded in several ways. Figure 2 summarizes the results.

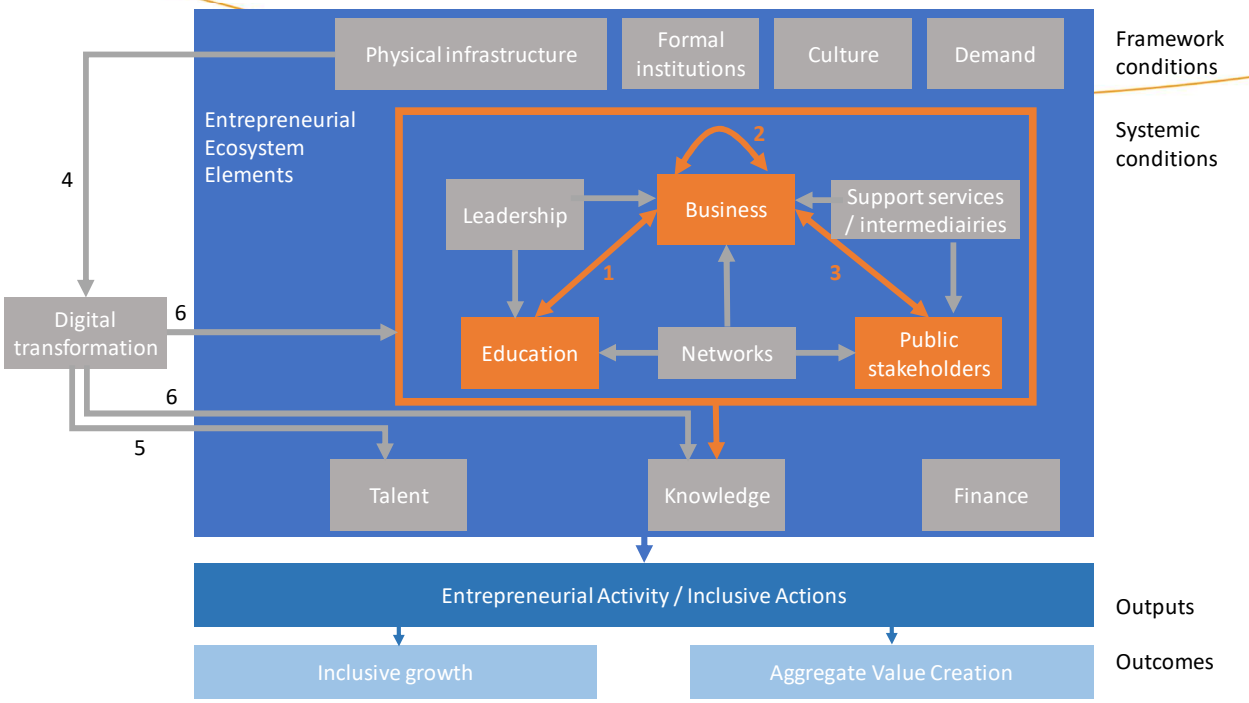

Figure 2. The expanded framework of the entrepreneurial ecosystem and its elements, based on Stam (2015)

The model of Stam (2015) has been redrafted by this study. At the core of the entrepreneurial ecosystem are the **knowledge spillovers**. The fact that knowledge spillovers exist and are stimulated at the regional level drives the success of specific regions and ecosystems. To understand the knowledge spillovers, three specific spillovers are in focus: between education and business (**arrow 1**), between businesses (**arrow 2**), and between business and public stakeholders (**arrow 3**). These spillovers are represented by the orange arrows and allow integrating the information on leadership, support services/intermediaries and networks. These three systemic conditions are of interest to the degree that they generate these spillovers. Leadership is measured as actors taking a leadership role in an ecosystem. This can be the lead or flagship company and actors in the education system (for example, in leading major EU projects). Support services/intermediaries are relevant for supporting businesses and public stakeholders in different ways. Leendertse et al. measure these through the number of accelerators/incubators, which we can see as drivers of spillovers between these two actors. Networks connect all actors and help knowledge exchange in different ways. Leendertse et al. see these networks mainly as a percentage of SMEs engaged in innovative collaborations or as a percentage of SMEs in a region. Only the first indicator points towards networks. Their model's description of the element is somewhat broader: "connectedness of business for new value creation". Networks are in the middle of the three actors in the figure above. The figure allows integrating the information of these three systemic conditions in these knowledge spillovers. We are interested in what degree such knowledge spillovers exist in entrepreneurial ecosystems and how successful these spillovers are. The 'knowledge' indicator, as measured by the Stam-model, measures the degree of success of these spillovers. Leendertse et al. limit this to intramural R&D expenditure. For the purpose of this project, innovation expenditures

per person employed, employment in innovative SMEs and employment knowledge-intensive activities are also included in this systemic condition.

The proposed model reduces the actual systemic conditions to the three core variables talent ('labour'), knowledge and finance ('capital').

The Stam-model already includes several elements of **the digital transformation**. The physical infrastructure includes the digital infrastructure (households with access to the internet). Talent also covers the percentage of the population with e-skills. The digital transformation is seen as the ability a region or ecosystem has to shift to digital-driven business models (as operationalised in European Commission, 2021b). Can regions use digital technologies to change their offerings to the market? The indicator IT specialists in a region are used to measure this shift. Employment in the information and communication sector (Nace J) is the best indicator for this. The use of such talent is driven by the presence of the right physical infrastructure (arrow 4).

The digital transformation affects the talent base in a region (arrow 5). This relationship requires specific analysis and will result from exploratory discussions with stakeholders in the ecosystems (Proeger & Runst, 2020).

The digital transformation is also seen as a knowledge spillover for companies and regions. In the framework, these relationships (arrows 6) are explored in the discussions with stakeholders in the ecosystems.

Entrepreneurial ecosystems help regions to develop more entrepreneurial activity. This relationship is already the focus of studies conducted by Leenderste et al. (2021) and Schrijvers et al. (forthcoming). These results will be cited. This study focuses on two outputs: the **impact of the digital transformation on entrepreneurial activity** (does a shift to more digital sectors, business models and products, help in the rise of start-ups and new activity?); and, secondly, the **impact on inclusive growth**. For inclusive growth, the focus is first on the gender distribution in employment, second on the distributional effects of unemployment among educational groups, and lastly on how the growth of people at risk of poverty and social exclusion have developed themselves. These data have been calculated from the Eurostat data. There is insufficient information about wage development for the regions and over time in the Regional Innovation Scoreboard (2021). Impacts such as polarisation cannot be checked. However, the case studies provide some data here and will be studied in WP8.

These additions require defining and operationalising these concepts more precisely. These concepts are first developed in the Guidance document (D2.1).

2.3 Concepts

Incumbent entrepreneurial ecosystem and incumbent business ecosystem

The term incumbent entrepreneurial ecosystem refers to the concept of *incumbent industry.* Incumbent industry is an already longer existing business ecosystem with a strong presence in the region, often represented by a large 'anchor' firm with its headquarters and R&D facilities, and sometimes also main production facilities in close regional vicinity, together with its main suppliers, and other relevant stakeholders such as relevant research institutes and universities and local/regional government.[2] While such ecosystems often emerge around large enterprises, with notorious examples such as in consumer electronics (e.g. Philips, Eindhoven area, Netherlands), automotive (e.g. BMW, Munich area, Germany), mobile phones (e.g. Nokia, Espoo, greater Helsinki area, Finland) or pharma (e.g. Bayer, North-Rhine Westphalia, Germany), business ecosystems can also be shaped differently with several larger, multiple anchor firms in the same area (e.g. in banking) or (e.g., business service industry). Note that one region can be the locus of more than one ecosystem (e.g. the Munich area was and is also home to Siemens, a company that since the 20th century has been active in various different market segments, ranging from – once – consumer electronics and household appliances to – nowadays – energy and mobility). Many of these incumbent business ecosystems from the past are still there and are reinventing themselves and/or being transformed due to market competition, changing market demand and other forces/drivers. The business ecosystem is the core building block of an entrepreneurial ecosystem. The other elements of an ecosystem relate to non-business institutions such as the schooling system, capital provision, policy intervention, social innovation and other public support. We list the framework and systemic conditions included in the Stam-model for the other building blocks.

For BEYOND4.0, it is important to limit the scope of entrepreneurial ecosystems to what happens in the industry, mainly focusing on Industry 4.0. With Industry 4.0, we keep the focus on the main digital technologies such as e.g. artificial intelligence, robotisation and connected computing. Industry 4.0 is the European strategy to digitise the European industry (European Commission, 2021c). Entrepreneurial ecosystems can be found in other sectors such as culture, media, etc., but they are not the focus of this project.

Emerging entrepreneurial ecosystem and emerging business ecosystem

The term *emerging industry* refers to a business ecosystem that still is in the process of being formed, hence not yet fully mature, and is created around/related to a specific theme or industry (e.g. in health, food, biotech, or pharma), or applies to new industries (smartphones, solar panels, wind farms). Emerging business ecosystems can be – but not necessarily are – characterised by a high number of growth-oriented start-ups. An emerging ecosystem can also arise from the dissolution/disintegration of a large incumbent ecosystem (e.g., bankruptcy, relocation of part of the production facilities by its parent company, a merger or a financial transaction). An emerging

[2] The term incumbent ecosystems refers to 'embryonic ecosystems' in the Brown and Mason typology (see for an extensive list of characteristics Brown and Mason, 2017:23). The term embryonic is somewhat misleading, as the dominant actors are established (!) incumbent firms surrounded by only limited numbers of start-ups. The incumbent firms drive the start-up process.

entrepreneurial ecosystem may, over time, transform itself into a *scale-up ecosystem* with mature characteristics, such as strong levels of interaction, large rapidly growing companies, strong vertical networks, a strong base of financiers and many more characteristics (see further Brown and Mason, 2017). Silicon Valley and Cambridge (UK) are examples of such scale-up ecosystems.

Knowledge spillovers

The Knowledge Spillover Theory provides a context for understanding which kinds of spillovers are interesting to support new entrepreneurship (Audretsch & Link, 2019). The first step in the analysis is to provide a taxonomy of how knowledge spillovers may occur (Cuvero et al., 2019). Cuvero et al. provide the perspective from the start-up company: what kind of knowledge needs to 'spillover' in which phase? This approach allows to identify spillover of business ideas at the conceptualisation phase of the start-up; the (tacit) learning of entrepreneurial activities to develop the company and forming alliances to integrate (explicit) technological knowledge during the seed phase; and learning from customers, suppliers and markets in the growth phase. Literature analysis and taxonomy building underpin the first step. However, the focus remains solely on the start-up or entrepreneur and what happens for start-ups to take off. Less is known what the main actors within an entrepreneurial ecosystem actually do to share (or not share) knowledge. Therefore, the second step is to look at the eight ecosystems and determine how the knowledge spillovers in these ecosystems function and which elements are important. The analysis of the regional case studies has provided information for this second step.

Table 1 provides an overview of possible knowledge spillovers between education, public institutions and companies. These settings provide opportunities for idea sharing between actors in an ecosystem. Some of these mechanisms are described in the European Regional Innovation Scoreboard (European Commission, 2021a).

Table 1. A taxonomy of knowledge spillovers in entrepreneurial ecosystems (own development)

Education/schools/knowledge providers – companies	
1. Public, private co-publications (RIS)	This indicator from the RIS captures public-private research linkages and active collaboration activities between business sector researchers and public sector researchers, resulting in academic publications. The indicator is measured as the public-private co-publications per million population.
2. Internships, apprenticeships	This is a traditional mechanism in which new talent is integrated into the companies. In addition, companies connect with the school system and can develop networks with the schools to keep their training infrastructure up to date.
3. Major programmes	Knowledge providers such as RTOs can conduct major innovation programmes that lead to PPPs (García-Estévez et al., 2020).
Companies – companies (Scarrà & Piccaluga, 2020)	
4. Business ecosystems, business supply chains	Companies' supply chain provides a knowledge transfer from the focal (flagship) company to the suppliers. The knowledge transfer may also be the reverse. It may also be that ecosystems learn from one another. Flagship enterprises have positive impacts on start-up rates (Anokhin et al., 2021)
5. Take-over of personnel	Personnel can move from one company to another and secure knowledge improvements at the receiving company.
6. Knowledge sharing through business networks	Several different types of business networks may be active in regions. They can vary from service clubs to sectoral associations to more directed meetings between (top) managers. Major fairs or exhibitions allow knowledge spillovers.
7. Life-long learning (RIS)	The RIS measures life-long learning as all purposeful learning activities, whether formal, non-formal or informal, undertaken on an ongoing basis to improve knowledge, skills, and competence. The intention or aim to learn is the critical point that distinguishes these

	activities from non-learning activities, such as cultural or sporting activities. It can work as a spillover mechanism in combination with mobility, keeping knowledge updated in companies. The RIS measures lifelong learning as the share of the population aged 25-64 enrolled in education or training aimed at improving knowledge, skills and competencies.
8. Innovative SMEs collaborating with others	The RIS measures the degree to which SMEs are involved in innovation cooperation. Complex innovations often depend on enterprises' ability to draw on diverse sources of information and knowledge or collaborate on the development of an innovation. This indicator measures the flow of knowledge between public research institutions, enterprises, and other enterprises. The precise measure is the innovative SMEs collaborating with others as a percentage of SMEs (Audretsch, Belitski, Caiazza, 2021).
Public stakeholders – companies	
9. Labour market measures	The (local) labour market agencies may be active to direct labour to companies. This is not directly knowledge support but labour input. However, support may be directed to improve knowledge and information in the region.
10. Business support networks	An important mechanism to secure connection between companies is the activity of a local Chamber of Commerce or any other business support system. It is important to understand how active these are and what they are able to achieve. The mere existence is not sufficient to support knowledge exchange (Audretsch & Link, 2019).
11. Funding opportunities, incubators	Public authorities can support any of the described knowledge transfer mechanisms. Of course, direct financial support (if allowed) can be helpful, but this is capital transfer rather than knowledge spillover. In addition, public authorities can create incubator systems to support start-ups.

In the six countries (eight regions), we have investigated what information is available in the RIS or regional statistics from Eurostat[3]. NUTS-2 is used as an indicator for a sector. For more insight into what is happening, the information is supplemented with interview information.

Digital transformation

BEYOND4.0 is about the impact of digital transformation on regions and ecosystems. The digital transformation is already partly covered in the Stam-model (2015). The model identifies the physical infrastructure as a framework condition. The digital-physical infrastructure is an important driver of change within companies and other institutions within a region. The digital transformation is, however, more than infrastructure. Companies need to deal with new technologies and need to understand what these mean for their business model. The Flash-Eurobarometer makes the distinction between digitisation, digitalisation and digital transformation (European Commission, 2021b). **Digitisation** is merely converting analogue information into digital bits, allowing further steps such as digitalisation. **Digitalisation** is using digital technologies to transform business processes, based on digital information. New goods and services are possible. **Digital transformation** is one step further. This uses digital capabilities to change the relationship with the customer and outcompete the competition with new business models (Hess et al., 2016). Digital transformation requires the complete transformation of a company's practices and business models, leading to smart products, services and improvements in productivity (DigitaliseSME, 2020).

Digital transformation brings with it uncertainty and risk. The context of an entrepreneurial ecosystem can be helpful to create knowledge spillovers: what are the opportunities of the digital transformation? For our study, we focus on two separate topics: are the dominant business models used by the companies and industrial networks within an ecosystem changing because of technology? Are their business models under threat? How do the industrial networks see

[3] https://appsso.eurostat.ec.europa.eu/nui/

themselves affected by the digital transformation? This requires us to investigate which investments in digital technologies are conducted to see if these investments (hardware, software, training) show some coherence at the ecosystem level. Can we see some strategic plan arising because of the digital transformation? Does the ecosystem have an idea to direct the actors in a specific direction? This also requires us to select an incumbent entrepreneurial ecosystem that needs to deal with industrial transformation. Our focus is, therefore, on Industry 4.0-projects and plans.

Secondly, we want to see how the ecosystems tackle the digital transformation's threats and opportunities. This part is forward-looking and takes account of the views of the stakeholders in the ecosystem. How do they share opportunities?

However, digitalisation is not the only factor that matters, and it will often be complex to disentangle the impact of digital transformation from other factors/drivers as there are a number of other factors/drivers that also impact the evolution of an ecosystem, such as globalisation, the financial crisis, climate change and the ageing population. And, even if the ecosystem is limited by its territorial boundaries by definition, this does not imply that anchor companies within the ecosystem do not operate outside their entrepreneurial ecosystem boundaries. On the contrary, input (e.g. technology) and product markets more often than not are global markets nowadays. This holds both for large companies – usually multi- or transnational companies – but to an increasing extent also for small and medium-sized companies, stimulated and incentivised by digitalisation.

Inclusive growth

Current entrepreneurial ecosystem research covers mainly value creation and productivity results. The Stam-model includes information about the outputs and the outcomes. Schrijvers (2021) presented the idea to expand the entrepreneurial outcomes to well-being. In this study on entrepreneurial ecosystems, 'inclusive growth' is mainly a supply-side concept: improving the situation of groups in society or on the labour market. The concept stresses less the situation at the demand side: what is happening within companies and company policies may or may not stress inclusiveness. 'Inclusive growth' is also a clear European concept, which is clarified above. From our discussion, we focus inclusive growth on the following topics:

1. In what way do the ecosystem and its development affect work and human capital (e.g. skills requirements; work content; health at work (OSH)?
2. How is social inclusion affected (e.g. labour participation; gender balance; (un) employment)?; and
3. What can we see in (re)distribution (e.g. income and wealth by skills, by gender, by age; high vs low paid jobs; regional income) in view of the structural change and dynamics caused by digital transformation.

Other questions in this analysis are: Are these issues discussed, and is policy or action developed? How are the benefits divided at the IEES level? How do the IEEs deal with these issues if an economic downturn is experienced?

3. Research framework and research questions

3.1 Constructing a regional comparative-analytical framework

This project connects the functioning of the entrepreneurial ecosystems as described by the Stam-model to the digital transformation and inclusive growth. To develop understanding, we use a comparative methodology and require a comparative-analytical framework to understand our results. The entrepreneurial ecosystem is studied as a system. Figure 2 shows that the focus is on knowledge spillovers within the entrepreneurial ecosystem. If we study a 'system' like an entrepreneurial ecosystem, we need to know the boundaries of that system. The entrepreneurial ecosystem literature does not define the clear boundaries of an ecosystem (Schrijvers et al., 2021), but it is considered to be between the local and the national level.

The next step is to look within a region for an industrial sector or business that is relevant to study the digital transformation and its 'Industry 4.0' characteristics. It is important to observe that an entrepreneurial ecosystem in a region often comprises all industries involved (all businesses), but that a business ecosystem is concentrated, on the one hand, within one type of industry, but is not limited to a specific region per se. Thus, a strict and clear demarcation of a business ecosystem within an entrepreneurial ecosystem is often impossible. This is, however, not an insurmountable obstacle if we focus our lens on the mechanisms that explain why a particular business or industrial sector is thriving in a specific region. The focus also needs to include how knowledge spillovers work between the three identified actors. For this purpose, the entrepreneurial ecosystem model is instrumental, as it distinguished ten rather tangible elements that determine its success (Stam and Van de Ven, 2019). The challenge herewith is to find meaningful data of all ten elements by which one can compare the different ecosystems across Europe. The model in Figure 2 visualises a region within its environment (e.g. the country), and the impact on the region by the digital transformation on the one hand, and the outputs of the entrepreneurial ecosystem in the region in terms of (1) work, (2) social inclusion, and (3) the distribution of wealth.

3.2 Research questions

We distinguish between academic questions and recommendations for policymakers. Finally, we relate the questions to the type of comparison we will be conducting; they are clarified in the next section.

Academic research questions

- How do regions successfully achieve inclusive economic growth, and which elements of the entrepreneurial ecosystems in these regions play a decisive role? How can ecosystems and regions respond and adapt based on the elements of the entrepreneurial ecosystem model? What do the distinction of the incumbent and emerging entrepreneurial ecosystems bring?

- Comparison 1 between the QCA-study made by Schrijvers (2020) and IEEs teaches us about the necessity of the different conditions for entrepreneurial performance. It also informs the statistics perspective. What does our in-depth information (knowledge spillovers) bring as extra understanding to the abstract statistical data that is currently used? How do the conditions aid capital, labour and knowledge transfer?
- How entrepreneurial are the regions? How can we evaluate the impact of institutional voids?
- How do local stakeholders evaluate the strengths and weaknesses of the regions? Can we get explanations from the stakeholders on what works and what does not? Comparison 1 between the IEEs teaches us about the difference in performance conditions.
- The statistical material used by UU is very general. Also, some regions have experienced the impact of a significant downturn in the recent past. What does this mean for the evaluation of the ecosystem? Can we describe how the ecosystem elements have changed and if these conditions help the regions survive these downturns?
- Comparison 4 between IEEs/UU model and EEEs informs us what the EEEs are focusing on. What are their challenges?
- Comparison 4 between EEEs shows us the diversity of approaches.

- How do entrepreneurial ecosystems deal with the digital transformation?
  - Comparison 2 delivers details on how IEEs use the digital transformation opportunity. The stakeholders share with us which strategy they follow.
  - Are the dominant business models, used by companies and industrial networks within an ecosystem, changing because of digital technology? Are existing business models under threat? How do the industrial networks see themselves affected by the digital transformation?
  - How does the digital transformation affect these ecosystems' functioning and (future) performance?
  - Comparison 4 delivers the same information for EEEs.
  - Digital transformation: enabler of change? Does context matter?
- How does the digital transformation affect new skills and competencies and employment and educational levels?
  - Comparison 3 and 4 unveils these social impacts.
    - How do the ecosystem and its development affect work and human capital (e.g. skills requirements; work content; health at work (OSH)?

        - How is social inclusion affected (e.g. labour participation; gender balance; (un)employment)?; and
        - What can we see in (re)distribution (e.g. income and wealth by skills, by gender, by age; high vs low paid jobs; regional income) given the structural change and dynamics caused by digital transformation.
    - An important question is if the results of better economic performance are also connected to a better distribution of economic wealth. The question is if we can see how inclusive the selected ecosystems are for their employees and inhabitants?
    - We also use part of the material to understand the functioning of the Emerging Entrepreneurial Ecosystems.
- What are the inclusive-growth related impacts of digital transformation at the ecosystem and regional level? What can be concluded about the regional economic development strategies and inclusiveness in the studied emerging and incumbent ecosystem?
    - Comparison 3 and 4 shed light on these social impacts.
    - Other questions in this analysis are: Are these issues discussed, and is policy or action developed? How are the benefits divided at the IEEs level? How does the IEEs deal with these issues if an economic downturn is experienced?

Policy recommendations

- What policy recommendations can be derived from the analysis for each region? At what level should policymakers deal with the EE?
- Does the digital transformation change the game in EE?
- What should policymakers at the regional use as a policy mix to support economic and social development in EEs?
- How to make economic growth more inclusive?
- Is there a role for EU policymakers?

4. Methodology

4.1 Comparative case study approach

To answer the research questions, we conduct four comparisons. They are included in Figure 3.

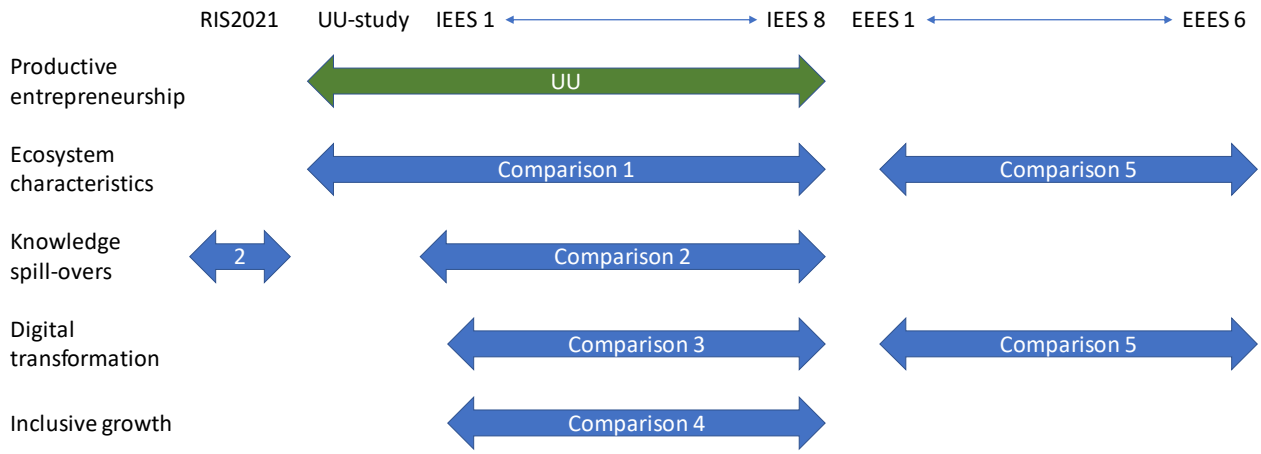

Figure 3. A regional comparative-analytical framework (UU = study by Mirella Schrijvers (2020))

1. The **first comparison** is between the Schrijvers (et al., 2020)-study and in-depth case studies of incumbent ecosystems. Schrijvers et al. (2020) have conducted a quantitative assessment of the entrepreneurial ecosystems at the EU level using QCA. This analysis provided insight into entrepreneurial ecosystems' strengths and weaknesses using the Stam-model and the case studies (Stam and Van de Ven, 2019). The limits to this approach are that it remains quite abstract to understand how companies and stakeholders actually operate in such an ecosystem, and next, it does not allow for the distinction between incumbent and emerging ecosystems within the regions. This study provides us with a reference point for our evaluations. We have a standard that allows us to understand the following:

- How well the Stam-model explains what is happening within an ecosystem?
- Which elements of the Stam-model may need further development?

Understanding how ecosystems arise and survive is crucial for understanding why certain regions remain strong economic performers over time. In this report, we chose to conduct case studies at the level of a selection of entrepreneurial ecosystems. The comparison between incumbent entrepreneurial ecosystems, and next, between incumbent and emerging ecosystems, helps us develop a deeper understanding of the functioning and challenges of the ecosystems, given the digital transformation. We can understand the impact of possible institutional voids (Bendickson et al., 2021).

As a comparison base, the research team developed 'thick' descriptions of the incumbent ecosystems in their countries. This 'thick' description, in turn, has consisted of the:

- Comparison of objective (quantitative) information at the (NUTS2 or NUTS3) regional level.
- Comparison of the subjective (qualitative) assessment of (interview & workshop) respondents from the ecosystem itself.

There are some **limitations** to the comparisons. The comparison based on objective information from **statistical sources** is limited because, more often than not, the entrepreneurial ecosystem is not entirely contained within one (NUTS3) region. Furthermore, for most of the indicators that can be used as operationalisations for the elements of the model, statistics are only available at the NUTS2 level.

The nature of **qualitative research** limits the comparison between respondents' assessment from the ecosystems themselves and the subjective evaluations of respondents from the ecosystems. For example, when an individual respondent (or several respondents) states that a certain element (e.g. 'Leadership') plays a crucial role in the ecosystem's success, these statements can only lead to the conclusion that this element is *perceived* to be an important factor in this particular ecosystem. It is not necessarily more important than in another ecosystem where respondents have not made such statements. The researchers need to decide in their 'thick report' which answer is used. The discussions in the workshops, however, offer the possibility to inform these assessments.

2. The **second** comparison looks at the influence of the digital transformation on the IEEs. As indicated, we focus on several questions. First, we try to understand how the industrial networks saw themselves affected by the digital transformation. Are their business models under threat? Secondly, how does the IEEs tackle the threats and opportunities the digital transformation brings? Information comes from statistical data sources, interviews with stakeholders and comparing these results in workshops.

3. The **third** comparison focuses on clarifying how the development of the IEEs can be seen as inclusive. The focus is on work and human capital, social inclusion and distributional effects. We assess these topics by looking at the following two indicators: How are the benefits divided at the IEEs level?; How does the IEEs deal with the economic downturn? Again, we build on statistical data, interviews with stakeholders and workshops.

4. The **last comparison** is between the EEEs. We also refer to the Stam-model. EEEs are, by definition, incomplete ecosystems (Hannigan et al., 2021). We want to understand to what degree these EEEs have the opportunity to arise next to the level of the existing IEEs. The question is complicated, mainly because the EEEs are not homogeneous. We need to assess to what degree we actually can conduct the comparisons. Only the Dutch EEEs-case is a separate region, in the other cases, we are more looking at industrial networks that are competing within the existing IEEs for more importance. Some of the cases rely on much of the same resources the IEEs rely on. The analysis remains instructive because it also helps us understand how existing IEEs may be a barrier to developing new industrial networks.

4.2 Qualitative analysis

The main ingredients of this report are six summary tables of our findings on 'incumbent' and 'emerging' ecosystems, their elements, the impact of digital transformation and (inclusive) socio-economic outcomes. The research teams developed their basic country reports ('thick' analysis), from which we first developed basic tables (see Annexe 1). These basic tables were further reduced by inductive coding to the core content (core variables), for which we can then compare the cases (Miles, Huberman & Saldana, 2013). Each of the team members checked the coding and eventually also reviewed it in the final country workshops. The final tables are presented as analytic memos that allow us to make comparisons: we can see the differences and similarities in the codes (Skjott Linneberg & Korsgaard, 2019). The concepts are connected to identify logic and meaning (Miles et al., 2013).

The study's design is such that we can improve the validity and reliability of our research material by using multiple sources, comparing a great number of cases, and allowing for stakeholder discussions and feedback on our results. This is the first time that such an approach has been conducted for the topic of entrepreneurial ecosystems. Most studies rely on regional statistics that only partially reflect what happens at the ecosystem level (see comments Dhondt, 2021) or focus on one (country or city) ecosystem (e.g. Alaassar et al., 2021; Bendickson et al., 2021). The connection between what happens in business ecosystems and entrepreneurial ecosystems is also a first. Therefore, the material from this study is unique in quality, understanding, and recommendations. Networks of stakeholders support the recommendations in each of the ecosystems.

The case studies were conducted by probing with different sets of interviews into the functioning of the ecosystems. The methodological idea is that combining interviews with different stakeholders in an ecosystem and then combining these stakeholders in workshops could develop this deeper insight. The workshops allow for corroborating the interview results. They also allowed for the development of future perspectives. The procedure contains several feedback cycles to improve the quality of the results. This report is limited to the outcomes of the national workshops. In a follow-up activity, workshops are organised in which stakeholders from different countries are included. These results will be reported in a follow-up publication (D4.2).

4.3 Methods

The following methods were used for the case studies.

Desk research

The first part of the research work consisted of reviewing literature and websites with qualitative and quantitative information on the region and its development. One aspect was to build on work

done by Utrecht University (UU) and Beyond4.0 in the field of entrepreneurship[4]. UU developed the entrepreneurial ecosystem model applied in the BEYOND4.0 project and conducted empirical research to test the model. Desk research also helped us to define what we understand as an entrepreneurial ecosystem (scope, actors, incumbent/emerging nature).

Development of interview guides

The second step was to develop a method to measure the main variables of the study to answer the research questions and to operationalise the dominant concepts and constructs. Since the study aims to understand better the mechanisms of how ecosystems evolve, the accent was on a qualitative approach, supported by (as much as was possible) quantitative information. Sources of data to answer the questions were: stakeholders in regions, the ecosystem and the particular businesses, core companies and companies in the network of companies; existing publications; statistical databases, documents; and websites and other sources. We developed an interview guide[5] to conduct interviews with stakeholders and company representatives, which contained the operationalisation of the main concepts and the elements of the entrepreneurial ecosystem model. All teams used this guide which ensures comparability of research findings.

Fieldwork

Having a clear view of an entrepreneurial ecosystem, we identified which actors could help us assess an ecosystem's performance and functioning. The fieldwork consisted of conducting interviews with regional stakeholders and company representatives. Regional stakeholders were representatives of governmental bodies (like provinces, regions, municipalities, and national institutions), business associations, employer organisations, unions, knowledge institutes and educational institutions, financial institutions (like investment banks), and regional development organisations. Company representatives were mostly managers, sometimes employees and members of works councils. Much of the information gathered via these interviews is processed in deliverables that describe company strategies for the digital transformation (in Work Package 8)[6]. In annexe 3, we provide an overview of the type of actors consulted in the fieldwork without identifying the persons. The COVID-19 crisis seriously impacted the data collection. After preparing the instruments at the end of 2019, the research virtually came to a stand-still. The research teams moved with different paces to circumnavigate the different lockdowns. Nearly all interviews needed to be conducted over digital tools, reducing the possibility of more engagement by the different actors. However, the digital meetings offered the possibility to have more actors present than would have been possible in a live setting. There are some benefits. The disconnect between the teams slowed down the possibilities to cooperate during the data collection.

[4] The group of prof. Erik Stam, Utrecht University School of Economics / Utrecht University Centre for Entrepreneurship; Mirella Schrijvers is an associated researcher.

[5] Oeij, P., van der Zee, F., Dhondt S., and Pomares, E. (2020). Interview Guide WP4-WP8. [October 2020; Version 3.0; March 2021; Adapted Version 3.1] Informal Working Document 2. BEYOND4.0; s.l. Published as annex to Oeij, P. & van Zoelen, S.A. (June 2021). D1.1. Quality Assurance Plan – Update M30. BEYOND4.0; s.l.

[6] A detailed research protocol was applied to select, invite and interview the participants in the study, and to take into account the requirements concerning reported data, privacy protection and data management (see the Data Management Plan, D3.1).

Regional workshops (coherence, future perspectives)

The fieldwork delivered us sets of separate accounts of what happens at the ecosystem level. Two sets of regional workshops with the ecosystems were conducted to integrate this material. The workshops allowed us to identify to what degree the actors understood the performance and impacts. The first sets of regional workshops with stakeholders and company representatives within each ecosystem were held (12 in total). Rather in parallel than sequentially, these regional workshops were applied as a method of data-gathering while the research process continued. The function of the workshops was, therefore, twofold. From a research perspective, information was gathered to complete and validate the overall view we had developed, looking back at how ecosystems had developed, mainly based on analysing the ten elements of the entrepreneurial ecosystem model and its outputs. From a policy recommendation perspective, the workshops addressed the strengths and weaknesses of the functioning of the ecosystem and pinned down opportunities and threats for the future. This particular information will also be used as input for a subsequent round of workshops to develop scenarios for the future development of the ecosystems (and a follow-up report D4.2 within WP4). It should be mentioned that the fieldwork and regional workshops were seriously delayed due to the COVID-19 pandemic.

Separate country reports

The primary input for this 'overview report' is the six separate ('thick') unpublised/internal reports of each country where both an incumbent and emerging ecosystem were under investigation by the respective partners.

Integration of findings

Integrating the findings from all countries was a joint endeavour of all partners. While TNO, as leading partner, took the lead in laying out the headlines and format and principal author, the partners added their information as pieces of a jigsaw to the report. Meanwhile, several online meetings were organised to discuss findings and conclusions thoroughly.

5. Data: introducing the fourteen ecosystems

5.1 Selection of regions and cases

We conducted in-depth qualitative research into 'incumbent' and 'emerging' ecosystems in six countries: Finland, Bulgaria, Germany, the United Kingdom, Spain and the Netherlands. In total, we have studied eight different regions (namely two different (NUTS) regions in Finland and Germany) and fourteen ecosystems (six incumbent with two double cases, six emerging).

The geographical unit in Europe that most closely resembles a useful regional demarcation is the NUTS2 classification. NUTS2 regions are defined based on existing administrative boundaries in a country and population size, which in a NUTS2 region varies between 800,000 and 3 million people. Therefore, the NUTS2 level is the best option, also given the current data availability.

The selection of regions has been made in a pragmatic way. The six research teams have been asked to select an incumbent and emerging entrepreneurial ecosystem in their respective countries, showing Industry 4.0 activities and confronted with digitalisation. The selection needed to follow the NUTS2 level and identify ecosystems that allow the assessment of the impact of the digital transformation. The actual selection is clarified further.

5.2 The Incumbent Entrepreneurial Ecosystems (IEEs)

Six BEYOND4.0-partners have focused their research on the neighbouring ecosystems. This proximity helps with access to data and stakeholders. Each of the partners has developed a separate (internal) report on their incumbent and emerging ecosystem[7]. The data in this report is developed from this material.

An important input to our study is the research note from UU-researcher Schrijvers (2020)[8] on these six BEYOND4.0-regions. We summarize her findings. Schrijvers (2020) used QCA to understand the strength of the ecosystem of each of the BEYOND4.0-regions, in a similar way as in the overall study

[7] Kirov, V. (2021) Regional report Sofia. Sofia: IPS-BAS (April) (not public)
Pomares, E., Unceta, A. (2021) Regional perspective analysis. Analysis of the incumber (machine tool) and emerging (smart mobility) ecosystems in the Basque Country (Spain). San Sebastian: Sinnergiak (not public)
Kangas, O., Karonen, E. (2021) Regional perspectives and prospects: Oulu and Salo. May. Turku: University of Turku (not public)
Götting, A., Kohlgrueber, M., Behrend, C. (2021) Digital transformation and inclusive growth at business ecosystem and regional level. Dortmund: TUDO (not public)
Dekker, R., Dhondt, S., van Bree, T., Hulsegge, G., Oeij, P., and F. van der Zee (2021) Regional perspective analysis. Analysis of the incumbent (Brainport region) and emerging (West North Brabant) ecosystems in The Netherlands. Leiden: TNO (not public)
Barnes, S-A., & Wright, S.A. (2021). Analysis of the incumbent (Advanced Automotive Manufacturing and Engineering) and emergent (Digital Health) entrepreneurial ecosystems. WP4 Regional Report: West Midlands, UK. BEYOND4.0. (not public)

[8] Mirella Schrijvers / UU is an affiliated partner of the H2020 Beyond4.0-team. Together with prof. Stam, she has has tested and checked quality of the H2020 Beyond4.0 material. She has been engaged by the BEYOND team through several discussions and meetings, her participation in the Summer Schools and workshops.

of 273 regions (Schrijvers et al. 2021). The 'strength' of an ecosystem is measured by looking **at high-growth firms, which is an indicator of productive entrepreneurship.** She also looked at which of the EE-framework conditions – i.e., the ten elements of the entrepreneurial ecosystem model - are necessary and sufficient conditions for productive entrepreneurship.

For the BEYOND4.0-project, she rated the eight BEYOND4.0regions in comparison to the 273 other regions in Europe on these conditions. Productive entrepreneurship is measured with the number of Crunchbase firms per 1,000 inhabitants, i.e. the number of major growth firms. We refer to her paper for the procedure to classify the regions with the QCA-method (Schrijvers, 2020; Schrijvers et al., 2021). Schrijvers warns that her statistical analysis does not completely overlap with the selected BEYOND4.0-regions. The BEYOND4.0 regions are at different NUTS levels, with different data availability. We should therefore be careful with interpreting the results for the BEYOND4.0 regions. The Ruhr area falls under two NUTS2-codes: Arnsberg and Düsseldorf.

Table 2. BEYOND4.0 regions with their NUTS2 codes

Beyond4.0 region	NUTS2 region	NUTS2 code
Salo	Southwest Finland	FI1C
Oulu	Northern Osthrobrothnia	FI1D
Sofia	Yugozapaden	BG41
Duisburg (NUTS 3)	Düsseldorf	DEA1
Dortmund (NUTS 3)	Arnsberg	DEA5
Zuidoost Noord-Brabant	Noord-Brabant	NL41
Basque Country	Basque Country	ES21
West Midlands	West Midlands	UKG3

Schrijvers finds that none of the ten elements of the EES model is a necessary condition for productive entrepreneurship, as defined by being in the top 25% of entrepreneurship output. For very high entrepreneurial output (top 10%), she finds that leadership or intermediate services are needed. These conditions will, in practice, always be combined with other conditions. This is visible in Table 3 ('truth table'), which shows which ecosystem elements are present in the BEYOND4.0-regions. We only focus on the conditions.

Table 3. Excerpt from the truth table with the BEYOND4.0 regions, showing the configurations of conditions (the elements from the framework) that the BEYOND4.0 regions exhibit (1 = condition present; 0= condition not present; N=No; Y=yes). (Schrijvers, 2020)

	Salo	Oulu	Sofia	Basque Country	Duisburg	Dortmund	West-Midlands	Noord-Brabant
Institutions	1	1	0	0	1	1	1	1
Culture	1	1	0	0	1	1	0	1
Infrastructure	1	0	0	1	1	1	1	1
Demand	0	0	0	1	1	1	1	1
Finance	1	1	1	1	1	1	1	1
Talent	1	1	0	1	1	1	1	1
Knowledge	1	1	1	1	1	1	1	1
Intermediaries	1	0	1	1	1	0	1	1
Networks	1	1	0	1	0	1	1	1
Leadership	1	1	0	1	0	0	1	1
Productive entrepreneurship	Y	Y	Y	Y	Y	N	Y	Y

Schrijvers's observations are the following:

- Almost all regions are a member of a configuration that is sufficient for productive entrepreneurship, with the exception of Dortmund (low consistency score; entry=0 means there are no cases with a high score on productive entrepreneurship; 1=all cases have a high score on productive entrepreneurship).
- There is a wide variety of configurations, and only West-Midlands and Noord-Brabant of the BEYOND4.0 regions share practically the same configuration. We have a variety of growth strategies in our research.
- West Midlands, Salo, the Basque Country and North-Brabant are well-developed entrepreneurial ecosystems. The other BEYOND4.0 regions show entrepreneurial ecosystems with at least two elements lacking (although this does not exclude these regions from having high scores on productive entrepreneurship).
- Sofia is an interesting case because of a high level of productive entrepreneurship but quite a weak ecosystem. It is the only capital region in the BEYOND4.0-study. It has intermediate services and knowledge as a sufficient condition for the outcome.
- It seems possible to have productive entrepreneurship without high scores for all the ecosystem elements. Ecosystems perform well with very different configurations of conditions.
- Of all elements, only 'knowledge' seems to always 'present' in the configuration of each ecosystem.

An important remark is that the data on which Schrijvers (2020) builds her results dates back some years. There have been fundamental changes in the dominant business ecosystem that need to be pointed out in the past years. These changes may shift some of the results of the entrepreneurial ecosystem. These will be discussed further in the report. Table 4 shows the shifts in the dominant business ecosystems.

Table 4. BEYOND4.0 regions: description of major changes in the business ecosystem (regional reports)

Beyond4.0 region	Dominant business ecosystem	Change 2010-2022
Salo	Mobile technology	The Nokia business ecosystem collapsed in 2011. The region shows a strong decline. After 2018, Valmet started with battery production, using Industry 4.0 technologies (robotisation, IoT)
Oulu	Mobile technology; Wood Processing	The region experiences the replacement of the Nokia business ecosystem by the emerging ICT ecosystems and incumbent wood processing. Both new sectors develop new avenues with Industry 4.0 technologies (IoT, informatisation).
Sofia	ICT sector	The continuous growth of ICT, branching out. This is not an industry sector, but the focus is on supplying industrial ICT solutions to the whole of Europe and North Amerca. In this sense, they are driving Industry 4.0 efforts.
Duisburg	Steel sector	The sector experiences a steady decline of heavy steel, continuing restructuring. The new solutions lie in integrating digital solutions in the production systems.
Dortmund	Steel sector	The steel business ecosystem is not dominant anymore; new business ecosystems are on the rise.
Zuidoost Noord-Brabant	Advanced manufacturing	Advanced manufacturing has taken over the role as the dominant business ecosystem. This sector is at the core of the Dutch Smart Industry (or Industry 4.0).
Basque Country	Machine tool	This sector is also slowly declining but still the most important business ecosystem in the region. The machine tool is representative of Industry 4.0 in Spain.
West Midlands	Car manufacturing	This is a slow declining sector but still the most important business ecosystem in the region. Car manufacturing uses a great degree of robotisation and other Industry 4.0 technologies.

5.3 The Emerging Entrepreneurial Ecosystems (EEEs)

The 'emerging' ecosystems selected for this study are new industrial networks in development. They can also be reviving networks where new economic activities emerge or collapsed areas that revive. They are, per definition, not yet top-performers of productive entrepreneurship (anymore), as indicated for incumbent systems. We have selected the following networks.

Table 5. An overview of selected industrial networks that are aimed to support entrepreneurial ecosystems (see footnote 7).

Beyond4.0 region	Main aim of the EEEs
Finland: emerging Digital and Health EEEs (Salo & Oulu)	To help revive the region with new industrial growth networks.
Bulgaria: BPO EEEs (Sofia)	An extra industrial network, building on the IEE-strength
Basque country: Smart mobility EEEs	An extra industrial network, building on the IEE-strength
Germany: Logistics EEEs (Dortmund)	To help revive the region with new industrial growth networks.
United Kingdom: Digital Healthcare	A new industrial network to broaden the regional strengths, building on the national Health sector strength
Netherlands: Aerospace EEEs West North-Brabant	To support a region to make better use of existing public infrastructure and develop new industrial networks. Some actors are spin-offs of the older Fokker ecosystem.

These networks are diverse in the background:

- EEEs within existing IEEs, in which these networks need to compete for the same resources as the dominant networks. We have two types of such EEEs: (1) the first type are networks that have the potential to replace existing networks within an IEE (Spain, Bulgaria). For the Bulgarian case, the ICT and the Business Process Outsourcing (BPO) sectors have strong links to one another. They cover different markets, but many organisations in Sofia operate in both markets. In Spain, the smart mobility sector is trying to develop a strong place next to the machine tool sector, for its link to the auxiliary industry of components for the automotive sector. And (2), networks developed to help existing IEEs find new sources to revive themselves (Finland, Germany and the United Kingdom). In these three regions, the dominant business ecosystem is in crisis, and regional authorities are desperately searching for new employment and growth opportunities (see also Schrijvers et al., forthcoming).
- In regions that are outside of the IEE and which are in need of further development (Netherlands). This has as advantage that the EEE is not always fighting for the same resources in the region with the IEE as in the other cases, with the exception of Talent. The EEE is also not trying to replace the existing IEE. One particular aspect of the Aerospace EEE is that we could classify the EEE as an old entrepreneurial ecosystem. The Netherlands used to have a thriving aerospace cluster with the aviation company Fokker at its centre. After the closure of Fokker in the 1990s, the aerospace cluster has been trying to find new purposes and strategies. The new collaboration in the West North-Brabant region is therefore still identified as an EEE.

For these networks, we evaluate their performance on the EES-model criteria. This gives us an indication to what degree these networks are able to shape new leading ecosystems for the future. The comparison is also not so much with the existing IEEs, but rather to see what these networks need to do to gather momentum, scale up, and stimulate productive entrepreneurship.

6. Result 1: comparing incumbent ecosystems with UU-study

6.1 How entrepreneurial are the selected regions?

Schrijvers et al. (forthcoming) have compared the eight BEYOND4.0 regions selected on the **Entrepreneurial Ecosystem Index** measure and for the **output of the ecosystems**. The first measure indicates the quality of the ecosystem, which we will look into further in the next section. The second one directly compares the number of Crunchbase firms founded in the five last years. This output measure indicates the number of innovative firms in the ecosystem requiring funding (Schrijvers et al., forthcoming). Table 6 only shows the relative ranking in each of the colons, with 1 as the highest rank.

Table 6. Ranking of the entrepreneurial activity level of the BEYOND4.0 ecosystems (Schrijvers et al., forthcoming)

Beyond4.0 region	Ranking Entrepreneurial Ecosystem Index	Ranking Entrepreneurial output	Quartile output
Salo	3	2	1
Oulu	4	4	1
Sofia	8	1	1
Duisburg	6	7	2
Dortmund	7	8	3
Zuidoost Noord-Brabant	1	3	1
Basque Country	5	6	2
West Midlands	2	5	1

Schrijvers et al. (forthcoming) suggest a positive relationship between both indicators for the whole dataset. A Spearman rank-correlation between the two rankings in Table 6 does not show any association. If we leave out Sofia, then there is a correlation between the rankings ($R_s = 0,8$; $p<0,05$). Schrijvers et al. also see Sofia as an outlier in the data. The reason for this strong performance of Sofia is that the ICT-EES profits from strong foreign investments over the past two decades. In the next analyses, this result will be further elaborated.

The Brainport region shows the strongest position for the quality of the IEE and for the entrepreneurial output. Salo also ranks high on the table. This is strange because of the decline the region has experienced after the closing of the Nokia factory in 2012. The figures in the table reflect the past more than the present, it would seem.

Duisburg and Dortmund are at the bottom of the rankings, which may only partially reflect the performance of the regions. As Schrijvers et al. (forthcoming) report, the Crunchbase data may not reflect sufficiently the performance of middle-class ("Mittelstand") enterprises, typical for the German context.

The ecosystems are quite diverse, spreading to the different quarters of the two rankings. As the table suggests, the comparison allows us to understand if the different ecosystem characteristics are responsible for the different entrepreneurial performances.

6.2 Which elements are driving entrepreneurship?

Comparing UU and case studies

Comparison 1 between the results of Schrijvers (2020) and the IEE-case studies teaches us about the necessity of the different conditions for performance. It also informs the statistics perspective used by the University of Utrecht (Schrijvers et al., forthcoming). What does our in-depth information bring as extra understanding to the abstract statistical data that is currently used? How do the conditions aid capital, labour and knowledge transfer? We are taking three steps here: comparing the UU-results to the regional analysis; analysing the knowledge spillovers in these regions; and understanding if there are institutional voids in the different ecosystems.

However, the main findings are presented in Table 7, allowing for comparisons between incumbent ecosystems, with the limitations mentioned above. Conclusions are, therefore, carefully made[9]. Annexe A.1 presents the detailed background table. Table 7 summarises this annexe's main contents and compares it with Schrijvers (2020) results.

[9] Furthermore these conclusions will be discussed in a series of workshops in the remainder of the research project (i.e., WP4.2).

*Table 7. Summary of the results of the qualification of the six entrepreneurial ecosystems (1=present, 0=absent): comparison of **BEYOND4.0**-results (BEY) to study by Utrecht University (UU) (Schrijvers, 2020) [see A.1 in annexe] (blue text = difference in evaluation between UU and **BEYOND4.0**-team).*

	Finland: incumbent IEE (Salo & Oulu)		Bulgaria: ICT IEE (Sofia)		Spain: Machine tool IEE (Basque Country)		Germany: Steel IEE (Duisburg)		UK: automotive IEE (West Midlands)		Netherlands: Brainport IEE (East North-Brabant)	
	BEYOND4.0	UU	BEYOND4.0	UU	BEYOND4.0	UU	BEYOND4.0	UU	BEYOND4.0	UU	BEYOND4.0	UU
Formal institutions	Strong institution-nal context, but locally focused (exclusive)	1	Insulated IEE, not supported by institutional environment	0	Strong institutional context, well deve-loped network and attitudes	1	Diminishing institutional support for traditional IEE	1	Strong institutional context, with complete coverage of support	1	Half directed institutional context, not focused on entrepreneurship	1
Entrepreneurship culture	Strongly develop-ped in the two regions. Trust in entrepreneurship.	1	IEE is strongly entrepreneur focused	0	Strongly developed and supported	0	Fractured entre-preneurial culture mainly driven by anchor company	1	Traditional entrepreneurial culture, R&D and MNC driven	0	Collaborative culture, trusting relations	1
Physical and IT infrastructure	Strongly developed, multi-modal	1	Developed through airport and IT connection	0	Strongly developed, multi-modal	1	Strongly developed, multi-modal	1	Strongly developed, multi-modal	1	Strongly developed, multi-modal	1
Demand	Markets are global, not building on local demand. For new products, local demand is important.	0	Only focus on international markets	0	Markets are global, not building on local demand	1	Markets are global, also building on local and national demand	1	Markets are global, not building on local demand	1	Markets are global, not building on local demand	1
Finance / financing	Broad financial support for start-ups, for scale-ups it is less sufficient	1	International and EU funding mainly, with issue of corruption	1	Well-developed and strongly funded financial system	0	Funding is at risk for making the necessary transition(s)	1	Well-developed, strongly funded financial system (cause: Brexit)	1	Well-developed and strongly funded financial system, not dependent on local funding	1
Talent	Mixed picture for education levels: tight for high levels, abundant for low skills	1	Strong supply of talent	0	Strong supply of talent and system to support it	1	Supply of talent is in a turmoil, with dwindling supply to the IEE	1	Strong supply of talent	1	Supply of talent is average, mainly by extraordinary demands	1

	Finland: incumbent IEE (Salo & Oulu)		Bulgaria: ICT IEE (Sofia)		Spain: Machine tool IEE (Basque Country)		Germany: Steel IEE (Duisburg)		UK: automotive IEE (West Midlands)		Netherlands: Brainport IEE (East North-Brabant)	
(New) Knowledge	Mixed situation with excellent knowledge supply in Oulu, less so in Salo	1	Local optima, but overall, not strong knowledge position	1	Strong knowledge system support for EES	1	System dominated by anchor company, limiting innovation direction	1	Strong knowledge system support for EES	1	Strong knowledge system support for EES	1
Services by Intermediaries	Strongly developed in Oulu, average for Salo	1	Strongly developed network of intermediaries	1	Strongly developed network of intermediaries	1	Strongly developed network of inter-mediaries, focu-sed on Anchor co.	1/0	Strongly developed network of intermediaries	1	Strongly developed network of intermediaries, not limited to region	1
(Social) Networks	Well networked regions	1	Starting network development	0	Very strong, historical networks in the IEE	1	Very strong, historical networks in the IEE, dominated by Anchor company and partly EU focuses	0/1	Well networked region, but conflicting interests	1	Very strong, historical networks in the IEE	1
Leadership	Anchor company driven leadership	1	Entrepreneur driven leadership with foreign influence limiting clear local visions	0	Sector associations driven leadership	1	Anchor company driven leadership	0	Dispersed leadership, through OEM and networks	1	Business leadership	1

Thirty per cent of the cells show a difference between the evaluations based on the separate data analysis and interviews with the UU-figures. Several explanations are possible. The scope of the regions is different from the ecosystem. Most of the deviations are with the systemic condition 'demand'. Here, the scope may also play a role: the ecosystems are more limited to sectors, and they may be more focused on the international market, as the table shows.

The strongest deviations in results exist for Duisburg/Dortmund (5), Sofia (4) and the Basque Country (3). The data on the Basque Country reveals stronger performance than recognised in the statistical data. An explanation is not easily given. For Sofia, the UU-results are less positive than the BEYOND4.0-results. The explanation is probably that the UU-results encompass the whole region, also outside Sofia, whereas the other results only reflect the situation for the ICT-IEE. For Duisburg, the role of the anchor company deviates from the results for the region. In most other deviations, the UU-results show more positive results. The stakeholders from the regions are possibly more critical about what they see. They do not necessarily have an international comparison in mind.

Separate conditions

Formal institutions are often only mentioned by respondents as a 'hygiene factor': the interviewees in the ecosystems do not consider it a very important element, and this is likely related to the fact that the quality of the formal institutions is generally up to standard in the regions in the study. We already saw from Schrijvers (2020) and the separate study (Focacci & Kirov, 2021) for the Bulgarian ecosystem that this element is problematic for companies. The BEYOND4.0-information shows that businesses have to deal with an institutional environment in which corruption and unsupportive public policy play an important role. The businesses in this Bulgarian IEE manage to 'circumvent' the negative impacts of this context. The companies (and other stakeholders) operate as insulated from their institutional context and are able to do that because of the international firms that dominate this IEE. These companies do not want to get entangled in these local issues.

The German steel ecosystem is an old, strong networked environment. However, the formal institutions related to environmental regulations and associated CO2 emission targets are seen as a major challenge for the ecosystem and involve large technology investments. The IEE sees an increased need for support from its institutional context. Stakeholders in the networks are devising counter-strategies to keep the ecosystem alive in the international competition. Table 7 shows that the content may be quite different and evaluated differently within this dimension of strong formal institutions. The Finnish IEEs are locally focused and exclusive, in this sense, the policy partners are not prepared to help the industrial networks attract more international talent. The reverse is the case for the Dutch IEE, in which there is already very supportive institutional support. From the discussions with the separate companies, it would seem that less support for entrepreneurship seems available in the future. The comments from the Dutch Brainport region were that they found too many impediments in the institutional environment (e.g., much insistence on new environmental rules (PCBs) and putting a lot of risk on management) to support entrepreneurship. In the UU-results, such impediments are not recorded or are seen as relatively unimportant.

For the element of entrepreneurship culture, we find mixed results. In the Finnish, Spanish and Dutch ecosystems, culture is considered an important element, and the assessment is that the ecosystem has a good entrepreneurship culture. For the Spanish situation, the UU-data indicates otherwise. The local stakeholders find entrepreneurship strongly developed. The Etxabe (2019) study also presents such an interpretation, which also points out that informal networks and social

capital drive the actual dissemination of knowhow in the Basque region. For the Bulgarian incumbent ecosystem, the entrepreneurship culture is less prevalent in this sense that the companies within the system are focused on their separate performance. There is no match between what the industrial networks support and the broader Sofia region. For the German IEE, the major steel company still drives the entrepreneurial culture of the Ruhr region. This culture is more and more contested by newer industrial networks, not directly related to the core business of steel, such as delivery, subcontracting, material tracking and logistics. In the United Kingdom, the incumbent ecosystem was well established and had a long history in the region, and as a result, entrepreneurial activity, in terms of the supply chain, had been prevalent in the past. Entrepreneurial activity is now more limited as companies with niche specialities have been established. With the current ecosystems, SMEs are now more likely to collaborate when dealing with large organisations to have a stronger position in the supply chain.

Regarding the element of **physical (and ICT) infrastructure**, respondents from all regions/ecosystems are stating that the multimodal physical infrastructure (road, rail, waterways, air) is sufficiently well-developed in the region, even if most regions indicate congestion problems. In that respect, it could also be regarded as a 'hygiene' factor for the functioning of the ecosystem. With respect to ICT infrastructure, there also seems a consensus among the six ecosystems that this is up to standard. For some ecosystems (e.g. the Ruhr region in Germany), there is an explicit mention of the geographical advantages of where the region is located, with respect to access to trimodal transport options via water, road and rail. In the United Kingdom, the infrastructure had, over time, built up around the ecosystem, with large, multi-national companies driving demand. For the Sofia region, the software activities are local but with strong connections to the international mother firms. The international airport is supportive of this purpose. The whole region may be evaluated as having a less supportive infrastructure. The IEE has less need for intermodal infrastructure support to optimise its performance. The UU-results indicate otherwise. Again, this is explained by the difference in scope between the two studies.

The element of **(regional) demand** is considered unimportant by all respondents in all regions. The reason for that is that the products and services generated by the entrepreneurial ecosystem are marketed over a much larger geographical area than the (NUTS3) regions. Most ecosystems cater to the global market. However, when observed more in detail, the respondents see local demands as important (e.g., German companies processing the steel products).

For the element of **Finance**, we find that this is a factor that is considered more important by the respondents than suggested in Schrijvers (2020). There is a strong emphasis on public financing of investments by national and EU levels in the ecosystem in some regions, with the German steel ecosystem as a prime example. The German steel industry requires substantial (public) funds to make the future transitions it is confronted with. The Bulgarian ecosystem explicitly mentions EU funding as the main source of Finance. National funding is under development and not yet at the level of the other EESs. For the Finnish ecosystem, there is more emphasis on *private* actors that provide financing options for investment. However, the support is seen as incomplete: scale-ups have difficulty finding sufficient support to grow. In the Basque (Spanish) ecosystem, autonomy in designing and implementing the region's industrial policy offers more flexible options for financing ecosystem companies. In the United Kingdom, funding is driven by national priorities, with funding

often channelled through regional bodies to align with regional industrial priorities. Brexit may be used as an instrument to provide more public funding, which was not allowed before. Overall, this element scores as sufficient in the regions (except in Sofia) but at the same time causes worries for the future. Nevertheless, the source of finance does seem to have an impact on eventual labour relations in the ecosystems under consideration. Whenever there is a major role for listed multinational firms in financing the businesses in the ecosystem (e.g. in the Bulgarian case), this comes with the risk of a strong emphasis on 'low road' HR practices that create fewer and more precarious jobs. This could, in turn, lead to less inclusive outcomes at the level of the ecosystem as a whole.

The element of **Talent** is considered a crucial factor by almost all respondents in all of the ecosystems in this study. All ecosystems mention the availability of qualified personnel as a factor contributing to the current success. The situation in Sofia is evaluated by Schrijvers (2020) as different from our study. Again, here the difference in scope is important. The ICT-sector in Sofia finds sufficient supply, and the improving financial situation in the sector helps to keep talent in Sofia. The sector pays Western-European wages, but the costs are very low. This is not visible at the regional level. For the German steel sector, the changing perspective on working in the sector affects the attractiveness of working there. The sector is confronted with a dwindling labour supply to the sector. This factor does not contribute to the performance of the business networks.

For most ecosystems, the future availability of qualified personnel is explicitly mentioned as a risk factor. It is about the right mix of available talent in the Finnish situation. The main emphasis is on highly skilled workers with higher (or medium vocational) education qualifications. In the United Kingdom, a driver of entrepreneurial activities was management and leadership skills. It was suggested that entrepreneurial activity is dominant in companies with a team or an individual that can drive this activity. Digital transformation and entrepreneurship were viewed as important to the growth and hindered in some companies by a lack of management and leadership skills rather than 'digital' skills.

For the element of **New knowledge**, many respondents in all ecosystems point to (access to) research institutes (e.g. universities) and the spending on R&D, either private or public. The general impression in the six ecosystems is that they benefit from relatively easy access to research institutes and sufficient R&D funding. Furthermore, respondents state that both 'access to research institutes' and 'level of R&D investment' are up to standard. In the United Kingdom, universities with industry collaborations are seen as anchor companies leading on R&D. The knowledge support is mixed in the Finnish Oulu region but quite weak in Salo. The downfall of Nokia in this Salo region has affected the existing knowledge support, which is less in line with the required new developments. New faculties are in development in the region (from Turku University), but they may only impact the future. The next section on knowledge spillovers informs this systemic condition more specifically.

Services by intermediaries are an element that seems to create some confusion with respondents. Some of them focus on traditional business services (e.g. accounting), whereas others talk about regional development agencies that are often Public-Private Partnerships (PPPs). Desk research provides only very little information on the prevalence of 'incubators' or other forms of support for start-ups related to research institutes. Respondents in the Spanish and Dutch ecosystem refer to

the existing 'incubator' type of intermediaries. Generally speaking, all respondents consider this an important element. This was also seen as a necessary condition by Schrijvers (2020) for very high productive entrepreneurship. Still, we have to allow for the fact that there is a great deal of heterogeneity among respondents concerning what 'services by intermediaries' are.

Social networks are considered an important element in most ecosystems. This makes sense because, without at least some network connections, it would be difficult to identify an ecosystem in the first place. Since most respondents recognize that they are part of an ecosystem, they imply that the element of social network is a relevant factor for the ecosystem. More specifically, most ecosystems respondents refer to 'triple' or 'quadruple helix' types of networks between businesses, government, education/research, and society. A noteworthy finding is that many respondents stress the need for cooperation (much less so, competition) between businesses within the region/ecosystem. This could refer to vertical cooperation in supply chains but also to horizontal forms of cooperation within and across supply chains. Examples are found in the Dutch ecosystem in the East of North-Brabant and in the United Kingdom ecosystem in the West Midlands. The situation in Sofia is related to the fact that the ICT-industrial network operates as an insulated network, insulated from its broader environment. The broader network development will be a factor for the future.

The same finding for 'Services by intermediaries' is true for the element of Leadership: it creates some confusion with respondents about what 'leadership' actually is (for example: is it thought leadership, business leadership?). Nevertheless, it is often mentioned as an important element, especially concerning social networks. Sometimes the leadership is located within the industrial network (Dutch and Bulgarian ecosystem), whereas in other ecosystems (e.g. in Germany and Finland), it is more located in the so-called focal firm(s). UU (Schrijvers, 2020) evaluates this leadership as missing from the German situation. This fact may be explained by the rough measure of leadership in Schrijvers (2020): the number of H2020-leaders in the region. The steel sector may be less focused in general on EU-research funding. In the United Kingdom, leadership was located with the regional networks that supported growth in the sector and collaboration, but it was also located in the larger firms that dominate and drive demand. The stakeholders evaluated the leadership as quite dispersed, driven by OEMs and diverse networks.

Assessing the necessary conditions

In summary, the entrepreneurial ecosystem model seems to be recognized by actors from the ecosystems as a useful tool for investigating and assessing these ecosystems. Some elements, however, are problematic. The (regional) Demand element is considered irrelevant because most of the production generated in the ecosystem is not sold in the region. Furthermore, the elements of Leadership and Services of intermediaries are unclear to respondents, and it is not very easy to compare the findings on these elements across ecosystems. These elements are evaluated in the UU-study (Schrijvers, 2020) as necessary conditions for very high productive entrepreneurship. More discussion with stakeholders may be needed to understand these conditions better.

Regarding the question of the interplay between elements that create success (or lack thereof) for the ecosystem, there is still a lot of work to be done. Schrijvers (2020) indicates that there are several ways to productive entrepreneurship. The only less performing region would be the

Duisburg area, in which the redefinition of the position of the steel industry dominates the entrepreneurial debate. We find that some elements are considered important by most respondents in all regions from our qualitative research efforts. This seems to be true in particular for the element of Talent. The Finnish cases show that there is a need to employ international talent, but the local partners are not supporting such a strategy. The reverse is the case in the Dutch case in which local partners run the extra mile in attracting international talents. International talent is helping the IEE to outperform other regions in the world. Furthermore, the elements of Formal institutions and Physical infrastructure are considered 'necessary' (but not sufficient) conditions for the success of ecosystems. This is not the outcome of the UU-research (Schrijvers, 2020), where no condition was deemed 'necessary'. This is probably due to the fact that the scores of these elements are calculated *relative to the EU median*. In general, the level of these elements is measured at a high statistical level in Europe, which is why scoring above the EU median is not necessary to have a good ecosystem. The social network element is considered important too, but we cannot exclude the possibility of 'circular reasoning' with respondents. A well-functioning social network is often reported as the success (result) of the ecosystem, not as an 'input' element. We find mixed results for the elements of Knowledge, Finance, and Entrepreneurship culture. Most respondents characterize these elements as important resources for businesses, but often they consider them not as important as the element of Talent.

If we compare the overall result with the UU-study, we see that most results are in line with each other but that there are also several differences. The level of the study explains the main differences. Our study focuses more on the business networks instead of the regional level (i.e. specific industries within a particular entrepreneurial ecosystem). These differences do show that IEEs may not always be aligned with their broader environment. The Sofia-case is illustrative for this. The ICT-sector is an important driver of productive entrepreneurship. However, this sector operates as insulated from the broader environment. For the EES-model, the complication is to understand what drives economic growth: is it the business system, or is the support by the broader environment from the ecosystem that drives growth?

Another difference is that the data provided by UU (Schrijvers, 2020) is from the past. For example, the downfall of Nokia in the two Finnish regions is not fully accounted for in the evaluation of the ecosystem characteristics. Salo is seen as a region with ticking nearly all the boxes of the entrepreneurial ecosystem model. In reality, the region is still in an economic slump and is aiming at attracting traditional industries (e.g. car industry) to restore employment levels. Also, the difficult transformation for the German steel sector is not captured in the current statistics, even though UU points to the fact that productive entrepreneurship does rate lower in the Duisburg area.

More importantly, does the actual evaluation for productive entrepreneurship change with the outcomes of Table 7? Six of the eight ecosystems show less positive scores for the entrepreneurial ecosystem model than Schrijvers (2020) evaluated. Oulu drops with four points. This seems strange because the region is recovering much better from the Nokia downfall than the Salo-region. The German cases drop by three points. The results from Schrijvers (2020) may reflect a too optimistic evaluation. The reverse is the case for Sofia that goes from three to six conditions present. This reflects the strong position of the ICT EES, which is certainly not comparable to the broader Sofia

region. This outcome does show the need to distinguish between regional and ecosystem-level comparisons.

6.3 Which knowledge spillovers exist in the IEEs?

Table 7 shows that Knowledge and Intermediaries are perceived as necessary conditions for entrepreneurial activity in the observed ecosystems. How can we evaluate the knowledge spillover mechanisms if Knowledge is so important? The taxonomy of spillover mechanisms developed in Section 2.2 is used to describe the main mechanisms in the IEEs.

Two topics are central in dealing with these knowledge spillovers. First, which knowledge spillovers are used in each case, and how have they been used to create more entrepreneurial activity? The basis for the evaluation is statistical information in the Regional Innovation Statistics (European Commission, 2021a), the separate case studies (see institutional maps in Annexe 2) and the analysis of the SCOPUS database for co-publications and patents (Dhondt, 2022). The sources are used to inform the use of these spillovers. Secondly, institutional voids may exist within specific ecosystems. The question is then which knowledge spillovers exist, why they work or why they are in decline in a particular ecosystem. In Annexe 4, a separate analysis of the knowledge spillovers is included. This section looks at the main conclusions.

None of the regions outperforms the others in innovation performance. Sofia shows a remarkable growth in R&D personnel and employment in knowledge-intensive sectors. They have caught up with the rest of Europe and are even in a leadership position. The two German regions have similar outcome results, underperforming for all indicators except for the employment in innovative SMEs. Investments and employment in knowledge-intensive sectors are down, but innovative SMEs may counterbalance this. The Basque Country has a high number of employed in knowledge-intensive sectors and shows relatively high innovation expenditures. Noord-Brabant in the Netherlands is seen as an innovation leader, but the figures show weaknesses for overall investments and innovative SMEs. Salo has felt the impact of the closure of Nokia in the hardest way. Only employment in innovative SMEs seems to help the region. Oulu has only experienced a decline in employment in knowledge-intensive activities or professions but sees high levels of R&D investment and action from innovative SMEs. The same may be said of the West-Midlands.

Table 8. Summary table outcome indicators for the eight regions (+=strong performance; 0=medium performance; - = low performance) (source: annexe 1, Table A3-B-G)

Outcome indicators	1. Employment knowledge-intensive activities, profession, and growth	2. R&D expenditures business sector, and growth	3. Innovation expenditures per person employed	4. Employment in innovative SMEs	Knowledge (Schrijvers et al., forthcoming; Table 7)	Performance subgroup (European Commission, 2021a)
Sofia	+	-	-	-	+; 0	Emerging innovator +
Duisburg	0	0	0	+	+; 0	Strong innovator -
Dortmund	0	0	0	+	+; +	Strong innovator
Basque Country	+	0	+	-	+; +	Strong innovator -
Noord-Brabant	+	+	0	0	+;+	Innovation leader -
Salo	-	-	0	+	+;+	Strong innovator +
Oulu	-	+	+	+	+;+	Strong innovator +
West Midlands	0	+	+	+	+;+	Strong innovator +

How does this evaluation compare to the qualification given in the Regional Innovation Scoreboard (European Commission, 2021a)? Table 9 provides the comparison of the regions relative to the EU scores.

Table 9. Assessment of the positions of the eight regions in the Regional Innovation Statistics (European Commission, 2021a)

	2021 relative to EU in 2014	2021 relative to EU in 2021	Change over time
Sofia	63.8%	55.6%	11.4%
Duisburg	123.9%	107.0%	5.8%
Dortmund	126.5%	110.2%	10.2
Basque Country	119%	103.6%	14.7%
Noord-Brabant	147.4%	128.3%	14.8%
Salo	134.4%	117%	19%
Oulu	136.2%	118.6%	18.7%
West Midlands	139.1%	121.1%	20.6%

The RIS2021 evaluates Noord-Brabant as an innovation leader (European Commission, 2021a). The table shows that the improvement of the position is not that great compared to the other regions. The region is strong because of its past, reflected in patents and employment in knowledge-intensive sectors. There is a risk for the future in the relatively limited employment in innovative SMEs and the relatively limited amount of investments. These figures reflect what Hannigan et al. (2021) have indicated: incumbent ecosystems may spend a lot of activity on organisational maintenance rather than innovation and new knowledge creation. These figures can act as a

warning. **Sofia** is an emerging innovator+, improving the employment situation, but still lacking strong fundamentals as sufficient innovative investments and innovative SMEs. The **two German regions** are strong innovators, mainly because of their SME effort. The innovative SMEs allow dealing with the declining steel industry. The **Basque Country, Salo, Oulu and West Midlands** are all strong innovators, but for different reasons. Salo, Oulu, West Midlands score high on digital skills and innovative SMEs. The Basque Country finds its strength mainly in a highly educated region.

Table 10 summarises the strengths of the different knowledge spillovers.

Table 10. Summary: which knowledge spillovers exist in the eight ecosystems (scores reflect rankings in previous tables, network figures in Annexe 2)

	Sofia	Duisburg	Dortmund	Basque Country	Noord-Brabant	Salo	Oulu	West Midlands
Education/schools – companies								
1. Public private co-publications	-	0	0	+	+	+	+	0
2. Internships, apprenticeships	-	+	+	+	+	-	+	+
3. Major programmes	+	+	0	+	+	-	+	-
Companies - companies								
4. Business ecosystems, business supply chains	+	+	0	+	+	0	+	0
5. Take-over of personnel	0	-	-	-	0	-	+	-
6. Knowledge sharing through business networks	+	0	0	+	+	-	+	+
7. Life-long learning	-	-	-	0	+	+	+	0
8. Innovative SMEs collaborating with others	-	+	+	-	0	+	+	+
Public stakeholders – companies								
9. Labour market measures	-	+	+	-	-	?	+	0
10. Business support networks	+	+	+	+	+	0	+	0
11. Funding opportunities, incubators	+	-	-	+	+	-	+	-

Rating: +: present and active; 0: present, but no action visible; -: not present, no action visible

Oulu shows the use of most of the knowledge spillovers. The Salo region shows that there are several institutional voids. Good scores for several measures reflect past performance. The current situation is one in which actors such as SMEs need to find their own way.

Noord-Brabant relies as Oulu on most of the mechanisms. The main weakness is the degree to which innovative SMEs collaborate. Possibly, the cause is that there are so many possibilities to exchange ideas that SMEs cannot find their place.

For Sofia, the main institutional voids are the connection between education and companies, and between companies.

The German cases are interesting in this sense that the dominance of the Steel Company reduces the use of the different knowledge spillover mechanisms. It seems that the good score for innovative SMEs collaborating reflects a kind of measure of last resort. Since most of the support is directed towards the leading Steel IEE, companies can only rely on their direct collaboration to create entrepreneurial activity.

In the Basque Country, public support drives most of the knowledge spillovers. However, even if companies drive several types of spillover, the guidance of major programmes is crucial to achieving the necessary new ideas.

6.4 Summary

The main question for this section 6 was to evaluate what drives the entrepreneurial performance of the eight IEEs. Table 7 compared the entrepreneurial quality of the eight regions and a comparison with the UU-results. The UU is helpful because it provides us with a context to evaluate the entrepreneurial performance of the regions. The following table extracts the evaluation of the entrepreneurial quality of the eight regions.

Table 11. Summary of the results of the qualification of the six entrepreneurial ecosystems (1=present, 0=absent): BEYOND4.0-results

	Salo	Oulu	Sofia	Basque Country	Duisburg	Dortmund	West-Midlands	Noord-Brabant
Institutions	1	1	0	0	1	1	1	0
Culture	1	1	0	1	0	0	0	1
Infrastructure	1	0	1	1	1	1	1	1
Demand	0	0	1	0	0	0	0	0
Finance	1	1	1	1	0	0	1	1
Talent	0	0	1	1	0	0	1	1
Knowledge	0	0	1	1	1	1	1	1
Intermediaries	1	0	1	1	1	0	1	1
Networks	1	1	0	1	0	1	1	1
Leadership	1	1	0	1	1	1	1	1

As indicated, one-third of the quality scores differ from the UU-study. Overall, the quality of a factor is rated as lower by the stakeholders in the region than the statistical information shows. Stakeholders are more critical of the functioning of their region. Noord-Brabant still shows a healthy ecosystem context. Two conditions are rated as of concern: institutional context and local demand. The results from Table 10 show that Noord-Brabant uses many mechanisms to create and sustain entrepreneurial performance. Two other regions have moved up to the same quality evaluation as Brainport: West Midlands and the Basque Country. The Basque Country reflects the profile of Noord-Brabant. The region sees entrepreneurial culture as more stimulating for entrepreneurship than statistics allow to judge (Etxabe, 2019). However, the funding in the region is more driven by

public authorities rather than by private venture capital, as in Brainport. Again, the qualifications are not straightforward, mainly because venture capital is also active in the Basque region.

The biggest change in the table is for the two German regions. The 'downgrading' of entrepreneurial quality reflects the strong position of the leading Steel company in the region. A lot of entrepreneurial activity is siphoned away to support this IEE. For policymakers, the actions are to maintain this major producer with a great number of jobs.

It seems as if there is some movement of all quality scores towards the 'average'. Three regions come out on top: Basque Country, West Midlands and Noord-Brabant. The strongest movers downward are the Finnish and German regions. Stakeholders are more critical of the performance of the ecosystems than regional statistics show. This asks for statistics at another level (Dhondt, 2021). It may be that the outcomes lead to another perspective on driving forces for more entrepreneurship. The additional perspective on knowledge spillovers is therefore helpful.

7. Result 2: impact of the digital transformation for the IEEs

Our next question is to understand how the digital transformation is seen as impacting the IEEs. The whole idea of entrepreneurial ecosystems relies on the idea that creative destruction brings about new enterprises and businesses within such systems. Digital technology is pressuring existing companies to look at new opportunities for growth and development. In the ecosystem model (Stam, 2015), digitalisation appears in two forms: infrastructure (framework condition) and talent (systemic condition). To understand how companies deal with digital technologies, we need a broader and separate perspective on technology: to what degree do companies use these technologies and to what degree do these technologies inform the business models of these companies (Proeger & Runst, 2020)? The ecosystem perspectives require us to look at how the stakeholders in the ecosystem perceive and share ideas on these technologies. For example, Lammers et al. (2021) investigate how two cities (Sydney and Berlin) try to compete to become the artificial intelligence capitals in the world. Specific urban policies are required to achieve this outcome. To what degree do the technologies lead to new business, and does this require new skills (Talent) from the companies.

From Table 7, all ecosystems indicate that they enjoy **mature digital environments**. The ecosystems do not experience any Infrastructure impediment to launch new types of business. However, the digital literacy of the Talent in each of the ecosystems is strongly different. Leendertse et al. (2021) use the percentage of the population with e-skills as an indicator, measuring people with advanced levels of digital skills. In the RIS (European Commission, 2021a), such skills are defined as "Above basic overall digital skills represents the highest level of the overall digital skills indicator, which is a composite indicator based on selected activities performed by individuals on the internet in four specific areas (information, communication, problem-solving, content creation)". Leendertse et al. (2021) see the "inclusion of digital skills as important because digital literacy is essential for working in any type of enterprise in the current digital society". Table 12 provides an overview of the e-skills in the eight regions, according to the RIS (2021).

Table 12. Overview of digital skills in the eight regions (European Commission, 2021a)

	Digital skills
Sofia	0.084
Dortmund	0.707
Duisburg	0.707
Basque Country	0.640
Noord-Brabant	0.956
Salo	0.968
Oulu	0.932
West Midlands (UK)	0.957

The table provides an interesting insight into what is happening in the regions. Sofia shows an extremely low figure for digital skills. Noord-Brabant, Salo, Oulu and the West Midlands show very high levels of digitally skilled populations.

The environment and the 'stock' of skills do not yet uncover what the digital transformation is doing to the companies. For this, we need better insight into the **presence of highly specialised IT knowledge and the way companies deal with the digital transformation**. Several questions were discussed with the stakeholders in the ecosystems. First, we tried to understand how the industrial networks saw themselves affected by the digital transformation. To what degrees are the ecosystems integrating the newest technologies in the companies? Secondly, how do the IEES tackle the threats and opportunities the digital transformation brings. Are the business models of the companies under threat or changing? Table 13 shows a summary of results in Table A.2. The table classifies the way the region or IEEs react to the challenges the digital transformation brings.

Table 13. Summary of reaction of entrepreneurial ecosystem towards digital transformation [see A.2 in annexe]

	Finland: incumbent EESs (Salo & Oulu)	Bulgaria: ICT EES (Sofia)	Spain: Machine tool EES (Basque Country)	Germany: Steel EES (Duisburg/ Dortmund)	United Kingdom: Digital health EES (West Midlands)	Netherlands: Brainport EES (East North-Brabant)
IT specialists (European Commission, 2021a)	0.420-535	0.866	0.427	0.384-451	0.471	0.647
Use of digital technologies	Digital technologies well embedded in whole ecosystem.	Digital technologies well present, and in development.	Digital technologies mainly with limited functions in the sector; sectorial application of technologies (industry 4.0).	Large steel companies in particular are already using digital technologies on a grand scale to optimise processes. However, there seem to be big differences to SMEs, some of which are not yet digitising to a great extent.	Digital technologies are seen as opportunity, but spread is low among SMEs.	Digital technologies well embedded in whole ecosystem.
Impact on business models	Data-driven I4.0 business models well embedded in ecosystem	Ecosystem is digitally minded, but lags behind in data-driven business models	Data-driven business models only with lead companies, mainly traditional automation.	Business models are mainly traditional automation, digital business models are not yet engrained.	Data-driven business models only with lead companies.	Data-driven business models well embedded in region, with anchor companies and local companies.

The **presence of IT specialists** is remarkedly different from the e-skills in the population. The RIS 2021 data are used for Table 13. Sofia shows an extremely low (normalised) score for digital skills in the population. On the other hand, the position for IT specialists far exceeds the position of all other regions. It is clear that Sofia is an IT-intensive region, with a great number of IT specialists. However, these figures clarify that the digital divide is quite pronounced in Sofia. Digital

technologies seem not to be common in the Bulgarian household. The reverse seems to be the case in the other regions. Basic digital skills are well present in all other regions, but the number of IT specialists seems to be limited. Even in regions such as Oulu and Salo, the number of IT specialists seems not to be particularly high. Noord-Brabant does, however, position itself quite high in both rankings. It has the means in Talent to keep up with the digital transformation.

Four of the entrepreneurial ecosystems are at the centre of the digital transformation. The mobile technology sector of Oulu, Brainport and the ICT IEE in Sofia are major players in developing and application of digital technologies. The Sofia region is supplying IT services to the whole of Europe. Companies in Brainport and in Oulu manage IT subsidiaries in Sofia. The Basque machine tool IEE and the German Steel IEE see themselves mainly as consumers of digital technologies, as does the automotive IEE in the West Midlands in the UK. Companies are far in automation, but digital technologies do not transform production systems. The level of adoption of these technologies depends very much on the separate companies. The different uptake of these technologies is also reflected in the impact on the business models used in the ecosystems.

In the Bulgarian, Dutch and Spanish cases, the new technologies allow attracting even more business to the region. For the Sofia companies, several are developing BPO models with new digital possibilities. However, integrating digital technologies to develop new (platform-driven) business models seems to be lagging because of a lack of local knowledge support to develop these business models. IoT technologies allow major companies to develop new service models for the Dutch and Spanish ecosystems. The products that are delivered remain digitally connected to the core companies. Big data supports the companies to find extra activities in their markets. Again, the message is that this is a possibility but not yet a reality. In none of the regions, Amazon-type of companies is being constructed. In the West Midlands case, the approach is integrated as in the other cases, but all stakeholders do not support the reaction. There is a need for more leadership. The dispersed leadership context is not helpful for this.

For the Finnish, German and British regions, the digital technologies are used to improve the current (traditional) production models. Even if in Oulu, the mobile technologies are redeveloped into new applications, Big Data and IoT are mainly used to rationalise internal processes further. New services are not yet on the agenda. For the German Steel IEE, the digital transformation helps the anchor company to continue its improvement of the production process and the rationalisation strategy thus improving efficiency. For the UK automotive IEE, digital technologies are improving supply chains but only implemented by OEMs.

Many of our respondents indicate that the digital transformation in the ecosystems is still in its infancy in many respects and the current trends are just the beginning. In addition, some respondents refer to a lack of action on behalf of the government (Bulgaria), some (Spain, Germany) report that stakeholders show a sufficient level of awareness, but concrete action is sometimes lacking.

The general conclusion is that the digital transformation is omnipresent in the discourse in the ecosystems under study but not sufficiently present in the different stakeholders' actions, which is considered a risk for the future. The reactions are at best haphazard and seen as slow by the stakeholders. Given sufficient digital infrastructure and high-level digital skills, more could be

expected at the level of business models and technology adoption. More entrepreneurial possibilities should be possible. This result also explains why few of the stakeholders see digital technologies as a threat to current employment in the ecosystems. On the question, if there may be future impacts on employment, the reactions are more pessimistic. This pessimism does not inform concrete actions from the ecosystems.

8. Result 3: inclusive socio-economic outcomes and the IEEs

8.1 Introduction

Well-developed entrepreneurial ecosystems generate more economic growth, allowing better employment and life opportunities for those regions. But do we see this result for the selected ecosystems? And are employment impacts inclusive? These questions are assessed by looking at several indicators:

- Impacts on work and human capital: which changes are visible in sectors of employment, types of jobs, and unemployment?
- Distributional impacts: can we see if changes in jobs, employment opportunities and poverty risks, are the same between men and women, between different skills levels?

The main information missing to make a full analysis is wages. The analyses rely on statistical data and on stakeholder views. These data have been calculated from the Eurostat data. There is no comparable information about wage development for the regions and over time available. Impacts such as polarisation cannot be checked. The case studies provide some data here. The Regional Innovation Scoreboard (European Commission, 2021a) does not provide this insight. The available data have been processed to show the trends: are the situations improving? Can the trends help to understand how ecosystems deal with economic downturns? The stakeholder views inform us of how the changes are perceived in the ecosystems and how insider-outsider phenomena should be interpreted.

With the material, in the overall assessment, we answer the question to what degree the development in the entrepreneurial ecosystem is responsible for the results.

The statistical results and stakeholder perspectives (green fields) are summarised in Table 14. The actual data are included in Annexe Table A.3.

Table 14. Summary of reaction of entrepreneurial ecosystem towards inclusive outcomes? [see A.3 in annexe + EUROSTAT-data]

	Finland: incumbent IEE (Salo & Oulu)	Bulgaria: ICT IEE (Sofia)	Spain: Machine tool IEE (Basque Country)	Germany: Steel IEE (Duisburg)	UK: automotive IEE (West Midlands)	Netherlands: Brainport IEE (East North-Brabant)
Impacts on work and human capital						
Sectoral shifts (Eurostat)	Decline in industry, transport. ICT strong growth.	Strong growth in ICT, stable in transport, decline in industry.	Decline in industry and transport, small growth in ICT.	Stability in industry and transport, strong growth in ICT.	Growth in industry and transport, strong growth in ICT.	Growth in industry and transport, stability in ICT.
Technology and Knowledge-intensive jobs	Strong growth	Strong growth	Growth	Strong growth	Stable, no growth	Stable, no growth
Unemployment growth 2010-20	-16%	-49%	-16%	-33%	-46%	-19%
Unemployment compared to Sofia 2020	+132	Reference	+163	+42	+27	-1
Employment – Evaluation stakeholders	Recovering region, with different social and economic trajectories. IEE partially work to deal with restructuring core company.	Full employment ecosystem, region. IEE works as an excluding system. High skilled are retained, limited opportunities for low skilled.	Recovering region, with still considerable unemployment. IEE has worked as buffer for the economic crisis in the whole region.	Recovering region with persistent unemploy-ment due to high wages. IEEs have worked as buffer for the economic crisis in the region. IEEs work as inclusive for low skilled.	Region has persistent unemployment and hardest hit by economic crisis. Pockets of innovation driving demand for technical skills.	Full employment region. IEE is driving economic growth to unseen heights. The question is not how to share the economic crunch, but rather how to share profits.
Productivity and innova-tion –stakeholders	Innovation driven region	Innovation and internatio-nalisation driven region	Productivity driven region	Productivity driven region	Productivity driven region	Innovation driven region
Distributional impacts						
Sectoral employment	Equal development	Equal development	Men more in ICT	Equal development	Equal development	Equal development
Technology and Knowledge-intensive jobs	Stronger growth for men	Stronger growth for men	Equal development	Equal development	Strong decline for women	Growth for women
Unemployment Men - women	Equal development; 20% higher for women	Equal development; 26% higher for women	Equal development; 12% higher for men	Equal development; 40% higher for women	Equal development; 20% higher for women	Equal development; 5% higher for women
Unemployment skill-level [10](no gender effects)	Mostly ISCED 3-4 (52%)	Mostly ISCED 3-4 (57%)	More polarised (35% - 24% - 40%)	More ISCED 1-4 (lower skills)	Mostly ISCED 3-4 (41%)	Equal distribution

[10] ISCED:

- Less than primary, primary and lower secondary education (levels 0-2)
- Upper secondary and post-secondary non-tertiary education (levels 3 and 4)
- Tertiary education (levels 5-8)

Unemployment skill-level trend	Rise in ISCED 5-8	Decline in all levels, strongest in ISCED 3-8	Rise for women in ISCED 5-8	Decline in all levels, strongest in ISCED 3-5	Rise for women in ISCED 5-8	Rise in ISCED 5-8
Risk of poverty or social exclusion	Decline, average in EU	Strong decline, high level in EU	Decline, low level in EU	Decline, average in EU	No decline, highest level in EU	No decline, low level in EU
Diversity and discrimination – Evaluation stakeholder	Inclusive within Finnish context, but improvements needed	Gender equal, but high-education selective and partially age selective ecosystem	Gendered and 'national' employment, but few other selective mechanisms	Gendered employment, but few other selective mechanisms	Gendered employment and significant wage disparities	Quite selective employment situation, gendered, skill levels and wage disparities.

8.2 Incumbent IEEs of Salo and Oulu

The closure of the Nokia plants occurred in 2012. The impacts of this closure were felt throughout the last decennium. This is particularly visible in the higher number of people at risk of poverty and social exclusion. Salo and Oulu have reduced their number of excluded persons, but the levels are still at a higher level than, for example, the Basque Country and Noord-Brabant. One explanation for this is that the threshold to measure people at risk is higher in the Finnish regions than in the rest of Europe. This makes, for example, that pensioners and students fall below the threshold. Oulu has recovered more strongly but, however, in the figures, this is not really visible. This is because the Salo region has seen a migration of high skilled personnel to Turku and to Helsinki.

Employment is shifting. For both regions, employment is growing in industry and transport (etc.) sectors. ICT employment has increased dramatically over the past ten years. Both regions see strong growth in technology and knowledge-intensive occupations. The strong growth in information and communication jobs is equal at the level of both regions, but with reverse figures for males and females: Salo sees more jobs in ICT for women, Oulu sees more jobs for men in ICT. The type of jobs must, however, be different. Men experience stronger job growth in technology and knowledge-intensive sectors.

Unemployment is still high (index = 132, relative to Sofia) but steadily declines after 2015. The two Finnish regions experience unemployment levels that are more than double the Noord-Brabant figures. Finnish men have higher unemployment rates than women. The number of unemployed men has particularly risen in the period 2012-2015, after the Nokia closure. Even if their number is declining strongly after that date, they still experience higher unemployment than women.

The gender differences in unemployment mask stronger developments between educational levels. The ISCED 3-4 levels represent half of the unemployed (equal for men and women), but the growth is higher ISCED-levels (5-8). The number of lowly skilled unemployed is declining rapidly in these regions.

These figures confirm the evaluation by the stakeholders that the regions are recovering and show different social and economic trajectories. The stakeholders qualify the region as an innovation-driven region but into more diverse sectors. The more diverse economic context and the stronger knowledge support in the Oulu regions help the region overcome Nokia's downfall. The remaining parts of Nokia are helping the region to direct itself to new opportunities. The past reliance on Nokia in Salo has impacted the region quite severely. The restructuration of the regions is much more painful for the former high skilled personnel. It seems that those highly skilled persons, probably in higher age groups, are ‘trapped’ in unemployment and cannot leave the regions. The new ICT sectors are employing younger age groups. The fact that there are few low-skilled unemployed is probably why employers in both regions are urging Finnish policymakers to allow more migrants to come into the Finnish labour market. That is still not allowed.

8.3 Sofia ICT IEE

Sofia shows declining employment in industry and stability in wholesale, retail, transport (etc.), but a strong increase in information and communication jobs for men and women. These jobs are also technology and knowledge-intensive jobs. The growth in such jobs is nearly 50% stronger for men. The employment growth is connected to a decline in unemployed and socially excluded groups. Unemployment has halved over the past decennium, for men and women. Sofia shows the strongest decline in people at risk of poverty or social exclusion over time of the different ecosystems. The number of persons in these situations has nearly halved in ten years. Still, in 2020, Sofia has relatively the highest percentage of people at risk of poverty or social inclusion, except for the West Midlands.

The positive developments are not equally distributed between skill levels. Most unemployed (57%) have upper secondary and post-secondary educational levels. In Sofia, 22% of unemployed people have less than lower secondary or lower education level; and 20% have tertiary education. The developments affect men and women equally.

As indicated earlier, the Sofia IEE works insulated from the broader environment. The ICT sector has transformed itself from communist times to a formidable supplier in the world ICT industry. This means that this ecosystem itself does not (yet) have to deal with negative developments but rather with the distribution of the benefits. For the Bulgarian incumbent entrepreneurial ecosystem in and around Sofia, the outcomes are mainly positive for employees because the ecosystem is considered the main contributor to regional and even national economic growth, thereby also keeping talent in the region. Moreover, this does contribute to the inclusion of women in the labour market. The overall picture is not only positive. The minority group of Roma gipsies, for example, do not, on average, have the required qualifications and skills for the ICT sector. The development of the ICT sector only reaches high skilled groups with the Sofia region. The overall inequality is enhanced.

8.4 Basque Machine Tool IEE

The Basque country's employment is shifting towards more ICT jobs, technology, and knowledge-intensive sectors. Machine tool is declining in size and changing in the type of jobs. The development is equal for men and women. Unemployment is the highest of the six cases, more than double the rate of Noord-Brabant. The number of females unemployed is significantly higher than for males, the only region of the six cases. Females see also a slower decline in their unemployment rate in the observed period.

The Basque Country is also different from the other regions with a very polarised unemployment structure: the middle level of education shows low unemployment percentages. Highly skilled persons are responsible for 40% of unemployed, somewhat higher for highly skilled women. Certainly for highly skilled women, the situation is becoming even bleaker, with nearly twenty per cent unemployment growth among this group over the past decade.

Strangely enough, the Basque Country has improved the situation for the people at risk of poverty or social exclusion and is at the level of Noord-Brabant.

For the Basque Country, the incumbent ecosystem (machine tool) contributes substantially to the overall economic activity in the region. However, labour productivity growth is slowing down compared to wages, but the machine tool sector provides higher productivity levels per person. With respect to inclusion, the region shows less polarized unemployment than other regions in Spain but is still quite polarised compared to other regions. The social networks and institutional supports allow the companies to find faster opportunities for unemployed men with low educational degrees and reach new growth. Employees find more opportunities for employment through these actions. Even if we see a shift towards ICT and knowledge-intensive jobs, this shift is not benefiting highly educated women.

8.5 Duisburg Steel IEE

The Steel IEE shows its resilience. In employment, the industry figures have not declined over the past decade. However, the region sees employment growth in the wholesale (and other) and strong growth in the information and communication sectors. The growth in technology and knowledge-intensive sectors is also substantial. These figures indicate that the Steel IEE is playing on the defensive side, trying to maintain job levels, even if new employment is shifting towards other sectors. The situation is not different for men and women (even if some of the figures for Duisburg are not complete).

The two German regions have higher unemployment (40% higher than Sofia), mainly among males, but the unemployment is decreasing strongly from 2010 to 2020. Both regions show high unemployment among the lowest educational group (mainly men) and substantial unemployment levels among middle-level educational groups. Highly educated show very low levels of unemployment. These figures probably reflect the difficulty of unemployed steel workers to find other jobs.

The region of Duisburg/Dortmund is struggling to reduce the number of poor and socially excluded people and is only just better in comparison to Sofia. The Duisburg region has seen bigger improvement over time.

In the steel industry in the Ruhr region, digitalisation does not seem to play a significant role to improve the inclusion potential. Despite the sharp decline in the importance of the steel sector, the ecosystem remains one of the most important employers in the region. The ecosystem is also still rather inclusive towards relatively low skilled workers and provides them with relatively high wages and re-employment opportunities. Furthermore, employers have training programmes (and subsequently jobs) for unskilled workers. For those steel workers who do lose their jobs, job opportunities seem few.

8.6 West Midlands automotive IEE

West Midlands and Noord-Brabant do not show real differences in employment opportunities between males and females.

In the West Midlands, employment grows in all sectors, but most strongly in information and communication. However, the West Midlands is one of the few regions in which technology and knowledge-intensive employment for women have declined. The shift in employment is towards ICT, but this is not toward better jobs for women. Unemployment has decreased by nearly fifty per cent but still remains a quarter above the Sofia level. Unemployment is a general phenomenon for all educational levels. Highly skilled women are the only group that has seen their unemployment level rise.

The West Midlands figures show more disturbing figures. It is the region with the highest percentage of people at risk of poverty and social exclusion, a figure that has stayed completely stable over the past ten years. More job opportunities have not helped to reduce the number of persons at risk.

Digital transformation has been driven by anchor companies leading R&D and OEMs that lead the IEE. In the region, automation drove significant changes in the IEE, but major transformations have not been visible. There continues to be high demand for technical and project management skills to lead developments and changes. For SMEs, digital transformation has required resourcing – financial and skills – which has limited their capacity to change. Technology has been implemented where it has been assessed as cost-effective. Innovative and entrepreneurial networks of existing SMEs have recently been developed to strengthen their negotiating power with anchor firms in the IEE; their impact is yet to be assessed.

8.7 Noord-Brabant Brainport IEE

In Noord-Brabant, employment is growing equally for men and women in all sectors. However, Noord-Brabant is the only region not to show employment growth in the information and communication sector. Employment in technology and knowledge-intensive sectors remained quite stable, however, jobs have grown for women at the expense of men. Noord-Brabant is the only region where employment for males in these sectors has declined in the past decade.

Noord-Brabant shows the lowest percentage of unemployed compared to the other regions in 2020, with more men unemployed than women. Even at its low level, unemployment has continued to decline in the observed period, with the strongest decline for women.

Noord-Brabant shows more middle educated levels unemployed, with no difference between men and women. Surprisingly, unemployment has only risen among highly educated persons and women (+28%). Another surprising fact is that Noord-Brabant is the only region showing a rising (+2%) poverty or social exclusion risk. This is probably caused by the fact that this percentage is the lowest among the six regions by far.

In terms of economic output, the Brainport region had an above-average growth compared to other regions in the Netherlands. Particularly the professional and science service sector has grown strongly since 2000. The breaking-up of the multinational Philips company has mainly generated new opportunities for the region. Nowadays, manufacturing still accounts for about 24% of total Gross Value Added in the region (2000 = 26%). Even during the COVID19 crisis, employment is still growing, as is the innovative capability. However, inequality seems to increase since the main focus in the ecosystem is on highly qualified personnel with technology skills, while there is no deliberate strategy to contribute to a more inclusive labour market in the region. Overall, the Dutch taxation and social security system does provide for equalising impacts. The housing situation in Brainport has deteriorated quite strongly, leading to more inequality in housing opportunities. Expats working within the major companies are supported in this situation. Outsiders pay the price.

8.8 Summary

The six regions rate differently on the entrepreneurial ecosystem index. All regions show rising employment and disappearing unemployment levels. For at least three of the regions, the changes in employment and unemployment are related to the growth of the IEEs: the Finnish regions, Sofia ICT IEE and Brainport. The impact of the changes is different, mainly because of the different starting contexts. The Finnish cases had to absorb the closure of Nokia plants, Sofia has experienced mainly employment growth in the ICT cluster, and Brainport seems to have reached the limits of employment growth.

Can this growth be called inclusive? The shift towards more ICT- and technology/ knowledge-intensive work has profited men and women. The impacts have sometimes been in favour of women. Growth does certainly not always lead to gender-biased results. Unemployment has strongly been reduced, even if the IEEs have invested in digital technologies and new business models. What is striking is that unemployment growth has mainly occurred among the higher educated groups and among men. As far as technology has an impact, it more affects higher skilled personnel. Possibly, highly skilled jobs show higher turnover rates. The changing nature of the regions has mainly helped to reduce the risk of poverty and social exclusion, even in the context of major events such as the break-up of Philips in the Netherlands, the downsizing of the Steel sector in Germany and the closure of important Nokia plants. The growth generated by the IEEs has helped the regions to absorb these events. In this sense, entrepreneurial growth can be called inclusive. The fact that there is no clear group losing out on the labour market also allows us to qualify the growth as inclusive.

The only answer that cannot be given is if the distribution of income between employers and employed has changed over the past decade. Therefore, it is necessary to complete such information to evaluate inclusive growth fully.

9. Result 4: understanding the emerging entrepreneurial ecosystems

9.1 Introduction

This section directs its attention to how emerging entrepreneurial ecosystems (EEE) can surface next to existing incumbent entrepreneurial ecosystems (IEE). How can digital technologies help new companies and/or business models arise within existing incumbent entrepreneurial ecosystems or next to such IEEs? If an ecosystem works within an IEEs, the results will be, of course, much more different than if the EEEs starts outside such IEEs. Only the Dutch Aerospace case is geographically a separate region, in the other cases, we are more looking at industrial networks competing with the existing IEEs for more importance. Some of the EEEs rely on much the same framework and systemic conditions the IEEs rely on. The analysis remains instructive because it shows how existing IEEs may be a barrier (or driver) for developing new industrial networks and new growth.

The analysis is focused on comparing the EEEs on the Stam model-criteria. First, to which degree can we see the different conditions support the development of the entrepreneurial activity. Secondly, the knowledge spillovers that drive entrepreneurial ideas in these ecosystems are assessed. Thirdly, the impact of the digital transformation is evaluated for the adoption of technologies and new business models. There is no separate analysis of inclusive social impacts, mainly because these ecosystems are only in a build-up phase, and it is impossible to identify such social impacts. The final assessment identifies institutional voids in these ecosystems with all this information. What are the chances that these ecosystems can deliver sufficient entrepreneurial activity to survive?

9.2 Comparing the ecosystems on the Stam model-criteria

Table 15 first indicates which growth potential is foreseen for the EEEs and then summarizes the evaluation of the core elements of the EES-framework for the different EEEs, using the Stam-model.

Table 15. Comparison of the six emerging entrepreneurial ecosystems [see A.4 in annexe]

	Finland: Digital and Health EEE (Oulu)	Bulgaria: BPO EEE (Sofia)	Basque Country: Smart mobility EEE	Germany: Logistics EEE (Dortmund)	United Kingdom: DIgital health EEE (West Midlands)	Netherlands: Aerospace EEE West North-Brabant
Economic performance	Disparate and limited initiatives. The expectation is strong future growth.	A strong growth sector within /in parallel to the ICT-IEE.	New products and services for existing mar-kets allowing current produ-cers to maintain market share and create new ones.	Strong investment sector with expectation of technology growth.	New products, for future growth.	Acquiring more market share in expected consolidating market.
Formal institutions	Strong trustworthy institutional environment	Unsupportive environment, EEEs operates in international isolation	Strong trustworthy institutional environment	Strong trustworthy institutional environment	Disparate system with few national leads	Strong trustworthy institutional environment; but disparate support system
Entrepreneurship culture	Strongly developed	Not present	Strongly developed	Strongly developed, supportive	Public sector culture, not entrepreneurial	Separate, disparate culture
Physical and IT infras-tructure	Strong infrastructure in Oulu	Strongly developed	Strongly developed	Strongly developed	Poorly developed	Partly developed
Demand	Divided image: no local demand for digital; health is mainly local, but small in size	Only focus on international markets	Local demand and international focus	Local demand is substantial because of connecting industries	No local demand for health, COVID is changing situation	Strong local demand
Finance / financing	Mixed picture, but scale-up funding is main issue	No local support	Well-developed public and private funding system.	Unclear picture, with unclear start-up funding	No local funding support	Mixed, mainly public system
Talent	Shortage in supply of specialists.	Abundant supply.	Abundant supply.	Shortage of skilled workers, companies need to deve-lop themselves.	Undirected supply.	Shortage of supply.
(New) Knowledge	Sufficient knowledge support	Underinvesting knowledge networks	Sufficient knowledge to support EEEs	Strong supply of knowledge	Unclear situation	Undirected knowledge networks
Services by Intermediaries	Strong intermediaries in Oulu	Systemic support system	Systemic support system; public and private cooperation.	Strong institutional network of services	Underdevelo-ped service sys-tem, partly knowledge net-work support	No intermediary support available
(Social) Networks	City networks house loosely coupled networks	Strong sector association networks	Strong sector association networks	Research part-ners networks, build up to-wards institu-tionnal partners	Consumption networks, loosely coupled	Loosely coupled networks, not integrated
Leadership	Local public sector driven.	Large foreign companies leadership.	Public sector leadership with strong partici-pation of lead companies.	Knowledge parties leadership.	Public sector leadership.	Public-private initiative, but lack of leadership.

The selected EEEs are not yet driving the main economic growth in their regions, except for the Dutch Aerospace cluster. This Dutch cluster is the main economic activity in the region, and the expectation is that its growth depends on more entrepreneurial activity. Stakeholders have indicated that next years will see a strong consolidation in parts of the supply chain in the Aerospace cluster. This offers the opportunity for the cluster, but this requires several choices to be made. With this background, it is clear that the ecosystem is not particularly new. Aerospace has already long time been an important sector for the Netherlands. However, the nature of the sector has changed dramatically. Up to 2020, many actors in the sector were focused on resurrecting the Fokker aviation industry. This strategy has now been abandoned, and the remaining cluster is now focused on developing new propositions for the Maintenance-Repair-Overhaul (MRO) market. The global MRO market is quite fragmented in different propositions, companies and activities. The development of a Dutch entrepreneurial ecosystem is seen as a possibility to create innovations in business models and services needed to survive in the expected consolidation phase. A more or less separate cluster is linked to the F-35 Joint Strike Fighter programme. The Aerospace EE shares the (military) airport between private and non-private organisations (i.e. the Dutch Royal Airforce). Regulations and contracts with U.S. military partners make synergy between both industries difficult.

In the Finnish, German and United Kingdom cases, the new industrial networks are focused on completely new products. Therefore, success for the EEEs depends on finding new niches and achieving growth. For the German Logistics EEE, the hope is that the new sector provides technological offspring for other sectors. In the Bulgarian and Spanish cases, the new sectors are meant to develop or keep the market share of companies with new products within existing markets. Therefore, the nature of the EEEs is quite different between the cases.

How do the EEEs compare on their framework and systemic conditions? Just as was the case for incumbent ecosystems, formal institutions are often mentioned by respondents only as a 'hygiene factor': it is not considered a crucial element because the quality of the formal institutions is generally up to standard. For the Bulgarian ecosystem, the businesses in the ecosystem are managing to 'circumvent' the negative aspects of this element. The BPO-sector develops itself as a part of the ICT sector. The Dutch Aerospace EEE builds on a strong collaboration within the region. However, the interests of the institutional partners are not fully aligned to support the growth of the ecosystem. For example, the Ministry of Defence operates the Woensdrecht airbase mainly from a defence interest and requires the private parties at the airport to follow their planning and priorities. The MRO-future is only recently embraced by the partners, which still limits the alignment of interests.

For the element of entrepreneurship culture, results are mixed. The Finnish, Spanish, German and Dutch ecosystems consider a common culture an important driver for innovation. The defence context for the Dutch ecosystem is not always supportive of developing new business. This hampers developing a collective mind on new business. The Bulgarian BPO-ecosystem is dominated by foreign companies who do not share the same entrepreneurship culture. Stakeholders report a common culture as less important for the functioning of the ecosystem. These results are much in line with what was written for the IEEs. For the United Kingdom situation, the new ecosystem is

dependent on a public sector context. The environment is not very entrepreneurial as there are limited funding opportunities, which hampers clear support for experimenting.

Regarding the element of **physical (and ICT) infrastructure**, respondents from all regions/ecosystems are stating that the physical infrastructure (road, rail, waterways, air) is sufficiently well-developed in their regions. In that respect, it could also be regarded as a 'hygiene factor' for the functioning of the ecosystem, just as was the case with the incumbent ecosystems in the same regions. One exception is that for the Dutch Aerospace EEE, access to a landing strip (and related facilities at Woensdrecht airbase) is a crucial factor for the existence of the ecosystem. The private companies are in the good graces of the Defence partner to get access to the facilities. There also seems a consensus among the six ecosystems that the digital infrastructure is up to standard. For the United Kingdom, the EES is dependent on a strong and reliable ICT infrastructure. Significantly, the region was a testbed for 5G, which has helped develop demand in the EEE. The physical infrastructure does not impact the EEE in the West Midlands. For some ecosystems (e.g. the one in the Ruhr region in Germany), there is an explicit mention of the geographical advantages of where the region is located, concerning access to trimodal transport options via water, road and rail.

The element of (regional) **demand** is considered unimportant by half of the respondents. The defence environment is only partly a demand factor for the Dutch Aerospace cluster. In the past, the Dutch government expected the F-35 air fighter to provide growth opportunities at the airbase. These opportunities are only available for the logistics companies in Woensdrecht. The MRO partners at the location are focused on servicing non-defence airlines outside of the region. The Dutch airport of Schiphol is certainly 'local demand'. For the two Finnish emerging ecosystems that were identified (Digital & Health), regional demand from the Oulu University Medical Centre drives much of the innovations. In fact, the size of the demand is a limiting factor for strong growth. In Germany's emerging ecosystem, the logistics sector in the Arnsberg administrative district, regional demand from local companies and private individuals plays a major role in new products and services. This is not true for the other emerging ecosystems because the products and services generated by these ecosystems are marketed over a much larger geographical area than the (NUTS3) regions. For the Basque Smart Mobility, public procurement of new mobility systems is important. Without such local launching customers, it would be hard for the sector to grow. The public sector can act as a leading customer for new industrial networks. How this works remains a complex issue. The interests of the public sector need to be fully aligned with the industry partners, and this is rarely the case.

For the element of **Finance**, we find that this is a more 'problematic' condition for emerging ecosystems in all regions. In most new ecosystems, economic activities are considered riskier, resulting in concerns by venture capital and other private funds to support the companies. The availability of venture capital for start-ups, scale-ups, and SMEs is limited. The Finnish and German ecosystems indicated this. Also, there is some emphasis on public financing of investments in the ecosystem, with the Dutch aerospace ecosystem as a prime example. However, we reported that public funding here is not straightforward. The Bulgarian ecosystem explicitly mentions foreign direct investment as a source of Finance since the businesses in the ecosystem are subsidiaries of foreign firms. Overall, this seems to be an element that is available at a sufficient level but at the

same time causes worries for the future. For example, in the United Kingdom, there is funding as it is a priority for the national government, but political changes may shift this priority and funding may be withdrawn or expanded. Brexit may be helpful since the British government is less bound by EU-rules[11]. These worries are more prevalent for emerging ecosystems. The exception to this overview is the Basque Smart Mobility. Much support is given by the local governments that have the possibility to fund new emerging sectoral developments.

All emerging ecosystems see the systemic condition of **Talent** as crucial for new entrepreneurial activity. All ecosystems mention the availability of qualified personnel as a factor contributing to the development of the ecosystem. For most ecosystems, the future availability of qualified personnel is explicitly mentioned as a risk factor for future growth. The main emphasis is on highly skilled workers with higher (or medium vocational) education qualifications. The Dutch ecosystem depends on local labour market supply. It is affected by the IEE of Brainport. This impact may become bigger in the future. The Finnish case shows that new industrial networks are affected by the general growth in the regions. Certainly, new networks compete with the dominant Nokia remains for talent in the Oulu region. The Bulgarian BPO ecosystem (partially) and Basque Smart Mobility rely on talent from the existing IEEs, and seem to be able to shift sufficient talent to develop new propositions. The lack of sufficient talent constrains the growth of the German logistic EEE. Collaboration with the local universities and Fraunhofer IML are needed to supplement the lack of talent.

For the element of **New knowledge**, many respondents from the emerging ecosystems point to (access to) research institutes (e.g. universities) and less so to the spending on R&D. The general impression in the six ecosystems is that they benefit from relatively easy access to research institutes (e.g. the Fraunhofer institute in the German case). This support is not always directed at the interests of the new networks. In the Dutch case, the knowledge needs to come from some distance (TU Delft), which does not help have a living knowledge community at Woensdrecht. The knowledge support is undirected towards the needs of local companies. Furthermore, respondents state that the level of 'access to research institutes' is up to standard. In the next section, a critical analysis is done of the possible knowledge spillover mechanisms in these ecosystems.

For **Services by intermediaries**, all respondents consider this an important element, but we have to allow for the fact that there is a great deal of heterogeneity among respondents with respect to what 'services by intermediaries' are and what the role of this element is in the success of the emerging ecosystems. In the Finnish, Bulgarian, Basque and German cases, the new networks' intermediary support is well developed and used. In the Dutch case, the intermediary networks are mainly focused on the Brainport (and other) sectors, therefore not supporting the local cluster. Much has to be done by the companies within the EEEs.

Social networks are probably the most important driving element for emerging ecosystems. Mainly because we are looking at new networks and relationships, developing common interests and finding ways to support each other is crucial for the survival of these emerging ecosystems. Some respondents refer to the lack of social networking and consensus building as a risk factor for

[11] For example, the Brexit-agreement still requires the British government to ensure that sufficient 'local' production is foreseen in any initiative it funds.

developing the emerging ecosystem further. The nature of these social networks is different, mainly influenced by the launching partner networks. In Germany and the United Kingdom, the knowledge partners drive the new networks. They play the central place in the social network. In Finland, the City Networks drive the partners to collaborate. In Bulgaria and the Basque Country, the main existing ICT and manufacturing networks are helpful for the new industrial network. In the Dutch case, the social network is supported by educational institutions. These networks are still very loosely coupled. A clear vision of the future does not exist. However, most respondents do recognise that they are part of an ecosystem. More specifically, from most ecosystems, respondents refer to 'triple' or 'quadruple helix' types of networks between businesses, government, education/research and society at large.

The same finding for '**Services by intermediaries'** is true for the element of **Leadership**: it creates some confusion with respondents about what 'leadership' actually is. Nevertheless, it is often mentioned as an important element, especially in relation to social networks. Sometimes the leadership can be located with one actor (e.g. a PPP (Mubil) in the Basque Country, Dutch Airforce in the West of North-Brabant) in the network, whereas in the Bulgarian ecosystem, it is located outside of the region: foreign companies that 'lead' their Bulgarian subsidiaries. For the Dutch situation, as the Dutch Airforce has quite different interests as the industrial networks, it is the collaboration between companies that drives the network. However, within this network, clear leadership is still missing. One of the core companies has identified this lack of leadership and acknowledged that they needed a strategy change to be able to develop a leadership role in the ecosystem. The public sector (communes, public health service, research institutes, agencies) seem important to keep new networks alive (Finland, Basque Country, Germany, United Kingdom).

9.3 What drives knowledge spillovers in these EEEs?

Table 16 provides an overview of the main knowledge spillover mechanisms used in the different EEEs. Table 15 showed that half of the cases indicated to experience sufficient Knowledge support to develop their innovations and start new businesses. Table 16 relies on the case studies developed in the project. Annexe 2 provides an overview of the networks that support the business networks. These overviews indicate which knowledge spillovers are central to an ecosystem.

Table 16. Knowledge spillover mechanisms for the EEEs (+ = present; - = not present)

	Finland: Digital and Health EEE (Oulu)	Bulgaria: BPO EEE (Sofia)	Basque Country: Smart mobility EEE	Germany: Logistics EEE (Dortmund)	United Kingdom: Digital Health EEE (West Midlands)	Netherlands: Aerospace EEE West North-Brabant
Education/schools – companies						
1. Public-private co-publications	+	-	-	+	-	+
2. Internships, apprenticeships	+	+	-	+	-	-
3. Major programmes	+	+	+	+	0	-
Companies – companies						
4. Business ecosystems, business supply chains	+	+	+	+	-	+
5. Take-over of personnel	-	+	+	-	-	-
6. Knowledge sharing through business networks	+	+	+	+	+	+
7. Life-long learning	-	-	+	-	0	-
8. Innovative SMEs collaborating with others	+	-	+	+	0	-
Public stakeholders – companies						
9. Labour market measures	-	-	-	-	-	-
10. Business support networks	+	+	+	+	+	+
11. Funding opportunities, incubators	+	+	+	+	0	+

The **Basque Smart Mobility EEE** and the German Logistics EEE found support from knowledge providers and business support systems. Both these ecosystems also use several business-related networks to develop ideas. A successful PPS (Industria e-mobility) has been started, which drives the digital transformation in the industry in the Basque Country with a growing network of firms. Also, in the Basque situation, three major business networks are driving the Smart Mobility activities (Irizar, Mondragon Corporation and CAF). In Germany, at least with regard to the Dortmund ecosystem, new logistics services are also supported by media companies. In the **German situation**, the support from the Fraunhofer IML research organisation helps these efforts quite considerably. In the **Oulu Digital Health ecosystem**, the support by the Oulu Medical University is crucial to test new technologies, next to support from companies (Nokia) and from business support networks such as BusinessOulu. BusinessOulu deploys 160 persons to aid new start-ups. The start-ups in this ecosystem still lack sufficient knowledge support to develop their ideas further. In **Sofia**, the BPO EEE rely mainly on foreign companies' business networks. The public sector has started with some programmes to back-up new initiatives, but these are not at the level of what can be seen in Finland or the Basque Country. In the **Dutch Aerospace ecosystem**, knowledge spillovers are quite limited and mainly are driven by company networks and several public driven network organisations (e.g. Midpoint Brabant). A whole set of knowledge institutes exist to support initiatives, but a clear target to support MRO and logistics is not yet present. There have been limited start-ups in the UK digital health EEE with digital transformations being led by R&D due to the resourcing required. Skills transfer and knowledge spillovers are apparent from other sectors as there are limited education courses and opportunities in the field. The pandemic has changed perspectives on digital health, which is now driving digital transformations in the EEE. However, the transformation will be slow as ICT infrastructures need to be updated.

9.4 Impact of digital transformation and emerging ecosystems

The digital transformation is a driver of the EEEs. Digital technologies such as AI, IoT and Big Data analysis are crucial for start-ups and innovation efforts. Table 17 shows how our interviewees evaluated the impact of the digital transformation on industrial networks. The regions overlap for a great deal the regions in Table 13, so the data on e-skills and ICT-expertise are not repeated.

Table 17. Impact of the digital transformation on the six EEEs [see A.5 in annexe]

	Finland: Digital and Health EEE (Oulu)	Bulgaria: BPO EEE (Sofia)	Basque Country: Smart mobility EEE	Germany: Logistics EEE (Dortmund)	United Kingdom: Digital health EEE (West Midlands)	Netherlands: Aerospace EEE West North-Brabant
Use of digital technologies	Digital technologies are well embedded in the whole ecosystem.	Digital technologies are well present and in development.	Digital technologies are well embedded in the whole ecosystem.	Digital technologies are well embedded in the whole ecosystem.	Digital technologies are at the centre of the whole system, but updating for intermediaries and users is slowing development	Digital technologies are slowly integrating into mainly manual production (maintenance)
Impact on business models	Data-driven I4.0 business models are well embedded in the ecosystem.	The ecosystem is digitally minded but lags behind in data-driven business models	The sector is in the process of implementing new business models based on digitalisation.	Data-driven I4.0 business models are well embedded in the ecosystem.	The ecosystem is unevenly developed. R&D and pilots well established, but not well embedded in the ecosystem	Digital driven business models are only being considered. The sector is only in the development phase.

Table 17 shows that all EEEs, except for the Dutch Aerospace cluster, digital technologies are well present and used to develop new propositions and products. For these five EEEs, the technologies are the reason to develop new business models. In the **Finnish Digital and Health EEE**, IoT is used to develop different medical devices and market solutions. The **Smart Mobility EEE** in the Basque Country is focused on the electrification of buses, relying on Big Data and IoT. The ecosystem is developing data-driven companies to support the major players in the region. The **Logistics EEE** in Germany requires fine-grained information on deliveries and other logistic services. The companies are experimenting with different business models to serve customers in last-mile logistics. Digitalisation is one of the reasons why the ecosystem has been able to develop in this way and has grown steadily, not only because of the region's industrial prerequisites but also because of internet trade, which is of great importance in the Ruhr conurbation. In addition, it is digital technologies that are driving the industry forward. Ultimately, all logistics processes are considered

algorithmically enabled and can therefore be mapped using digital technologies. This development is far from complete, but there is great potential for the future.

The situation is not always as promising as these EEEs show. Big data analytics and blockchain technologies support the service system and manage the parts inventory systems for the Aerospace EEE. However, these companies are 'muddling through' with the new technologies. There is no shared approach to learning about the possibilities. This is the same in the ICT-minded city of Sofia. The Bulgarian EEE relies on AI for new supporting business process outsourcing activities. Companies are working on their solutions and not sharing. This lack of sharing has been seen as a barrier to further growth of the BPO-sector. Public investments are made to support major knowledge suppliers such as the Bulgarian Academy of Sciences to develop a high-tech experimentation context.

Although only happening recently, this was the case in the United Kingdom with clear political steer and incentives to drive developments and funding. The services developed in the emerging ecosystem are predominantly aimed at international (B2B) markets, which would deliver services to local intermediaries and consumers. In the United Kingdom, the pandemic and the shift in consumer demand is driving developments in the emergent ecosystem. In these cases, respondents from the ecosystem state that they are optimistic about the developments and claim to be frontrunners in their respective fields.

9.5 Assessing the conditions for entrepreneurial activity

Comparing the six EEEs helps to understand how the quality of the entrepreneurial ecosystems enhances or constrains future development. The analysis provided insight into how the ecosystems have developed themselves over time and which challenges they experience. These challenges can be identified as 'institutional voids' (Bendickson et al., 2021). In combination with the assessments by the stakeholders, these voids can be better understood. The results guide policymakers in supporting such new endeavours. Table 18 shows the previous assessment from Table 15, but now coded as the Schrijvers (2020)-analysis. This is a qualitative assessment to understand which of the Stam-framework conditions are sufficiently present to support economic development as the interviewed respondents and workshop participants understood. This is a more subjective assessment than the quantitative approach (relative to the EU median) taken by Schrijvers (2020).

Table 18. Recoding of the ecosystem -framework elements for the six EEEs (1 = sufficiently present; 0 = not present)

	Finland: Digital and Health EEE (Oulu)	Bulgaria: BPO EEE (Sofia)	Basque Country: Smart mobility EEE	Germany: Logistics EEE (Dortmund)	United Kingdom: Digital Health EEE (West Midlands)	Netherlands: Aerospace EEE West North-Brabant
Formal institutions	1	0	1	1	0	1
Entrepreneurship culture	1	0	1	1	1	0
Physical and IT infrastructure	1	1	1	1	0	0
Demand	0	0	1	1	1	0
Finance / financing	0	0	1	0	0	0
Talent	0	1	1	0	0	0
(New) Knowledge	1	0	1	1	1	0
Services by Intermediaries	1	1	1	1	0	1
(Social) Networks	1	1	1	1	0	0
Leadership	1	1	1	1	1	0

The Table shows that the different factors are far from present in the different EEEs. Also, the table provides an overview per EEEs of its strengths and weaknesses.

The table shows that the **Basque Smart Mobility EEE** covers all conditions to operate as an incumbent EES. The initiative should be able to stimulate new entrepreneurial activity in the Basque region. This is actually the case with a whole bunch of lead manufacturing companies operating in the region (Irizar and CAF) and start-ups. This EEE is thriving because of the support from major cooperative companies such as Irizar and Mondragon Corporation. The start-ups can function under the umbrellas of these lead companies, but it is worth mentioning the public support for cross-sectorial diversification and the creation of new companies. It would seem that these companies reduce the risks for start-ups to launch, but also that these corporate groups work as knowledge spillover context to these new initiatives. However, cross-sectorial diversification and new market niches for existing companies seem to be important growth vectors. The support by the Basque regional government is through major support programmes and active network organisations (Industria e-mobility; Mubil). The Spanish government also supports as a launching customer, buying electric buses for several cities. The **German Logistics EEE** has successfully developed a broad set of initiatives and start-ups. The EEE is driven by knowledge partnerships in which Fraunhofer IML plays an important role. The only weak points are the access to funding and sufficient high-skilled talent. The implemented digital technologies require skills sets that are not easily found in the labour market. From vacancy profiles of several start-ups, it is clear that they are expanding the recruiting to neighbouring countries. The growth of the sector will depend on fulfilling this condition. The **Oulu Digital and Health EEE** case relies on the strategy followed by the communes in these regions. The important weaknesses are Finance and Talent. The EEE is integrated into university settings, and this helps drive more solutions and entrepreneurial activity. The **Bulgarian**

BPO shows a lot of opportunity for growth, but the main weaknesses are the embedding in international company networks and the poor support from the knowledge and institutional networks in Sofia. The fact that many of the companies in the EEE also operate in the ICT IEE, brings as a risk that the EEE does not have a separate position. It may lose importance and get integrated into the dominant ICT IEE. The Dutch and United Kingdom EEEs cases still have a lot of work to do to achieve a positive launching condition. The Aerospace EEE is experiencing a relaunch, and a lot depends on the capability of partners to develop new companies, partnerships and networks. Many (digital) initiatives seem to only remain within the confines of existing companies and not a spin-off. In the UK, changes and developments are underway, but there is a reliance on Talent, Finance and Knowledge to drive the EEE.

The evaluation in Table 18 provides apparently more positive scores for conditions than was visible for the IEEs. However, this is a misleading result, mainly because the performance of these EEEs cannot be fully evaluated. Only the future will tell if these evaluations are more wishful thinking or reality.

For the industrial networks to (start) thrive, network partners will need to consider the framework context and work on these. We can see that the EEEs strongly differ in conditions. They all need to develop these conditions further. There are still many barriers to future growth. The entrepreneurial ecosystem model seems to be recognised by actors from the ecosystems as a useful tool for investigating and assessing these ecosystems. However, for emerging ecosystems, more elements are problematic.

The core condition, Knowledge, is only well organised in two EEEs. The analysis of the knowledge spillovers shows different approaches used by the EEEs to find and develop new ideas. Finance is a complicated condition, mainly because these innovative sectors have difficulty in attracting sufficient private funding. Most of the networks rely on some kind of public funding. The element of (regional) Demand is considered irrelevant in most regions because most of the production generated in the ecosystem is not sold in the region. However, the public sector as a leading customer is only helpful to a certain degree, but it might have been essential to get the ecosystem started. The NHS and the Dutch defence department are locked into their own logic, and these do not always support the local private initiatives. As indicated in the Schrijvers analysis (2020), Leadership and Services of intermediaries are seen as necessary conditions for very high productive entrepreneurship in the whole of Europe. Here we can see that without clear Leadership, all the other elements of the Stam-model do not fall into the right place. For new industrial networks, this Leadership seems to be quite different in nature (public, research partner-driven, agency, company). It remains unclear which future success EEEs will most benefit from the type of Leadership. This is a topic that requires more attention in future research. The Services by intermediaries require special attention. Most new industrial networks complain that clear support for their ideas is missing. The support systems are again different, and how this works merits more analysis. From the table and the interviews, it is also clear that Talent is only sufficiently present in the Spanish and Bulgarian cases, mainly because they are part of the IEEs. Talent needs to be sufficiently present for an ecosystem even to launch itself. For the other four EEEs, this lack of talent seems a major development risk.

Regarding the interplay between elements that create success (or lack thereof) for the ecosystem, there is still a lot of work to be done. We see that the German EEE resembles a Knowledge-driven EEE, the Bulgarian and Spanish EEEs resemble Talent driven EEEs (Schrijvers et al., 2020).

10. Conclusions, discussion and policy recommendations

10.1 Conclusions

This study focuses on understanding how creative destruction helps regions deal with the challenges social and technological change brings. Regions have the option to revive their economic fabric by creating more opportunities for entrepreneurial activity. Therefore, technology is not seen as a threat to employment and growth but rather as one of the instruments companies and other actors can use to develop new products, processes, and business models. The Stam-model of entrepreneurial ecosystems (Stam, 2015) is used in this study to understand which framework and systemic conditions need to be fulfilled to develop this entrepreneurial activity. The main objectives of the study are to answer the following questions:

- What are the inclusive-growth related impacts of digital transformation at the ecosystem and regional level now and in the future?
- How can ecosystems and regions respond and adapt to future changes, and how can more inclusive-growth futures be achieved?
- Where could the EU help and support regions and regional ecosystems in adapting and changing course; what ingredients are needed for a suitable EU strategy at the regional level?

This study has used several systematic comparisons between fourteen entrepreneurial ecosystems in Europe to achieve these objectives. Two types of ecosystems have been compared: existing, incumbent entrepreneurial ecosystems (IEEs) and newly created, emerging entrepreneurial ecosystems (EEEs). Also, the study compares the information from the ecosystems to recent scientific research on entrepreneurial ecosystems. The information on the fourteen ecosystems has been collected and analysed with a qualitative methodology. Using comparison tables and systematic coding has made the vast information on the ecosystems accessible. Furthermore, discussions with stakeholders in each identified ecosystem have helped improve our results' reliability and make the policy recommendations relevant for these actors.

In this conclusion, we focus on our answers to the main question and then discuss the limits of the results. These discussions allow us to formulate policy recommendations at different levels.

- *Question 1: How do regions successfully achieve inclusive economic growth, and which elements of the entrepreneurial ecosystems in these regions play a decisive role? How can ecosystems and regions respond and adapt based on the elements of the entrepreneurial ecosystem model? What does the distinction between incumbent and emerging entrepreneurial ecosystems bring?*

This question has been broken down into several questions.

We first focus on the incumbent entrepreneurial ecosystems. Several studies have already been made on these ecosystems, allowing us to compare our results with these studies (Schrijvers et al.,

forthcoming; Leendertse et al., 2021; Schrijvers, 2020). We added an extra dimension to the Stam-model (2015) by looking more deeply into the knowledge spillovers (Audretsch et al., 2005; Audertsch et al., 2021) that are at the heart of the model. Next to Capital and Labour, Knowledge is a main driving force for developing entrepreneurial activity. Using the theory of knowledge spillovers, we can identify how the regions try to inform actors in an ecosystem on new opportunities.

1. How entrepreneurial are the regions?

Table 6 provides this answer. This table allows us to assess the relationship between the quality of the ecosystem and entrepreneurial output. Schrijvers et al. (forthcoming) indicate that the data suggests there is a positive relationship between the quality of the ecosystems and the entrepreneurial output. If regions improve their ecosystems' framework and systemic conditions, then they can expect more entrepreneurial activity. The selected incumbent ecosystems for this study spread across the entrepreneurial output index, with five ecosystems in the top quarter entrepreneurial output ranking. The diversity in case studies on the output side informs us about what works. The performance of Sofia ICT IEE is an outlier in the results. The reason for this is that the international and domestic investors in the ICT sector, insulate themselves from the local environment. The international performance does not reflect the regional statistical information. Even after this study, it remains difficult to assess the regions' performance. The ecosystem of Salo performs still strongly in the entrepreneurial output data (see performance subgroup 'strong innovator +' (RIS: European Commission, 2021a), but in the knowledge spillover data (Table 8), Salo has lower ratings for three core indicators. West Midlands, Noord-Brabant, Oulu, and the Basque Country perform strongly in each output table. This constitutes half of the IEEs sample, rendering a comparison not that relevant. We mainly learned more about was needed to be a leading ecosystem.

2. Which elements are driving the entrepreneurship of the incumbent entrepreneurial ecosystems? How can we evaluate the impact of institutional voids?

The Stam-model informs which framework and systemic conditions drive entrepreneurship. Table 7 compares the evaluation by Schrijvers et al. (forthcoming) and the case studies. A first observation is that about one-third of the qualifications of the conditions differ between both studies. The reasons for the discrepancy are the different scope of the studies (regional data is broader than the ecosystem perspective) and the different time perspectives. The Sofia ICT IEE was illustrative of this fact. The temporal perspective is different: the regional data is from the past; our data is more recent. There are deviations because of differences in interpretation of the separate conditions and for specific ecosystems. The Sofia case was already commented on, but bigger differences exist between the Steel IEE (Germany), and the Machine Tool IEE (Basque Country) results in both studies. The stakeholders in the cases are less positive about several conditions than the Schrijvers-study. The case studies inform us about several conditions that have more impact on entrepreneurial activity than a statistical study can uncover. The example is for the Brainport IEE, in which the stakeholders see the growing environmental legislation (PFAS etc.) as harming entrepreneurial activity. One main concern with the evaluation from the Stam-model is that successful ecosystems are more and more becoming 'settled' ecosystems. Actors in incumbent entrepreneurial ecosystems focus on organisational maintenance rather than new entrepreneurial

activity (Hannigan et al., 2021).). Meanwhile, the German Steel IEE is striving to remain competitive. This is sought less through the development of new products, but rather by increasing efficiency and effectiveness as well as optimising production processes. Even the Brainport IEE is now dominated by strong producers that support a new activity in the region, but these efforts are small compared to their main investments in maintaining their market lead. The equal presence of lead companies and entrepreneurial activity is certainly possible, showing the Oulu region results in which stimulating entrepreneurial activity has been central to revive the region throughout and after the Nokia crisis.

The differences between the statistical study and the case studies are informative. More comparability can only be achieved if more data were available at the ecosystem level. In most cases, the regional statistical information is at a too high level, too abstract to inform policymakers. The combination of the data is, however, helpful. As Schrijvers et al. (forthcoming) indicate, the case study approach is needed for just this purpose.

In summary, the entrepreneurial ecosystem model seems to be recognised by actors from the ecosystems as a useful tool for investigating and assessing these ecosystems. Some elements, however, are problematic. The (regional) demand element is considered irrelevant because most of the production generated in the ecosystem is not sold in the region. Furthermore, the elements of Leadership and Services of intermediaries are unclear to respondents, and it is not very easy to compare the findings on these elements across ecosystems. These elements are evaluated in the UU-study (Schrijvers, 2020) as necessary conditions for very high productive entrepreneurship. More discussion with stakeholders may be needed to understand these conditions better.

Regarding the interplay between conditions that create success for the ecosystem, there is still a lot of work to be done. Schrijvers (2020) indicates that there are several ways to productive entrepreneurship. The only less performing region would be the Dortmund area, in which the redefinition of the position of the steel industry dominates the entrepreneurial debate. Considering the core conditions, most respondents address Talent as the main explanation for entrepreneurial success. Performance of the ecosystems can be explained to access to sufficient talent. The Brainport IEE has a lot of policy support to attract talent, something missing in the Finnish cases. A lack of talent translates into less entrepreneurial activity. Furthermore, the elements of Formal institutions and Physical infrastructure are considered 'necessary' (but not sufficient) conditions for the success of ecosystems. This is not the outcome of the UU-research (Schrijvers, 2020). This is probably due to the fact that the scores of these elements are calculated *relative to the EU median*. In general, the level of these elements is measured at a high statistical level in Europe, which is why scoring above the EU median is not necessary to have a high-quality ecosystem. A well-functioning social network is often reported as the success (result) of the ecosystem, not as an 'input' element. We find mixed results for Knowledge, Finance, and Entrepreneurship culture elements. Most respondents characterise these elements as important resources for businesses, but often they consider them not as important as the element of Talent. For Knowledge, more in-depth insight into the knowledge spillovers that can be achieved is helpful to understand what drives entrepreneurial activity.

3. How do knowledge transfers occur in the IEEs?

Table 8 shows the integrated results of the analysis of knowledge spillovers in the IEEs. To evaluate the performance of these spillovers, RIS2021 (European Commission, 2021a) and Eurostat regional information was used. Table 1 develops a taxonomy of possible knowledge spillovers, tracing them to relations between education and companies, between companies and between public stakeholders and companies.

The analysis in Table 8 shows that no region outperforms the others for innovation performance. Sofia shows a remarkable growth in R&D personnel and employment in knowledge-intensive sectors. They have caught up with the rest of Europe and are even in a leadership position. For Sofia, the main institutional voids are the connection between education and companies, and between companies. Here, the integration into the international (software) supply networks seem to help the sector perform. However, the many institutional voids do point to several economic risks the region runs. The ICT sector chooses to remain insulated from the political regime, but the growing social distance from the region may lead to major problems in the future. Also, without sufficient local support to develop its knowledge position, the sector remains at the mercy of the international conglomerates. The two German regions have similar outcome results, underperforming for all indicators except for the employment in innovative SMEs. Investment in knowledge-intensive sectors is down, but innovative SMEs may counter-balanced this. The dominance of the Steel Company reduces the use of the different knowledge spillover mechanisms. Since most of (institutional) support seems directed towards the leading Steel IEE, companies can only rely on their direct collaboration to create entrepreneurial activity. The Basque Country has many employed in knowledge-intensive sectors and shows relatively high innovation expenditures. Public support drives most of the knowledge spillovers. Even if companies do drive several types of spillover, the guidance of major programmes is crucial to achieving the necessary new ideas. Noord-Brabant is seen as an innovation leader, but the figures show weaknesses for overall investments and innovative SMEs. Possibly, the cause is that there are so many possibilities to exchange ideas between leading innovators that SMEs cannot find their place. Salo has felt the impact of the closure of Nokia in the hardest way. The Salo region shows that several institutional voids have arisen. Only employment in innovative SMEs seems to help the region. Oulu has only experienced a decline in employment in knowledge-intensive activities or professions but sees high levels of R&D investment and action from innovative SMEs. Oulu shows the use of most of the knowledge spillovers.

The same may be said of the West Midlands UK, with OEMs leading overall investment and innovation in the IEE and SMEs needing further investments and talent to strengthen their position in terms of digital transformation.

The results also indicate that regions can suffer several institutional voids and still become top-performers on several indicators. The case of Sofia is illustrative of this result. Even if the entrepreneurial ecosystem index, as developed by Leendertse et al. (2021), is a measure of necessary conditions to stimulate entrepreneurship, the results from this study indicate that regions need to have a broad perspective on the outcome side too. It is not sufficient only to be a leader in patents etc., novel entrepreneurial activity among SMEs also needs to be developed. The figures show that there can never be a moment of rest for policymakers. Complacency in stimulating entrepreneurial activity can easily arise.

4. How do emerging entrepreneurial ecosystems perform?

For policymakers and (major) companies, a core question remains if they need to invest in existing incumbent entrepreneurial ecosystems or if they need to divert investments to emerging entrepreneurial ecosystems. To make this more concrete: what should policymakers do with their support to the Steel IEE? Should they abandon tens of thousands of jobs for a new business that only represents a couple of thousands of workplaces? The next issue is that it is already hard to come with new inventions to the market and also be thinking about the framework and systemic conditions to create sufficient entrepreneurial activity around the innovation. Therefore, the first question is if the emerging entrepreneurial ecosystem distinction is helpful. In the selection of emerging ecosystems, very different activities were selected. Only one of the ecosystems stood outside existing incumbent entrepreneurial ecosystems. The Dutch Aerospace cluster is looking for new paths forward, building on the remains of the demised Fokker aviation industry. The Dutch ministry of defence's support is seen as crucial to build-up a new industry. The five other ecosystems are either spin-offs (Sofia BPO EEE, Basque Smart Mobility) or new ventures next to an IEEE (German Logistics EEE, Finnish Digital + Health EEE, UK Digital Health). This means that we have three different EEEs and that these differences affect the building and scale-up conditions for entrepreneurship.

Comparing the six EEEs helps to understand how the quality of the entrepreneurial ecosystems enhances or constrains future development. The analysis provided insight into how the ecosystems have developed themselves over time and which challenges they experience. These challenges can be identified as 'institutional voids' (Bendickson et al., 2021). From the comparison of the entrepreneurship conditions, it appears that the **Basque Smart Mobility EEEs** covers all conditions to operate as an incumbent EES. The initiative should be able to stimulate new entrepreneurial activity in the Basque Country. New products and services appear to function under major companies' umbrellas in the region. These companies reduce the risks for new products and services to launch, and work as knowledge spillover context to these new initiatives. The EEE ticks all of the framework and systemic conditions needed for an entrepreneurial ecosystem, which makes us wonder why the EEE cannot be defined as an incumbent. Of course, this EEE still needs to prove its ability to survive in the local and international markets at the output side. The strong support conditions arise from the support of the cooperatives, which may be a lesson for other EEEs: the driving effort by anchor companies may be needed to make new business take-off and survive. The **Bulgarian BPO EEE** shows many of the same strengths of the Basque Smart Mobility EEE, but at the same time, the weaknesses of the ICT IEE it has sprung from. The EEE is embedded in much the same international company networks and lacks strong support from Sofia's knowledge and institutional networks. These facts help the sector arise, and at the same time, put it at risk. The support from international companies may disappear overnight. Insufficient knowledge support inside the region is needed to secure longer-term development. The **German Logistics EEE** has successfully developed a broad set of initiatives and start-ups. The current success of the EEE arises from knowledge partnerships in which Fraunhofer IML plays an important role. The sector's future depends greatly on the ability to attract funding and sufficient high-skilled talent. The **Oulu Digital and Health EEE case** developed itself on the remains of Nokia. The advantage was the abundant supply of knowledge. Still, the EEE sees this systemic condition still as a risk for the future. The **Dutch Aerospace EEE** is quite different from the other cases. It would seem that the Dutch ministry of

defence's support is an important help as a launching customer. From the discussions, this defence context is at the same time a barrier for growth. The interests of the different stakeholders still need to be aligned. The main issue remains with the EEEs themselves. The main actors are not aligned with the Aerospace cluster's direction. A lead company has been missing. Entrepreneurial activity has remained limited, mainly because of this lack of direction. The United Kingdom Digital Health EEE cases still have a lot of work to achieve a positive launching condition. R&D companies in the EEE are leading developments, but these are limited in terms of scope due to ICT infrastructure at the intermediary and consumer level. Nevertheless, national funding and report requirements are driving changes.

The comparison of the EEEs on the framework and systemic conditions shows more positive scores for conditions than was visible for the IEEs. This is, however, a misleading result, mainly because the performance of these EEEs cannot be fully evaluated. Only the future will tell if these evaluations are more wishful thinking or reality. The EEEs can use the EE-model to improve their situation, but overly optimistic evaluations should be countered by measuring the output side simultaneously. The entrepreneurial ecosystem model seems to be recognized by actors from the ecosystems as valuable for investigating and assessing these ecosystems. However, for emerging ecosystems, more elements are problematic. The core condition, Knowledge, is only well organised in two EEEs. The analysis of the knowledge spillovers shows different approaches used by the EEEs to find and develop new ideas. Finance is a complicated condition, mainly because these innovative sectors have difficulty in attracting sufficient private funding. Most of the networks rely on some kind of public funding. The element of (regional) Demand may be considered irrelevant in most regions, however, the public sector seems to be a leading customer in most cases. For the EEEs to use this support, they need to understand how to use such support. Locked into public sector logic is rarely helpful for entrepreneurial activity. Leadership and Services of intermediaries are seen as necessary conditions for very high productive entrepreneurship in the whole of Europe.

Here we can see that without clear Leadership, all the other elements of the Stam-model do not fall into the right place. The lack of growth in the Dutch Aerospace cluster illustrates just this point. Such Leadership can also come from knowledge institutes like the German Logistics EEE shows. The Services by intermediaries require more attention in all EEEs, and it would be helpful to have better tools to evaluate the quality of this support. Talent is only sufficiently present in the Basque and Bulgarian cases, mainly because they are part of the IEEs. Talent needs to be sufficiently present for an ecosystem even to consider launching. For the other four EES, this war on talent may not be an international issue but more war with incumbent IEEs for future growth opportunities.

Regarding the question of the right interplay between elements that create success (or lack thereof) for the ecosystem, there is still a lot of work to be done. Policymakers need to bank on a lot of elements to create successful EEEs. An easy recipe is not yet available.

- *Question 2: How do entrepreneurial ecosystems deal with the digital transformation?*

For this question, the answers for the IEEs and EEEs need to be integrated. The differences between these ecosystems are also reflected in digital technologies. The IEEs are built on legacy ICT systems, and the digital transformation means integration of the legacy systems in the next software

contexts. That is not an easy task. It also explains why digital transformation is a slow-moving process in these IEEs. The EEEs have been created to profit from the digital transformation opportunities. Digitalisation allows new products for Digital + Health, new last-mile solutions in the Logistics sector, new BPO-solutions and Smart Mobility. Digital technology is already a constituting element of the entrepreneurial ecosystem model. Regions need to be able to rely on digital sound infrastructure. Therefore, it is not a changing context but a necessary condition for entrepreneurship. This is acknowledged in all EEs and, therefore, not a factor that allows us to differentiate between cases. Digitalisation also appears in the Talent condition, since sufficient e-skills in a region are seen as a precondition for companies to absorb the opportunities of digitalisation. The digital literacy of the ecosystems shows a strong spread in practices. Sofia rates as very low as a digitally-minded region, which is in contradiction with the existence of the ICT IEEs. The other regions vary between medium positions to lead regions in the level of digital skills. This study adds two extra elements. The first is that the companies need to have adopted the digital technologies themselves. The Flash Barometer (European Commission, 2021b) assesses this adoption with the measure 'digital transformation (dX)', but this measure is not yet available at the regional level. The second is that digitalisation needs to lead to new business models (Proeger & Runst, 2020). The response to question 2 addresses these two extra elements. These elements show how the EEs have picked up the digital transformation.

The environment and the 'stock' of skills in a region do not yet uncover what the digital transformation is doing to the companies in an ecosystem. For this, we need better insight into the presence of highly specialised IT knowledge and the way companies deal with the digital transformation.

The presence of IT specialists is remarkedly different from the e-skills distribution in the population, as shown by the RIS2021 (European Commission, 2021a). Sofia shows an extremely low (normalised) score for digital skills in the population. On the other hand, their position for IT specialists far exceeds the position of all other regions. It is clear that Sofia is an IT-intensive region, with a great number of IT specialists. However, these figures also confirm that Sofia's digital divide is quite pronounced. Digital technologies seem not to be common in the Bulgarian household. The reverse seems to be the case in the other regions. The number of IT specialists is a better reflection of the need for high-level IT knowledge. It does not reflect how digitalisation affects the business models in the EEs.

What we see is that companies in four of the ecosystems are driving the digitalisation in the world. What they do, forces other companies to change their practices. The mobile technology sector of Oulu, Brainport, the ICT IEE in Sofia and the digital health EEE in the West Midlands are major players in developing and application of digital technologies. The Basque machine tool IEE and the German Steel IEE see themselves as digital technologies consumers. In the Sofia, Dutch and Spanish cases, the new technologies allow attracting even more business to the region. In the UK, new technologies are attracting more businesses at a national level and limited infrastructure at the local level. The question is if these contexts are sufficient to deal with the digital transformation. Does digitalisation impact the business models? Are the strong players at risk to be outmanoeuvred by new market players? Many of our respondents indicate that the digital transformation in the IEEs is still in its infancy in many respects and the current trends are just the beginning. The data and the

discussions with stakeholders do not show that the regions are home to the new Amazon-type of companies. New digital business models are still rare in these IEEs. In addition, some respondents refer to a lack of action on behalf of the government (Bulgaria), some (Spain, Germany) report that stakeholders show a sufficient level of awareness, but concrete action is sometimes lacking. In the IEEs, digitalisation is integrated into the production systems and service models, merely in a traditional way. The business models are not yet changing. The companies achieve extra efficiency, but mainly using the new technologies in the same way they have been doing with automation and mechanisation. Given sufficient digital infrastructure and high-level digital skills, more could be expected at the level of business models and technology adoption. More entrepreneurial possibilities should be possible with the technologies.

The contrast with **the EEEs** is striking. The digital transformation is the main driver of entrepreneurship in the EEEs. Digital technologies such as AI, IoT and Big Data analysis are crucial for start-ups and innovation efforts. For all EEEs, digital technologies are well present and used to develop new propositions and products except for the Dutch Aerospace cluster. For these five EEEs, the technologies are the reason to develop new business models.

These results explain why few of the stakeholders see digital technologies as a threat to current employment in the ecosystems. In the IEEs, a lot of employment opportunities arise for the companies to deal with changing their legacy systems. The EEEs require a constant stream of highly skilled talent to keep on growing. On the question of whether there may be future impacts on employment, the reactions of the stakeholders are more pessimistic. This pessimism does not inform concrete actions from the ecosystems. The digital transformation impacts both EEs as an enabler of change and more employment, but for very different reasons. Context does matter.

- *Question 3: How does the digital transformation affect new skills and competencies and employment and educational levels? What are the inclusive-growth related impacts of digital transformation at the ecosystem and regional level? What can be concluded about the regional strategies of economic development and inclusiveness in the studied emerging and incumbent ecosystem?*

Well-developed entrepreneurial ecosystems generate more economic growth, and with economic growth arise better employment and life opportunities for the population in those regions. This requires that these opportunities are distributed in a fair and equal way. Do we see this result for the selected ecosystems? This question is assessed by looking at several indicators:

- The first part of the question is investigated by looking at the impacts on work and human capital: which changes are visible in sectors of employment, types of jobs, and unemployment?
- The second part is checked by looking at distributional impacts: can we see if changes in jobs, in employment opportunities and poverty risks, are the same between men and women, between different skills levels? This question could also be checked with information on wages and incomes. However, this data is too anecdotal to use in this analysis.

The analysis concentrates on uncovering trends in these figures and comparing ecosystems. The analysis is limited to the IEEs: the issue with EEEs is that there is not really a comparison base: the organisations are mainly start-ups, and the life situation is not mapped in major statistics. For five of the EEs, the EEEs overlap with the IEEs. It is impossible to untangle results.

The report documents the developments at the level of each of the separate ecosystems. The comparison results show that all regions show rising **employment** and disappearing unemployment levels. This is not only because of better general economic conditions but also because of the performance of the IEEs in several of the cases. For at least three of the regions, the changes in employment and unemployment are related to the growth of the IEEs: the Finnish regions, Sofia ICT IEE and Brainport. The impact of the changes is different, mainly because of the different starting contexts. The Finnish cases had to absorb the closure of Nokia plants. Sofia has experienced mainly employment growth in the ICT cluster, and Brainport seems to have reached the limits of employment growth with personnel from the region, but even with finding the expert technical expertise at a global scale. Men and women have profited from both of these developments, with some minor differences between regions. However, not all changes have been in the same direction.

More importantly, the shift towards more ICT- and technology/ knowledge-intensive work has profited **men and women**. The impacts have sometimes been in favour of women. Growth does certainly not always lead to gender-biased results. Unemployment has strongly been reduced, even if the IEEs have invested in digital technologies and new business models. What is striking is that unemployment growth mainly impacts the **higher educated groups** and more men. As far as technology has an impact, it seems to affect higher skilled personnel. Possibly, highly skilled jobs show higher turnover rates. The improved economic regional performance has mainly helped reduce the **risk of poverty and social exclusion**, even in the context of major events such as the break-up of Philips in the Netherlands, the downsizing of the Steel sector in Germany, and the closure of important areas Nokia plants. The growth generated by the IEEs has helped the regions to absorb these events. In this sense, entrepreneurial growth can be called inclusive. The fact that there is no clear group losing out on the labour market also allows us to qualify the growth as inclusive. The data miss a comparison with less performing regions, uncovering if the reverse result would be true: economic downturn correlated to more discrimination.

One question that remains unanswered is if the distribution of income between employers and employed has changed over the past decade. It is necessary to complete such information to evaluate inclusive growth fully. An analysis at the level of the separate companies (WP8) is needed to answer this question.

10.2 Discussion of results and future research

The methodology used has been a combination of qualitative analysis in the combination of regional statistics (European Commission, 2021a; Eurostat regional statistics). The main issues are that there is a significant discrepancy between the information at the regional level and at the ecosystem level. The case of Sofia ICT IEE is illustrative of this deficiency. The excellent performance of the ICT IEE

contrasts strongly with what everyday Bulgarian experience as economic context. The results show how these foreign investments do not yet help to improve the societal fabric. Therefore, Bulgarian society has significant risks in maintaining the separation between the ICT IEE and the Bulgarian environment.

The set-up of this study was not aimed to provide a European representative perspective. Still, the spread over regions and the fact that the ecosystems cover different performance levels allow deducting several lessons at the EU level.

The approach to use the EE-perspective on inclusive growth and the digital transformation provides a better account of what is happening in the general economy than currently is tried with more technology deterministic approaches (Frey & Osborne, 2017; Nedelkoska & Quintini, 2018). The Stam-model has been very helpful in describing the reality of the different ecosystems. Stakeholders in these ecosystems acknowledged the usefulness of the model in assessing their situation. The model requires a deeper analysis of the ecosystems provided with the qualitative 'deep' descriptions underlying this report and with a separate analysis of the knowledge spillovers. The ecosystem perspective allows understanding how the digital transformation affects companies and societies. The outcome is that technology is a useful tool for companies and actors to develop innovations and new business. However, integrating technology into company processes and business models requires serious investment by companies. The size of the investment makes the introduction of new technology slow and sticky. The advantage of the comparison at the ecosystem level is that experiences of separate companies or types of investments do not dominate the overall social change evaluated.

The material presented in the report reflects the situation in the ecosystems at the start of the COVID-19 crisis. Even if the pandemic affected the ecosystems, the focus in this report has not been on the way the ecosystems have dealt with the crisis. Some more anecdotal information is included in Annexe 2.

The study has used a broad approach to inclusive impacts. The main missing indicator has been income distribution. Even if the results show that the transformation of the ecosystems, connected to the digital transformation, has not exacerbated societal or gender discriminations, these distributional impacts may be different. In the company case studies (WP8), more attention can be directed at inclusive wage impacts.

More results are underway for the ecosystems in the shape of thirty company case studies. These companies present a more deep and selective insight into how ecosystems function. This information is needed to complete the full approach intended in the BEYOND4.0 project.

10.3 Policy recommendations

This report helps ecosystem stakeholders, regional, national and EU policymakers with four major policy recommendations.

- *What policy recommendations can be derived from the analysis for each region? Is the EE-model a sensible policy level?*

Currently, policymakers do develop action at the level of regions. The EE is not yet a relevant policy context. The results show that entrepreneurial activity needs to be stimulated at the level of the ecosystems, which differs from the regional level. More and new business development requires connecting innovation development in knowledge institutes, in SMEs and between companies. To be able to do that, policymakers will require more information. Statistical data needs to be developed for policymakers to understand what is changing in their environments.

The EE-model shows the importance of a multi-pronged approach to stimulate entrepreneurial activity and inclusive results. The Stam-model insists that all conditions are necessary to achieve these results. The heterogeneity of results shows that multiple approaches are needed to stimulate the indicated outcomes. This also stresses that there are several ways to achieve more entrepreneurial activity. Policymakers need to learn what works and which risks exist with choices made from other cases.

The results show that policymakers will not have an easy choice between supporting IEEs with a lot of economic importance and stimulating new EEEs with uncertain futures. The lesson from the cases is that policymakers need to make anchor companies aware of their responsibility to their regions. Stimulating entrepreneurial activity should not be seen as a hobby or small-scale activity in such regions but as a main responsibility to share innovation among companies and other stakeholders.

The case of Nokia brings an important lesson in this respect. Nokia profited from the mobile revolution until it lost. The social consequence of the lost business had to be carried by several regions in the world. The proactive approach to deal with the downfall of Nokia in the Oulu region is a lesson for policymakers. They need to understand how they can stimulate entrepreneurial activity to allow new businesses to compensate for the economic downfall of major companies. The broad approach to stimulate more knowledge spillovers is useful in other regions.

- *Does the digital transformation change the game for ecosystems?*

The digital transformation certainly is a game-changer for the ecosystems. The lesson is that within EEs, the take-up of technology and new (IT-driven) business models should be stimulated. Technology should not be seen as a risk for future employment but rather as a means for companies to survive in future markets. Moreover, technology offers opportunities for new products, more efficient operations and new business models. This is the perspective that policymakers should promote.

The lesson is also that the digital transformation means something else for IEEs and EEEs. In IEEs, the legacy systems make it hard to adopt the newest technologies swiftly. However, these IEEs need to use the technologies to improve their survival rate. The EEEs live for the opportunities the digital transformation brings. Developing a healthy ecosystem context is important for (new) companies to upscale their uncovered opportunities.

The issue is not so much a general level of IT skills in society, but excellent IT skills are. Companies need to understand and integrate the newest digital technologies. This requires more than just the availability of basic IT skills. The comparison between the skill levels for e-skills and IT skills shows

how different results between EEs are. Sofia is nowhere with e-skills in the population, but the software leader in Europe with the number of IT specialists. The attention of policymakers should be on IT specialists. For the Stam-model, the advice would also be to change the indicator.

The digital transformation manages itself. This means that policymakers should not focus on dealing with technological transformation. Instead, the attention should be stimulating companies to invest more in the adoption of technology and the application of new business models.

- *What should policymakers at the regional use as a policy mix to support economic and social development?*

This study has not been focused on differentiating approaches to inclusive social impacts. Consequently, we have little to say about which approach delivers more inclusive impacts to a region. The main recommendation is that stimulating entrepreneurial activity by improving the entrepreneurial quality of an ecosystem, has helped the selected regions provide more employment, reduce unemployment, and generate more equal outcomes. These outcomes are not the result of specific policy objectives in the region. More research will be needed to understand the benefits of specific entrepreneurial ecosystem approaches.

- *Is there a role for EU policymakers?*

The ecosystem cases have shown EU interventions in different ways. The main activities that have been identified are specific funding for regions to stimulate entrepreneurship, and knowledge acquisition and sharing. Nearly all cases show the benefit of this support. More specific research is needed into the effectiveness of this support at the level of the ecosystems.

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Annexe 1 – Comparative tables

Table A.1. Comparison between six incumbent regional entrepreneurial ecosystems: elements of the incumbent entrepreneurial ecosystem (IEEs)

Finland: incumbent IEEs (Salo & Oulu)	Bulgaria: ICT IEE (Sofia)	Spain: Machine tool IEE (Basque Country)	Germany: Steel IEE (Duisburg)	United Kingdom: automotive IEE (West Midlands)	Netherlands: Brainport IEE (East North-Brabant)
Formal institutions					
Strong institutional context, but locally focused (exclusive)	Insulated IEE, not supported by institutional environment	Strong institutional context, well developed network and attitudes	Diminishing institutional support for traditional IEE	Strong institutional context, with complete coverage of support	Half directed institutional context, not focused on entrepreneurship
• The anchor company Stora Enso and Nokia comply with national regulations and tax policies • At the local level, there is constant communication with the municipality, which tries to take into account Nokia's wishes. Oulu infrastructure is supportive of the company. Telecommunication facilities are good, and the company has some logistic systems of its own to deliver products to the global markets. • The government is not very flexible when it comes to employment-based immigration. The visa processes are too slow and prevent hiring a highly skilled labour force from abroad.	• The ICT ecosystem in Sofia has a relatively favourable tax environment (10% rate) and an increasingly strong voice through different business associations. • The ICT ecosystem, in a way, manages to escape from the "captured state" and corruption in Bulgaria. However, these phenomena are a major barrier to the ecosystem development. • Respondents agree that the development of the ecosystem is taking place despite the formal institutions, not because of the institutions and their support. • A limiting factor is that Bulgaria is also a centralised country, which does not allow regional support systems.	• The Basque Country scores relatively well on the Quality of Government; with an index score of 63.3 in 2019, the Basque Country counts as best performing region, above national and EU levels. However, this score is somewhat lower than the index score of 76.63 in 2010. • The regulatory framework for entrepreneurship (number of days to start a business, difficulties encountered when starting a business, barriers to entrepreneurship and ease of doing business, as shown by the Global Entrepreneurship Monitor (Basque Country GEM) of 2018, ranks the regional conditions at 5.3 out of 10. • The region is the main actor, driving programmes for professional education (IMH), for research (Invema), for funding and for strategic programmes to support the machine tool sector. The plans are supported and comprehensive.	• Transition of 'normal production': for example, rules and regulations for the Steel industry to produce CO2 neutral steel until 2030, with hydrogen technology seen as the means to enable such a transition. • Major demands for compliance to competition rules (cartel law), particularly affecting steel SMEs •EU-regulations have a partially negative impact on the competitiveness of steel companies in the ecosystem, especially in comparison to international, e.g. Chinese, steel producers	• The West Midlands is seen as one of two key regions in the UNITED KINGDOM dominating the automotive sector. • There is a range of formal institutions in the region that play a role in the EES. Regional organisations funded by the government are responsible for supporting growth within key sectors in their region. These formal institutions support skills development both at the supply level but also within the current labour force. They also support inward investment to support growth and development. • Universities across the region have strong collaborations with industrial to support R&D, growth and skills development. • OEMs and Tier 1 and 2 companies provide a formal structure to the EES and drive demand and development in Tier 3 and 4.	• Quality of formal governance institutions is average compared to other regions in NL, and this is considered higher than the EU average. • The regulatory framework for entrepreneurship is average.
Entrepreneurship culture					
Strongly developed in the two regions. Trust in entrepreneurship.	IEE is strongly entrepreneur focused	Strongly developed and supported	Fractured entrepreneurial culture that mainly is driven by anchor company	Traditional entrepreneurial culture, R&D and MNC driven	Collaborative culture, trusting relations
• The role of the entrepreneurial 'Spirit of Oulu' is very important. One of the most important things in the Oulu region is the strong work ethic and strong bonds between various actors. The Oulu region has a very strong entrepreneurial spirit and a strong sense of mutual trust. These networks of trust have been very important in creating the 'miracle of Oulu'. If something is agreed upon, one can trust that the agreement will be kept. Trust is the key. • There is a strong entrepreneurial	• Private economic activities only started after 1989. In general, there exists a low orientation of the population towards entrepreneurship. • Compared to other sectors in Bulgaria, the ICT ecosystem in Sofia has a relatively high percentage of start-ups and supporting actors (e.g. hubs, accelerators). • Different cohorts of entrepreneurs that do not yet cooperate easily.	• The entrepreneurial culture indicator in the region, according to the 2018 Global Entrepreneurship Monitor (NUTS2), scores 5.4/10 (Saiz et al., 2019). This indicator is ranked as the second most important framework condition, after access to infrastructure and services, indicating the relevance of "social and cultural norms and societal support".	• The many start-ups that are important for the regional steel industry are not directly related to the core business of steel production but rather concern much more cross-sectional functions in the companies. (e.g.logistics optimising supply chains). • Within the anchor company, especially in the areas where business models and value chains impact customer demands and in areas where digital technologies are significant, work is being done to	• Within the West Midlands region, the automotive sector is well established, and there is a long history of the sector in the region. •Entrepreneurial activity in the sector is driven by R&D lead by the MNCs and universities.	• Considered above the Dutch average in the Brainport region; there is a deeply rooted culture of (multidisciplinary) collaboration between companies and in the triple helix. • Open innovation model (collaboration), high mutual trust between partners in the region.

spirit in Salo as well. Still, the other prerequisites (distance from bigger cities, a university, strong technological basis) for such a miracle as in Oulu are absent.			become faster and more agile, which is partly achieved in cooperation with external partners, including start-ups.		
Physical and IT infrastructure					
Strongly developed, multi-modal	Developed through airport and IT connection	Strongly developed, multi-modal	Strongly developed, multi-modal	Strongly developed, multi-modal	Strongly developed, multi-modal
• Oulu has always been a region in constant economic transition, yet with a strong industrial basis to build on including big international operating companies. • The Port of Oulu is the largest port in Northern Finland, and important for the global exports of final products. Railways and road transport are particularly important for domestic logistics. • In Oulu, telecommunications facilities are good, and the Anchor company Stora Enso has some own logistic systems to deliver products to the global markets. • The main reason for Nokia's location in Oulu was the availability of suitable labour for production and the specialized electronics industry. This was driven by the University of Oulu's Faculty of Technology, its collaboration on the production of electronic measuring equipment for industrial purposes and an overarching goal of building an electronics industry hub in Oulu.	• Sofia is well connected by air to most EU capitals; this is important for the ICT sector that mainly operates on foreign markets. • Sofia has high-quality internet connectivity	• The Basque Country is well connected with other regions in Spain and internationally via road and (high speed) rail networks. The Basque Country has three airports and two important commercial maritime ports. • According to the Digital Economy and Society Index of the Basque Country (which measures connectivity, human capital, use of internet services, integration of digital technology and digital public services), the region stands out as a leader among the EU countries as a whole.	• Dedicated transport infrastructure in the form of a rail and road network, and port system. The transport infrastructure underpins the importance of logistics as a cross-sectional function in steel companies of the ecosystem. • In addition to the important locational advantage due to the favourable location on the Rhine, the importance of the Ruhr should also be emphasised. Various canals of the river enable a further form of goods distribution and the ramification of different parts of the Ruhr region. The waterway is a decisive location factor in the ecosystem and an important link to the Dutch and Belgian seaports.. • Thereby, the trimodality of the location, especially in the city of Duisburg, was key for the establishment of the steel ecosystem: road, water and rail together form a widely interwoven transport infrastructure.	• The West Midlands is well located in the UNITED KINGDOM in terms of physical and IT infrastructure. There are good road, rail and air networks. •The logistics network is well developed as a result of the strong manufacturing culture in the region, which has been significant to the automotive sector and its growth. •Digital infrastructure is good, but the region is piloting the 5G superfast network to support connectivity.	• The Brainport region has a good physical infrastructure, with connections by road, rail and air. However, congestion puts pressure on regional access and mobility. • Digital infrastructure and connectivity meet the high demands of the high-tech manufacturing industry. • Almost all households in the region have broadband internet access.
Demand					
Markets are global, not building on local demand. For new products, local demand is important.	Only focus on international markets	Markets are global, not building on local demand	Markets are global, also building on local and national demand	Markets are global, not building on local demand	Markets are global, not building on local demand
• Domestic markets are not that important for the incumbent ecosystem around Stora Enso; global markets and large companies are the most important customers. • Nokia has its own ecosystem that is partially in Oulu. Since Nokia is a global company, its ecosystem is mainly outside Oulu, in fact, it is everywhere in the world. Domestic markets are not that important for Nokia. • For the Salo region anchor company	The companies are mainly focused on the international markets. The growing size of the sector does however push more local demand for services between companies.	Exports account for 80% of the turnover in the sector. The sector has a profile of a top-ten world manufacturing centre.	In connection with steel as a product, there is talk of a high depth of value creation. After all, steel is an essential component for various sectors, such as the automotive industry or the construction industry. Customers are thus in regional proximity and distributed nationally, for example in the case of the German automotive industry, while at the same time there is global demand for steel, which is also served by steel producers in the ecosystem.	• The region has a strong manufacturing history, and the automotive sector now drives this. The supply chain within the region feeds into the sector. There are 100s of SMEs that supply parts to not only the local MNCs but internationally. • Automotive demand is mainly from international markets.	• Even if the region has an above average, high income working population and is relatively affluent region, most of the demand is outside of the region. • Primary demand for the manufactured goods and services is located outside the region, on global markets. The region is a major exporter in high-tech manufacturing. These markets are global.

(automotive), domestic markets are not very relevant; global markets and large companies (Mercedes, Saab, Porsche, Ford, and Opel) are the most important customers. The small Salo-based IoT firms mainly operate in local contexts. Enterprises that produce various applications/devices are more export-oriented. • Oulu: the situation is diverse. For the healthcare digital technologies, local demand is important. The hospital and the city are important first customers. However, export is expanding. Regarding 'pure' high-tech enterprises, the main markets are outside Finland, regardless of whether they are incumbent (Stora Enso and Nokia) ecosystems or the emerging high-tech ecosystem.					
Finance / financing					
Broad financial support for start-ups, for scale-ups it is less sufficient	International and EU funding mainly, with issue of corruption	Well-developed and strongly funded financial system	Funding is at risk for making the necessary transition(s)	Well-developed and strongly funded financial system (Brexit leads to overfunding from government)	Well-developed and strongly funded financial system
• Funding for small-scale start-up enterprises is generally sufficient. The problem is finding (domestic) investors for bigger enterprises trying to expand their activities. Enterprises in the incumbent ecosystem (Stora Enso and Nokia) are self-sufficient. • The problems in Salo are the same as in Oulu. However, in Oulu, there are more local investors.	• Important role for EU financial funds; about 350 million euros have been invested through the JEREMIE-programme in the last 12 years. • A problem exists with corruption in the absorption of EU funds. • NEVEQ funds for innovation/venture capital are available and well used. • Some respondents consider the financial infrastructure in Sofia, despite improvements, still insufficient to meet the needs for further development of the ecosystem.	• In the Basque Country, as a result of the possibility to levy local taxes, the Basque Government founded the "Sociedad gestora de entidades de capital riesgo" in 1985 to promote and develop venture capital activity in the Basque Country. • EUROSTAT data on financing, expenditure and venture capital in the period 2012-2019 indicated that the financial situation in the Basque Country is more favourable than other regions in Spain. • The Basque Country is the third capital in Spain in terms of investment attraction after Madrid and Barcelona. From a sectoral point of view, foreign investment in the Basque Country in recent years (2014-2017) is concentrated in medium-high technology industrial sectors. • Investment is a critical axis in the machine tool ecosystem. However, in scenarios of industrial disinvestment, and due to the high level of specialisation of the sector with customer orders, the macro-economic situation plays a determining role.	• Public funding plays an important role in the steel industry ecosystem. • For the European Union's climate requirements and the associated conversion to Co2 neutral steel, the steel producers in the region are not able to make these investments on their own and are therefore dependent on help from the European Union and the German government. • Funding opportunities for research projects also play a major role in this context. Thereby, the topics of hydrogen production and CO2 reduction in the steel sector are strongly promoted regionally, state-wide and nationally. However, other funding opportunities and funding pots, for example, with regard to digitalisation, relate less to the steel sector in particular but rather to specific technologies and subject areas. • With regard to funding opportunities, the anchor company also benefits from its organisation in different steel associations. According to the experts, these associations are	• Government funds and regional investments play an important role in supporting entrepreneurial activity and growth in the sector. •Universities in the region often work in close collaboration with industrial companies to deliver innovations in technology support electrification and zero-carbon targets. Financing is driving the development of green jobs.	• Funding is well-developed for all types of companies, and situation is improving. The average amount of venture capitalist finance in the Brainport region over the last five years is €11,39 million, which is relatively high compared to other Beyond4.0 Regions. • 96% of SME's in the ecosystem report no constraints regarding access to finance.

			also of fundamental importance with regard to funding and financing opportunities - after all, market developments are monitored very closely here so that not only large steel players but also smaller steel companies in the region benefit.		
Talent					
Mixed picture for the different educational levels: tight for high levels, abundant for low skills	Strong supply of talent	Strong supply of talent and system to support it	Supply of talent is in a turmoil, with dwindling supply to the IEE	Strong supply of talent	Supply of talent is average, mainly by extraordinary demands
• Salo: The main part of the workforce's educational level in the incumbent ecosystem around Stora Enso is secondary level or lower tertiary level. Planning and developmental staff have polytechnic or university level education. There are no possibilities for outsourcing, except for the wood harvesting process and logistic services. A foreign labour force is not required. • A sufficient number of employees is available. For example, after the Nokia collapse, the anchor company Stora Enso employed former Nokia sales, HR, and management personnel. • Oulu: The main part of the workforce's educational level is higher tertiary or PhD level education. There are many possibilities for outsourcing and taking advantage of the smaller companies that belong to the same economic ecosystem. These possibilities are enlarged when Nokia moves into its new localities between the university and the Technology Village. There is a huge demand for a highly-skilled technical labour force. The national supply is insufficient to satisfy demand. Therefore, there is a high need for a foreign labour force. This pressures national decision-making to implement immigration and tax policies that make it easier for skilled labour to move into the country. • Education is excellent, but the education system cannot satisfy the demand for a skilled labour force. Therefore, the Technical University (polytechnics) specialises in offering	• Talent is the strongest ecosystem element of Sofia. With the concentration of both universities and ICT companies in Sofia, labour supply is concentrated here, also due to the international migration of IT specialists. • Sofia attracts talent from other Bulgarian regions; students stay in Sofia after graduation. • A new venue is to attract talent from Belarus, Ukraine and other former Soviet republics.	• The Province of Gipuzkoa has the highest share of the working population with a professional qualification (20.2%) in Spain. With a share of 32%, there are fewer than, on average, people with primary education. 21.6% of the working population has a university degree. • 22.4% of the total labour force potential (people >16 years) of the Basque Country has a university degree; 20% is formative professional training; 32.5% is primary education, and 4.6 % is unqualified. • Talent in terms of skills, training, and education is important to highlight in the machine tool ecosystem. The IMH (machine tool institute) and the network of vocational training centres are deeply rooted in the territory, particularly due to the proximity of the educational centres to the companies. In addition, aspects such as up-skilling and re-skilling through master studies or specialisation courses in digital technologies are gaining importance.	• Since the founding of the Ruhr University Bochum in 1962, the Ruhr region has developed into an important educational location within a few decades. However, the steel ecosystem, among other sectors, is struggling with graduates migrating to other parts of the country or working in other industries. Particularly with regard to highly qualified workers, it seems evident that technological developments also lead to changes in the content of studies. The expectation in this context is that the university landscape will also change in the course of this and that this will have an impact on the content of steel-related chairs. • In general, especially the demand for a highly qualified workforce is leading to a regional “war for talents” for years, also in the steel ecosystem. Therefore, improving the attractiveness of STEM is a generally common task, recruitment for steel jobs especially, due to the bad image of work in the steel industry which is still depicted as dirty, hazardous and heavy work. • All in all, recruiting skilled workers and academics in the steel ecosystem is difficult. In many cases, unskilled, regionally recruited workers are used, who are in turn trained and educated within the company. There is also a concern in this context that the supply of unqualified people, who have the necessary social, personal and methodological skills, is reported to have become smaller in the region.	• There is a good supply of talent in the region that feeds into the automotive sector. Three main universities supply highly skilled employees. • SMEs are able to attract local talent, whereas the MNCs recruit from international labour markets for highly skilled employees. •The region has a number of educational institutions offering vocational training. With MNCs in the region offering apprenticeship and vocational routes into the sector. •One strand of work of the regional agencies is focused on supporting regional growth by helping companies meet skill needs and gaps from within their current workforce. Universities are offering professional development and postgraduate courses in collaboration with industry. Plus, new activity is around practical skills development in lab-based settings and industrial placements.	• Talent availability is average. The region requires an ongoing supply of very highly skilled (international) employees. There is a 'war on talent' in the current tight labour market for high-tech employees. • 44.2 Percent of secondary or medium vocational education students in South Brabant opt for a technological profile in 2019. For Southeast Brabant, the share has increased by 0.1% point compared to 2018.

further education and life-long learning.					
(New) Knowledge					
Mixed situation with excellence knowledge supply for Oulu, limited knowledge supply in Salo	Local optima, but overall not strong knowledge position	Strong knowledge system support for EE	System dominated by anchor company, limiting innovation direction	Strong knowledge system support for EE	Strong knowledge system support for EE
• In the Oulu area, the R&D investment both in Euros per inhabitant (€2,835) and relative to the local GDP (7.7%) are higher than in the capital area (€2,001 and 3.7%, respectively). Both the absolute and relative numbers for Oulu are the highest in Finland, and they correspond to 11% of the total R&D expenditure for personnel in Finland. • Stora Enso is a global actor, and therefore, it is not as dependent on the local circumstances as smaller, emergent companies. As a result, there is not much collaboration between Stora Enso and the local ICT enterprises. • The university is not very important for Stora Enso as a catalyst. However, the university and the whole education system play a role as important sources for personnel with sufficient qualifications. The typical background of our operators is a technical background from the local university of applied sciences. With higher positions, the education is usually from the University of Oulu. • There is no university in Salo, which is one important difference between Oulu and Salo and their possibilities to develop emerging innovative ecosystems. • In April 2021, Nokia announced that the company would like to build new research, development, and production facilities. The new localities would be geographically located between the university and the Technology Village.	• Within Bulgaria, most R&D investments are concentrated in Sofia which contributes to Sofia as most innovative region. • In comparison with other EU member states, Bulgaria is a "modest innovator" (< 1% of GDP invested in R&D). • Traditional businesses do not recognize the need for investments in R&D and innovation. Low tendency to invest. • Sofia is the centre of education and research institutions in Bulgaria. But the SoftUni is mainly a supplier of personnel, not of technological innovation. The intention is to have the Bulgarian Academy of Sciences develop this position.	• Spending on research and development (R&D) in the Basque Country in 2019 totalled 1,481.4 million euros, 4.1% more than the previous year. In relation to GDP, the Basque Country stood at 1.86% in 2019. This figure places the region below the Europe-27 average of 2.19%. However, within Spain, the Basque Country has the highest R&D intensity (R&D expenditure as a percentage of GDP in Spain is 1.25%) • 4GUNE is the University Training Cluster in Engineering, Science and Technology in the Basque Country. In its configuration, its aim is to contribute to the strengthening of cooperation between the University and Businesses in the Basque Country in the RIS3 scenario, promoting and implementing collaboration models and co-creation mechanisms. The 4GUNE Cluster is mainly focused on Industry 4.0. • Additionally, it is worth mentioning the Basque Digital Innovation Hub (BDIH), a non-profit initiative framed within the implementation of the Smart Specialisation Strategy. Focusing on advanced manufacturing, BDIH aims to support better access to scientific and technological capabilities. The digital hub comprises a variety of actors, such as research and development centres, vocational training centres, universities, business R&D units. • the Basque Country has more than 30 institutions and 127 infrastructures, in which there are 364 research and development facilities and 589 research groups.	• Steel ecosystem does not have a well-developed cooperation network with the local University of Duisburg-Essen. This is also due to the fact that steel does not play a major role in the university, unlike, for example, in the Technical University of Clausthal in Lower Saxony. • The anchor company, just like the other large steelworks in the region, has its own research centres for different topics such as digitization or hydrogen research. The region's research institutes work together with such corporate research centres and compete with them in certain areas. • There are steel associations in place in the region that closely observe the market and point companies to funding opportunities for research projects. • In contrast to big steel producers, small and medium-sized steel enterprises in the region often do not have comparable capacities.	• In the United Kingdom, R&D is driven by industry, the public sector, and higher education across the country. Universities and OEMs are drivers of new knowledge.	• Above Dutch average of participation in innovation projects and high R&D investments. Brainport has the largest concentration of private R&D expenditures in the Netherlands and compared to other Beyond Regions. • The region of South-East North-Brabant has a third position in the number of patents in the Netherlands. In the period 2016-2019, the Brainport region has achieved 75.9 patents per 100.000 inhabitants. • Strong collaboration of companies with TU Eindhoven and other public knowledge providers.
Services by Intermediaries					

Strongly developed in Oulu, average for Salo	Strongly developed network of intermediaries	Strongly developed network of intermediaries	Strongly developed network of intermediaries, focused on the Anchor company	Strongly developed network of intermediaries	Strongly developed network of intermediaries
• In Oulu, BusinessOulu, the City of Oulu, and employment services are supportive to companies. In Oulu, the emphasis has been on nudging and establishing enterprises. • BusinessSalo and the public authorities have been helpful, but their resources are smaller than the resources in Oulu.	• Access to and use of intermediaries has only recently been developed after Bulgaria became an EU member. The European Investment Fund was instrumental to this development. • Sofia Tech Park (2018) functions as a platform for knowledge exchange between academia, businesses, government and society (offices, labs, incubators, conference facilities). • ICT Cluster functions as an umbrella organisation for the Bulgarian ICT industry (> 280 SMEs and six technical universities). • Various ICT business associations are present. • Sofia Invest (Sofia Investment Agency [municipality] acts to attract investors in ICT in Sofia. • Innovation Sofia (Municipality; formulation of Digital Transformation Strategy and Vision Sofia 2050)	• The Basque Country has 38.4% of total employment dedicated to knowledge-intensive services, compared to 40.7% in the EU. The evolution in the last decade, although upward, is below the European average.	• Numerous important institutions, intermediaries and networks in the steel industry are based in Düsseldorf, such as the Trade Association Steel (Wirtschaftsvereinigung Stahl), the Steel Institute VDEhor the employer's association steel (Arbeitgeberverband Stahl e.V.). • The Association of German Iron and Steelworkers played a particularly special role for the ecosystem in the past. In this association, exchanges with other engineering fields, mechanical engineering and universities were held for over 100 years. In this way, a complex network of contacts was built. However, as experts point out, the VDEh no longer has the significance it had back then. • Trade unions traditionally also play a major role in the regional and national steel sector. • Through the co-determination model, there is always a trade union representative on the board of large regional steelworks in the ecosystem. As a result, business development and local politics also have good contact with the boards of big steel players. However, the thematic focus in this context is mainly on labour and human resources and less on the technological area.	• Within the wider regional area, there are a number of services aimed at partnership working and collaboration to support regional growth. For instance, there are: •six Local Enterprise Partnerships (LEPS) - partnerships between local authorities and businesses. They decide what the priorities should be for investment in roads, buildings and facilities in the area • one Skills Advisory Panel – which is a local partnership between employers and skills providers including colleges, independent training providers and universities; • six growth hubs – these are local public and private sector partnerships in England that are led by each of the Local Enterprise Partnerships. • In addition, there are a significant number of associations and bodies which provide a range of services to the automotive sector. •The sector is serviced by a strong supply chain in the region.	• The Brainport region has eight incubators per 1000 inhabitants; this is the highest number of incubators of all BEYOND4.0 regions. • Intermediary role played by Brainport Development (PPP), Brainport Industries and the Brainport Industries Campus.
(Social) Networks					
Well networked regions	Starting network development	Very strong, historical networks in the IEE	Very strong, historical networks in the IEE	Well networked region, but conflicting interests	Very strong, historical networks in the IEE
• There is a strong collaboration between Nokia and Oulu University. The university is not the catalyst, but the collaboration between the university and the company is an important driver. • Gradually, VTT, Nokia, the university, and new ICT-based enterprises started cooperating and formed a growing and innovative new economic ecosystem that successfully unified research, development, designing, manufacturing, and selling around electronics and mobile	• Compared to a few years ago, companies collaborate more rather than (only) compete. • Specialisation of companies increased collaboration; partnerships based on specific competencies. • Newly created State Agency for Science and Innovations to create interconnections between business, state and regional institutions and scientific organisations. • Foreign dominant networks make sharing locally an issue. Focus is international, not local.	• For the machine tool ecosystem, clustering becomes critical. The fact that AFM- the machine tool cluster is located in Gipuzkoa (Basque Country) shows the importance of this industrial activity in the Territory. The cluster has an R&D research institute (INVEMA) that drives advances in adapting and adopting new digital technologies (c.f. AFM). This leadership has its translation in the education and training system with institutions such as the IMH (Machine Tool Institute), originally promoted by	• There are several initiatives that reference the Ruhr valley region as a common area of economic development strategies, such as Metropole Ruhr and the Regionalverband Ruhr. Düsseldorf, the capital of the North-Rhine-Westphalia NUTS2 region, and the headquarters of major steel players. • Networks continue to play a major role in the steel ecosystem. This is true for topics such as hydrogen development, where a network of partners cooperates, including energy	• There are regional networks where organisations are brought together to discuss wider issues that impact the sector and its operation. • In terms of labour force supply and development, there are strong networks within and between universities and industry. These are to ensure supply meets the needs of the industry. • Only one network of collaborating SMEs was found that share practice. This was set up with funding and led by one university.	• The Brainport region can be characterised by a relatively close-knit network of businesses, knowledge institutions, and the (local and regional) government: a 'triple helix'. Based on earlier industrial networks (around Philips) and local (regional) governments and TU Eindhoven. • There are five PPP-collaborations in the Brainport region: Brainport Industries, Flexible Manufacturing Fieldlab, High-Tech Software Cluster, Smart connected Supplier Network fieldlab, Fokus Fieldlab.

technology. The greater collaboration began in the late 2010s. • The Technology Village was established in 1982, when the City of Oulu, the University of Oulu, and a number of shareholder companies established Oulun Teknologiakylä. The purpose of this joint venture was to gather top technology experts in Oulu and accelerate the ongoing transformation of the economic structure in the region. The overarching theme was to launch an image of Oulu as a knowledge and competence centre for the Finnish electronics industry.		the cluster and currently integrated into the University of the Basque Country. The IMH is a strategic partner of the cluster in areas such as digitalisation or additive manufacturing (c.f. AFM; IMH). The IMH is also a pioneer in dual training combining apprenticeship and on-the-job training (alternating). • see also # intermediaries. Other networks are linked to the BIEMH (exhibition), promotion societies, AIC etc.	suppliers and political actors, as well as for other research projects and innovation developments. • There is still a lively exchange among research institutions in the region and supra-regionally, which are not necessarily only connected with the steel industry: engineering departments of RWTH Aachen University, the University of Duisburg-Essen and TU Dortmund. Another important institution for the regional steel industry is the Steel institute VDEh, which has existed for over 100 years. • Nevertheless, the University of Duisburg-Essen has relatively few links to the region's coal and steel industry. • Above that, the regional steel ecosystem in Düsseldorf District is embedded in national and European networks, which is why national and European institution of self-organisation of the industry such as the German Steel Association, the Federal Association of the German Foundry Industry, and the Professional Association of Cold Rolling Mills have their headquarters and national branch, respectively, located in the region.	• It is evident that are some networks are in operation between SMEs, which have been set up to deal with OEM. However, there was little evidence of networks between companies, particularly in terms of entrepreneurial activity. The automotive sector is highly competitive.	
Leadership					
Anchor company driven leadership	**Entrepreneur driven leadership, with foreign influence limiting clear local visions**	**Sector associations driven leadership**	**Anchor company driven leadership**	**Dispersed leadership, through OEM and networks**	**Business leadership**
• Nokia still is an important player in the Oulu area, and it still has a significant impact on the local high-tech ecosystem. • With its planned new R&D and production facilities in the Technology Village of Oulu, Nokia will be located in the (geographical) centre of the technology hub and a central actor in telecommunications. • In a way, Nokia is a part of the incumbent ecosystem, but it has an important role in enhancing and generating new ecosystems. Thus, Nokia, with about 2,600 employees in the region, is still a strong	• Entrepreneurs in Sofia (old and new; domestic and foreign-owned) share the vision that focus should be on the upgrade of activities in value chains towards more complex products and services.	• Participation and leadership in research-related activities (competitive funding programmes such as Horizon 2020), The Basque Country is the leading region in terms of per capita return from the European H2020 programme, with a catchment in the 2014-2018 period of 242 million euros per million inhabitants. • For the machine tool ecosystem, clustering becomes critical. The fact that AFM- the machine tool cluster is located in Gipuzkoa (Basque Country) shows the importance of this industrial activity in the Territory. The cluster has an R&D research institute	•The role of the anchor company is particularly important. With around 12,000 employees plus partners and external companies, the company employs the most people in the ecosystem and is thus the largest employer in Duisburg. • In Duisburg, the anchor company runs the largest integrated steelworks in Europe • In the context of digitalisation, several research institutes are also important. Thereby, companies rely on competencies from institutes that are located within the ecosystem, as well as the research expertise of universities.	• As automotive is a competitive sector driven by international demand, leadership is focused with OEMs. • However, leadership (to a less of extent) is also located with the regional networks that support growth in the sector and region. Regional leadership tends to focus on inward investment and labour supply, as well as supporting digital transformation.	• Leadership is located at the focal firm (ASML),which is a world leader in its business sector and plays a leading role in the regional value chain. • The Brainport region has 163 H2020 innovation project coordinators, which is 0.0000652 coordinators per 1,000 inhabitants. Compared to the other regions in the Beyond4.0 project, this is about average.

undercurrent in the technological ecosystems in Oulu.		(INVEMA) that drives advances in the adoption and adaptation of new digital technologies (c.f. AFM). This leadership has its translation in the education and training system with institutions such as the IMH (Machine Tool Institute), originally promoted by the cluster and currently integrated into the University of the Basque Country.			

Table A.2 Comparison between 6 incumbent regional entrepreneurial ecosystems: Impact of digital transformations

Finland: incumbent EESs (Salo & Oulu)	Bulgaria: ICT EES (Sofia)	Spain: Machine tool EES (Basque Country)	Germany: Steel EES (Duisburg)	United Kingdom: Digital Health EES (West Midlands)	Netherlands: Brainport EES (East North-Brabant)
Digital technologies well embedded in whole ecosystem.	Digital technologies well present, and in development.	Digital technologies mainly with limited functions in the sector.	Digital technologies are seen as an opportunity, are partly well embedded on the side of large corporations, but spread is low among SMEs	Digital technologies are seen as opportunity, but spread is low among SMEs.	Digital technologies well embedded in whole ecosystem.
Oulu is a Finnish pioneer in planning, developing, and piloting operator-independent and open Internet of Things (IoT) platforms in different areas. IoT platforms are implemented in public and private real estate, such as schools and kindergartens, shopping centres, offices, and sports and cultural facilities. The Oulu vision is to develop a smart city of the future where services will be electronic and based on wireless data transmission. The problem is not insufficient data; it is that it is not always possible to utilise the data best. Many enterprises and projects are tackling that problem in Oulu. Two ventures represent the emerging digital service ecosystem: Haltian, which specialises in IoT in maintenance services, and the OP-bank, which develops digital banking systems. One of the most ambitious projects of the OuluHealth ecosystem is the Future Hospital OYS 2030 programme. The main idea behind this initiative is to modernise the OYS to utilise the most advanced technologies, such as 5G/6G, IoT, Artificial Intelligence, and big data analytics applied in analysing the extraordinary Finnish health-related registers. The Future Hospital project also brings business opportunities for health technology companies that provide innovative solutions to healthcare challenges.	• The development of digital infrastructure has been an important element for the ICT ecosystem in Sofia. • The Sofia ICT ecosystem supports digital transformation of sectors and companies. Recent ecosystem developments are targeted at the evolution of international demand and specific clients' needs.	• The potential of robotics, artificial intelligence, data management, digital twins for products and processes and even new business models open up a range of new possibilities for manufacturing companies. Within the Regional Smart Specialisation Strategy of the Basque Country, advanced manufacturing is a priority.	• The demand for Industry 4.0 solutions strongly depends on their customer structure for the steel and metal trading industry. Steel producers and processors who supply to the automotive and mechanical engineering industries are therefore already using digital process sequences due to customer requirements, while sectors such as energy and electrical engineering do not have these customer requirements, and therefore, there is little demand for industry 4.0 applications. • The industry is facing considerable challenges with regard to digitalisation: These must be solved by the companies themselves, for example, with regard to what is necessary to meet the cultural change; but is also challenging politicians. With regard to formal institutions, this concerns the development of broadband infrastructure and the establishment of uniform industry standards.	• In the United Kingdom, digital transformation is well established with developments and changes responding to new technology in large anchor firms. In SMEs, there was a lack of digital transformation, which is mainly considered to be the result of resourcing (where the cost of implementing technology or digitalising an activity is not considered cost-effective).	• The high-tech manufacturing industries are a breeding ground for 'smart industry' or industry 4.0 applications, such as flexible and additive manufacturing processes and logistics. Primary production processes are more and more automated and robotized, and supply chains are getting more data-driven with digital information exchange between suppliers. Data and information exchange are more often located in the core of primary production processes. Digital twinning (e.g. 3D or 4D virtualizations) or even digital factories are more often applied and optimise global production processes of manufacturing companies.

Data-driven I4.0 business models well embedded in ecosystem	Ecosystem is digitally minded, but lags behind in data-driven business models	Data-driven business models only with lead companies, mainly traditional automation.	Business models are mainly traditional automation, digital business models are not yet engrained.	Data-driven business models only with lead companies.	Data-driven business models well embedded in region, with anchor companies and local companies.
There are about 100 high-tech enterprises involved (including those that have been discussed above. The OP-bank is indirectly involved by providing health insurance policies) in the Oulu region in developing programmes and/or health technology devices. During the last decade, the number of employees in the sector has increased by 28% and there are now over 2,000 employees. In the wood-processing, all companies are integrated into one digital information systems, which allows integration into one digital business model. Improvements in the sector are driven by this perspective.	• Bulgaria lags significantly behind in strategic planning for digitalisation of the economy. However, the team of Innovative Sofia (a department within the Municipality) was involved in the formulation of the Digital Transformation Strategy for Sofia. • Labour force development with a particular focus on digital skills contributed to the ecosystem development. The development of the digital infrastructure has been an important element for the successful development of this EES. In addition, the labour force in the EES has always been highly skilled, with a particular focus on digital skills. But more importantly, the companies from the examined EES are supporting the digital transformation of many other sectors and companies, internationally or domestically. In reality, there is not enough well-coordinated effort and proactive development of this transformation.	• The knowledge of Gipuzkoan companies related to the concepts and technologies associated with Industry 4.0 exceeds that of companies located in other territories in the region. • Companies are reported to have greater knowledge of Additive Manufacturing, Big Data, Blockchain, Internet of Things, Collaborative Robotics and Predictive Analytics. Additionally, companies in the territory consider 'Data Analytics' (50%), 'Sensorisation Technologies' (33%) and 'Collaborative Robotics' (25%) as the three most beneficial technologies in the adoption of Industry 4.0. • According to Adegi (2019), approximately 40% of companies in Gipuzkoa have a defined strategy for implementing Industry 4.0. This percentage for the Basque Country as a whole is reduced to 28%. The adoption of 4.0 strategies exceeds 56% for companies with more than 50 employees in the territory and reaches 75% for large companies. In other words, the size of the company seems to have an impact. • A key aspect of the transformation of the machine tool industry is maintenance. The key to predictive and proactive machine maintenance in the industry is operational data and the analysis of using big data and artificial intelligence tools.	• Stakeholders agree that digitalisation can make an important contribution to greater efficiency and process optimisation in the steel industry. Many parts of the production are automated; potential for further automation is lower in the production of the steel itself. Other areas, such as predictive maintenance, have still much potential for automation and other types of digitalisation. • Although the steel industry itself is not one of the pioneers of digitalisation; the topic has gained massively in importance in recent years. • For the anchor company, with a complex production network comprising an integrated metallurgical network, with suppliers, complex material flows, complex plant and equipment, different options and customers with different needs, digitalisation and a digital control of the supply chain offer excellent opportunities.	•Automation and digitalisation have been established in the automotive sector for several years. Developments progress with technological changes, but big changes are not expected in short to medium term. •It is recognised that digital transformation and entrepreneurship can drive growth in a sector, but good leadership is needed to manage and drive the process. • Automation has driven changes to the sector. Organisations in the supply chain that have not adopted technology are unlikely to change due to cost factors.	• In the Brainport Smart mobility programme, regional companies, knowledge institutions, and the City of Eindhoven develop smart mobility concepts (such as Mobility as a Service) and Intelligent Transport systems based on, e.g. IoT and cooperative adaptive and autonomous vehicle technologies.

Table A.3. Comparison between 6 incumbent regional entrepreneurial ecosystems: (inclusive) economic and social outcomes

Finland: incumbent IEEs (Salo & Oulu)	Bulgaria: ICT IEE (Sofia)	Spain: Machine tool IEE (Basque Country)	Germany: Steel IEE (Duisburg)	United Kingdom: Automotive manufacturing IEE (West Midlands)	Netherlands: Brainport IEE (East North-Brabant)
IEE partially work to deal with restructuring core company. Different social and economic trajectories are clear.	IEE works as a selective system. High skilled are retained, no opportunities for low skilled.	IEE has worked as buffer for the economic crisis in the whole region.	IEE has worked as buffer for the economic crisis in the whole region. IEE works as inclusive for low skilled, within the sector. National system is supporting IEE.	IEE can be seen as supporting economic growth but was hardest hit by economic crisis. Region has persistent unemployment and hardest hit by economic crisis. Pockets of innovation driving demand for technical and project management skills.	IEE is driving economic growth to unseen heights. The question is not how to share the economic crunch, but rather how to share profits.
Employment and unemployment					
Recovering region, with different social and economic trajectories	Full employment region.	Recovering region, with still considerable unemployment.	Recovering region with persistent unemployment due to high wages.		Full employment region.
• Both the Oulu and Salo region were severely hit by the collapse of Nokia. Salo – as well as Oulu – were classified as areas of abrupt structural change (ASC), which refers to a situation wherein an important employer or sector of regional or national significance makes redundant a large number of employees at once because of extensive adjustment measures • Oulu has recovered, whereas Salo still struggles. While Oulu witnessed a surge of new medium-sized (50 to 150 employees) high-tech enterprises, such a phenomenon was mainly absent in Salo. The role of the existing traditional metal industry manufacture of machines and technical products became more important in Salo's recovery.	Strong growth of employment. No unemployment	• Gipuzkoa accounts for 33.45% of employment in the Autonomous Community and 1.69% of the total for Spain. In the last five years, an increase of unemployment to 8.45% was observed, somewhat higher than the Basque rate (8.01%) and lower than the Spanish rate (12.11%). The Machine Tool sector has been able to maintain its employment levels.	• Despite the sharp declines, the steel industry is still one of the most important employers in the region, especially concerning Duisburg. Various important steel manufacturers can be found in the city, and Europe's largest steelworks in terms of area is also located in Duisburg. • The steel and industrial sector in the ecosystem is characterised by good salaries and excellent social security systems. Workers in the steel system earn significantly more than warehouse workers in logistics. • Because low-skilled workers in the steel sector are employed at above-average market conditions, reintegration into the labour market after unemployment is often difficult. At this point, ecosystem actors such as the Federal Employment Agency point out the importance of qualification for the low-skilled workers .	• The automotive sector key employer in the region with strong national and international networks. MNCs dominate the region and employment growth is dependent upon and driven by the wider automotive market. Whilst employment is the sector is consistent, demand is high for specialist and technical skills. Brexit and global trends will impact future growth of the sector in the region.	• Employment: growing (until now, even during the covid-19 crisis low unemployment rate.
Productivity and innovation					
Innovation driven region	**Innovation and internationalisation driven region**	**Productivity driven region**	**Productivity driven region**	**Productivity driven region**	**Innovation driven region**

• The Oulu case exemplifies a gradual change and shifts in both the incumbent and the emerging ecosystems. The incumbent ecosystems are innovative as well, and they adapt their activities according to circumstances.	• The ICT ecosystem is considered one of the main engines and drivers of the Bulgarian and Sofia economy.	• In terms of labour productivity adjusted to wages in the manufacturing industry, in 2008-2016, the Basque Country has fallen back compared to the national and European averages. • Productivity per person in the Manufacturing sector for the same period (2008-2017) indicates an annual increase, with higher machine tool-related activities levels.	• Generally, the German steel industry has made considerable progress in productivity over the past 30 years: labour productivity - measured by crude steel production per employee - has almost tripled over this period. These developments in the drastic increase in productivity may also explain the huge reduction in employment in the sector.	Economic output is high and growth relatively stable given impacts of Brexit and pandemic. Automotive manufacturing key employer in the region, but this has declined over the last 10-15 years.	• In terms of economic output, the Brainport region had an above-average growth compared to other regions in the Netherlands. Particularly the professional and science service sector has grown strongly since 2000. Nowadays, manufacturing still accounts for about 24% of total GVA in the region (2000 = 26%).
Diversity and discrimination					
Inclusive within Finnish context, but improvements needed	Gender equal, but high-education selective ecosystem	Gendered and 'national' employment, but few other selective mechanisms	Gendered employment, but few other selective mechanisms	High wage differentials and gendered employment	**Quite** selective employment situation, gendered, skill levels and wage disparities.
The Finnish regions are traditionally 'inclusive', in the sense that they have low levels of polarisation in wages, limited wage gaps. Employment is still gendered in wood processing, but more equal in the digital sectors. Employment is quite 'national', mainly because of restrictive immigration policies.	• The ICT ecosystem keeps highly educated Bulgarians staying rather than migrating to other EU member states. • Relatively large number of women employed in the ICT sector. • High education and digital skills requirements make the ecosystem not relevant for low qualified Roma.	Moderate polarisation of wages. Sectors are still quite gendered and mainly focused on Basque natives (language requirements), with more opportunities for men. More opportunities for all educational levels.	Steel work is mainly a male job, also as a consequence of OHS-rules. Most jobs are on-the-job training that allows low-skilled and migrant workers. However, many of such groups are pushed into temporary agency jobs.	Sector dominated by male employment. On the job training preferred with in-house technical skills developed. Wage differentials between those working on shop-floor and those in middle management roles. Jobs are dominated by shift work and variable hours.	Gendered employment in technology companies, male-female distinction in jobs. Wage disparities are growing and highly selective international presence.

EUROSTAT DATA

Table A3-B – Employment growth (index 2020) by sex, age, economic activity and NUTS 2 regions (NACE Rev. 2) between 2010 and 2020 [lfst_r_lfe2en2] (Eurostat, 2021)

	Industry (except construction)			Wholesale and retail trade, transport, accommodation and food service activities			Information and communication		
	Total	Males	Females	Total	Males	Females	Total	Males	Females
Sofia	86	86	86	101	106	96	140	157	119
Dortmund	98	98	98	100	106	93	139	141	135
Duisburg	101	99	108	104	100	108	130	141	80*
Basque Country	89	89	88	89	86	92	104	107	98
Noord-Brabant	110	109	112	107	111	102	98	97	101
Salo	89	89	88	83	80	86	158	148	182
Oulu	91	94	83	86	90	80	140	153	116
West Midlands (UK)*	105	103	113	116	116	116	138	140	133

*2010-2019

Eurostat - Data Explorer (europa.eu)

Table A3-C – Index 2020 employment as percentage of total employment in technology and knowledge-intensive sectors by NUTS 2 regions and sex (from 2008 onwards, NACE Rev. 2) [htec_emp_reg2] (Eurostat, 2021)

	Total	Males	Females
Sofia	151	164	138
Dortmund	123	122	122
Duisburg	134	143	85*
Basque Country	114	117	110
Noord-Brabant	98	93	105
Salo	121	129	106
Oulu	121	128	103
West Midlands*	100	100	88

* 2019

Table A3-D - Unemployment growth (index 2020) by sex and NUTS 2 regions (1 000) [lfst_r_lfu3pers]

	Index Sofia = 100	Males/Females in 2020	Index 2010-2020		
			Total	Males	Females
Sofia	100	126	51	52	49
Dortmund	144	155	70	70	71
Duisburg	140	123	64	56	78
Basque Country	263	88	84	75	95
Noord-Brabant	99	105	81	87	75
Salo	216	118	83	81	85
Oulu	248	123	85	82	90
West Midlands*	127	120	54	48	64

* 2010-2019

Table A3-E - Unemployment distribution (index 2020) by sex and educational attainment level and NUTS 2 regions (1 000) [lfst_r_lfu3pers]

	Total	Males	Females	Total	Males	Females	Total	Males	Females
ISCED-levels	0-2	0-2	0-2	3-4	3-4	3-4	5-8	5-8	5-8
Sofia	22%	22%	22%	57%	64%	49%	20%	19%**	28%
Dortmund	44%	43%	33%*	37%	39%	49%*	15%*	14%*	17%*
Duisburg	42%	46%*	35%*	42%	42%*	52%*	13%*	12%*	
Basque Country	35%	44%	28%	24%	22%	27%	40%	35%	45%
Noord-Brabant	37%	37%	38%	34%	34%	34%	28%	29%	28%
Salo	21%	25%	17%	52%	56%	48%	27%	19%	36%
Oulu	22%	23%	22%	56%	60%	50%	22%	17%	28%
West Midlands*	33%	35%	29%	41%	39%	44%	26%	26%	27%

* 2019; ** 2018

Table A3-F - Unemployment growth (index 2020) by sex and educational attainment level and NUTS 2 regions (1 000) [lfst_r_lfu3pers]

	Less than primary, primary and lower secondary education (levels 0-2)			Upper secondary and post-secondary non-tertiary education (levels 3 and 4)			Tertiary education (levels 5-8)		
	Total	Males	Females	Total	Males	Females	Total	Males	Females
Sofia	83	84	83	43	47	38	55	51**	59
Dortmund	77	74	44*	53	56	49*	79*	70*	96
Duisburg	63	54*	41*	54	40*	57*	98*	90*	
Basque Country	71	73	68	83	66	101	101	84	119
Noord-Brabant	70	70	71	72	89	60	128	122	135
Salo	61	67	52	83	86	79	118	94	141
Oulu	70	68	76	84	82	88	113	112	112
West Midlands*	43	41	45	51	42	66	102	97	109

*2010-2019; **2010-2018

https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=lfst_r_lfu3pers&lang=en

Table A3-G – Growth index 2020 for people at risk of poverty or social exclusion by NUTS regions and relative position of regions in 2020 (or other date) compared to Sofia 2020 [ilc_peps11]

	Growth index	Period	Relative position (Sofia 2020)	Comparison
Sofia	57	(2010-2020)	100	2020
Dortmund	94	(2016-2019)	98	2019
Duisburg	80	(2016-2019)	89	2019
Basque Country	85	(2010-2020)	67	2020
Noord-Brabant	102	(2016-2020)	66	2020
Salo	91	(2010-2020)	78	2020
Oulu	99	(2010-2020)	92	2020
West Midlands	100	(2010-2018)	111	2018

Table A.4. Comparison between six emerging regional entrepreneurial ecosystems: elements of the emerging entrepreneurial ecosystem (EEEs)

Finland: emerging Digital and Health EEEs (Salo & Oulu)	Bulgaria: BPO EEEs (Sofia)	Spain: Smart mobility EEEs (Basque Country)	Germany: Logistics EEEs (Dortmund)	United Kingdom: Digital Health EES (West Midlands)	Netherlands: Aerospace EEEs West North-Brabant
Formal institutions					
Strong, trustworthy institutional environment	Unsupportive environment, EEEs operates in international isolation	Strong trustworthy institutional environment	Strong trustworthy institutional environment	Disparate system with few national leads	Strong trustworthy institutional environment; but disparate support system
• Digital: Companies comply with national regulations and tax policies. The municipality of Oulu is very flexible and supportive of the evolvement of new innovative enterprises. • Health: Companies comply with national regulations and tax policies. The municipality of Oulu is very flexible and supportive of the evolvement of new innovative enterprises. The activities comply with special regulations concerning data secrets, anonymity, and the utilisation of registers and my-data.	Captured state and corruption in general, but the EEEs escapes from this capture because of the strong foreign players. Relatively favourable tax environment.	The quality of government (consisting of corruption, accountability and fairness scores) is analysed through the Quality of Government Survey (Charron, Lapuente & Annoni, 2019). At the NUTS3 level, the Basque Country region scores in the 2017 exercise with an EQI100 score of 63.3 (best performing region; above national and EU Levels). However, this is somewhat lower than the EQI100 score of 76.63 achieved in 2010.	The regional logistics industry has benefited from Formal Institutions. Ultimately, the emergence of a strong, regional logistics industry was also promoted by the municipal side and enabled by excellent research and education facilities. In present times, however, new rules and regulations are needed, for example to deal with the shortage of space in the ecosystem. At the same time, framework conditions must also be created in the area of digitalization	The ecosystem benefits from the support of the Department of Health and Social Care that manage health region and local trusts that deliver services. There are few actors in the digital health care sector; R&D lead by universities and services delivered by the private sector. Intermediaries and consumers have limited options as the sector is evolving. Poor intermediary ICT infrastructures limit implementation and therefore entrepreneurial activity.	Mixed results: generally speaking, the region profits from good governance in NL. The ecosystem (logistics) profits of support from the ministry of economic affairs and the so-called Top sectors. Also, the province of North Brabant is an important actor in support. For the MRO-part, more awareness of the central government is necessary. There are a lot of actors with different interests that do not cooperate.
Entrepreneurship culture					
Strongly developed	Not present	Strongly developed	Strongly developed, supportive	Public sector culture, not entrepreneurial	Unambitious, disparate culture
• Digital & Health: The entrepreneurial 'Spirit of Oulu' is an important factor in the emergence and functioning of the ecosystem	Not very high in general but developed in this EEEs. Few locally established companies.	According to the 2018 Global Entrepreneurship Monitor (NUTS2), the entrepreneurial culture indicator in the region scores 5.4/10 (Saiz et al., 2019). Furthermore, this indicator is the second most important framework condition after access to infrastructure and services, indicating the relevance of social and cultural norms and societal support.	Logistics is considered an industry that generates many innovations, new ideas, entrepreneurs and start-ups beyond the boundaries of the regional ecosystem. The Ruhr region can be attested a particular strength as an innovation location with regard to the formation of sector-specific clusters. In addition to the cybersecurity and health care sectors, this applies above all to the logistics sector	Entrepreneurial activity in the sector mainly takes place in a few large organisations that operate nationally. However, large organisations dominate the sector. There is limited entrepreneurial activity in the sector, probably due to a lack of financing.	Entrepreneurship from companies such as OneLogistics and Aeronamic has played an important role. However, joint entrepreneurial culture is missing in the ecosystem and certainly in Defence Ecosystem. The ecosystem is regionally focused and too happy with 'simple' maintenance tasks. The culture has little interest in crossover of technological innovations. In fact, the local areas functions as three separate sub-ecosystems: logistics & defence, MRO and new materials.
Physical and IT infrastructure					
Strong infrastructure in Oulu	Strongly developed	Strongly developed	Strongly developed	Poorly developed	Partly developed
See IEEs	Sofia has been increasingly well connected by air to most of the EU capitals (NSI). Bulgaria and, more concretely, Sofia are known for the high quality and accessible internet since the 1990s.	The Basque Country is in a privileged geographical position. Its geographical situation places it at a key point in the Atlantic corridor of the Pyrenees and as a strategic link for the transport network of southern Europe. The regional transport infrastructure is	With about 5.5 million inhabitants and a gross domestic product of 120 billion Euros, the Ruhr Valley itself is one of the most important agglomerations in the European Union. Trimodal transport routes via truck, rail, port are excellent. The	The IT infrastructure is key to the sector. SMEs that benefit from developments and products struggle due to poor IT infrastructure and the resources to improve. Physical infrastructure is less significant to the sector.	Existing infrastructure (landing strip, airbase) has played a major role for MRO-tasks. Public transport infrastructure is not very good (especially the connection with the east of North Brabant), but the region

		configured as a system that brings together railways, roads, ports and airports. According to the Digital Economy and Society Index of the Basque Country, the region stands out as a leader among the EU countries as a whole	digital infrastructural prerequisites are sufficient to conduct high-tech research in Dortmund • The Port of Duisburg is the largest inland container port in the world and the leading logistics hub in Central Europe.		is well-positioned between Antwerp and Rotterdam.
Demand					
Divided image: no local demand for digital; health is mainly local, but small in size	Only focus on international markets	Local demand and international focus	Local demand is substantial because of connecting industries	No local demand for health, COVID is changing situation	Strong local demand
• Digital: Domestic markets: Relevant only in the beginning; expansion occurs in the global market (except the OP-banking that operates in domestic markets). • Health: Domestic markets: They are the most important. In the sparsely populated northernmost part of the country, digital health and social care solutions offer possibilities to deliver services and combat huge geographical distances (maximum is 700 kilometres). However, approximately 10% of the revenue comes from the export of objects and services. Export is increasing. Health The educational level and disciplines of the personnel vary. Most of the planning and development occurs collaboratively between engineers and health care professionals. Most of them have tertiary level/university-level education, and the research staff have PhD degrees.	The companies are mainly focused on the international markets. The growing size of the sector does however push more local demand for services between companies.	The sector attracts a lot of public funding to develop the whole roadmap needed for the electric mobility future. For the launch of its products, it relies on investments by Spanish public authorities. Local demand is important.	With regard to the logistics ecosystem, demand also arises on a regional level in various ways: parcel service providers benefit from the high population density in the Ruhr region; the density of companies also offers a location advantage for trade logistics. Above that, the logistics sector emerged from heavy industry, with the delivery and supply of goods in the foreground. At the same time, logistics still plays a role in various sectors not only as an independent industry, but also as an internal corporate function. The competencies of logistics service providers are in demand, while at the same time innovative, digital solutions from the leading research institutes in the ecosystem also find their customers within the region.	Government policy has been driving developments, but there was little incentive for companies to demand products. Therefore, there has been limited impetus from organisations operating in the sector, so demand has not been high. This has resulted in a lack of entrepreneurial activity in the sector as it is not seen as financially worthwhile. However, the pandemic and political changes in response to the pandemic has significantly changed demand. The sector is dominated by a few national organisations that have responded to demand and enhanced their services. As a result, there has been a significant uptake in products, so companies have expanded their services.	Given that the aerospace market is international, the MRO sector does profit from demand at Schiphol and from Defence sector.
Finance / financing					
Mixed picture, but scale-up funding is main issue	No local support	Well-developed public and private funding system.	Unclear picture, with unclear start-up funding	No local funding support	Mixed mainly public funding system
• Digital: There are no major problems in obtaining capital for the start-up, but there is insufficient funding to scale up the activities. In many cases, the company is sold to foreign investors. • Health: There has not been any major problem in obtaining capital for the start-up ideas. In addition to funds the City of Oulu offers, there are various national and EU-level research funds are available. Safeguarding research funding is a constant process.	Sofia's financial infrastructure is not particularly relevant for the EES as most of the companies are subsidiaries of multinationals and depend on foreign direct investment (FDI).	The presence of private equity firms is now gaining prominence. Companies such as EASO Ventures and BERRI UP are two accelerators that showcase new funding sources (c.f. EASO Ventures). Additionally, access to new funding sources has been strengthened through accelerator programmes at both regional and sub-regional levels. In the regional sphere, the Basque Government maintains a line aimed at the areas of intelligent specialisation of the territory where, specifically and	Mixed results. According to one expert, start-ups have insufficient funding opportunities in the ecosystem, especially against the background of the Corona crisis. Another expert states that the willingness of larger companies and SMEs to invest in start-ups and buy innovative solutions from them should be increased. However, this statement contrasts with other expert opinions, which emphasise that enough money and funding	There is little financing in the sector for entrepreneurial activity. R&D have all been driven by universities and research institutes that have financed activities through government and research council funding. Research has also been undertaken on understanding consumer needs which, it is hoped, feeds into service/produce enhancements. SMEs lack the time, money, knowledge and skills to implement products, so demand has been low.	Aerospace is a traditional sector, depending on a lot of public funding. Without such funding, there would not have been an ecosystem (payback period for investments is long, so subsidies and credit are essential). Furthermore, it is difficult to find new financing because of the long payback times and inflexible long-term contracts and closed innovation systems (defence). There is a need for more ambitious plans to attract financing. Local funders are reluctant to fund national projects.

		through the BIND4.0 programme, it favours the attraction of innovative business ideas and their acceleration.	opportunities are also available for start-ups in the region.		
Talent					
Shortage in supply of specialists.	Abundant supply.	Abundant supply.	Shortage of skilled workers, companies need to develop themselves.	Undirected supply.	Shortage of supply.
• Digital/Health: The educational level varies. Most of the planning and development personnel are engineers with tertiary level/university-level education. Most companies outsource the manufacturing of their devices, and some use other companies in the ecosystem in their planning and development. After the collapse of Nokia phones, there was an abundance of employees. Nowadays, there are problems in finding experts in general and software designers in particular. Foreign employees are needed.	Sofia is the centre of secondary and higher education institutions (both public and private), providing specialists in STEM skills and fluency in foreign languages. The city concentrates the supply of labour because of the universities concentrated here, the ecosystem and the internal migration —a combination of digital skills and language skills. Weak point is that there is competition with the dominant ICT-EES.	In the region, the population aged 25-34 with tertiary education is 50.4% (2019, more than 25% have university studies. In relation to Vocational Education and Training (VET), 10.6% of the population aged 16 and over have higher education studies (198,337 people). Gipuzkoa (NUTS3) stands out as the territory with the highest proportion of people with vocational qualifications, with a total of 20.2% (EUSTAT, 2019). Regarding lifelong learning, at the regional level, the percentage of the population aged 25-64 participating in lifelong learning is 8.5% (2018). However, in the specific case of Gipuzkoa, 39.6% of the population aged 25 to 74 years report having participated in some learning activity - whether formal and/or non-formal- in the last 12 months. Technical skills are in good condition in the Basque Country. The regional comparison of regional indicators in Spain indicates that the region has the highest number of STEM university graduates (16.6 per 1,000 young people aged 20-29, compared to 12.8 in Spain.	The Interview results confirm a shortage of skilled workers in the regional logistics sector in medium and high levels of qualification. Companies thereby have difficulties finding the appropriate training and study graduates on the labour market and must therefore partly qualify their employees themselves for the corresponding positions.	As an emergent sector, knowledge, skills and expertise are supplied from a range of disciplines. One postgraduate programme has been designed with industry to support the development and growth of the sector.	Lack of technical personnel is considered a large risk for the further growth and development of the ecosystem. Talent seeps away to Brainport area.
(New) Knowledge					
Insufficient knowledge support	Underinvesting knowledge networks	Sufficient knowledge to support EEEs	Strong supply of knowledge	Unclear situation	Undirected knowledge networks
• Digital: The technical university (polytechnics) and the University of Oulu are important actors as a source of innovation and inspiration. The plans to expand the high-tech sector in Oulu may face problems in finding a skilled labour force for the company's purposes. • Health: Further education/life-long learning and learning by doing are	Sofia is the most innovative region in Bulgaria, but the data about R&D investments is slightly controversial ups and downs; systemic increase since 2016, but not sufficient - still less than 1% of GDP. According to the EU, Bulgaria as a whole in a modest innovator. See ICT EES.	Private R&D spending is quite low. However, investments are increasing. The local RTOs play an important role to stimulate the knowledge development required for Smart Mobility (Tecnalia, Vicomtech, Cidetec).	A central player in the research and dissemination of digital technologies is the Fraunhofer Institute for Material Flow and Logistics (IML). Broad set of universities and applied sciences partners to develop knowledge.	Digital technologies and consumer demand has driven the development of new knowledge. Digital literacy is seen as a barrier.	There is sufficient knowledge and skill available in the Netherlands (collective track record) (e.g. we are good at logistics and aerospace). This position was an important factor in attracting F-35 maintenance to the Netherlands. Some mention cooperation with knowledge institutes helps innovation, others say this is lacking. Innovation not at a high

important. However, the education system is inadequate to supply a sufficient skilled labour force to satisfy the demand of companies.					level, but this was not necessary to attract the F-35 maintenance to the Netherlands. No open innovation. SME's do innovate, but the Dutch Airforce does not.
Services by Intermediaries					
Strong intermediaries in Oulu	Systemic support system	Systemic support system	Strong institutional network of services	Underdeveloped service system, partly knowledge network support	No intermediary support available
Stakeholders and representatives of companies emphasised that Oulu is big enough to foster innovative potential but small enough to enhance mutual trust and collaboration. The strength in Oulu is that local authorities, employment offices, regional councils, educational institutions, and company representatives act closely together to analyse the situation and decide the policy measures needed.	Large business parks Association of companies in the ecosystem - AIBEST Municipal bodies supporting the EES – e.g. Sofia Invest, Innovative Sofia and so on.	Broad network of business innovation centres, support by ADEGI, ASLE and chamber of commerce. In the partnership an Industria e-mobility plan has been developed.	Intermediaries that are in the foreground in this regard, such as the Employment Agency, the Economic Development Agency and the Chamber of Industry and Commerce, are important institutions in the ecosystem, have several vital functions and play an important role with regard to the promotion of knowledge exchange between key players, the placement of workers and the definition of training and further training contents in the regional logistics sector	A few universities are serving the ecosystem, with one in the region leading the sector to supply new knowledge. However, as a relatively new ecosystem, there are few intermediaries.	Few respondents mention this as an important factor; some even claim that this is 'unimportant'. The provincial development agency (BOM) was sometimes mentioned as unimportant, but others did find the BOM an important actor.
(Social) Networks					
City networks house loosely coupled networks	Strong sector association networks	Strong sector association networks	Research partners networks, build up towards institutional partners	Consumption networks, loosely coupled	Loosely coupled networks, not integrated
• Digital: The local support received from the City of Oulu and BusinessOulu has been crucial for establishing individual enterprises and the whole ecosystem. • Health: The municipality of Oulu is very flexible and supportive of the evolvement of new innovative enterprises. The activities comply with special regulations concerning data secrets, anonymity, and the utilisation of registers and my-data.	Well established partnership, mediated by the sector association, AIBEST. Foreign dominant networks make sharing locally an issue. Focus is international, not local.	The Mobility and Logistics Cluster organises activities to support the EE. The Basque Energy Agency and other partners drive the MUBIL network. ADEGI, ASLE and the Chamber of Commerce have put down Industria e-mobility as a forum focused on electric mobility 2018. The forum is made up of 72 organisations with production or commercial presence in Gipuzkoa, which is in continuous growth. Other supporting associations are TXEKIN, INGIMOB, IBIL.	Very high degree of networking in the ecosystem. For example, research institutions work closely with each other. They are in close contact with various intermediaries such as the Chamber of Industry and Commerce, which cooperate with companies inside and outside the ecosystem.	Networks are in operation between consumers, suppliers and universities. Products have been implemented and piloted within small regional networks.	Cooperation and the existing network within the region were seen as very important—many network meetings. Parties are not open/transparent and hardly ever work together. It is very difficult for new parties to enter. In fact, there are three separate ecosystems (logistics + maintenance + new materials).
Leadership					
Local public sector driven.	Large foreign companies leadership.	Strong public sector and private sector leadership.	Knowledge parties leadership.	Public sector leadership.	Public-private initiative, but lack of leadership.
See social networks.	This ecosystem has a leadership shaped mainly by large foreign companies. Focus on development and more complex projects.	Leading companies in the Automotive EES (Irizar, CAF) are pushing the Smart Mobility agenda. The public discourse is pushed by a set of plans to develop the agenda (e.g. Integral Electric Mobility Plan 2020). Also, here, MUBIL is important as a foundation created by the main public institutions of the territory and which aims to become a reference pole for	Digitalisation is substantially driven by the cooperation between logistics companies and research institutes of Fraunhofer Institute for Material Flow and Logistics (IML), TU Dortmund University and the University of Applied Sciences Dortmund. While there is hardly a company in the logistics ecosystem that can be described as a focal firm in the	Leadership in the sector is driven by the NHS who have set out guidelines for implementing products and services across the sector.	Important was a 'joint vision' from businesses and the government. Others stressed the role of the Dutch Airforce and the province. There is not really a joint vision with joint interests. And focus on the military part of the ecosystem. There is a lack of an unified vision from businesses and BOM.

		smart and sustainable mobility in the region.	ecosystem, the Fraunhofer IML occupies a central position in Dortmund's logistics ecosystem and is seen as a hub for new innovations and digital solutions.		

Table A.5. Comparison between 6 emerging regional entrepreneurial ecosystems: Impact of digital transformations

Finland: emerging Digital and Health EEEs (Salo & Oulu)	**Bulgaria: BPO EEEs (Sofia)**	**Spain: Smart mobility EEEs (Basque Country)**	**Germany: Logistics EEEs (Dortmund)**	**United Kingdom: Digital Health EEEs (West Midlands)**	**Netherlands: Aerospace EEEs West North-Brabant**
Digital technologies are seen as the main mean to develop the EEEs. Companies are using technology as a solution.	The EEEs is driver of the digital transformation. The impact for the EEEs is managed, the societal impact is not.	The EEEs is driver of the digital transformation.	Digital technologies already play an important role in logistics. For the future, digitisation is expected to impact the ecosystem even more	Concentration within EEEs as results of digital transformation. Insufficient leadership to manage impact.	Companies are 'muddling through' digital impact. Left to their own in dealing with impacts
Digital technologies well embedded in whole ecosystem.	Digital technologies well present, and in development.	Digital technologies well embedded in whole ecosystem.	Digital technologies well embedded in whole ecosystem.	Digital technologies are seen as opportunity, but spread is low among SMEs.	Digital technologies are slowly integrating in mainly manual production (maintenance)
Very much same context as for IEEs.	Very much same context as for IEE.	With the strong pressure by the local government, the attention is to drive a comprehensive sets of digital technologies to support the change towards Smart Mobility.	Logistics is home to IoT, autonomous vehicles, which are already being used in logistics warehouses, fully automated warehouses, picking systems. Various expert interviews also show that the digitalisation of administrative processes plays a major role in many companies. There seems to be a need to catch up in some places, for example with regard to digitalised timesheets. Other digital themes, such as artificial intelligence, are therefore already being applied on a large scale in the logistics industry and also in the ecosystem in various areas. However, the technology has still not broken through to its full extent and in all its possibilities, especially with regard to automation.	Digital developments and advances in technology have driven the development of this emergent sector. Digital transformation has mainly been led by a few large organisations that also operate in international labour markets. R&D that informs developments and enhancements to products is undertaken by a few universities. Whilst the pandemic has driven digital transformations in the sector, there remains a lack of leadership at a local level to drive changes and implementation of digital technologies. In addition, digital skills, literacy, and access remain barriers to implementation.	MRO and logistics are traditional manual labour driven sectors. Both sectors are integrating digital solutions as big data and AI solutions. The uptake of these technologies is in a start phase.
Data-driven I4.0 business models well embedded in ecosystem	Ecosystem is digitally minded, but lags behind in data-driven business models	Sector is mainly in start-up phase and not driven by digital business models	Data-driven I4.0 business models well embedded in ecosystem	Data-driven business models only with lead companies.	Digital driven business models are only being considered. Sector is only in development phase.
One of the most ambitious projects of the OuluHealth ecosystem is the Future Hospital OYS 2030 programme. The main idea behind this initiative is to modernise the OYS to utilise the most advanced technologies, such as 5G/6G, IoT, Artificial Intelligence, and big data analytics applied in analysing the extraordinary Finnish health-related registers. The Future Hospital project also brings business opportunities for health technology companies that provide innovative solutions to healthcare challenges.	Very much same context as for IEE.	The resource to drive this digital transformation is competence by teachers in the VET system, to be able to bring VET students to the right level. Three main VET-schools have the task to develop and offer such training. Sector is really new and requires more development and products for new business models to arise.	Staff acquisition are also now being done digitally in many cases, and the Corona crisis has helped to exacerbate this trend. Fraunhofer IML was significantly involved in designing an IT architecture for the B2B sector. Through close cooperation between various companies and the relevant research institutes and universities, however, digital technologies diffuse more strongly in the region. According to the experts, companies are developing heterogeneously and at different speeds with regard to digitalisation. Through logistics, with	Digital developments and advances in technology have driven the development of this emergent sector. Digital transformation has mainly been led by a few large organisations that also operate in international labour markets. R&D that informs developments and enhancements to products is undertaken by a few universities. Whilst the pandemic has driven digital transformations in the sector, there remains a lack of leadership at a local level to drive changes and implementation of digital	Because companies are only experimenting with the newest technologies, business models are still very traditional.

There are about 100 high-tech enterprises involved (including those that have been discussed above. The OP-bank is indirectly involved by providing health insurance policies) in the Oulu region in developing programmes and/or health technology devices. During the last decade, the number of employees in the sector has increased by 28% and there are now over 2,000 employees.			the help of digital technologies, data has been collected, which is now used commercially in the context of corporate strategy in the form of new business models and concepts. The requirements for employees have also changed in recent years due to the influence of digitalisation. The use of digital technologies is thereby also changing the organisational structures in companies, as other forms of cooperation.	technologies. In addition, digital skills, literacy, and access remain barriers to implementation.	

Annexe 2 – Qualitative case descriptions of the entrepreneurial ecosystems in the six countries

2.1 High-Tech Entrepreneurial Ecosystem in Oulu, Finland

Main characteristics of the entrepreneurial ecosystem

This is an incumbent ecosystem with many emerging small and medium-sized high-tech enterprises established on the ruins of Nokia Phones. The Oulu case shows that the incumbent and emerging ecosystems are intertwined with each other in many ways. Nokia's inheritance offered a boost for new enterprises producing high-tech devices, ICT/digital services, and health technology. Nokia is still closely involved in the other ecosystems as well. The fate of Nokia phones and the restructuring of the ecosystems in **Oulu is a good example of Schumpeterian creative destruction**.

The high-tech ecosystem is closely related to Nokia, a big employer in Oulu in terms of research and planning and manufacturing. There are lots of new (or relatively new) high-tech enterprises in the Oulu vicinity: Polar (producing sports watches), Ouraring (intelligent rings), Haltian (internet of things), QuiteOn (noise filtering earplugs), MediaTek (internet industry), Iloq (intelligent locks), The Hospital of Future (digital health care). There is Paras Biopharmaceuticals Linked to digital medicine whose primary objective is biologics manufacturing by incorporating advanced digital technologies in creating solutions to make healthcare more affordable. The major part of digitisation in the Oulu high-tech ecosystem is based on the traditional production of electronic devices in the third industrial mode.

In addition to the core companies mentioned above, there are hundreds of smaller enterprises and Oulu University Hospital applying all possibilities of Industry 4.0. As regard stakeholders, the role of the City of Oulu, local employment office, BusinessOulu (offering business advice from testing business ideas to financial possibilities). Also, the role of the university and technical (polytechnics) university is crucial.

The socio-economic quality of the ecosystem

The Oulu technological ecosystem is a high-road case. Employment is on the rise, unemployment has risen over time but has declined in the last years. Females have not been affected differently from the developments than males. Educational levels do play a role in unemployment, with upper secondary and post-secondary non-tertiary education ('middle groups') being more represented in unemployment. However, the main growth in unemployment has been in tertiary level education, and this has affected females more than males. Poverty levels seem higher, but this is more a definition effect than a real issue in the region.

- Most of the enterprise representatives said that their enterprises do not have specific policies for including vulnerable groups. However, the common notion was that companies have a skills-first approach. If the applicant has the skills the company requires, the

workplace environment will be adapted according to the employee's specific needs. For immigrant employees and their families, there are special services available.

- As regard, the overall impact of the expansion of industry 4.0 in the Oulu region, poverty in Oulu is significantly higher than the average for the whole country. There are two explanations. First, the median income in Oulu is rather high compared with the rest of the country, therefore, the poverty threshold on which the measure is built is higher. Second, many pensioners and students fall below the poverty line due to the higher poverty threshold. Oulu is an education hub in Northern Finland, and students with low study grants comprise a significant part of the population and increase the overall poverty rate of the town.

- In Finland, monetary rewards from the digital economy have not been as big as in many other countries. One reason for that is concentrated wage negotiations. However, if we examine the developmental patterns in total median income more closely, we can see steadily increasing income curves in the 2010s in Oulu, both for males and females. This applies to those working in the high-tech sector, and in other sectors, i.e., the wage increases in the digital economy are not expanding income gaps between the technology sector and the other sectors of the economy. That said, those employed in the technological sector earn approximately €15,000 more per year than the total median income for Oulu.

- The high-tech sector has expanded rapidly in Oulu. By now the number of employees in the sector is higher than it was in the best Nokia years. Consequently, the employment rates have gone up, and unemployment diminished. Simultaneously the demand for engineers has increased. The problem is the shortage of skilled labour force needed in the 4.0 industry. The shortage forms bottlenecks and leads to outsourcing activities in countries where suitable labour is available. Up to now, there is no strong side of polarisation, at least in terms of wages/salaries (as explained above).

Strong points of the ecosystem

After the collapse of Nokia phones, the Oulu municipality, employment services and BusinessOulu were strong feeders and mentors (in Stam's terms) in the digital in establishing new enterprises and hence in the digital transformation. The Oulu University has a strong technical orientation. The government reacted rapidly and offered support for the dismissed Nokia engineers. Furthermore, the Ostrobothnia region (which Oulu is part of) is labelled by a strong entrepreneurial ethos and a high level of mutual trust. Both of these aspects are important ingredients for new innovations.

The innovative 'Oulu spirit' has resulted in the fruit collaboration between enterprises, the public sector actors (municipality of Oulu and central government agencies) and the educational system. A good example of this is the G6 research project initially financed by the Academy of Finland.

Digital transformation

The core company in this particular ecosystem still is Nokia that has adopted advanced digital devices 1) to connect their people and research/manufacturing sites in different corners of the world; 2) to develop digital innovations, and 3) use industry 4.0 based solutions in their production.

The future of smaller enterprises depends on their ability to be innovative and smart enough. The digital transformation is, therefore, mainly benefiting the region.

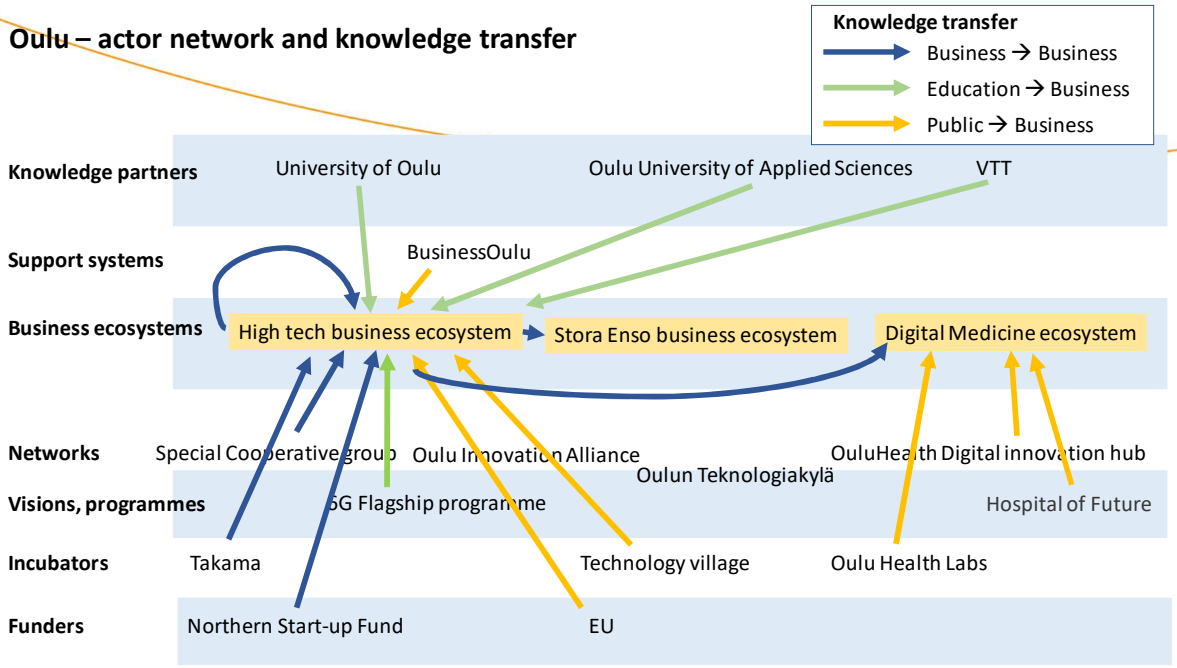
Main learnings to support the emerging / incumbent ecosystem

In the Finnish, case we compared two former 'Nokia townships', i.e., Oulu and Salo. The comparison emphasised the role of interaction between emerging enterprises, public actors and universities and technical universities. Whereas in the Oulu case, all of those elements were there, they were more or less absent in the Salo case. Salo shows many institutional 'voids'. Consequently, outcomes were highly different. For Oulu, the main 'void' would be the lack of public policy support to help the companies in attracting 'migrant talent'. A second 'void' is the lack of funding instruments for scale-ups. As a result, these companies run the risk of being sold to foreign owners, possibly transferring innovations and employment.

Pointers for policymaking

- The high-tech ecosystem of Oulu is strong in innovations, but the problem is access to skilled-labour force, which may jeopardise the competitive position of this incumbent ecosystem in the future. The future of the incumbent and emerging digital (Industry 4.0) ecosystems depends on how sufficient stock of skilled labour will be safeguarded. The attention should be on how to attract this talent.
- As regards the emerging part of the ecosystem (e.g., the Hospital of the Future or Industry 4.0 –based social services), the availability of the labour force is also the problem. Policymakers should support more immigration.
- To ensure further scale up and scale-out, the crucial question is financing. There is financing for start-up enterprises, but there are often problems finding domestic investors when the company expands. Therefore, there is a tendency that medium-size enterprises will be sold to international investors. Policymakers should fill this gap in financing.
- As regard the impacts of the COVID pandemic in Oulu, many enterprises have shut down, but on the other hand, there has never been such a boom of new enterprises as now. The funding during the pandemic seems to have worked well.

Oulu – actor network and knowledge transfer



2.2 Wood-Based Entrepreneurial Ecosystem in Oulu, Finland

Main characteristics of the entrepreneurial ecosystem

This is both an incumbent (StoraEnso) and an emerging ecosystem (the digital procurement process of forest logistics). StoraEnso is the motor that is combined with enterprises specialized in wood procurement, harvesting and logistics (as exemplified by Ponsse) and smaller enterprises taking care of the actual process of wood harvesting and logistics from the Northern Finnish forests to the StoraEnso factory in Oulu and elsewhere in Finland. The StoraEnso-bases ecosystem shows that the incumbent and emerging ecosystems are intertwined with each other in many ways. The Oulu paper mill clearly is an established part of the traditional wood-based industrial backbone of Oulu. However, the procurement process is a part of emerging industrial 4.0 economic activity. In the 1950s, some 200,000 small-holders and forest workers felling logs and transported them to the roadsides. Then some self-employed lorry drivers took the wood to the factory. All work processes were manual, and only simple mechanical tools (as cranes) were used. Now the whole procurement process is more or less digitalised, from buying the wood from forest owners to harvesting and transporting logs to StoraEnso. Nowadays, there are some 2,000 persons included in the whole digital procurement chain:

- The forest owned by private persons supplies about 80 per cent of the wood industry needs. Thus, selling forests in Finland and selling forests in the Northern and Eastern parts of the country, in particular, is an important source of income. The wood must be harvested and transported to the factory – in this specific case, to StoraEnso factory in Oulu.
- Harvesting demands special equipment, and most of the harvesters have advanced digitalised programs that can control the whole work process: timber species and dimensions, logistics, reporting, map applications, efficiency and time tracking etc. Thus, the forest-based business ecosystem bifurcates into mechanical engineering (planning and producing various kinds of forest machines, tractors and trucks) and into developing digital systems for controlling the whole wood harvesting process from the forest to the factory.
- The logistic side consists of getting wood to the factory, which private truck enterprises take care of. On the end side of the wood processing, the product must be transported from Oulu to its destination all over the world. To do that, StoraEnso is involved in port operations - stevedoring, forwarding and ship clearance. The Port of Oulu is the largest port in Northern Finland. Furthermore, logistics on rail and roads are important in particular in the domestic delivery of products.

The ecosystem is based on the wood (and previously exclusively on paper) industry. The wood procurement chain is highly digitalised in an Industry 4.0 manner. When the timber trade is digitally made between StoraEnso and the forest owner, StoraEnso's planning system informs the wood harvesting entrepreneur where the forest sold is situated. The harvester gets information on the quality and amount of the stock in the forest, and receives maps and details of the terrain. In Finland, there is one single digital system (Wood Force) that StoraEnso and all other companies use. Also, all the harvesters use the same system. Previously, each company and operator had its own system. The communication processes have been standardised, which enables easier digital

conversation between different actors. Furthermore, the development of harvesting machines (e.g., Ponsse) rapidly goes towards Industry 4.0.

In this ecosystem, the core company in the Oulu region is StoraEnso. There are some 50 harvesting companies (usually small-size companies or self-employed owing the harvesters) and some 50 enterprises taking care of the transportation of the wood to the factory either in Oulu or in some other factories in Finland. Due to integrated information systems, different companies share their information, and if there, e.g., is a need for large logs in the UP-Kymmene factory in the Southern part of Finland, StoraEnso Oulu can provide the stuff needed. On the other hand, if StoraEnso Oulu would need thinner wood that is not available in Ostrobothnia, UP-Kymmene could provide the needed stuff to the Oulu factory.

The socio-economic quality of the ecosystem

This ecosystem is a combination of low-road and high-road approaches. Those planning the information systems in StoraEnso have excellent possibilities for further education and skills development, whereas the manual workers on the floor do not necessarily have the same possibilities. Logistics and harvesting are the intermediary cases. Previously, the clearly were low-road cases, but there is a need for transformation because of digitalisation.

- As stated above, historically, the development of the digitalized wood procurement process employed some 200,000 persons, whereas the present number of people involved in the procurement process is one-tenth of that. Due to the strong union, wages in wood processing have been relatively high and employment secure. However, times have changed and, e.g., in 2021, StoraEnso decided to close down its factory in Kemi (150 km to the north from Oulu). The digitalisation has increased wage dispersion within StoraEnso. It is difficult to evaluate the consequences of the transportation and harvesting side. There is much self-employment. However, the 2,000 employees, self-employed involved in logistics and harvesting, certainly do better than the 200,000 small-holders and lumberers did in the 1960s.

- Inclusiveness is affected by these developments. There are no specific inclusive policies for including people with disabilities. In the wood processing sector, there is a need for a labour force, and therefore, the ecosystem must try to get foreign labour, mainly from Estonia and Russia.

Strong points of the ecosystem

- Worldwide, StoraEnso is one of the biggest companies that process pulp, paper and other forest products. StoraEnso's headquarter is in Helsinki, Finland. The company is a global actor. The majority of sales occur in Europe, but there are also significant operations in all continents. The production has expanded from pulp, paper, packaging and wood to wider utilisation of renewable materials such as formed fibre (plastic-free, made of renewable materials, recyclable and biodegradable), intelligent packaging solutions, bio-based chemicals, paperboard materials, products and solutions for the sustainable construction of houses, granulates, i.e., wood-fibre bio-composite etc. Thus, the wood-based incumbent ecosystems are expanding to new production forms, enhancing sustainable growth . Which undeniably is a strong competitive factor in the green future.

- The driving forces of the ecosystem, the mechanism/elements (Stam model) that explain the present situation, and the economic competitiveness:
    - Domestic markets are not that important; **global markets** and large companies are the most important customers.
    - The main part of the workforce's educational level is **secondary level or lower tertiary level**. Planning and developmental staff have polytechnic or university level education. No possibilities for outsources except the wood harvesting process and logistic services.
    - The whole value chain **complies** with national regulations and tax policies.
    - **Communication facilities** are good, and as said above, there is seamless communication systems and programmes.

Digital transformation

- All actors in the ecosystem apply the same information system and share data and information. All change of essential information is digital. As regards the harvesting technology, there **is a strong move towards Industry 4.0**. All actors in the ecosystem apply the same information system and share data and information. All change of essential information is digital. There is a rapid move towards Industry 4.0 type activity regarding the harvesting technology. A telling example is a development in harvesting machines (e.g., Ponsse). The programme used in the harvesting machines generates detailed harvesting instructions for forest machine operators. The wood harvesting forwarders are seamlessly connected to the whole wood procurement management process enabling monitoring of how the procurement process proceeds. There are technical developments towards more or less digitalised harvesting. In the Industry 4.0 mode of harvesting, the digital leap, the forestry machinery is like a computer on wheels that sends information of the characteristics of wood, quality and quantity to the information system. The producers of harvesting machines are already preparing machine vision and cameras integrated into a computer that suggests how the harvesting should proceed (taking the terrain and the wood stuff into consideration) and automatically steering the harvesting.

Main learnings to support the emerging / incumbent ecosystem

- One of the crucial factors is the shared information system from the trade of the wood to the Factory and from the factory to the client. In addition, the shift from the paper and pulp industry towards new forms of products that are in line with sustainable, green growth.
- The common information systems is a clear strength, too.
- To ensure further scale up and scale out (if emerging ecosystem), the harvesting technology's digital development is a great strength.

Pointers for policymaking

- Policymakers should support the shift from the paper and pulp industry towards new forms of products that are in line with sustainable, green growth.
- Challenges are linked to the access of the labour force. Policymakers should focus on solving this issue with the ecosystem. This is much in line with the Oulu high-tech ecosystem.

2.3 Digital Medicine ecosystem in Oulu / Finland, Emerging Entrepreneurial Ecosystem

Main characteristics of the entrepreneurial ecosystem

This is an emergent ecosystem based on joint efforts of the Faculty of Medicine, the University Hospital and the electricity/electronic producers (research and development) in the Oulu vicinity.

- Oulu University Hospital (OYS) is a research and development-oriented provider of the highest quality healthcare. The special responsibility area of Oulu University Hospital covers the whole of Northern Finland – accounting for more than half of Finland's geographical area and 750,000 people.
- The ecosystem is based on regional collaborative development and an electrical platform for that. These have been in use internally in Oulu University Hospital, in the areas in Northern Ostrobothnia. The aim is for different actors to develop both technological and non-technological services. Various health laboratories test digital services and collaborate with companies that have solutions for welfare and health technologies, information processing and artificial intelligence, and how they can be used in diagnostic and other health care purposes.
- When Nokia collapsed in 2011, the Oulu Centre for Health and Technology (CHT) was established and linked to the university. The CHT hired a group of Nokia engineers to be part of the health technology team. The CHT coordinates research, development, and innovation activities in the multi-stakeholder OuluHealth ecosystem.
- There is a strong collaboration between academic researchers at the university/university hospital, private companies, and healthcare professionals.
- By now, in the Oulu area, there are more than 100 enterprises in the health care technology services, employing almost 600 persons. In the whole health and welfare technology sector, 540 firms are employing 3,500 people.
- The exports of the Oulu-based health industry have been growing steadily for ten years; it is around 10% of turnover. There are new start-ups, research, innovations and development. In the Oulu area, the Printed Electronics by VTT have had a long tradition, developing at-home measurement and diagnostics. Also, devices produced by enterprises such as Polar and Ouraring collect my-data that can be used for health care and diagnostic purposes. A technical environment has been created, and from a production point of view, it is a major change in the area.

The socio-economic quality of the ecosystem

- This is a high-road approach. Those planning the digital-based health care systems are highly skilled and have excellent possibilities for further education and skills development. There is a mixture of technical experts, specialists in medicine, and health care and nursing.

- University Hospital, the university (schooling medical doctors and PhDs in engineering), university of applied sciences (education nurses and engineers) work closely together in an "Innovation Alliance" with the State's Technological Research Center (VTT).
- The region experiences a highly knowledge-based, constant demands and life-long learning, and a combination of versatile skills: there must be technical expertise combined, with social and innovative skills. This situation is typical in the healthcare sector, even with nurses. Therefore, the increase in technological training would be significant in the whole field.
- As a rule, it is seen that digitalisation is not threatening jobs in any way. On the contrary, solutions will make job tasks easier and physically less demand in.
- The practical work is location-specific and not easily transferrable to countries such as India. Various laws and requirements need to be followed in the health and technology field. It is not possible to outsource most processes outside the European Union. The development in the health care sector is strictly regulated. This is a challenge for the companies. They need to know the national legislation and the European laws. Therefore, one central issue in future development is related to the legal aspects. Legislation is too slowly following the development in digital health care, and the utilisation of my-data collected, e.g. via Ouraring or Polar sport/activity watches.
- There is a need for a lot of additional education, moving from nursing to ICT.
- Wages in the digi-medicine are rather high (due to lack of skilled personnel). In particular, medical doctors and engineers have high salaries, whereas nursing personnel have much lower salaries.
- The developers of the ecosystem see endless possibilities in the development of digital-based and remote medicine/health care. In a country with long distances, this a must to offer social and health care services to all municipalities. (e.g. the distance from the northernmost municipality to the Oulu University Hospital is 700 km.). Thus, the development in digital health also guarantees access to services for people living in remote rural areas.
- One problem in the Oulu digital health hub is that no manufacturers produce bigger equipment (e.g. robots taking care of logistics) for hospitals. The local supply of smaller technological solutions and IoT services is sufficient.
- There are no specific inclusive policies for including people with disabilities, whereas there are many different educational pathways tailored for immigrants to be involved.

Strong points of the ecosystem

- The driving forces of the ecosystem, the mechanism/elements (Stam model) that explain the present situation: Domestic markets in general and local demand, in particular, are important. Global markets are available for developed digital products.
- A strong point of the ecosystem is the conglomeration of the private business (the very strong Nokia-based technological inheritance), BusinessOulu, Technological Research

Centre (VTT), municipality of Oulu and the scientific research on technology and health care/medicine.

- The educational level of the main part of the workforce is lower or higher tertiary level. Planning and developmental staff have polytechnic or university level education.
- There are not many possibilities for outsourcing to other countries (e.g. in the case of Nokia). This is because the whole value chain complies with national regulations and tax policies.
- Factors that explain its competitiveness/added value: see the bullet point before the previous one.
- There is a strong commitment of the Oulu municipality and other local actors and public authorities.

Digital transformation

- This ecosystem is based on the possibilities of digitalisation (and IT technology). That makes this ecosystem a good example of Industry 4.0
- The digital transformation in Oulu has produced a high number of small (less than 100 employees) or medium size (100 to 250 employees) high tech companies with special knowledge in producing IoT and advanced technologies, that can be used in digital medicine. Correspondingly, education of health care personnel and medical research in the University and University Hospital are geared towards possibilities to apply ICT In health care. This applies to services in Oulu but much more to possibilities to organise remote services to remote rural areas in the sparsely populated Northern part of the country where distances are huge.
- Former Nokia engineers were retrained to become experts in health technology and logistical arrangements in the social and health care sector.

Main learnings to support the emerging / incumbent ecosystem

- One central learning is the quick responses of various actors (health care, employment services, educational system, BusinessOulu) to the Nokia crash. The engineers fired from Nokia had special high-tech knowledge and skills. Many of them were re-schooled to expand their healthcare sector skills. Simultaneously, the education of health care personnel was trained to use digital solutions. Cooperation and collaboration were successfully executed.

Pointers for policymaking

- Digital health care opens up new possibilities to meet people. Instead of walls, floors and ceilings, the Hospital of the Future is much more based on profiling, pre-diagnosing, sharing my-data collected by various devices (e.g. in Oulu Ouraring and Polar). This sector also allows access to people who have a longer distance to traditional health care. For policymakers, it is required to learn from such experiences: making the most of the qualities of the region.
- Challenges are linked to the access of a skilled labour force. This aligns with the other ecosystems in Finland.

- There is a need to expand the health ecosystem to include research and development in medicine and manufacturing equipment (e.g. robots).
- Furthermore, the collaboration between different productive ecosystems offers promising avenues. For example, collaborating between health, health technology, biotechnology combined with the forest industries would bring great benefits, e.g. in producing nano-based cellulose materials where they grow cells. In addition, artificial blood vessels and intestines made of cellulose are the future of health technology. R&D and investments need to be aligned to such crossovers.

2.4 Valmet Automotive: emerging ecosystem paves way for a new manufacturing branch in Salo / Finland, emerging ecosystem

Salo has a long history in electronics. Already in 1974, Salo-based Salora launched its first portable wireless phone. In 1982, the Nokia Corporation bought Salora, and five years later, the first Nokia mobile phone was ready. The expansion was incredibly fast. Nokia had approximately 5,000 employees in Salo (and about 2,000 subcontractors) at its peak. Nokia designed, tested, and manufactured its phones. In Salo, the emphasis was on manufacturing the phones, whereas research and product development took place in Oulu, Tampere, and Espoo. Gradually Nokia reduced its electronic subcontracting of components, plastic parts, and support activities in Salo. In 2014 Nokia decided to sell Nokia Phones to Microsoft, and a year later, Microsoft permanently closed down the Salo unit.

Main characteristics of the entrepreneurial ecosystem

- While Oulu, after the collapse of Nokia Phones, witnessed a surge of new medium-sized (50 to 150 employees) high-tech enterprises, such a phenomenon was mainly absent in Salo. New high-tech enterprises were relatively small (10 to 30 employees), mainly producing and planning software solutions. Persuading big foreign or domestic enterprises to start their activities in Salo failed. Some of them worked for a while in Salo, but they missed a feasible business concept. Instead, Salo invested in the existing ecosystem and existing enterprises. Salo has a rather strong industrial basis on traditional manufacturing.

- The new manufacturing ecosystem began to emerge when ValmetAutomotive decided to start a new production line of batteries for electric cars in Salo. Valmet Automotive (VA) was founded in 1968. Since then, about 2 million vehicles (for example: Saab, Mercedes-Benz and Porsche) have been produced in Uusikaupunki (130 km North-West from Salo). Recently, ValmetAutomotive has focused on electric mobility. The new battery factory manufactures hundreds of thousands of 48-volt batteries every year.

- VA battery plant is a locomotive for a new, rapidly growing business ecosystem. VA has 500 employees in Salo, and VA is looking for hundreds of new employees. VA is located in the previous Nokia premises. Hence, Salo became a part of the ecosystem of traffic electrification. In Uusikaupunki and Vaasa, they have minerals as well as the mining industry. In Uusikaupunki, they produce cars, and Salo manufactures batteries.

- Thus, the traditional manufacturing industry in Salo is expanding and forming a new business ecosystem focusing on electronic traffic systems. The ecosystem is highly international. In addition to Finland, Valmet Automotive has production lines in Germany, Spain, and Poland.

  Many of the smaller enterprises (including some of the IoT/digital companies established by the former Nokia engineers) in Salo are sub-contractors to VA. It is expected that the VA-based manufacturing will be a new Nokia for Salo.

The socio-economic quality of the ecosystem

- This is a mixture of high-road and low-road approaches. Those employees developing electric systems are highly-skilled and have excellent possibilities for further education and

skills development with decent salaries. However, the situation is different for the production line workers. As employees at the Nokia Phones assembly line, VA assembly line workers do not need to be highly skilled or to have higher educational attainments.

- Globally, VA has 4,500 employees and over 70 nationalities located in 3 countries (Finland, Germany and Poland). The majority of our employees are in Finland, and most of them work in the manufacturing of cars and batteries. Typically to the industry, around 75 % of the group's employees are men, and almost 60 % of the personnel is 20–39 years old.
- VA declares that there are possibilities for further education. For example, the Salo vocational school is preparing modules the employees possibly need to complement their know-how and skills (the same procedure was applied to Nokia employees.). The vocational school has special training courses for immigrants and people with disabilities.
- The Turku Technical University will open a study line to support work in Salo. The Salo University of Applied Sciences is in the former NokiaCampus where the VA production line is. It can be expected that research and development of innovations will be combined with production as they do in Oulu as well.
- A possible problem and worry is the automotive industry's volatile market. It is not clear what the driving force of motors will be and how sustainable the electrification of the car industry will be. Furthermore, Salo's problem with the VA may be the same as Nokia Phones. The big oak casts its shadow over smaller trees and prevents them from growing.

Strong points of the ecosystem

- A strong point in the emerging VA.based ecosystem is that it is future-oriented, and there seems to be a growing demand for car batteries and vehicle equipment.
- Domestic markets and domestic demand are not that important, whereas most of the manufactured products are sold globally. Thus, the expansion is highly dependent on global markets.
- There is a whole value chain in Finland that fortifies the overall success of the ecosystem. For example, there are raw materials (minerals), production of cars (in Uusikaupunki) and production of batteries (in Salo).
- The ecosystem will be much stronger if the production is successfully combined with research and development (Turku university and Salo university of applied sciences).
- There is a strong commitment of the Salo municipality and other local actors and public authorities.

Digital transformation

- Digitalisation (and IT technology) is at the core of this ecosystem, it is a good example of Industry 4.0.
- The ecosystem is future-oriented in producing electric vehicles and promoting green growth. Manufacturing is very much based on robotics and digital processes steering manufacturing processes.

- The emerging Salo ecosystem is a good example of 'path dependency' in ecosystems. Whereas Oulu (with a stronger tradition of research and high-tech production and skills and knowledge) developed a highly digitalised ecosystem, the transformation of the Salo ecosystem was based on manufacturing where digitalisation plays its role, but nevertheless is more based on manufacturing things and devices.

- There are good possibilities that the small-scale digital/IoT firms in Salo will be incorporated as sub-contractors to serve VA, and thus also, that the sector will grow and expand. There will be a strong 4.0 manufacturing ecosystem in Salo if this happens.

Main learnings to support the emerging / incumbent ecosystem

- One central learning in the emergence of this manufacturing ecosystem is the close collaboration of stakeholders (employment services, Salo municipality, BusinessSalo) to get the VA to Salo. The process did not start from scratch. There was a strong tradition of manufacturing machines and a tradition of the metal industry in Salo. During the Nokia period, that economic ecosystem did not expand as it most probably had done without Nokia. Furthermore, the previous Nokia Campus offered localities to start production in the new business.
- There seems to be a kind of path dependency that the economic ecosystems follow: (advanced) manufacturing in Salo and High-tech and ICT in Oulu.

Pointers for policymaking

- Local authorities and other stakeholders (motive) need to be involved in creating a new ecosystem. There must be sufficient localities available to start the production (possibility).
- Salo is well-connected via railway and highway to Turku and Helsinki (airports and harbours).
- It is good to be connected with a bigger value chain, in this particular case, the value chain (or ecosystem) is the electric car production.
- Challenges are linked to the access of the labour force (skilled and semi-skilled). See previous ecosystems.
- There is a need to expand the Salo ecosystem to include research and development.

2.5 Machine-tool Entrepreneurial Ecosystem in the Basque Country, Spain

Main characteristics of the entrepreneurial ecosystem

- The machine tool sector is a mature economic activity in the regional ecosystem that has been defined as **resilient**, especially at the territorial level (Valdaliso, 2020). Although the manufacturing sector has its roots back to the end of the 19th century, it is from the 1960s onwards that a domestic market and foreign trade began to grow. Since then, the sector has been at the **technological forefront**, first importing technology and later developing it, characterising the activity as highly specialised.
- The machine tool sector is important for the region, mainly because of its relevance in international markets. This industrial tradition is currently supported by the regional smart specialisation strategy, in which Industry 4.0 plays a major role. Furthermore, given the relevance of the application of machine tools in key sectors such as energy, aeronautics, and automotive, Industry 4.0 key technologies play a key role in the digitalisation process of the sector.
- The regional ecosystem is made up of a set of leading international companies. The sector is the third-largest machine tool producer in the world behind countries such as Germany and Italy, with exports exceeding 75%. The **sector consists mainly of SMEs,** which are highly flexible and specialise. In addition to business leadership, the ecosystem has a cutting-edge network of technology centres, assisted by a network of universities and vocational training centres that place it at the forefront of the sector. One example is the cluster of machine tool manufacturers (state-wide) established in the region (AFM). Another example, which emerged from the cluster, is IMH, the Machine Tool Institute, a pioneer in training and education.

The socio-economic quality of the ecosystem

- The **ecosystem can be characterised as high-road**. The ability of the machine tool sector to successfully adapt to different transformations over the decades is directly related to aspects such as "business size, flexibility and productive specialisation; absorptive and innovative capacity; and geographical concentration in a regional ecosystem highly favourable to skilled human capital formation, innovation and cooperation" (Valdaliso, 2020).

- The Spanish machine tool sector has been concentrated in the Basque Country region. Geographical proximity and clustering have facilitated learning and knowledge, improving firms' absorptive capacity and company collaboration. In this framework, it can be argued that the region has developed a productive system very favourable to innovation and human capital. From the 1970s onwards, the number of firms tends to decline. The sector has received institutional support that has allowed its reorganisation and internationalisation, in particular with the demand crisis at the end of the 20th century. Overall, **employment in the machine tool sector has remained stable**. Also, **during COVID-19**, despite the fact that sales in the sector declined significantly. In absolute terms, the final turnover for the sector in 2020 was lower than in 2019. In the context of digital transformation, the machine tool

cluster is working on a strategy for the reactivation and transformation into an Advanced Manufacturing and Machine Tool sector, which includes measures to support activity and employment-focused on digitalisation and sustainability.

- The Basque Country has developed a regional policy that has strengthened its industrial base by supporting industry-based skills (OECD, 2013). According to OECD data (2020), between 2000 and 2017, the region's labour market has become polarised: low and high-skilled jobs are growing, while medium-skilled jobs are decreasing. However, compared to other regions in Spain, **polarisation has been more moderate**. The effects of automation are determined by the pace at which technology is introduced, how workers adapt and the many differences in work organisation between countries and regions. The region has a higher proportion of jobs at high risk of automation than the OECD average (22.2% compared to 14% of OECD countries), which can generate inequalities (OECD, 2020). According to the Employment Agency of the Basque Country, **employment opportunities are likely to grow** in the period 2020 and 2030. First, there is the prospect of further economic development (expansion demand) and second by the need for replacement of personnel due to the retirement of people currently working in the Basque labour market (replacement demand). The estimate is that the manufacturing industry requires an increase of personnel by 4% (from 197,385 to 206,670 jobs). In terms of net job openings by occupation in manufacturing, fixed plant and machinery operators will decline by 7% (from 38,065 to 35,189).

Strong points of the ecosystem

- **Entrepreneurial leadership in conjunction with knowledge, intermediary structures, networks and talent** have positioned the ecosystem at the forefront. In addition, key aspects such as demand, infrastructure, talent and financing have played an important role in the survival of the sector.
- The determining factors of the machine-tool ecosystem in the Basque Country are related to **production flexibility** and its **specialised nature**, competing in a niche market of international dimension. The added value is thus translated into a competitive offer. The formation of human capital, supported by the training and research system and the innovation dimension, creates a favourable ecosystem that has proven to be sustainable over several decades and transformation processes.

Digital transformation

- Digital technologies are transforming traditional industrial production models. Industry 4.0 means that machines, lines and systems, and factories are connected. In particular, sensorisation, data collection and interpretation, process improvement, and the provision of new services are emerging as new ways of generating value.

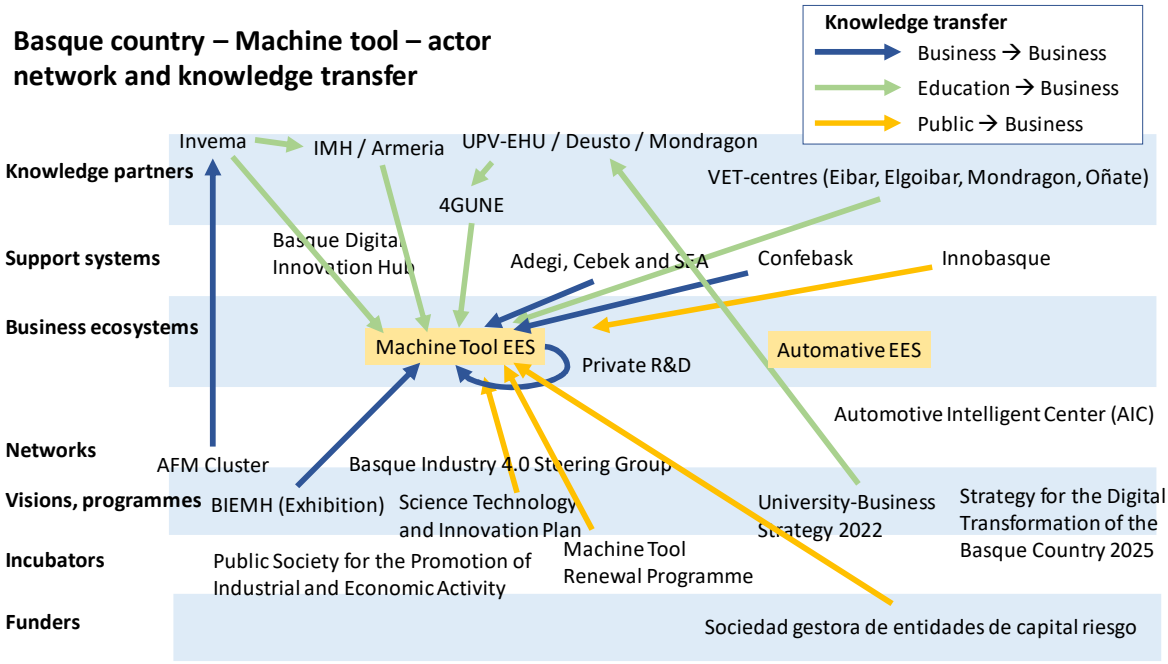
- Digitalisation in traditional sectors, such as Machine Tool, faces some problems, inherent risks and disadvantages linked to issues such as data-sharing and cyber-security.

Main learnings

- A key determinant of the sustained success of the machine tool industry is directly related to the **ability it has shown to cope with change**. In the configuration of the ecosystem, which

has a high concentration and geographical proximity, a network of knowledge has been formed that has allowed learning to take place. This capacity for absorption has allowed the research and training centres (university and vocational training) to respond to highly valued and competitive products in international markets, i.e. niches with a very specific range of products.

- The Machine Tool ecosystems enjoy major support from public and private agencies, education and knowledge providers and business support. The support network is dense and future driven. There seem to be no 'institutional voids' in this system, unless it may be that private investment to generate growth may lag public investments. The question is if the major (public) support may be at the expense of other sectors.
- Companies need to keep focusing on flexible production and specialised products in international niche markets to maintain a competitive position.



Pointers for policymaking

- For the future, among other things, it is critical to have highly qualified personnel available to deal with any problems that may arise during the digitisation process. In this scenario, coalition building with triple helix actor becomes relevant.
- The machine tool sector remains highly exposed to external shocks (especially related to investment levels due to their high dependence on strategic sectors). Therefore, the survival of the sector requires an industrial policy approach. The main topic would be how to stimulate more private investments.

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2.6 Smart Mobility Entrepreneurial Ecosystem; Basque Country, Spain

Main characteristics of the entrepreneurial ecosystem

- "Smart mobility" is an **emerging entrepreneurial ecosystem** in the Basque Country. The term refers to the application of new technologies in traditional sectors, which can lead to the emergence of new products and services related to transport and mobility. However, the concept of "Smart Mobility" in a broad sense covers different industrial sectors and activities. "Smart mobility" is at the core of the so-called Industry 4.0. Mobility is one of the most disruptive segments currently immersed in a technological, energetic, and social transition. **The ecosystem emerges due to the identification of a market in full development in which the automotive, energy and Electronics, Information and Communication Technologies (EICT) sectors converge**. This case highlights the cross-cutting and enabling nature of EICT in Industry 4.0. At the regional level, the Basque Smart Specialisation Strategy includes Advance Manufacturing and Energy as strategic priorities, focusing R&D efforts on the different phases of the value chain.

- The positioning of **local companies** has many faces as it addresses different activities ranging from the automotive industry, transport, logistics and intelligent transport systems. As a point of reference, the presence of large local companies operating in international markets, dedicated to the manufacture of buses and trains stands out. Currently, the ecosystem has a production capacity of about 4,500 electric vehicles per year and 14,000 products related to electromobility between companies such as Mondragon Corporation, Irizar Group and CAF. In addition, there are other agents in the energy sector (electricity, oil and gas). The ecosystem has a robust network of research centres and strong public institutional support in conjunction with business actors.

The socio-economic quality of the ecosystem

- According to the OECD, inclusive growth is economic growth that is equally distributed in society and creates opportunities. One of the characteristics of the electric mobility ecosystem in Gipuzkoa lies in the **Reference Centre called MUBIL**. This Centre for Intelligent and Sustainable Mobility brings together two transformation processes shared by administrations and companies: technological-digital and energy. MUBIL was created within the framework of the "Building The Future" collaborative and open governance programme, promoted by the Provincial Council of Gipuzkoa. The aim is to identify the challenges of the territory in order to plan and carry out projects for the future. One of the pillars is to reinforce the smart specialisation of the territory, with new mobility being one of the main lines of action. Smart mobility is included as a "strategic project for economic recovery and transformation" in the Basque regional government's "Recovery and Resilience Programme" (2021-2016)".
- The ecosystem has a strategy for employability and inclusive activation for the period 2018-2022 (Elkar Ekin Lanean), which aims to promote the development of an integrated strategy for; economic reactivation and competitiveness; quality employment; and social policies to improve the social cohesion of groups (such as people in a situation or at risk of exclusion;

unemployed people with a medium-low degree of employability; and people in precarious employment).

- Within the framework of the energy revolution, the automation of automobile production is causing a significant drop in employment in the industrial sector. However, the new mobility, electric and sustainable, has sufficient potential for the creation of new direct jobs in sectors related to new technologies. This leads to a scenario where competencies become highly relevant. In particular, the creation of new occupations will require the adaptation of the labour force to new occupations. Considering the industrial concentration and diversity of the Basque Country, the region has developed a policy that has reinforced industry-based skills, innovation and cluster development (OECD, 2013). The region has evolved from the traditional vision of industrial innovation policies towards a more systemic vision involving other departments such as education. However, between 2000 and 2017, the region's labour market has become polarised (OECD, 2020): low-skilled and high-skilled jobs are growing, while medium-skilled jobs are declining. During this period, medium-skilled jobs have decreased by more than six percentage points, while low-skilled and high-skilled jobs have grown by 1.6 and 4.8 percentage points, respectively. In relation to employment, the smart mobility sector brings together different activities such as the manufacturing industry (transport materials; machinery and mechanical equipment; electrical material and equipment transport and warehousing; ITC and energy provision. The diversity of activities encompassing this emerging ecosystem makes it difficult to have a clear picture. However, job opportunities and net employment projections for the period 2020-2030 can be obtained independently. The table below shows data projections generated by the Basque Government Employment Agency.

Sector		2020	2030	Variation	%	Replacement	Net
Industry	Machinery and equipments	23.191	24.661	1.470	6%	11.374	12.844
	Transport Material	19.631	18.483	-1.148	-5%	9.135	7.987
	Electric equipments	8.404	7.153	-1.251	-14%	3.266	2.015
Transport and Storage	Transport and storage	46.859	55.857	8.998	19%	19.882	28.880
ITC	Telecomnunication	2.072	1.542	-530	-25%	716	186
Energy	Electric energy, gas & steam	2.770	3.597	827	29%	1.031	1.858

Source: FutureLan, Basque Employment Agency.

Strong points of the ecosystem

- The driving forces of the ecosystem are mainly public and business leadership in direct conjunction with support services (intermediaries), leading to the creation of new knowledge. The territorial commitment aims at the creation of productive entrepreneurship.
- The local strategy, which involves a variety of actors, revolves around three axes: specialisation, excellence and collaboration. The first seeks to orient the mobility, transport, and automotive industries towards electric, connected, shared, and autonomous mobility. The excellence axis aims to turn the local industry into an international benchmark in intelligent and sustainable mobility. Finally, the collaboration axis aims to generate new

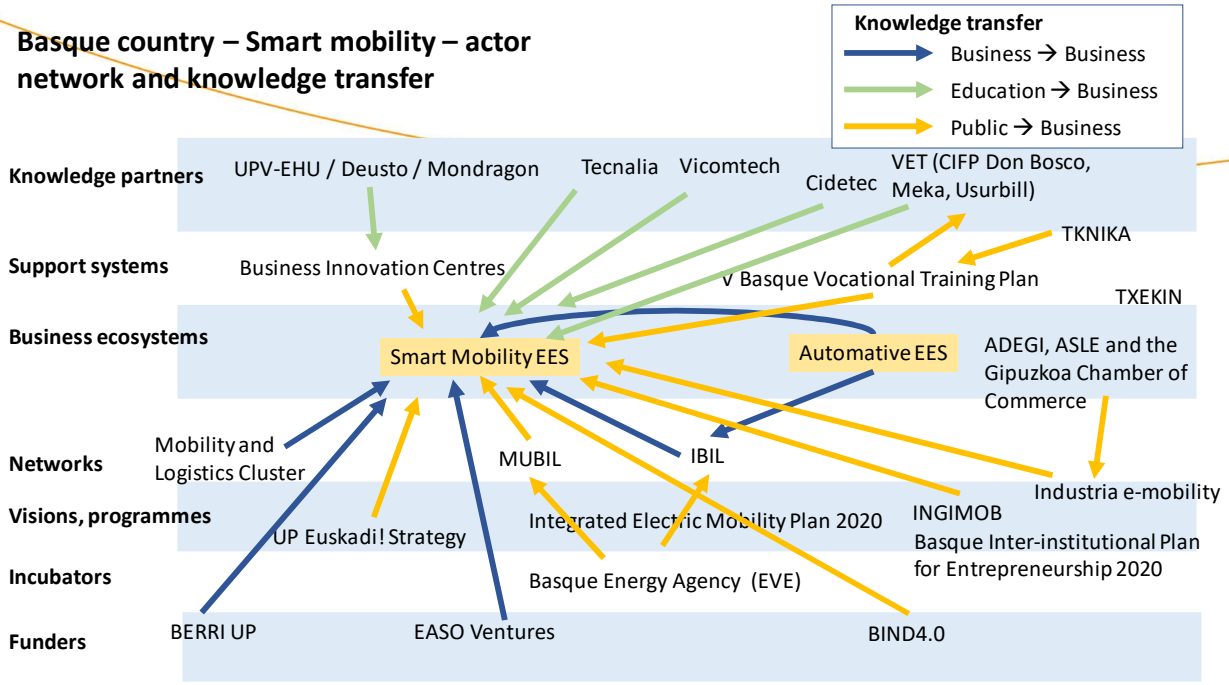
opportunities, transform and strengthen the industry ecosystem. The local strategy is clear in the ecosystem and drives the activities.

Digital transformation

- The development and application of information technologies are contributing to the generation of an **unknown amount of data**. New trends driven by digital technologies make it possible to generate a multitude of new services based on connectivity between people, vehicles and infrastructures. To carry out this interaction, it is necessary to develop technologies that companies in the sector must incorporate, such as smart sensors for data collection, 5G connectivity, data collection and analysis in the cloud through AI and cybersecurity to ensure protection.
- The alignment of policies for the creation of new value and inclusive growth of the ecosystem are aligned with other regional policies; this is how the entrepreneurship ecosystem takes advantage of the digitalisation process. Specifically, within the Smart Specialisation Strategy, which prioritises smart mobility, the set of core technologies transversally linked to the areas of specialisation are identified, such as AI, big data, 5G, IoT, cybersecurity and cyber-physical systems.

Main learnings

- The institutional capacity to link local action with regional policies is an element of success. Public support for the transformation of high contributing sectors (in economic and employment terms) and the promotion of sectoral diversification is a driving force in a process in which enterprises simultaneously undertake the adoption and adaptation of new technologies. The adoption of territorial strategies also contributes to the potential attraction of structural funds and the possibility of higher public and private investment levels.
- Strong institutional leadership and public-private collaboration in areas related to smart specialisation and market niches help direct efforts in a region.



Pointers for policymaking

- To help existing ecosystems survive future demise, regional authorities have already focused on supporting sectoral diversification. Understanding how digital technologies fit in this picture is important to find the right levers for change. The attention should be on how this diversification benefits not only the strong concerns, but also new initiatives.
- Supporting change requires adapting professional profiles (occupations) towards emerging activities. This requires initiatives in the broader ecosystem with the educational and company system to better align schooling and training.

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2.7 The Steel Incumbent Entrepreneurial Ecosystem in Duisburg, Germany

Main characteristics of the incumbent entrepreneurial ecosystem

The steel ecosystem of the administrative district of Düsseldorf (NUTS2 region DEA1) was chosen as the incumbent ecosystem. The city of Duisburg is thereby of primary importance, as the city can be considered the most important steel location in the Federal Republic of Germany. Mainly due to the influence of coal and the favourable location at the Rhine, the city of Duisburg has developed over the decades into one of the largest steel regions in Europe, and the Ruhr region has established itself strongly in the metal industry. After all, coal is the essential energy source for steel production, and thus, numerous steelworks were built in the ecosystem and throughout the Ruhr region thanks to the region's rich coal deposits. In this context, the city of Duisburg has played a particularly important role, as it is located directly on the Rhine and thus on Europe's largest waterway, where to this day, bulk goods such as ore are transported. The Ruhr valley itself, which today is one of the most densely populated, largest conurbations in Europe, ultimately grew around the industry. Accordingly, efforts to develop the transport infrastructure in a rail and road network connecting the various locations preceded population increase and urbanisation.

The city of Duisburg generally occupies a special position in the analysis of the ecosystem because several steel producers and processing companies are still located here today, including the anchor company. However, the capital of Rhine-Ruhr and eponym for the administrative district of Düsseldorf also plays an important role in the ecosystem, as numerous important institutions, such as associations and research institutes – with the latter being particularly important with regard to digital solutions – have their headquarters here.

The socio-economic quality of the ecosystem

Even though the steel ecosystem has a high demand for skilled workers and partly struggles to find suitable applicants in the region, the demand for unskilled labour in the steel industry is also relatively high. Yet, surveys show that the supply is greater than the demand at lower levels of qualification. Unqualified and low-skilled people thereby often only can work in steel companies via temporary employment agencies. The high proportion of temporary workers in the sector can be explained by the strong dependence on production and a fluctuating economic cycle. In general, the majority of the interview statements suggest that the steel sector's situation is associated with many uncertainties, also for employees, due to increasing international competition and major difficulties in the sector.

However, the steel and industrial sector in the ecosystem is characterised by good salaries and excellent social security systems. Workers in the steel system earn significantly more than warehouse workers in logistics. Because low-skilled workers in the steel sector are employed at above-average market conditions, reintegration into the labour market after unemployment is often difficult. Therefore, ecosystem actors such as the Federal Employment Agency point out the importance of qualification for the low-skilled workers. Yet, in contrast to the logistics sector, fluctuation in the steel sector, and especially in the anchor company, is very low, which facilitates

qualification opportunities for workers; as companies tend to invest more in the qualification of their employees the longer they stay in the firm.

The digital transformation, which, in its impact on labour and human capital, is still in its infancy in the steel sector, confronts employees with new skill demands and challenges. Although the interviews conducted as part of **BEYOND4.0** show that numerous digital technologies, tools and solutions are already being used on a large scale in various areas of steel companies in the ecosystem, the potential for personnel savings is still far from being exhausted, according to the experts. Consequently, it is not possible to accurately predict which employees at which skill levels might be particularly affected by automation. With regard to skill requirements, it is revealed that although digital and professional skills are also important in the course of the digital transformation, personal and methodological skills are fundamental for the acquisition of such future skills. Accordingly, qualities such as openness, adaptability, willingness to change and motivation are essential for the acquisition of digital skills. Finally, experts in the steel ecosystem consider digitalisation to be so fast-moving that it is difficult to teach concrete skills in dealing with digital systems in the long term. As programmes and digital solutions continue to evolve, are updated or are replaced by new and better systems, skills related to and enabling lifelong learning are of particular importance for employees at all levels of qualification.

Strong points of the ecosystem

The steel ecosystem has been established in the administrative district and around the city of Duisburg for over a century and has had a significant impact on regional structures. For example, the region's physical infrastructure with trimodal transport routes via road, rail and water is well suited to the necessary logistical requirements of the steel industry. At the same time, the steel ecosystem is characterised by good networks, which, although in some cases slightly weakened by compliance regulations, can still be seen as a strength due to the long tradition and grown structures. In addition, the region has numerous universities and thus also enough talent growth, even though the steel industry partly struggles to attract skilled workers.

Digital transformation

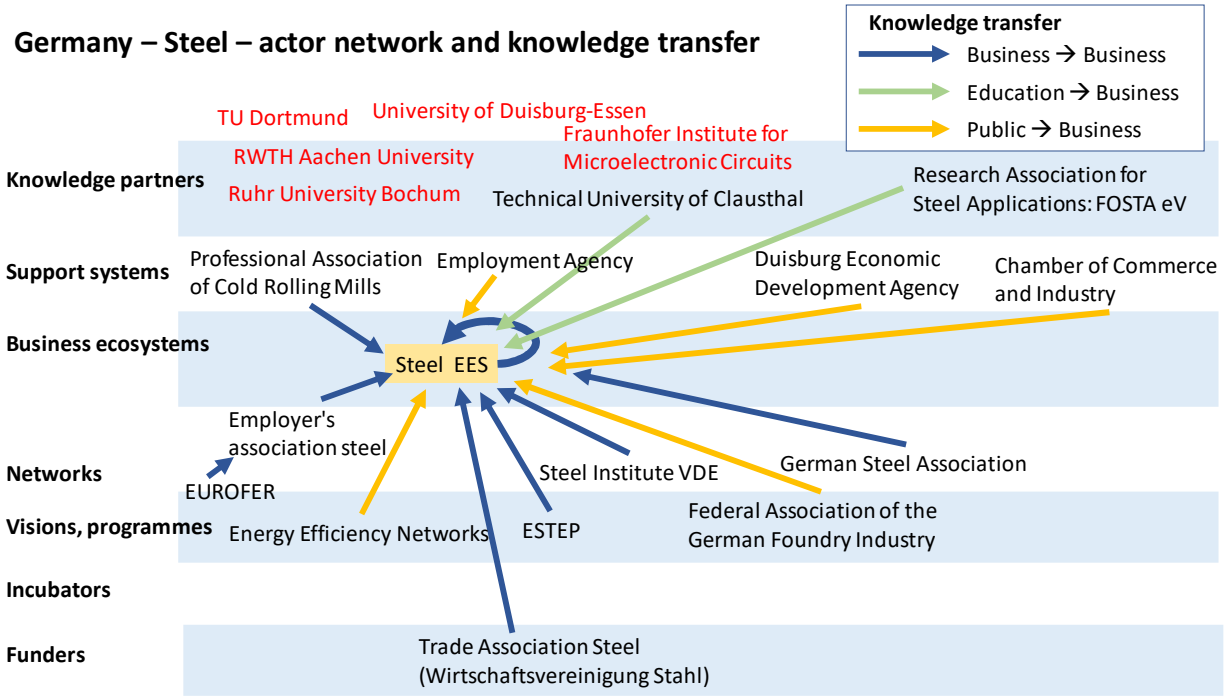
Even though steel can be considered an unchanging analogue product, all stakeholders agree that digitalisation can make an important contribution to greater efficiency and process optimisation and, at the same time, can lead to increased competitiveness of the steel ecosystem. With the digitalisation of the core business of steel production and steel processing only possible to a limited extent, expert assessments nonetheless show that digitalisation plays a significant role in the sector and that digital technologies are finding their way into more and more areas of the steel companies. Therefore, digitalisation has gained massively in importance in recent years and stands as one of the most important transformation topics of the upcoming years.

Main learnings of the incumbent ecosystem

Over the decades, the steel ecosystem has managed to overcome various crises and still represents one of the most important industries in the region and, at the same time, the largest employer in the city of Duisburg. Success factors include the sector's traditionally deep roots in the region, which

result in distinctive physical infrastructures and strong networks, among other things. At the same time, the digital transformation and the transformation towards more environmental awareness can strengthen the position of the ecosystem in the coming years.

There are several institutional voids that may hamper the future development of the Steel ecosystem. First, the ability of established networks to act is limited in part due to compliance regulations, which is partly associated with challenges in terms of cooperation culture, especially for steel SMEs. Second, the entrepreneurial culture is lacking, mainly because of the domination of one major business ecosystem. Third, the ecosystem relies on its own funding, which limits extra funding or sources for SMEs and start-ups. Surprisingly, one of the major voids is the poor knowledge relationship between the steel ecosystem and the many universities in the surrounding of the business ecosystem. However, the ecosystem does complement the lack of local knowledge input, with input from EU-based networks.



Pointers for policymaking

- The Steel IEE remains an important (employment) force for the future. Given the large challenges the ecosystem is confronted with, it is important to maintain support for the steel IEE. The focus needs to be on maintaining competitiveness against international competition and dealing with the different (environmental, inclusiveness) challenges of the region.
- The Steel IEE does not profit sufficiently from the knowledge networks in its environment. More attention should be directed at increasing collaboration with local universities to be able to learn new ideas for the future challenges and to further recruit talent. Actions should be on: improving the image of the steel sector; increasing the attractiveness of STEM subjects at universities

- Attention should also be on strengthening the network structures with regard to innovation cooperation for SMEs, also aimed at better knowledge spillovers. Certainly with respect to digital technologies, there are opportunities not used.
- The sector is reliant on a good trimodal transport infrastructure. The maintenance of the transport infrastructure to support the ecosystem remains important.

2.8 The German Emerging Entrepreneurial Ecosystem: Logistics in Arnsberg's administrative district

Main characteristics of the emerging entrepreneurial ecosystem

The logistics sector in the Dortmund area and thus in the administrative district of Arnsberg (NUTS2 region DEA5) was selected as an emerging ecosystem. Various factors were decisive for the choice. After the decline of these industries, strategies were developed in the region to shape structural change. Since the 1980s, logistics has proved to be an industry that can compensate for job losses in industrial sectors, as it has developed strongly in recent years, especially through online trade, creating jobs on a large scale. The establishment of companies such as a branch of Amazon has created thousands of jobs in the region. Logistics is also of central importance for trading groups such as IKEA and retail companies in the region such as REWE, just as it is in the manufacturing sector, for example, in the steel industry in the western Ruhr region.

With regard to the city of Dortmund and the analysed ecosystem, the strong role of applied research should be emphasised. Research institutes or local universities such as TU Dortmund University and particularly the Fraunhofer IML play a central role in the ecosystem. Ultimately, the logistics industry is considered a sector in which digital technologies are of great significance because many work steps can be transformed into algorithms. Accordingly, digital technologies are already used and implemented on a large scale in the logistics sector. In addition, the focus on innovation and research in the ecosystem around the city of Dortmund is giving rise to numerous start-ups and spin-offs, which emerge from the respective research institutes and offer innovative solutions for the logistics sector. The interface between logistics and IT also plays a major role in this context.

The socio-economic quality of the ecosystem

Even though logistics heavily relies on skilled workers, especially regarding the research institutes in the ecosystem, the level of unskilled workers is comparatively high in the sector in general and with regard to logistics in the eastern Ruhr region. The share of unskilled jobs is thus twice as high as in the economy as a whole, with a high share of unskilled workers, some of whom have no school-leaving qualifications. With regard to the inclusion of disadvantaged groups in the labour market, it can be seen that low-road strategies in logistics have the potential to create low-skilled jobs. Therefore, the logistics sector is a way for low-skilled and unemployed people as well as for migrants to find employment. Ultimately, especially in the field of warehouse logistics and mail-order business, the entry barriers and qualification requirements are low, as a large number of helper jobs are needed here - consequently, low-skilled workers are mainly employed here.

At all levels of qualification, the requirements for employees in logistics have changed in recent years due to the influence of digitalisation. For example, knowledge of MS Office is particularly in demand for classic office and administrative activities in the logistics ecosystem. At the same time, more and more in-depth IT skills are playing a role at higher qualification levels, even in professions where this may not have been the case 10 years ago. On the other hand, basic digital skills are

required at almost all qualification levels and for the majority of jobs in logistics. Employers sometimes require these skills during the application process, which in turn poses challenges for low-skilled workers. Furthermore, social skills are becoming more important across different professions in the course of digitalisation. Due to changed organisational structures in companies, more work is being done in projects with interdisciplinary teams, especially in more highly qualified areas. Other skills that the experts repeatedly emphasise are related to personal skills. In this context, openness and adaptability in particular play a major role, as digitalisation repeatedly leads to changes and new challenges that employees have to face. Above that, the ability to learn and to repeatedly familiarise oneself with new digital systems and programmes is of great significance, so that increasing demands are made on employees' learning skills and learning methods. In addition, basic methodological skills such as literacy and numeracy are seen as a precondition in order to acquire digital skills.

In the low-skilled sector, however, it is not only increasing requirements for employees, as digitisation also increases the chances for the low-qualified workforce to find jobs. Picking systems, for example, make work easier and support employees in individual work steps. In this context, voice-guided assistance systems are noteworthy, such as Pick by Voice technology.

Strong points of the ecosystem

The key success factors of the ecosystem are the research competencies of Dortmund's logistics and IT research institutes, which manifest the ecosystem as an important location beyond national borders. In the course of this, the close network structures between research institutes, companies and the public sector should also be emphasised. At the same time, the excellent infrastructure and the enormous population density play another striking role in the logistics ecosystem.

Digital transformation

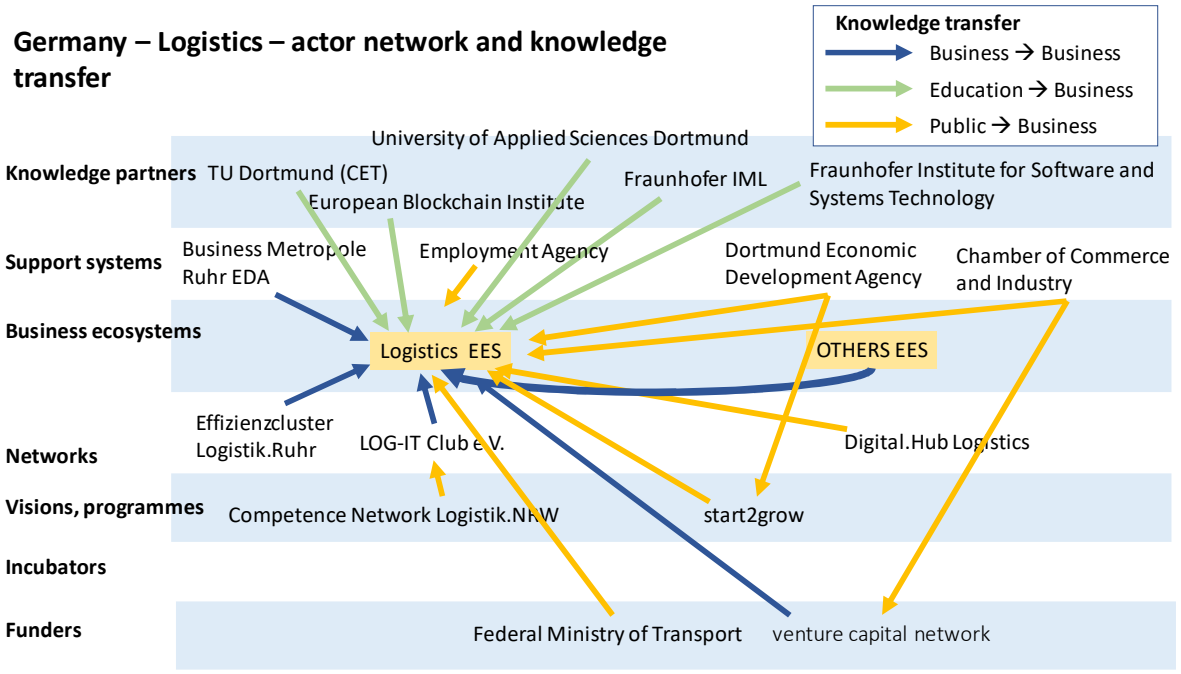
The digital transformation in the form of innovative technologies, automation and analytics is one of the megatrends in the logistics industry. Thereby, the advance of digitalisation has also enabled logistics to develop further. One thesis that was voiced in this context is that logistics has developed particularly through digitalisation. Independently of the increase in intra-trade, the better plannability and increasing consistency of information and material flows, which have made it possible to realise global transport and supply chains, have contributed to this. In the ecosystem, the Fraunhofer IML was already researching Industry 4.0 technologies before the term was coined in Germany. Above that, in logistics warehousing, picking systems, such as pick-by-voice, offer the possibility to include disadvantaged groups in the labour market.

Main learnings of the emerging ecosystem

Particularly noteworthy with regard to the city of Dortmund is the concentration on logistics research, where the interface between IT and logistics is especially important. Here, digital solutions are created that are important for various companies and sectors beyond the ecosystem's boundaries. The distinctive networks between the various actors in the ecosystem have also been

promoted and cultivated from various sides, from which good cooperation in the form of an innovation ecosystem benefits today.

The main institutional void is the lack of incentives to view workers less as a cost factor and more as an investment. Accordingly, more incentives must be created on the part of companies for further training measures and long-term employment.



Pointers for policymaking

- This EEE offers opportunities for low-skilled workers, not only on high skilled. This requires promotion and qualification of low-skilled workers (both employed and unemployed) by companies, further education institutes and public associations.
    - Companies need to be supported to strengthen their resolve to provide further training for low-skilled workers.
    - Low-skilled workers need to be motivated to undergo further training.
- The EEE offers many opportunities for start-ups. This requires more sharing of how new business models can help these start-ups. The knowledge partners (IML) should have a role here.

2.9 Advanced Manufacturing Entrepreneurial Ecosystem in Noord Brabant, The Netherlands

Main characteristics of the entrepreneurial ecosystem

- The Advanced Manufacturing IEE is a strong high-tech manufacturing industry, an exceptional design sector, and a unique collaboration model.
- The cluster of knowledge-intensive manufacturing industries is characterised by production in small volumes of technically complex, well-designed products. Original Equipment Manufacturers (OEMs) can rely on a variety of specialised suppliers in the region.
- It has the largest concentration of private R&D expenditures of companies in the Netherlands (the year 2016 data of Statistics Netherlands).
- Besides, a lively creative industry offers plenty of room for innovative start-ups. The region is characterised by Industry 4.0 sectors of advanced manufacturing, which is why this region was selected as an entrepreneurial ecosystem for the Beyond4.0 project. Furthermore, in the same province of North Brabant (but in the western part of the province) we can identify an emerging entrepreneurial ecosystem in the aerospace sector.

The socio-economic quality of the ecosystem

- The ecosystem is responsible for a sizeable share of employment in the region, both for highly educated tech professionals and for people with medium vocational-technical and other skills.
- Growth at the focal firm has been substantial, resulting in a current (November 2021) total number of employees (in 'FTE's) of 28073 worldwide (in comparison, the number of FTE's in 2015 was 14,681), of which about half work in the Eindhoven/Veldhoven region.
- Given the focus on highly trained professionals and the scarcity of such staff, the personnel strategy can be characterized as 'high road': high-quality jobs with ample possibilities for further development. Furthermore, the focal firm has reduced the share of employees on temporary contracts in recent years.
- Combined with the jobs at suppliers of the focal firm and other firms in the entrepreneurial ecosystem, the ecosystem substantially contributes to the high standard of living in the region.
- The high road personnel strategies, combined with the scarcity issues, also result, to some extent, in efforts for the inclusion of disadvantaged groups in the regional labour market.

Strong points of the ecosystem

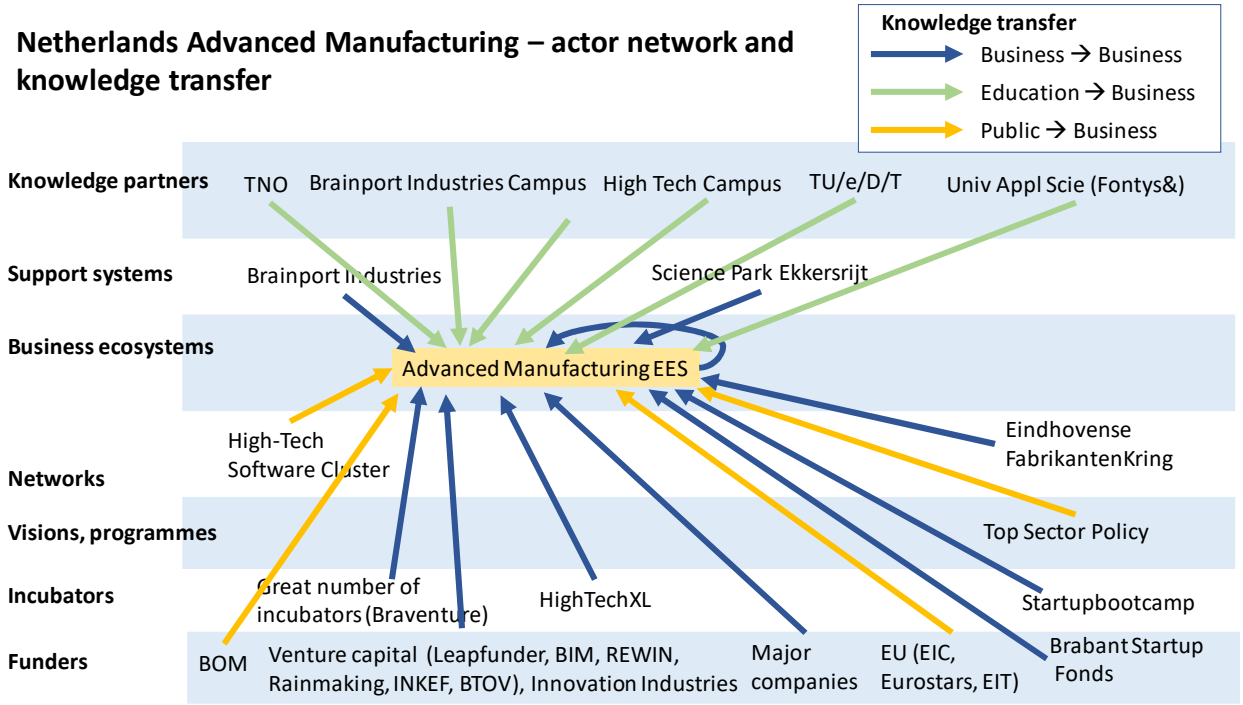
The ecosystem thrives through strong cooperation and historic social networks between the focal firm and its regional suppliers, regional knowledge/education partners, and the government (triple helix). There is a strong sense of trust and direction for the ecosystem as a whole. Only problems exist with respect to the availability of (technical) talent and physical infrastructure.

Digital transformation

The entrepreneurial ecosystem revolving around the focal firm in the east of North-Brabant is impacted by the digital transformation and at the same time plays a major, almost central, role in the further development of the digital transformation. That makes this ecosystem an interesting but complicated case. With its strong high-tech manufacturing concentration, the region requires excellent digital connectivity aimed at accelerating the digital transformation. In the regional smart mobility programme, regional companies, knowledge institutions, and the City of Eindhoven develop smart mobility concepts (such as Mobility as a Service) and Intelligent Transport systems based on, e.g. IoT and cooperative adaptive and autonomous vehicle technologies. The existing high-tech manufacturing industries are a breeding ground for 'smart industry' or industry 4.0 applications, such as flexible and additive manufacturing processes and logistics. Primary production processes are more and more automated and robotized, and supply chains are getting more data-driven with digital information exchange between suppliers. Data and information exchange are more often located in the core of primary production processes. Digital twinning (e.g. 3D or 4D virtualizations) or even digital factories are centralised and optimised in global production processes of manufacturing companies.

Main learnings to support the incumbent ecosystem

- The ecosystem in the east of Noord Brabant is characterised by a concentration of high tech manufacturing companies. These companies form a close-knit network with a clear sense of direction. Furthermore, a crucial element supporting the ecosystem is the availability of talent at different vocational and academic levels.



Pointers for policymaking

- Safeguard the continued availability of talent by strengthening the connection between (medium/high) vocational schools and universities and the businesses in the ecosystem. Furthermore, safeguard the access of international talent to the regional labour market.
- For the same reason, a direction for policy is to strengthen the systems for lifelong learning and intersectoral mobility on the labour market, based on (technological) skills.
- Be attentive that the core companies share sufficiently their experiences with new companies and scale-ups. The burden to launch high-tech start-ups requires sufficient investments that start-ups cannot afford. The input from private investors is required.

2.10 The Emerging Aerospace Entrepreneurial Ecosystem; Noord Brabant, Netherlands

Main characteristics of the entrepreneurial ecosystem

- The aerospace ecosystem in the west of North Brabant is built around the infrastructure of a military airport and adjacent facilities.
- The emergence of this ecosystem was critically dependent on the contract for F35 maintenance and part logistics that was won for all F35 fighter planes in Europe.
- The ecosystem can build on the joint facilities for aerospace maintenance and parts logistics for both military and civilian aircraft and can benefit from entrant firms in the field of 'materials', e.g. composites used for aeroplane bodies and helicopter rotor blades.

The socio-economic quality of the ecosystem

The ecosystem does generate a fair amount of employment of good quality in the region, but it is not as connected to other businesses in the region, because of the focus on military aircraft maintenance. Nevertheless, it is seen as a potentially growing ecosystem in terms of economic growth and jobs.

Strong points of the ecosystem

A strong trait of the ecosystem is its rather narrow focus (military aircraft maintenance). At the same time, this is a risk factor for future growth. So the development into civilian aircraft maintenance, parts logistics and new materials seem like logical options to diversify the scope of the ecosystem, leading to a more robust growth perspective for the future.

Digital transformation

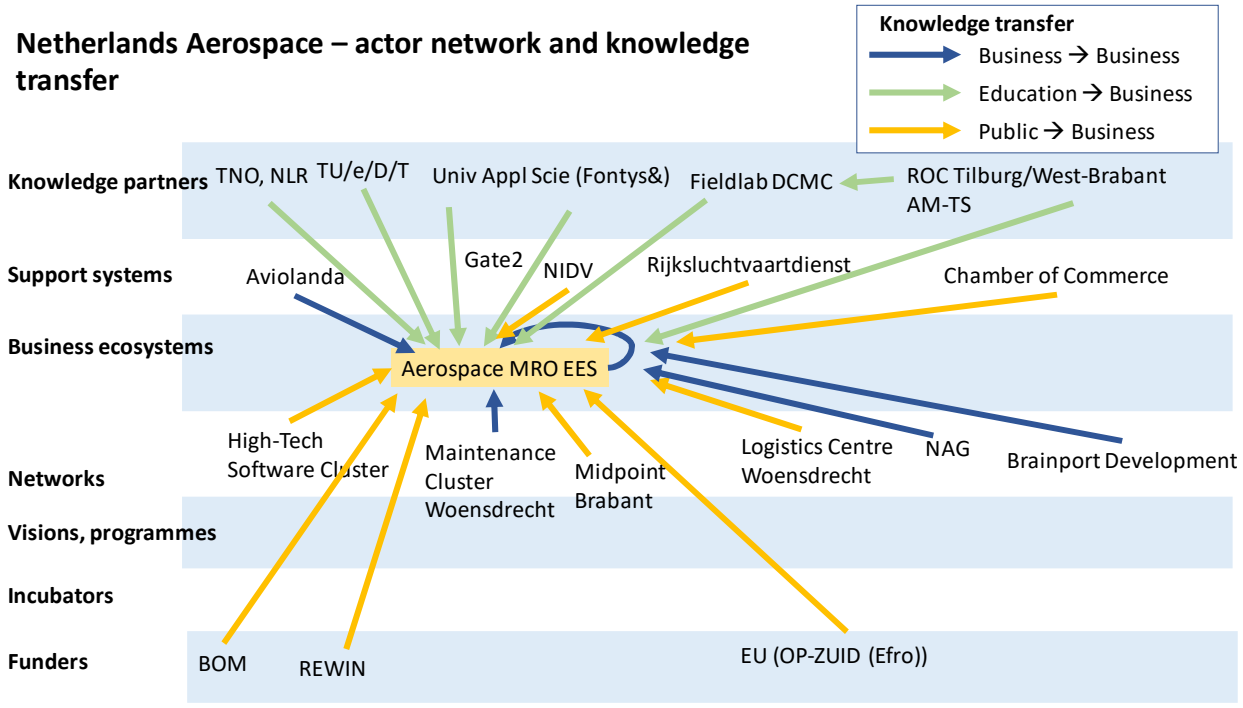
In recent years, a major development in the aircraft industry has been the digitalisation of maintenance information. Manuals are not on paper anymore, and modern aeroplanes produce a constant stream of digital monitoring data that is used for predictive maintenance. This development is driven mainly by aircraft manufacturers (OEMs) who were slow to adapt to the digital transformation, but once they did, the whole maintenance sector had to adjust instantaneously.

Data and AI will play a role in (parts) logistics, predictive maintenance, and 'smart' materials for the future digital technology. There are ample opportunities to develop new digital driven business models.

Main learnings to support the emerging ecosystem

As an emerging ecosystem, the aerospace sector is subject to strategic uncertainty. The leading companies have not been able to find a clear direction for the future; they operate as silos. It seems as if for the future, the sector is channelling its trusts into the parts and the maintenance areas of the aerospace sector. This remains still a broad span of interests which does not lead to strong collaborations between all partner networks. It seems as if there should be more separate interests and thus separate ecosystems.

The further development of the emerging (sub)ecosystem of MRO depends crucially on the fruitful cooperation between military and civilian aviation maintenance and services. Now there is too little collaboration and hardly any 'open' innovation. Furthermore, it is unclear which actor has a leading position in this emerging ecosystem. It is clear that military aircraft maintenance and parts logistics is a unique proposition to bring new companies into the region and raise awareness of the ecosystem. On the other hand, developing a broader product/service portfolio would be an opportunity to develop the ecosystem into a known European maintenance and innovation hub in aerospace and cross-over activities. However, this would require more entrepreneurial spirit, business/commercial thinking, and networking and collaborations beyond the own region.
Since the ecosystem depends heavily on the military infrastructure, the role of the (national) government in the further development of the ecosystem is crucial. At the same time, the military nature of the ecosystem (American legislation; national rules) makes it more difficult to cooperate and use joint facilities for maintenance, parts logistics and the application of new materials. The ecosystem is best supported by a clear long-term strategy from the Dutch military and government. In turn, the regional (local) governments and vocational schools can support this development by proactively supporting this ecosystem by providing it with the necessary resources, talent and good quality digital infrastructure in particular.



Pointers for policymaking

Policymakers should guide the company networks in their focus. Only if the networks develop a clear focus, the support in the development of a concrete product/service portfolio can be developed. Policymakers should focus on supporting ecosystem development at three levels: 1. Strategic choices of the Aerospace: not everything goes and it does not help to dwell on the past; 2. Tactical choices: defining how the public (defence) can best support the business networks; 3. Operational choices: in creating opportunities for the networks to develop more knowledge

spillovers and learning at the local level. For further ecosystem development, it is a precondition that an actual business case is formulated and is connected to the actions:

- Clear long term policy choices with respect to (military) aircraft maintenance and parts logistics.
- Supportive local policies for the provision of talent and good quality (digital) infrastructure.

2.11 ICT Entrepreneurial Ecosystem, Sofia, Bulgaria

Main characteristics of the entrepreneurial ecosystem

The incumbent entrepreneurial ecosystem (EES) selected in Bulgaria in Sofia is the ICT (with a focus on software production and related services). This ecosystem has a long history, starting from the early 1960s[12]. In the context of the poorest and less technologically developed EU country –namely, Bulgaria– Sofia[13] is an interesting case because of the spectacular development of the knowledge-intensive ICT sector experienced during the last decades both in the conditions of the socialist state economy and in the post-communist dependent capitalism[14]. This EES has no core companies but incorporates many ICT firms of all sizes. In addition, the EES includes public and private universities, private IT academies and other skills providers, tech parks, venture capital funds, branch organisations.

The socio-economic quality of the ecosystem

The examined ecosystem escapes from Bulgaria's "captured state" and corruption. It can be considered as a high-road case. The EES contributes to economic and inclusive growth. Respondents see it as one of the engines and drivers of the future of the Bulgarian and Sofia economy. The EES produces high value-added products and services, is involved in employment creation and provides very decent wages to its employees. Its employees are favourable to all possible benefits as the EES tries to provide to keep them. In addition, the ecosystem is economically viable and inclusive, as it allowed many young and highly educated Bulgarians to stay, work, have decent incomes, and live in their own country instead of heading for richer EU member states. Bulgaria is also particular because women are very well integrated into the ecosystem. At the same time, the EES could be considered exclusive from the integration of low-skilled or ageing workforce. Employees had become more responsible when they started to work remotely. The Covid-19 situation was considered as a favourable for the business.

Strong points of the ecosystem

The driving forces of the ecosystem are the talent (traditionally a high percentage of students in STEM), the relatively good infrastructure (concentration of educational institutions, good quality and accessible internet, and air connectivity to the major European capitals) as well as the access to EU funds and instruments. The ecosystem has developed on the basis of the previously existing ICT industry during the state socialism, which was transformed in a resilient way during post-communism, to integrate the global value chains and gradually move to more complex and value added projects even see the development of Bulgarian MNC. The strong position of the companies in the EES is also due to their understanding of the technical challenges and the clients' needs.

Digital transformation

[12] See Focacci and Kirov (2021)

[13] Sofia is the capital of Bulgaria and heads one of the 28 administrative districts (*oblasti*) in the country.

[14] Delteil, V., & Kirov, V. N. (Eds.). (2016). Labour and Social Transformation in Central and Eastern Europe: Europeanization and Beyond. Routledge.

The digital transformation has always impacted this ICT EES by its very nature. The EES's activities have been already digitalised. The EES was one of the first ecosystem in Bulgaria to support and introduce the idea of teleworking. As already mentioned, the development of the digital infrastructure has been an important element for the successful development of this EES. The labour force in the EES has always been highly skilled, with a particular focus on digital skills. Sofia's ICT ecosystem supports the digital transformation of sectors and companies. Recent developments of the ecosystem address the evolution of international demand and specific customer needs in developed countries in Western Europe and North America.

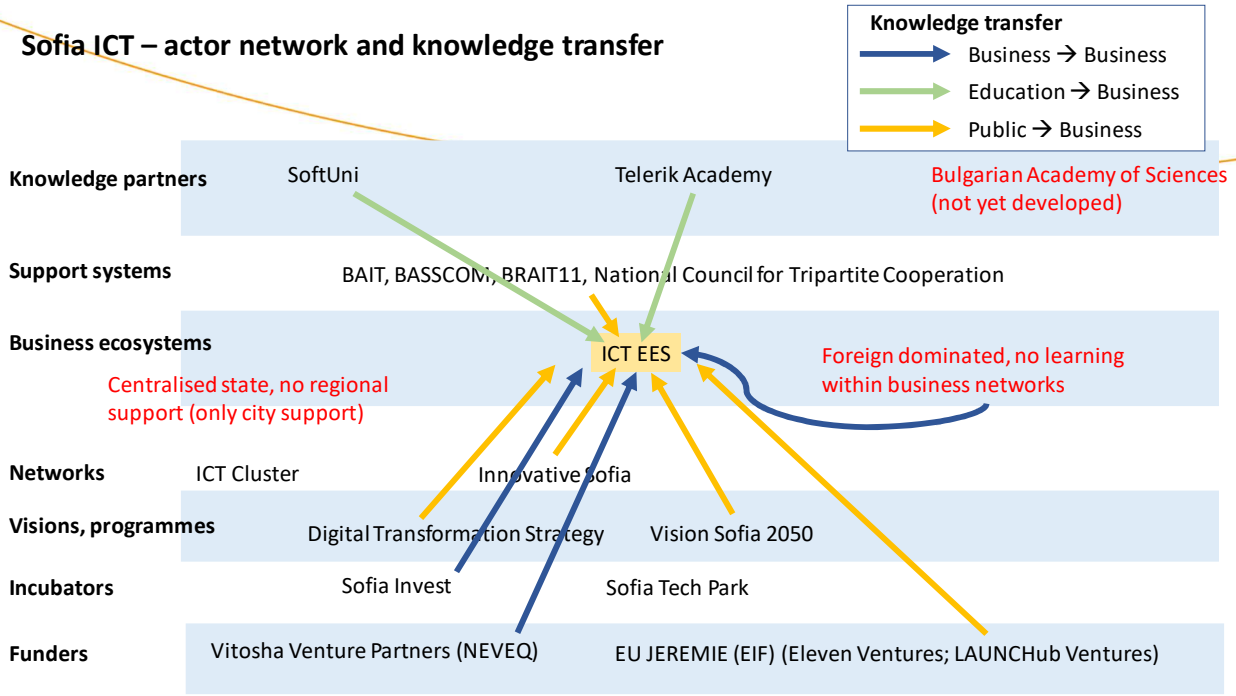
Main learnings to support the emerging / incumbent ecosystem

The other ecosystems could learn from this ecosystem the following lessons:

- Long-term focus and resilience can ensure survival and further development.
- Flexibility is needed to engage with clients from a variety of countries and sectors.
- The inclusion of educational institutions (especially higher education institutions) in the EES is important as it provides an influx of talent.
- The EES was boosted since the Bulgarian membership in the EU – EU support is very important.

The EES does, however, suffer from several institutional voids:

- The knowledge partner networks are not focused on knowledge relations but only on the supply of talent.
- The centralised state (and 'failed state') does not provide regional support structures that help drive entrepreneurship. For Sofia, the city does support innovation actions.
- Much funding to develop the sector still comes from the EU level, not enough local. This is also connected to the foreign dominance of companies. This limits the amount in which companies can learn from each other.



Pointers for policymaking

To maintain a competitive position:

- The IEE requires the development of a Bulgarian knowledge infrastructure that feeds into the companies. This requires that the national plans are further developed and that the return-to-the-society of the plans are clear. Policymakers should engage the international suppliers to help strengthening the local ecosystem (taxes?). An important element for this IEE is that it has insufficient leadership in what the future may be. The national plans should also focus on developing such leadership in the knowledge system, such as is done in Germany with the Fraunhofer institutes.
- The strengths of the ecosystem - talent, infrastructure and EU support - could be undermined by strategic mismatches: price competition from lower-wage destinations is a real possibility. That may impact the local IEE with a deficit of qualified labour and potential emigration and brain drain. This requires strategic thinking by policymakers to help improve the development chances of the sector, given this threat (see first action).
- The future points of attention relate to the collaboration among the stakeholders, the competitive position, and to invest further in R&D, with the support of national and local authorities. The stress should be on successful collaborations in the past years, that should model future support measures.

2.12 Outsourcing Entrepreneurial Ecosystem, Sofia, Bulgaria

Main characteristics of the entrepreneurial ecosystem

The **emergent** entrepreneurial ecosystem examined in Sofia is the business process outsourcing (BPO) and other forms of business services outsourcing. This EES was hardly known in Bulgaria amid the 2000s[15]. The movement of operations among companies active in outsourcing business services to Bulgaria was mainly driven by the available skills, relatively good infrastructure, and lower wage costs in the country. In some cases, activities were relocated to Bulgaria from former locations of the respective companies, situated in Western or Central Europe. **The EES is among the leaders in gathering information and transforming it into solutions that support different sectors; helping companies grow and improve the lives of millions of users around the world.** This EES **has no core companies** but incorporates a small number of large companies, most of them subsidiaries of multinationals. The EES includes public and private universities, private IT academies and other skills providers, business parks, branch organisations.

The socio-economic quality of the ecosystem

According to the AIBEST report, the ecosystem "employed nearly 62,000 people in 2018 and generated sales of €2.2 billion". Thus, the outsourcing industry has already contributed 10% of added value to the capital's economy (IME 2019). The examined ecosystem escapes from Bulgaria's "captured state" and corruption. The EES contributes to economic and inclusive growth. It is seen by respondents as one of the engines and drivers of the future of the Bulgarian and Sofia economy, together with ICT. It can be considered as a high-road case. The EES offers a competitive remuneration package, annual preventive medical check, additional health insurance; annual life insurance; access to sports facilities and activities. Advances in technologies make it possible to work from anywhere (geographically), which positively affects achieving better work-life balance by their employees. The EES has an internal staff training academies where employees can gain additional competencies or fill skill gaps. In addition, the ecosystem is economically viable and inclusive, as it allowed many young and highly educated Bulgarians to stay or find work in Bulgaria after studying abroad. Women are very well integrated into the ecosystem. At the same time, the EES could be considered exclusive from the integration of low-skilled or workforce from minority origin. The employees in the EES have regularly participated in anonymous surveys of their satisfaction with the work conditions. Based on their results, the EES's social policy has been adapted. No negative effects have been registered for the EES so far due to the COVID-19 crisis. In the conditions of Covid-19 pandemic, the EES also offers a free consultation with a psychologist if there is such a need from some of its employees or additional benefits (for example, an office chair for work at home and a safety glass for a monitor).

Strong points of the ecosystem

The driving forces of the ecosystem are the talent (traditionally a high percentage of students in STEM and with good foreign languages fluency), the relatively good infrastructure (concentration

[15] Kirov, V., & K. Mircheva (2009) Employment in call centres in Bulgaria. *Work, Organisation, Labour and Globalisation*, Summer, 3/1, 144-157.

of educational institutions, good quality and accessible internet, air connectivity to the major European capitals and offices class A), access to EU funds and instruments and the strong network of companies. This ecosystem also gradually moves to more complex and value-added projects.

Digital transformation

Sofia's outsourcing ecosystem supports the digital transformation of sectors and companies. Recent developments of the ecosystem address the evolution of international demand and specific customer needs in developed countries in Western Europe and North America. Among the technologies adopted by the EES are cloud computing, i.e., storing and processing files or data on remote servers hosted on the internet; smart devices, e.g., smart sensors, smart thermostats, etc., and big data analytics, e.g. data mining and predictive analysis. According to the interviewees, technological change increases work efficiency and improves the quality of work.

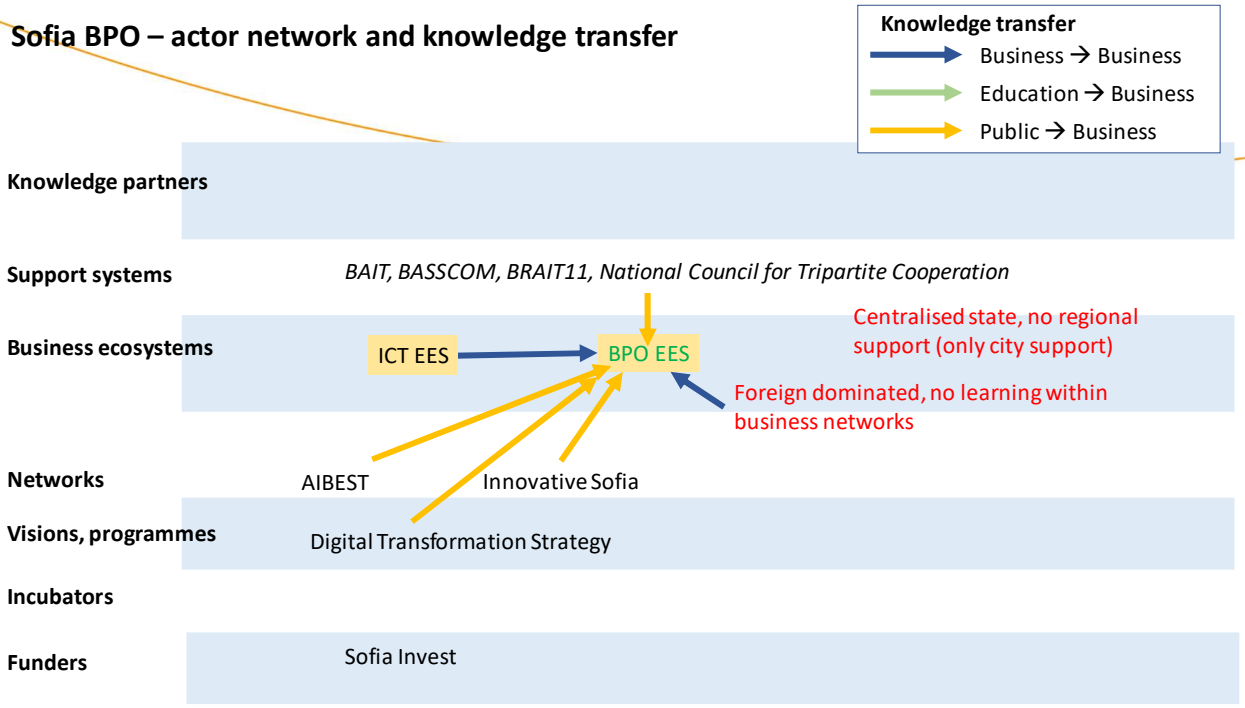
Main learnings to support the emerging / incumbent ecosystem

The other ecosystems could learn from this ecosystem the following lessons:

- Flexibility is needed to engage with clients from a variety of countries and sectors.
- How to make good of opportunities, developed in the context of global value chains restructuring.
- The EES was boosted since the Bulgarian membership in the EU – EU support is very important.

The new ecosystem needs to overcome several institutional voids if it can grow more entrepreneurship:

- There is a considerable overlap of companies (and foreign interests) with the ICT IEE. This provides an opportunity for the BPO EES to develop itself (learning from the other EES). At the same time, it makes the actors compete for the same talent, finances and other sources.
- At the same time, the ecosystem suffers from the same weaknesses as the ICT IEE: knowledge partner networks are not focused on knowledge relation; the centralised state does not provide regional support structures, only local; much funding comes from the EU-level; foreign dominance is a problem.



Pointers for policymaking

Policymakers should focus on ensure further scale-up and scale-out of the BPO-initiatives:

- The strengths of the ecosystem, talent, infrastructure, and EU support could be undermined by some of the weaknesses/challenges, namely: price competition from lower-wage destinations; relocation of companies or their activities to other Bulgarian cities or destinations with lower wages, automation of routine tasks and job cuts; deficit of qualified labour. See the policy pointers for the ICT IEE.
- The future points of attention relate to the collaboration among the stakeholders, the competitive position, and investing further in R&D, with the support of national and local authorities, e.g., the attraction of foreign specialists, e.g., from the former republics of the Soviet Union.

2.13 Automotive Incumbent Entrepreneurial Ecosystem; West Midlands, UK

Main characteristics of the incumbent entrepreneurial ecosystem

The West Midlands is one of the UK's largest metropolitan areas outside London, its central location puts it at the heart of the UK's transport networks and international connections. The region was one of the most prosperous areas of the UK until the 1970/80s, and prior to the onset of the Covid-19 pandemic, it experienced a resurgence of growth in areas such as technology-driven manufacturing. The West Midlands is seen as one of two key regions in the United Kingdom dominating the automotive sector. It is an established sector in the region, an incumbent ecosystem. A range of formal institutions in the region play a role in the EES. Regional organisations funded by the government are responsible for supporting growth within key sectors in their region. These formal institutions support skills development both at the supply level and within the current labour force. They also support inward investment to support growth and development. Universities across the region have strong collaborations with industry to support R&D, growth, and skills development. OEMs and Tier 1 and 2 companies provide a formal structure to the IEE and drive demand and development in Tier 3 and 4.

The socio-economic quality of the ecosystem

The region has several educational institutions offering vocational training, which provides an alternative pathway into the sector. Furthermore, there are also initiatives aimed at training the low skilled and the long-term unemployed which is driving new talent to the sector. This is helping to address the social inclusion agenda; a regional priority set by national government. Technical apprenticeship standards are also providing alternative routes into the industry and opening up opportunities for those wishing to take a vocational route. These are offered by MNCs and SMEs in the sector.

Strong points of the ecosystem

The West Midlands is well located in the United Kingdom in terms of physical and IT infrastructure. There are good road, rail, and air networks. The logistics network is, therefore, well developed and as a result of there is a strong manufacturing culture in the region. This has been significant to the automotive sector and its growth. The region has a strong manufacturing history, and the automotive sector now drives this. The supply chain within the region feeds into the sector. There are 100s of SMEs that supply parts to not only the local MNCs but internationally. Automotive demand is mainly from international markets. OEMs drive the ecosystem. A strength of the ecosystem is the strongly developed network of intermediaries that are aimed at support growth in the sector and the region. Regional leadership tends to focus on inward investment and labour supply, as well as supporting digital transformation.

Digital transformation

The automotive sector is long established in the region, but new investments mean the region is becoming a hub for new automotive technologies, such as electric vehicle manufacturing and connected and autonomous vehicle (CAV) technology. It is recognised that digital transformation and entrepreneurship can drive growth in a sector, but good leadership is needed to manage and

drive the process. The policy-push on climate change/emissions reduction, globalisation of trade, and the UK's departure from the European Union are also driving digital transformation.

Digital transformation is well established with developments and changes responding to new technology in large anchor firms in the region. In SMEs, there is a lack of digital transformation, which is mainly considered to be the result of resourcing (where the cost of implementing technology or digitalising an activity is not considered cost-effective). Organisations in the supply chain that have not adopted technology are unlikely to change. It is recognised that the manufacturing sector will need to adapt to robotics and AI. At a regional level there is a focus on improving skills (especially digital) and the qualification profile of the working age population in order to meet the current and future demands of automation and digitalisation. The sector will need to rethink its position in terms of digital business models and new services to support its production focus.

Main learnings to support the incumbent ecosystem

Government funds and regional investments play an important role in supporting entrepreneurial activity and growth in the sector. Local government institutions work with employers to support their development, in terms of innovation which is seen as a driver of entrepreneurial growth. Financing is driving the development of green jobs.

Universities in the region often work in close collaboration with industrial companies to deliver innovations in technology support electrification and zero-carbon targets. These collaborations have been key to the development of training to support upskilling of the workforce. A key success has been the implementation of technology and industry labs in educational institutions; learning from which is transferred to the organisational context.

Important for the region is the high level of people at risk of poverty or social exclusion.

Pointers for policy making

- To continue investment in professional development and upskilling of workforce to encourage innovation and entrepreneurial activity in the region.
- To promote and support collaborations between private sector and education institutions to ensure skills and labour demand can be met in the future.
- To support and resource networks at lower end of supply chain where automation is too costly.
- A challenge for the sector is to retain highly skilled employees that are attractive to international labour markets.
- Plans are needed to counter the high level of people at risk of poverty or social exclusion.

2.14 Digital Health Entrepreneurial Ecosystem; West Midlands, UK

Main characteristics of the emergent entrepreneurial ecosystem

In the local West Midlands Industrial Strategy, data-driven health and life sciences and healthcare innovation were mentioned as among the competitive strengths of the region. The local industrial strategy identifies the region as a growing centre for testing and proving health innovation, working in partnership with businesses and patients. The local strategy also states that one of its aims is to build on its growing health innovation cluster to deliver improved clinical care and health outcomes, alongside significant business growth and scale-up success. Digital health EEES is driven by knowledge development in the private, R&D sector. Organisations within the EEES operate at a national level supporting local adoption. At the local level public sector organisations (under government contracts to deliver services) operate independently.

Knowledge is distributed in the private sector amongst a few organisations with little entrepreneurial activity in SMEs. Two higher education institutions are developing talent and supply for the growing sector.

The socio-economic quality of the ecosystem

The EEEs has been slowly developing with recent growth in the result of technological advances, government strategy and funding. The entrepreneurial system is small and driven by a few national level organisations. As such, employment numbers are low and dominated by a small and highly skilled workforce. The impact of the sector on socio-economic outcomes at the regional level is limited. There is little optimism that employment numbers will change in the short-term. At the local consumer level, the products are helping some access services more easily.

Strong points of the ecosystem

Historically, there has been little incentive for companies operating in the sector to demand digital health products, so demand has not been high. This has resulted in a lack of entrepreneurial activity in the sector as it is not seen as financially worthwhile. However, government policy and resourcing have been driving developments alongside the need for services to be online in response to the pandemic; both of which have significantly increased demand. The sector is dominated by a few national organisations that have responded to demand and enhanced their services. As a result, there has been a significant uptake in products, so companies have expanded their services and entrepreneurial activity. A key strength of the EEEs is strong leadership from the NHS who has set out guidelines for implementing products and services across the sector.

Digital transformation

The global market for digital health was estimated to be worth £23 billion in 2014, it is expected to continue growing, particularly with advances in big data collection, linking and analysis, as well as advances in AI to support diagnostics. The UK market size for digital health was estimated to be worth £2 billion in 2014 and was expected to grow to around £3 billion by 2018, predominantly driven by digital health apps. Digital transformation has mainly been led by a few large organisations that also operate in international labour markets. R&D that informs developments and

enhancements to products is undertaken by a few universities. Whilst the pandemic has driven digital transformations in the sector, there remains a lack of leadership at a local level to drive changes and the implementation of digital technologies. In addition, digital skills, literacy, and access remain barriers to implementation and use by consumers.

Main learnings to support the emerging ecosystem

As an emergent sector, knowledge, skills, and expertise are supplied from a range of disciplines. A few universities are serving the ecosystem, with one in the region leading the sector to supply new knowledge. One postgraduate programme has been designed with industry to support the development and growth of the sector. However, as a relatively new ecosystem, there are few intermediaries. Products have been implemented and piloted within small regional networks. This is not usual practice but could be a way to drive future demand supporting the EEES.

Pointers for policymaking

- To support private and public sector organisation collaborations ensuring future talent are equipped with the skills needed to drive innovation in the sector.
- To provide resourcing to develop IT infrastructures at the local level to drive demand and, importantly, support service delivery.
- To enable local partnerships to share resourcing for the implementation of sector innovations.
- To fund research into understanding consumer needs which would drive innovation and feed into service and product enhancement

Annexe 3 – Overview of the type of actors consulted in the ecosystems in the six countries

The following table provides an overview of the type of actors consulted in the fieldwork for this report.

	Companies, employees	Policymakers, stakeholders	Research & Education
Bulgaria	4 managers (SME, large) 4 employees	Ministerial level 2 employer associations City level official	6 researchers representing 5 universities + consultancies
Spain	1 sectoral 11 managers (5 companies) 1 venture capital 9 employees (4 companies)	7 policymakers 4 associations specialist	2 educational specialists 4 technology experts, academics
Finland	13 company specialists 2 financial sector specialists	2 policymakers 2 regional policy makers 4 technical specialists 2 stakeholder organisations	6 researchers
Germany	3 managers 9 employees	7 intermediairies 2 network representatives 3 policymakers	4 researchers 2 educational specialists
Netherlands	28 interviewees, mainly managers	25 stakeholders representatives (Chambers of commerce, Brainport etc.)	3 educational specialists
UK	2 managers 1 trainer 3 technical specialists/employees	2 regional policy makers 2 regional stakeholders	1 educational specialist 1 researcher

Annexe 4 – Which knowledge spillovers are used by the ecosystems?

This annexe contains an analysis of the spillovers that exist within the incumbent entrepreneurial ecosystem, following the model developed in the methodology section.

4.1 Knowledge spillover education – companies

1. The first indicator is the public-private co-publications per million population[16].

Table 4.1 Education – company spillovers (Normalised scores for public-private co-publications: 2014-2021)

	Public private co-publications*
Sofia	0.381
Dortmund	0.615
Duisburg	0.538
Basque Country	0.715
Noord-Brabant	0.744
Salo	0.709
Oulu	0.726
West Midlands	0.547

** This table gives the normalised scores for all indicators for the most recent year. Scores relative to the EU average are not shown as these would allow recalculating confidential regional CIS data. (European Commission, 2021a)*

This indicator shows that Noord-Brabant has the highest level of collaboration and Sofia the lowest. Duisburg, West Midlands and Düsseldorf also show lower cooperation between public and private researchers. Spillovers are stronger in Noord-Brabant. The SCOPUS-data has also been analysed and limited to the companies belonging to the relevant ecosystems.

[16] The RIS formulates the following clarification: "For the calculation of composite indicators, the individual indicators should ideally follow a normal distribution, but indicators have an asymmetrical or skewed data distribution (where most regions show low performance levels, and a few regions show exceptionally high performance). Data have been transformed using a square root transformation if the degree of skewness of the raw data, after correcting for statistical outliers, a measure of the asymmetry of the distribution of the data, exceeds 1, such that the skewness of the transformed data is below 1. For the following indicators, the degree of skewness was above one and data have been transformed: International scientific co-publications, Non-R&D innovation expenditures, Innovation expenditures per person employed, Public-private co-publications, PCT patent applications, Design applications, and Sales of new-to-market and new-to-enterprise innovations.
Following this transformation, the data are normalised using the minmax procedure. The **minimum score** for all regions across all eight years is subtracted from the respective transformed score, which is then divided by the difference between the maximum and minimum scores observed for all regions across all eight years. The maximum normalised score is equal to 1 and the minimum normalised score is equal to 0."

Table 4.2 Education – company spillovers: number of co-publications (more than one author) for six ecosystems (Source: SCOPUS)

	NL-IEE	NL-EEE	BUL-IEE	SP-IEE	FIN-IEE	GE-IEE
2000-2004	189	12	14	54	95	39
2005-2009	407	13	25	293	905	155
2010-2014	383	16	42	579	2843	141
2015-2019	593	27	45	809	3407	117
2020+	261	13	8	431	1260	29

Table 4.2 is more specific than table 4.1 since it only contains co-publications related to companies belonging to the specific ecosystems of this report. There is no data for the UK-case. The figures show that the number of publications in growing in all ecosystems except for GE-IEE. The cases also show that there was a dip in co-publications after the financial crisis of 2008, but publications levels have more than restored themselves. The number of publications differs quite strongly between the ecosystems.

The following two graphs can illustrate the growing importance of these collaborations in Brainport. We selected one of the main organisations in this IEEs, and checked the number of co-publications over time.

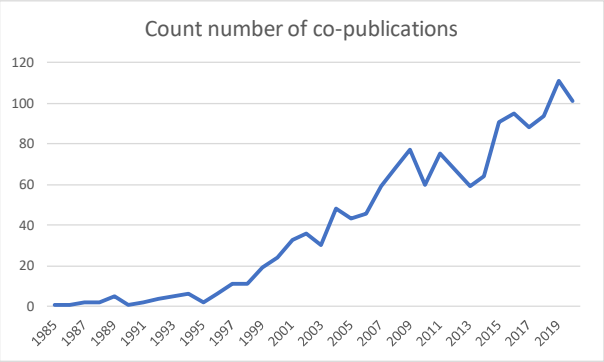


Figure 4.1 Number of co-publications made by researchers from the core-organisation in Brainport between 1985 and 2020 (source: Scopus)

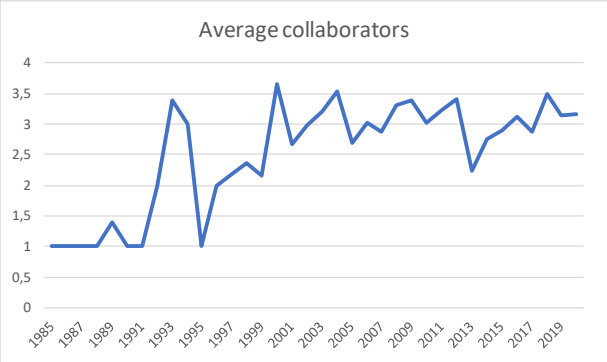


Figure 4.2 Average number of co-authors in publications core-organisation and others, between 1985 and 2020 (source: Scopus)

Figure 4 .1 shows that the number of co-publications is only rising over time. The average number of authors in a paper has risen up to an average of 3,5 authors/collaborations per paper (Figure 4.2). This last figure is not corrected for the number of co-company-authors. The figures show how important these co-publications have become for this network.

In Sofia, the ICT-EES sector is strongly in development and still dominated by foreign investors. This makes local cooperation on publications less obvious. In table 4.2, the figures include a local company but also the publications of one of the 'mother-companies' that publishes outsides of Bulgaria. The figures are not a clear representation of what happens in the ecosystem. It does show that the main (international) companies are not yet developed scientific collaborations locally.

2. We only have some qualitative data on the impact of internships and apprenticeships from the interviews. To increase the number of internships and collaboration between companies and education, the University of Applied Sciences in Oulu moved its location to the middle of the technology park. This is meant to improve exchanges between education and companies. The IMH (Basque Machine Tool Institute) is a pioneer in dual training combining apprenticeship and on-the-job training (alternating). This IMH is now integrated into the University of the Basque Country, and it promotes digitalisation and additive manufacturing among Basque machine tool companies. The IMH operates next to the already existing VET- and Polytechnic infrastructure in the region (e.g. Armeria Eskola). The dual training model transfers parts of the learning process to companies. It makes it possible to link training in study centres and in workplaces, better integrating technical and transversal or social skills.

Another concrete example of the transfer of skills for young people with little school education is a project of the Dortmund Economic Development Agency and local politics. Thereby, a business network was set up around secondary schools in the Ecosystem, in which one person working at each secondary school acts as an intermediary to place students with companies, among which are also logistics service providers in the region. The first aim was to clarify which basic virtues/skills are expected on the labour market and in companies and to convey these to the pupils, as basic virtues and basic skills are of enormous importance in professional life.

Brainport manages the process of internships for a great number of companies in the region. On its website, some 880 internships are listed for the last quarter of 2021. In the total province (NUTS-region), there were 2446. About 1/8 of the internships in Brainport are requested by the advanced manufacturing ecosystem.

3. Major programmes: the figures added to the summaries in Annexe 2 show which major programmes are launched and maintained to develop new ideas within the IEEs. Several examples show how these programmes are developed and needed. The following examples are insightful. The Bulgarian ICT IEE has mainly used the universities to supply talent. There have been no programmes to develop new ideas and innovations for companies. Only recently have partners in the network started with the Bulgarian Academy of Sciences to develop an IT-infrastructure (Peta-computers) to develop ICT-programmes that will profit companies. The Digital Transformation Strategy and the Vision Sofia 2050 are also helpful in this respect. To recuperate the knowledge that remains of the Nokia downfall, the 6G Flagship Programme has given direction to new opportunities for companies in the Oulu region. The number of investment projects supported by the Basque Government's Machine Tool Renewal Programme in the period 2013-2016 totalled 835. Many of these programmes were directed at digitalisation topics. To support the Smart Mobility ecosystem, several programmes such as INGIMOB has been launched by the General Directorate for Innovation and Internationalisation of the Government of Gipuzkoa.

4.2 Knowledge spillover companies - companies

4. The entrepreneurial ecosystem model indicates that one dominant business ecosystem drives economic activity. There are several observations that we can make from our analysis of the six regions:

- IEEs can be driven by more than one business ecosystem: this is precluded in our approach to compare incumbent and emerging ecosystems. Several major business systems may dominate regions. The first example is Noord-Brabant, in which we have at least three major business systems that dominate the regions: the Philips networks (Philips Medical, Signify), the ASML networks and the DAF (Paccar) networks. These companies employ thousands of employees and can co-exist. The North-Brabant regional authorities actively supported the development of supply chain networks to promote knowledge spillovers. These networks were not seen as that important by the companies themselves. The company case studies (WP8) will provide more examples of how knowledge transfer happens in supplier networks. The companies do share a significant amount of information in the supply chain to support new knowledge and innovation.
- The second example is Oulu, in which next to the Nokia network, the Stora Enso IEE (wood processing, paper production) co-exists. The Medical University also sustains a broad network of smaller companies.
- The Basque Country figures several business ecosystems such as the Machine Tool and the Automotive sector. With its three core companies, such as Irizar and CAF, and Mondragon Corporation, the automotive ecosystem has been supporting the rise of the Smart Mobility ecosystem.

Each of these business ecosystems supports knowledge exchange between core-companies and supplier networks.

5. Take-over of personnel between companies is something that doe occur. In most cases, certainly within a region, companies try to limit to do such actions openly. In Noord-Brabant, we noted that personnel does shift towards the leading companies in the ecosystem, but that companies have an understanding that stressing such a strategy for the core-company would be destructive for the overall collaboration. Things change if a major company goes bankrupt. In Oulu, the downfall of Nokia offered new opportunities for the surrounding company networks. Even the wood processing company Stora Enso was able to absorb Nokia personnel that was made redundant. This influx of knowledgeable personnel helped the companies improve their processes and innovation performance.

6. A common method is knowledge sharing through business networks. In the regional network maps, we can see which (leading) networks have been identified in all the regions (annexe 2).

In Oulu, several business networks had been specifically developed to deal with the probable downfall of Nokia. Already in 2008-2009, a Special Cooperative Group was created to deal with impact of the loss of Nokia. In Noord-Brabant, the Eindhovense Fabrikantenvereniging is an example

of a select network between companies to share ideas and strategies. For top managers, this (more secluded) network is preferred as a means to exchange information between top managers.

The example of the support of the major Basque companies Irizar, Mondragon Corporation and CAF show how they help grow the Smart Mobility cluster. All three companies have launched actions and strategies to position themselves in this emerging ecosystem. Within the region, public actions also support this network building (e.g. MUBIL The new mobility strategy is being managed by Fundación MUBIL and promoted by the Provincial Government of Gipuzkoa, San Sebastián City Council and the Basque Energy Agency (EVE). The main companies and agents from the industry participate in these actions.

7/8. Life-long learning; Innovative SMEs collaborating with others. Table 4.3 contains the information from the RIS2021 on both methods (European Commission, 2021a). The rankings are not consistent for all indicators. Salo and Oulu score high for both indicators, Sofia scores the lowest. But the other regions show quite some variation. For example, West Midlands is low for life-long learning but at the top for innovative SMEs collaborating with others.

Table 4.3 Company-company knowledge spillovers (Normalised scores for public-private co-publications (2014-2021)) (European Commission, 2021a)

	Life-long learning	Innovative SMEs collaborating with others
Sofia	0.127	0.250
Dortmund	0.264	0.453
Duisburg	0.317	0.523
Basque Country	0.484	0.640
Noord-Brabant	0.659	0.613
Salo	0.994	1.000
Oulu	0.983	1.000
West Midlands (UK)	0.499	1.000

4.3 Knowledge spillover public stakeholders – companies

9. Examples of labour market measures to develop knowledge are rather limited in the case studies. An example is the specific measure directed at immigrants in Finland to work in high-tech companies. In Duisburg, the Employment Agency specialises, among other things, in the promotion of continuing vocational education and training and publishes an annual education target plan which shows which qualifications are currently important in the labour market. The city of Duisburg is currently trying to design the training basis for conversion to green steel, creating corresponding training offers.

10. Business support networks. The Finnish regions provide an interesting case for how business support networks help knowledge exchange. BusinessSalo and BusinessOulu were the lead public organisations that were driving the reaction of the regions to the downfall of Nokia. Oulu was more prepared for the downfall of Nokia: they had planned 'after Nokia' and shared this plan with all actors, even with Nokia. Nokia provided funding at the time and even the possibility to use patents for free. The two network organisations were significantly differently equipped to deal with what

would happen. BusinessOulu was three times the size of BusinessSalo, which gave them much more power to get things done.

The Basque Country builds on a set of Business Innovation Centres and other network partners to create an exchange of ideas. The industrial clusters (AFM, Mobility and Logistics) focus on setting up support systems to transfer knowledge, such as INVEMA that develops knowledge between companies and the technical centres for the machine tool cluster. Another strategy for cooperation and innovation is MUBIL, the innovative pole for smart mobility.

The Brainport organisation, together with Brainport Industry Campus, position themselves as main business support network for the Eindhoven region.

11. Funding opportunities, incubators: The Finnish case again shows how differently the two regions operated during and after the Nokia downfall. BusinessOulu and other partners were able to develop the Northern Start-up Fund and several incubators, not only on the remains of Nokia but also connected to the existing (remaining) business ecosystems as for Nokia Telecom (6G Flagship programme), Takama, the Technological Village and the Oulu Health Labs for the Oulu Medical system.

In the Basque Country, next to private venture capital, the public company *Sociedad gestora de entidades de capital riesgo* supports companies in the Machine Tool ecosystem with risk money.

4.4 Knowledge spillover: summary and outcomes

The IEEs are active in all three connections: education – companies; companies – companies; public sector – companies. How effective are these connections for the IEEs? The actual success of such spillovers can be deducted from several developments and achievements within ecosystems. The attention is specifically on three main indicators: the growth of high skilled personnel, the growth in R&D investment and the growth in innovative SMEs (start-ups and scale-ups). The RIS 2021 provides a list of 14 indicators that express this success. Our analysis shows for these indicators that we can suffice with four indicators to express innovative performance, at least for the eight regions in our analysis: R&D expenditures business sector; innovation expenditures per person employed; employment in innovative SMEs; and employment knowledge-intensive activities. Table 4.4 discusses these indicators.

Table 4.4 Overview and discussion of possible indicators to evaluate knowledge spillovers

European Commission, 2021a	Eurostat Regional indicators	Clarification
1a. Employment knowledge-intensive activities	1b. Growth in R&D personnel and in Scientists & engineers	This indicator says more about the quality of employment, a driver for R&D and scale-ups.
2a. R&D expenditures business sector	2b. Growth in R&D investment 2c. Growth in knowledge products: patents, co-publications	These indicators show to which degree the regions are developing new innovations and products.
3. Innovation expenditures per person employed		This is a weighting of the previous indicator.
4. Employment in innovative SMEs		This provides insight into scale-up options in a region. Here we understand if people see the opportunity to grow.

The RIS-information is normalised as not to allow precise information on a specific region. For this reason, we add several other indicators that the Regional Indicators cover from Eurostat. To see the impact of knowledge spillovers, we translate this Eurostat information into growth indexes for the period 2010-2020.

1a/b. Employment knowledge-intensive activities and growth in R&D personnel

Table 4.5 makes a comparison between three indicators: the employment in knowledge-intensive activities; the growth in R&D personnel (FTE) in the eight regions and in the business enterprise sector, calculated for the period 2010-2019 (unless otherwise stated and the Eurostat data on growth in employment in technology and knowledge-intensive sectors. Ranks have been calculated for all colons, but the data for Noord-Brabant is not complete.

Table 4.5 Employment knowledge-intensive activities (normalised scores; RSI, 2021 index growth in R&D personnel and researchers by sector of performance and NUTS 2 regions [rd_p_persreg]; and index growth in employment in technology and knowledge-intensive sectors by NUTS 2 regions (from 2008 onwards, NACE Rev. 2) [htec_emp_reg2] as a percentage of total employment in technology and knowledge-intensive sectors by NUTS 2 regions (from 2008 onwards, NACE Rev. 2) [htec_emp_reg2] (Eurostat, 2021) (rank: 1 = lowest in ranking)

	Employment knowledge-intensive activities	Rank	Total rank	Full-time R&D equivalent (FTE) - business enterprise sector	Period	Rank	Index growth in technology and knowledge-intensive sectors	Rank
Sofia	0.736	7	8	535	2010-2019	7	151	8
Dortmund	0.631	5	5	111	2011-2019	3	123	6
Duisburg	0.626	4	4	127	2011-2019	5	134	7
Basque Country	0.706	6	7	113	2010-2019	4	114	3
Noord-Brabant	0.676		6				98	1
Salo	0.580	2	2	82	2010-2019	1	121	4
Oulu	0.384	1	1	100	2010-2019	2	121	4
West Midlands	0.616	3	3	232	2010-2018	6	100	2

Interesting to see is that Sofia comes out quite high for the three indicators. The growth in R&D personnel (5x) and in employment in knowledge-intensive sectors (+51%) has been the strongest in Sofia. Salo and Oulu score the lowest ranks for the first two indicators and average for growth. Noord-Brabant and West Midlands show a stand-still in the growth of technology and knowledge-intensive employment. Certainly, for Noord-Brabant, this is a surprising result given the enormous employment growth we have seen for a leading company such as ASML. Probably this is counterbalanced by the decline of Philips-employment? The West Midlands region shows a strong growth in R&D personnel. In fact, for the observed period, the number of R&D personnel has nearly doubled. The two German and the Basque regions only show moderate growth of R&D personnel in this period. Salo experienced a strong decline in R&D personnel in the surveyed period. In Oulu, the total number of R&D FTE has remained quite stable. Where Salo shows a continuing decline over the period, Oulu is recovering after the closure of (parts of) Nokia.

Relative to total employment in the region (not in the table), Sofia has more than double the percentage of employment in technology and knowledge-intensive sectors compared to Noord-Brabant, and nearly three times as much as in Düsseldorf. The other regions have caught up with Noord-Brabant. However, the rank correlation between the scores is, low and not significant between the RSI and the Eurostat-data.

The Eurostat data give information on the development of scientists and engineers between 2010 and 2020. Table 4.6 shows the percentage of this group as a percentage of the population in the labour force. This figure allows comparing the regions. Again, the growth in scientists and engineers in the West Midlands and Sofia is striking. This growth is catch-up to the level of the other ecosystems. For Sofia, the figures show that they have caught up with their Western-European partners. For the West Midlands, it seems that the region had experienced some major lag in these professions in comparison to the other regions. Interesting is that there are figures for North-Brabant. Given the message that they have the smartest region in the world[17], this is not so much reflected by this table. Sofia is in the lead. The two Nokia-regions seem not to be too affected by the closure of the mobile technology units. The two German regions show very slow growth over the past decade, which is responsible for the considerable lag in scientists and engineers in 2020. This puts the future development of the region at risk.

Table 4.6 Index 2020 Scientist and engineers by category and NUTS 2 regions [hrst_st_rcat]

	Index 2020	Percentage of population in the labour force
Sofia	217	10,8
Dortmund	152	8,1
Duisburg	142	6,6
Basque Country	152	9,5
Noord-Brabant	190	10,7
Salo	187	10,6
Oulu	161	9,6
West Midlands*	273	10,0

*2010-2019

[17] https://www.ad.nl/binnenland/eindhoven-is-de-slimste-regio-ter-wereld~a8d7eb91/?referrer=https%3A%2F%2Fwww.google.com%2F&cb=2b59424a8c07e4abc2c0a23c1b7c0a23&auth_rd=1

2. R&D expenditures and investments

Table 4.7 shows three indicators. The first is the normalised score for the R&D expenditures in the business score, comparing the eight regions. The second indicator shows the growth of the intramural R&D expenditure from 2010 to 2019 (unless otherwise stated). The last indicator compares the growth in reference to the situation of Sofia in 2011. This last indicator gives an idea of how the regions compare.

Table 4.7 R&D expenditures in the business sector (RSI 2021) and the intramural R&D expenditure (GERD) by NUTS 2 regions [TGS00042] - GERD by sector of performance and NUTS 2 regions [rd_e_gerdreg] (euro per inhabitant) (1=lowest rank)

	R&D expenditures business sector	Rank	INDEX 2019 Business enterprise sector		Rank	INDEX Sofia 2011 Business enterprise sector		Rank
Sofia	0.287	1	277	2010-2019	7	248	BG2011-2019	1
Dortmund	0.549	4	124	2011-2019	4	1324	BG2011-2019	7
Duisburg	0.380	3	146	2011-2019	5	805	BG2011-2019	3
Basque Country	0.549	4	115	2010-2019	3	1067	BG2011-2019	5
Noord-Brabant	0.811	8						
Salo	0.362	2	73	2010-2019	1	836	BG2011-2019	4
Oulu	0.574	6	81	2010-2019	2	1170	BG2011-2019	6
West Midlands	0.621	7	191	2010-2018	6	648	BG2011-2018	2

The ranks of the three indicators are poorly correlated (r^s = 0,39; n.s.; r^s = -0,07; n.s.). Noord-Brabant shows the highest R&D expenditures for the business sector. Even the West Midlands does not come close to what this region is investing in R&D. Sofia shows the lowest investments, followed by Salo and Duisburg. The growth of the intramural R&D expenditure in the business sector is, however, the strongest in Sofia. They lag behind, but the region is investing more and more to catch up with the rest. It interesting is to see that Salo and Oulu have seen a decrease in R&D expenditures in this period, linked again to the decline of Nokia. Even so, Salo and Oulu still see a very high level of investment in comparison to Sofia. The highest investments are visible in the Düsseldorf region. It is unclear in which sector these investments are.

We didn't include separate figures for patent applications, mainly because these figures are very much correlated with the R&D expenditures in the business sector. Noord-Brabant is clearly an innovation leader, whereas Sofia is far behind in this effort.

3. Innovation expenditures per person employed

The previous figures can also be related to the number of persons employed in the regions. This additional information allows weighing the innovation efforts somewhat more.

Table 4.8 Innovation expenditures per person employed (European Commission, 2021a) (1=lowest rank)

	Innovation expenditures per person employed	Rank
Sofia	0.361	1
Dortmund	0.593	3
Duisburg	0.583	2
Basque Country	0.688	6
Noord-Brabant	0.610	5
Salo	0.604	4
Oulu	0.794	8
West Midlands	0.775	7

The table still shows that Sofia is behind the other regions. Here Oulu and West Midlands are clearly the leading innovators. As was indicated in the country report on the Finnish cases, the Oulu innovation wonder is also connected to the high innovation investments per person employed. WE only get out of it what we put into it, is the message.

4. Employment in innovative sectors and innovative SMEs

The next table shows the employment in innovative SMEs (RSI, 2021).

Table 4.9 Normalised score employment in innovative SMEs (European Commission, 2021a) (1=lowest rank)

	Employment in innovative SMEs	Rank
Sofia	0.302	1
Dortmund	0.916	7
Duisburg	0.941	8
Basque Country	0.473	2
Noord-Brabant	0.585	3
Salo	0.754	5
Oulu	0.743	4
West Midlands	0.759	6

Düsseldorf and Duisburg show high (normalised) scores for employment in innovative SMEs. They may experience declining figures in R&D personnel (Table 4.8), but future growth may be expected from these SMEs. Sofia shows the lowest figure for such employment, but also the Basque Country and North Brabant are not well placed in this table.

Overview of tables and figures

Tables

Figures