BEYOND 4.0

Frontrunner companies and the digital transformation: strategies to deliver inclusive economic growth

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Document description

The D8.1 report tackles changes, challenges, frontrunner companies and recommendations for inclusive company policies in the digital transformation. Based on thirty company case studies, it analyses the strategies of companies within entrepreneurial ecosystems. The report comprises four separate 'working papers' as chapters. Different types of analysis are applied, namely qualitative comparative analysis, comparative case study analysis, statistical analysis of survey data and secondary analysis of existing datafiles. The company cases reflect the situation in frontrunner companies in six countries dealing with digital transformation. Their situation gives an insight into the choices these companies make to manage technological change and its impacts. The introductory section provides the main research questions. The concluding section provides a discussion of the answers to the main debate about digital transformation and its impact on company policies and worker impacts. This study provides a unique perspective on how companies manage to survive the main challenges put forward to them.

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Abbreviations

BG = Bulgaria

DX = digital transformer

EE = entrepreneurial ecosystem

EEE = emerging entrepreneurial ecosystem

EEEs = emerging entrepreneurial ecosystems

ES = Spain

FI = Finland

fsQCA = fuzzy-set qualitative comparative analysis

GE = Germany

IEE = incumbent entrepreneurial ecosystem

IEEs = incumbent entrepreneurial ecosystems

MST = Modern Sociotechnical thinking

NL = the Netherlands

QCA = qualitative comparative analysis

SME = small and medium-sized enterprise

UK = United Kingdom

Executive summary

BEYOND the Technology Trap?

The H2020 ***BEYOND4.0*** project title indicates that we must go beyond the Industrie 4.0 technology perspective. On the one hand, there is talk of promising productive technology. Industry 4.0 technology would become autonomous, able to function independently of people and thus free companies from all kinds of human boundaries. On the other hand, the perspective implied that humans would become superfluous in companies implementing this technology. But despite digitalisation and the COVID-pandemic, we see a growth of jobs and a labour shortage in many industries. What is happening? How are organisations dealing with digitalisation? And what does it mean for growth, jobs, skills and inclusiveness?

Content of the report

The D8.1 report tackles changes, challenges, frontrunner companies and recommendations for inclusive company policies in the digital transformation. Based on thirty company case studies, it analyses the strategies of companies within entrepreneurial ecosystems. The report comprises four separate 'working papers' as chapters. Different types of analysis are applied: qualitative comparative analysis, comparative case study analysis, statistical analysis of survey data and secondary analysis of existing data files. Very different research materials have been collected over time: interviews, surveys, secondary material and workshops. The research material is also the result of a long process of going back and forth with a set of thirty companies in six countries. The company cases reflect the situation in frontrunner companies in six countries dealing with digital transformation. Their situation gives an insight into these companies' choices to manage technological change and its impacts. This study provides a unique perspective on how companies manage to survive the main challenges put forward to them. The fact that the COVID-19 crisis 'happened' on the way of this research made research very complicated but added separate insights into how companies and workers deal with digital transformation. The only major event this report does not cover is the Ukrainian war.

The report consists of four separate working papers.

Working paper 1 - Which company strategies do the companies follow within the entrepreneurial ecosystem context?

We analysed company strategies to understand how these companies position themselves within the general entrepreneurial ecosystem context and develop strategies to support their own economic growth and inclusive behaviours. The entrepreneurial ecosystem context was developed in the D4.1 report to understand how regions and companies deal with digital transformation, inclusiveness and innovation (Dhondt et al., 2022). Company strategies are analysed against the

background of the main features of the entrepreneurial ecosystem they operate in. How do companies evaluate the strengths and weaknesses of their separate ecosystem context in light of entrepreneurial opportunities?

BEYOND4.0 applies the entrepreneurial ecosystem model, which distinguishes ten elements: Formal institutions, Entrepreneurship culture, Physical and IT Infrastructure, Demand (for products/services), Finance/financing, Talent, (New) Knowledge, Services by Intermediaries, (Social) Networks and Leadership. The model predicts that the presence of these elements in a region can explain 'productive entrepreneurship' in terms of economic growth and inclusiveness (i.e., inclusive growth).

Companies quite strongly align with their ecosystem in terms of elements they regard as important for their own success. Many elements of an entrepreneurial ecosystem that are deemed important at the regional level by regional stakeholders are seen as important to companies at the company level. Roughly there is a 65% overlap between the regional and company level, and as far as there is a discrepancy between company and ecosystem, the company cases tend to evaluate the performance of the ecosystem on the ten elements more positively than the ecosystem does itself. Much agreement was there with regard to the physical and IT infrastructure, leadership and (new) knowledge, and more disagreement with regard to finance, demand, services by intermediaries and talent.

We investigated if companies used combinations of the ten elements to configure their company strategy in the search for economic growth (productive entrepreneurship). Using the technique of Qualitative Comparative Analysis (QCA), there proved to be four paths or combinations of elements that resulted in economic growth, which were labelled as institutional, independent, free rider and rebel. The *institutional* path accommodated companies that made well use of several of the elements of the entrepreneurial ecosystem model, showing some alignment between the two levels. In the *independent* path, another kind of strategy appeared, namely one in which companies showed to operate largely independent of the ten elements of the ecosystem. The *free rider* strategy seemed to indicate that companies use the ecosystem wherever they can but do not necessarily contribute to it. And lastly, the *rebel* type of strategy is used by companies which, to a certain extent, go their own way, more or less disconnected from what the regional ecosystem does. Of course, these paths are based on a limited number of cases, but they nonetheless offer useful patterns of understanding how companies operate in different ways, which all lead to economic growth.

Although the four paths differ in their combination of elements, and not all elements were necessary factors for success, four elements of the entrepreneurial ecosystem model were almost always important for the company strategies: the presence of *networks* (for collaboration), an *entrepreneurship culture*, availability of *talent* (on the labour market) and (new) *knowledge* as basic to innovation.

In an additional step, inclusiveness was analysed as a policy option for the companies. In each of the four configurations, certain inclusiveness policies were present, such as taking into account job security, learning opportunities, employee representation, and equality and diversity measures. There appeared to be a relationship between companies' economic growth strategies and their

inclusiveness policies. Overall, one can observe that larger companies more often have inclusiveness policies.

An analysis of contextual factors made clear that the four paths are not easy to pin down in a characteristic set of differences, such as type of ecosystem, position in the ecosystem, size, technology, and type of inclusive policies. There is much heterogeneity.

The main recommendation is that regional stakeholders, to strengthen their ecosystem, should consider supporting the development of networks, an entrepreneurship culture, availability of talent, and (new) knowledge. A combination of these elements is expected to enhance chances for economic growth and inclusiveness. Since companies can follow different strategies, this requires made-to-measure support at the company level and specific policies for start-ups, SMEs, larger organisations, and emergent and incumbent ecosystems. However, specific recipes could not be deduced from the information because of the heterogeneity. More company cases are needed for that purpose. Regions that want to improve equality, diversity and inclusiveness are advised to consider broad collaboration among institutions and companies as this requires a common effort. Alignment between company strategies and entrepreneurial ecosystems policies is, however, an interesting finding of this analysis. It opens the door for policymakers to guide companies toward new policies such as, for example, Industry 5.0.

Including more company cases in future QCA-research is expected to unfold more paths to economic success. Although we cannot generalise the findings simply to other populations of organisations elsewhere, the paths found are quite robust. Within the dataset, these are consistent results and relative given the explorative nature of the study.

Working paper 2 - What do companies do on the digital frontier?

The second analysis looked directly at the digital transformation of the companies and assessed which direction the companies have chosen to manage technology and its impact on company performance and skills. The focus was on policies and measures companies apply to realise their digital transformation. The impact of COVID-19 was examined as well.

The working paper focused on the same thirty cases on the digital frontier. There is no one strategy for dealing with digital technologies. *Four types of digital transformation* could be identified: 1. companies that have invested in nearly all technologies (the 'TOTAL (digital)-category); 2. companies that have invested in AI/Machine Learning as the main distinguishing trait; 3. companies that have invested in robotics, next to other technologies (ROBOTIC type); and 4. companies that have some digital technologies but have no AI/ML or robotics (LOW-USER type). The small size of LOW-USER companies mainly explains their situation. These small companies are confronted by a lot of barriers in digitising their operations.

Digitalisation's most important motives were improving quality and serving the customer better. To understand the impact of digital technologies, more understanding of the organisational practices is needed because these proved to be essential. *Organisational practices* are focused on delivering more internal training, less flexible contracting, and using specific training and monitoring methods to deal with the high demands of digital transformation. The cases did not see dealing with digital

transformation as an impossible hurdle to take. However, recruiting sufficient new talent was challenging in all cases. The information of the cases rejects the idea that digital technologies will lead to the unemployment of a great number of personnel. Technologies are far from 'autonomous' and require a lot of technical expertise and 'hands' to manage digital transformation.

The organisational practices differed significantly between the cases. Still, the high investment, high involvement model with thirteen cases stands out. The TOTAL type only shows high investment – high involvement practices, which suggest *an association between organisation and technology practice*.

All companies are dealing with upskilling impacts and the need to attract more talent. High involvement – high investment organisational practices mediate the relationship between technology and employment in different ways: it helps to make the companies more attractive in the labour market; the HR measures need to be optimal to recruit, select and retain talent; the current workforce needs to be motivated to work with the technologies and develop their expertise, and organisational measures are needed to create cross-over learning and redevelopment of the workforce in the case markets fall out. The main shift in employment is *further upskilling in technological and digital skills*. The cases did not show any polarisation in their skill structures.

The *COVID-19* pandemic is an important (unforeseen) event that allows us to assess how companies deal with technology and organisation. COVID-19 has initiated major technological and organisational changeovers, but they were a long-time coming. Companies did not implement those changes in the past, fearing several impacts such as productivity loss. The pandemic shows that more technological and organisational changes are possible. This requires different expectations among managers. The question is whether management will use this example to change technology and organisational practices broadly.

The cases only provide information from the comparison between the technology and organisational types. Future research should delve deeper into the company settings for such understanding. The complexity of managing thirty cases at the same time is demanding. In the future, the use of QCA - as in study 1 - may be helpful in refining the strategies the companies are using.

Working paper 3 - Workplace innovation analysis

The third analysis operationalised the concept of the 'high road' companies policies, looking at workplace innovation (WPI) practices in the companies. Companies were questioned on how they implement digital technologies and what this means for the tasks of employees, given the workplace innovation content.

The *organisational context* mediates the relationship between technology and work impact. Although this reality is not recognised in much research, the European Company Survey 2019 has revealed this relationship in European companies. This mediating role has not yet been sufficiently explored. In this study, our thirty cases performing at the digital frontier were examined about their organisational model, technology, decision context and handling of work impact. Companies with a

workplace innovation model ensure that the impact of digital technology on employees is channelled differently from companies that follow a model of low investment, low involvement.

The key question in this chapter is what the connection is between digitisation and organisational practices. Does a company that chooses to digitise benefit from WPI? The research focuses on thirty cases, half of which can be classified as WPI. The prevalence of digital technologies is high in all cases but highest in these WPI companies. It shows that 19 companies can be classified as digital transformers.

Digital technology is also used in low-low companies. In these cases, we see that digital technology is used as a management tool. Algorithms help to reduce the complexity of the work of the employees. The cases organise the work in such a way that a high turnover of personnel is taken into account ('organising for attrition'). The knowledge of the employees is in the technology itself. In other low-low cases, there is simply a lack of development strategy for the employees. There, the new employees must be immediately employable. The lack of a development strategy further limits the growth of this type of company at the outset.

Among the high-high type companies, we see more applications of digital transformation strategies. Although all companies, including the low-low companies, report staff shortages, it is clear that digital transformation strategies require a lot of new knowledge and skills. Most cases focus on the recruitment of academic, technically skilled staff, but this is not always the case. There are several companies with VET employees who survive on the digital front. All companies indicate that they have to source their talent from further and further afield.

However, recruiting on an academic level only is a specific choice of companies. It is not necessary to be successful. More important is the development perspective that the companies offer to existing and new staff, and that for all education levels. Only the low-low cases in our research employ unskilled or low-skilled staff, and they limit the training opportunities and development perspectives of this staff.

Especially in workplace innovation cases, there is no single strategy for the development of existing and new knowledge. The cases apply a broad set of measures. In the workplace innovation cases, it is striking that these high-high cases go to great lengths to map all the available knowledge to organise new development paths on the basis of this knowledge. An important organisational context here is that these organisations should not be overly hierarchical. The cases show teamwork and project-driven work as models.

Workplace innovation cases let employees play a role in shaping digital transformation. The fact that these cases identify employee resistance as an obstacle to transformation does not reduce digital transformation at all. The opinions of the employees are channelled into improvements in the organisations.

Digital transformation does not lead to reduced staffing requirements or even plans for staff reductions in any company. All companies need staff growth to keep up with demand. None of the companies sees digital transformation as a threat. On the contrary, they need this transformation to meet their customers' quality demands and wishes.

Organisational policies help companies get the most out of their employees: some do this better than others. The choice of measures, and thus the opportunities to make better use of technology, depends on the extent to which employees can participate.

The thirty cases remain a biased sample. Nevertheless, the material shows that not only technology but the organisational context must be included in understanding the effects at the employee level. In broad surveys, more attention should be paid to workplace innovation as a driver of digital transformation.

Working paper 4 - Working on the digital frontier

The fourth analysis changed the perspective from the company level to the worker on the digital frontier. A group of workers from a selection of thirty companies was surveyed to investigate their experiences with digital transformation. The objective was to assess to what degree the workers shared the management perspective on digital technologies.

The analysis shows that workers from four countries cluster into two groups. Both groups think differently from the Industry 4.0 perspective. The most important item for the employees is that they think they can handle the digital transformation but are not sufficiently involved in its development. The study assessed the perception of workers working in advanced manufacturing and software service companies that operate on the digital frontier. Workers were surveyed to obtain a picture of perceptions about their work situation and that of their colleagues and to understand better the relationship between digital transformation and its impact on work.

Workers at the digital frontier have strong confidence in their own technical competencies and in dealing with technological change. Despite surveying 52 workers from twelve different companies located in four different countries, there were no discernible differences in the opinions of workers by job type, company or country. Answers of these workers cluster into a *group of workers that stress collaboration at work and the development of non-technical skills*; and a *group of workers giving priority to technical skills and the development of these skills*. When comparing these two groups in how they think of their immediate colleagues, it can be seen that both groups saw themselves as having greater control over their work situation than their colleagues. They also considered themselves better skilled than their colleagues.

Both groups of workers only partially reflect the Industrie 4.0 imaginary of working on the digital frontier. The workers did not report being fearful about their own situation in the digital context, perhaps holding opinions that viewed their colleagues as at greater risk than themselves. An important observation was that almost two-fifths (40%) of these technical specialists viewed technological change as given, perceiving limited capacity for them to drive or influence technological change in their companies. This suggests that the ideas of this group about technology or organisation are not taken into consideration by their senior management teams. This points to a potential problem whereby senior managers show reluctance in letting their leading technology specialists participate in this progress. Such participation is helpful for successful innovation, as shown by companies with workplace innovation practices.

Although the study did not capture all aspects of the work situation, knowledge development, participation, and job security are important aspects of the work. These workers still showed a preference for traditional employment relationships, being less open to occupational or firm mobility during their careers. The sociotechnical imaginary that workers at the digital frontier have about work, still reflects traditional values important for work: technical skills, collaboration, further education and training in the company context, a long-term perspective in the company context, and no fear of engaging with technology. However, their imaginary also reflects the limited power they experience at work. The conflict with management is present in this thinking.

General take-away of the studies

How one can shrug off the Industrie4.0 Technology Trap is the crucial question that remains. Frey (2019) indicates that the omens for employees' dealings with technology are not positive. If the technology takes its course, he expects mass unemployment and further erosion of employees' future prospects. However, the company cases show that none expect large-scale employment loss. An erosion of middle-level jobs is not visible in our cases. On the contrary, in many ways, companies are dealing with skill shortages and investing in bringing all employees up to a higher standard. Of course, the thirty cases are a biased sample but reflect the situation of companies at the digital frontier.

The technology, as seen in the thirty cases, is one of steady progression, with the continuous development of new tasks and jobs. Half of the personnel in the four TOTAL companies consists of R&D personnel. That percentage of R&D personnel also appears to be growing steadily. This indicates how difficult it is for these companies to innovate. The cost of R&D also appears difficult to control. The situation is that companies need more and more technology, are moving more and more towards software, and therefore need to develop their staff strongly. Employees feel that they should be more involved with what is happening at work. This is not a general dissatisfaction with technology and certainly not one that leads to a decision to put the brakes on technology innovation, a kind of neo-Luddism, as Frey (2019) fears.

On the contrary, more work needs to be done to create a perspective in which employees gain insight into their roles and autonomy. Employees want that autonomy and a future perspective. Ten years of Industrie 4.0 in the industry has not led to the expected productivity increase. Further productivity improvement is needed in all sectors and requires the input of qualified employees. The interdependence of innovation and human-centred technology is our way to escape from the Industrie4.0 Technology Trap.

1. Introduction

1.1 The 'technology trap' and case studies

The *BEYOND4.0* project aims to help deliver an inclusive European future by examining the impact of the new technologies on the future of jobs, business models and welfare. To achieve this aim, an understanding is needed of what companies and workers do that are dealing with the digital transformation. The *BEYOND4.0* project designed a specific work package to conduct several investigations into what companies leading in the digital transformation ('frontrunner companies') are doing and what their practices mean for their workers (Chris Warhurst et al., 2020). The results of these studies are included in this report. This D8.1 report tackles changes and challenges of frontrunner companies in digital transformation and develops recommendations for inclusive company policies. Thirty company case studies are used to analyse strategies of companies within entrepreneurial ecosystems. In six countries, incumbent and emergent entrepreneurial ecosystems were investigated (Report D4.1, (Dhondt et al., 2022)) and within each of these twelve ecosystems, company case studies were carried out. Interviews and surveys were collected from both employees, engineers, OSH staff, employee representatives and (HR-/ Operational)managers. This data was analysed with Qualitative Comparative Analysis (QCA) and other qualitative research methods to identify dominant business strategies and company behaviours. Observational studies at the workplace were planned but had to be cancelled because of the COVID-19 pandemic. The pandemic added an extra dimension to the research. It provided an opportunity to understand critical decision-making around new technologies in a difficult company environment.

This report provides several working papers that will be submitted to scientific journals or books. Data was collected from thirty company cases. Our task in the study of the regional level (WP4) was to examine the changes that Industrie 4.0[1] technologies will have on the nature and organisation of industries, on the nature and markets of products, and consequently on the impact of the configuration and dynamics of regions, in terms of entrepreneurial ecosystem dynamics. In fact, these technologies are expected to drive a system change that will define new forms of division of labour and inclusiveness, and new socio-economic spaces at the global, national and regional levels (Perez & Murray Leach, 2021). There is a pressing need therefore to analyse how regions, places and cities are positioned with respect to this change given their background, and how they might be able to respond given their historical and socio-economic identity (De Propris & Bellandi, 2021). There is a fear that the technological transition will be painful and disruptive on different levels, namely that this will be a truly destructive creation process which will see 'winners' and 'losers' on the labour market (Frey & Osborne, 2017). Technological transformation will engender that much resentment among workers and population that a technology trap may be expected. Frey (2019) sees a Luddite-type of resistance against Industrie 4.0 technologies that new innovation may be blocked for the future. Automation hollows out the middle-skill jobs and is again labour-replacing.

[1] The German spelling "Industrie 4.0" (Industry 4.0) stems from a national strategic initiative from the German government through the Ministry of Education and Research (BMBF) and the Ministry for Economic Affairs and Energy (BMWI). It aims to drive digital manufacturing forward by increasing digitalisation and the interconnection of products, value chains and business models. It also aims to support research, the networking of industry partners and standardization (European Commission. DG Internal Market, Industry, 2017).

Workers resist these changes and are drawing governmental responses which threaten to restrict the development and diffusion of technology. These neo-Luddite fears may lead to the 'technology trap', a situation which existed prior to the Industrial Revolution, 'in which labour-replacing technology was consistently and vigorously resisted for fear of its destabilizing force' (Frey, 2019, p.xiii). Policies are needed to address the situation of those made unemployed by labour-displacing technology. Therefore, there is a clear need to understand more deeply how companies and workers deal with Industrie 4.0 technologies. The company is therefore the right level for research.

WP8 provides this analysis. We are now looking at the company level, for which leading companies were selected from each of the ecosystems analysed in WP4. Selecting 'frontrunner companies' - both large incumbents and young high-growth start-ups/scale-ups - in technology and performance helps us to understand the possible development horizon for other companies. For each of the six countries we selected five companies, divided from the incumbent and emergent ecosystem. These companies can be qualified as vanguards on the digital frontier.

The analysis has been conducted with four separate studies. These studies are included in four working papers which will be used as the basis for journal applications, book chapters or conference proceedings. The studies are complementary to each other, with some overlap on the issues.

1.2 Four working papers

The working papers enlighten four aspects of how frontrunner companies succeed both economically and in terms of inclusiveness:

1. Which company strategies do the companies follow within the ecosystem context?

The companies have been selected from leading European entrepreneurial ecosystems. Little is known about how companies themselves position themselves within these contexts. The general assumption is that, within these companies, we may assume like-wise behaviour. We carry out an analysis of company strategies to understand how these companies position themselves within the general ecosystem context, develop strategies to support their own economic growth and inclusive behaviours. Company strategies are analysed against the background of the main features of the entrepreneurial ecosystem they operate in. How do companies evaluate the strengths and weaknesses of their ecosystem context in light of entrepreneurial opportunities? Can clusters of approaches towards the ecosystem context be identified that support companies' growth and inclusiveness strategies.

The activities for this analysis is:

- Investigate which of the elements of the entrepreneurial ecosystem are of main importance to the companies;
- Investigate which strategies and initiatives the companies try to implement for training, skills, regarding OSH (including job requirements, control options, human factors);

- Investigate the expectations of the companies for the near and far future and what they believe to be the driving and obstructing factors for becoming an inclusive economic policy.

2. What do companies do on the digital frontier?

The second analysis looks directly at the digital transformation of the companies and tries to assess which direction the companies have chosen to manage technology and its impact on company performance and skills. The focus is on policies and measures companies apply to realise their digital transformation. The impact of COVID-19 is examined as well. The main activities in this working paper are:

- Identify the core elements of the technological lead, on a European and global scale;
- Identify strategies on skill development, quality of work and work organisation;
- Identify implications of technological development on work, work organisation and OSH.

3. Workplace innovation analysis

The third analysis operationalises the concept of the 'high road' companies policies, looking at workplace innovation practices in the companies. Companies are questioned on how they implement digital technologies and what this means for the tasks of employees, given the workplace innovation content.

The central activity is:

- To investigate which social relations are present in the companies (power relations between employers and trade unions), composition of staff (gender ratio, age groups, education levels).

4. Working on the digital frontier

The fourth analysis changes the perspective from the company level to the worker on the digital frontier. A group of workers from a selection of the 30 companies was surveyed to investigate their experiences with the digital transformation. The objective was to assess to what degree the workers shared the management perspective on digital technologies.

The central activity is:

- To explore how workers at the digital frontier experience the digitalisation of work and which role they play in the process of digital transformation.

The data of the case studies allow even more studies to be conducted. After submitting this overall report, follow-up papers will be developed on specific issues that could not be taken up in these four studies. The following topics will be considered in spin-off papers and the D8.2 Toolbook:

- The financial strategies of the companies and the impacts on employment relations.
- Power relations between employers and trade unions.

1.3 Company cases and methodology

The core of WP8 is to carry out company case studies in thirty companies, and in each of those cases to gather information from management and workers.

1.3.1 Company cases

This study used a case study approach to understand the technological and organisational situation in the companies. The qualitative approach is exemplified by trying to reduce the different situations in the thirty companies to a limited set of types of technological and organisational practices.

We conducted in-depth qualitative research into 'incumbent' and 'emerging' ecosystems in six countries: Bulgaria, Finland, Germany, the Netherlands, Spain and the United Kingdom (Dhondt et al., 2022). Each of the six research teams selected cases from the (incumbent and emerging) ecosystems. In discussion with the stakeholders in each of the ecosystems, example companies were identified and selected. Stakeholders looked for companies that represented leading technological and organisational practices. They selected 'core companies' in the ecosystems and suppliers or customers to these core companies. A total of thirty companies were included in the study. Not all companies provided all the information we needed for the study. Table 1 shows the main descriptives for these companies. Two pagers of these case studies are included in Annexe 3.

Table 1. Descriptives for the thirty cases

		Number of cases
Country	Bulgaria	5
	Finland	5
	Germany	5
	The Netherlands	5
	Spain	5
	United Kingdom	5
Size	Large (> 250 -15000 employees)	14
	SME (> 30 – 250 employees)	8
	Start-up, small (< 30 employees)	6
	Missing	2
Date of establishment	<1899	2
	1900 -1999	14
	2000 - 2009	8
	2010+	5
	Missing	1
Main sector	Advanced manufacturing	12
	Software, digital health	15
	Logistics and maintenance	3

Half of the cases (18) belong to major corporations with multiple locations around the world. We limited the investigation to one geographical location of such major corporations. Interviews and surveys were conducted in each of these companies. Managers and employees needed to describe the situation for this location. Employee representatives assessed the possibilities for employee voice. The companies had very different historical backgrounds, which allowed us to understand different kinds of reactions to external changes. Sixteen companies have a long history; the others were younger than twenty years. The sectors show that the cases allow to reflect the situation in Industrie 4.0-type of companies (advanced manufacturing), and digitalisation from the perspective of software producers and users.

The sample enabled us to describe the level of digitalisation in the companies. Managers and employees (and their representatives) were asked to reflect on their company's motives to implement digital technologies and the barriers to their implementation. Because the core companies were selected as advanced in the six countries, the answers are biased towards digital 'survivors' and 'winners'. However, the start-ups were in the first phases of their development and may ultimately still fail. The database is thus quite heterogeneous and selective at the same time. To allow us to understand how the cases perform, for some of the comparisons we used external comparative sources: we used the FLASH-Eurobarometer (European Commission, 2021) and the results from the European Company Survey 2019 (Eurofound & Cedefop, 2020a).

As part of the ethical approval process (see the Data Management Plan, Greenan et al. (2019)), all companies and interviewees have been promised that they remain anonymous and unidentifiable (unless desired otherwise). Company summaries and survey material are available on the TNO-servers but all data have been anonymised.

1.3.2 Methods

Each of the four studies used different methods that will be described separately in the corresponding chapters. However, the general point of departure to approach the companies and gather and process the data are the following *BEYOND4.0* documents:

- D1.1. Quality Assurance Plan (and updates);
- D2.1 Guidance paper on key concepts, issues and developments. Conceptual framework guide and working paper[2];
- D3.1 Data Management Plan (and updates).

An interview guide[3] was developed to carry out interviews with company representatives (top- or operational management, HR management). The topics dealt with how the companies are performing within the entrepreneurial ecosystem. The role and significance of the ten elements of the entrepreneurial ecosystem for the company's performance and inclusiveness were assessed[4]. A protocol was followed to protect the privacy of participants and to achieve and store data in accordance with the GDPR and the data management guidelines of *BEYOND4.0*[5]. For each company case study the researchers of the six teams produced a confidential company case study report, based on the interview data and any documents shared by the organisation (such as annual reports, HR policies, strategies, websites etc.). The researchers provided thirty public two-pagers of each company case, which are added to this report as Annexe 3. Short interview reports (confidential and anonymous) are stored in the project's database (according to the guideline of the Data Management Plan, Greenan et al.(2019)).

1.4 Outline of the report

As indicated, this report contains chapters with separate working papers. The working papers can be read as stand-alone results from the project. In the last Chapter, a cross-sectional analysis is provided, pointing out the core results of the research.

Chapter 2 presents the results of the QCA analysis that unfolds the company strategies (study 1). Chapter 3 includes the results of the digital transformation analysis (study 2). Chapter 4 provides the results of the workplace innovation analysis (study 3). Chapter 5 deals with the experiences of workers at the digital frontier (study 4). Chapter 6 discusses the main results and formulates

[2] https://www.beyond4-0.eu/storage/publications/ D2.1%20Guidance%20paper%20on%20key%20%20concepts-,%20issues%20and%20developments/BEY4.0_WP02_D2-1-Guidance_paper_FINAL_v2_revision_20200621.pdf

[3] Oeij, P., van der Zee, F., Dhondt, S., and E. Pomares (October 2020). Interview Guide WP4-WP8. (Version 3.0). Informal document BEYOND4.0.

[4] Based on the document Oeij, P., van der Zee, F. and V. Kirov (December 2019). Research Note WP4-WP8. (version 1.0). Informal document BEYOND4.0

[5] Oeij, P., van der Zee, F., Pomares, E. & A. Unceta (January 2020). Research & Workshops Protocol WP4-WP8 (version 1.0). Informal document BEYOND4.0. See also: Greenan et al (2019) for BEYOND4.0's Data Management Plan (D3.1 – CNAM & TNO).

conclusions and recommendations. From the separate analyses, company strategies which stimulate leading economic and social performance in the EU- context are deducted, and conditions to improve performance are identified.

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2. Study 1: How do companies act within their ecosystems?

Peter Oeij, Gerben Hulsegge, Steven Dhondt with Vassil Kirov, Egoitz Pomares, Sally-Anne Barnes, Adrian Götting, Clara Behrend, Olli Kangas, Esa Karonen, Michael Kohlgrüber, Bagryan Malamin, Alfonso Unceta, Sally Wright, Gabriela Yordanova and Erika Kispeter

2.1 Introduction

The *BEYOND4.0* report on 'entrepreneurial ecosystems' (D4.1; (Dhondt et al., 2022)) showed that regions deal with digital transformation in different ways. Regions choose specific strategies to stimulate the digital economic growth of their companies and inclusiveness of the (working) population. These strategies should support businesses and enterprises in their region to flourish. However, the assumption that enterprises pick up on ecosystem policies is not really a focus in entrepreneurial ecosystem research. Much literature on entrepreneurship deals with the traits and behaviours of individual entrepreneurs or ventures, and most literature on entrepreneurial ecosystems investigates the contextual factors of entrepreneurial activity and how entrepreneurial regions evolve (Haarhaus, 2022). Most ecosystem research leaves out the company perspective.

An overlooked issue is how companies see themselves functioning within an ecosystem and what they understand as important elements of ecosystems to support them in undertaking their business. What do companies do with their entrepreneurial ecosystem context? How do they operate as, for instance, the core company or a satellite company in the ecosystem, and does this position influence how they experience their role and the usefulness of the ecosystem (Ma & Hou, 2021)? These questions are even more relevant now as these ecosystems try to develop policies to deal with and stimulate digital transformation or for other core issues such as more inclusiveness. This working paper tries to contribute to fill that gap partly.

In understanding entrepreneurial ecosystem structure, current literature has been criticised for focusing too much on the key components of entrepreneurial ecosystems, ignoring the combinations of elements that foster sustainable entrepreneurial activity in regions (Alvedalen & Boschma, 2017; Malecki, 2018). Moreover, research tended to describe entrepreneurial ecosystems as being composed of completely or partially disconnected elements and as characterised by causal or linear interactions among agents, while in fact, entrepreneurial ecosystems "emerge from nonlinear and dynamic combinations of sets of variables" (Roundy et al., 2018, p. 7). Thus, there is a growing need for research to investigate the complex interactions among the system's elements to provide insights into the facilitating mechanisms and emergent processes of entrepreneurial ecosystems (Haarhaus, 2022; Stam, 2015). Whilst this criticism is addressed to the level of ecosystems, the complexity and nonlinearity also apply to company behaviour. This company level is the focus of our study.

This working paper zooms in on what companies do in two ways. First, how do companies operate within these ecosystem strategies? Can we identify separate organisational strategies with these companies to get the most out of these entrepreneurial ecosystem strategies? Is the applied entrepreneurial ecosystem framework of the ten elements to assess these ecosystems (Stam, 2015) helpful for these purposes? Which of those elements are crucial in the company behaviour with the ecosystems? These questions focus on the relationship between the separate company and the regional ecosystem strategy. While companies may have unique strategies, the second analysis looks at how these strategies are the same across more ecosystems. Comparing the behaviour of companies within these ecosystems helps to identify specific elements that are crucial to support ecosystem strategies. Certain combinations of elements, which constitute a particular company strategy, may appear across regions.

The approach followed in this paper is to use direct comparisons of company actions to develop answers to the formulated questions. Qualitative comparative analysis (QCA) allows us to discover such variating patterns. QCA delivers the answer, which patterns can be identified. It provides us with qualifications for company strategies that can then be related to economic growth strategies. In a subsequent step, we analyse whether patterns vary in their inclusive policies.

The structure of this chapter is as follows. After developing a new approach to analysing the relationship between the entrepreneurial ecosystem environment and the company level, the methodology used, and the data, we present the results of three analyses. First, we assess whether there is a difference between how the ten ecosystem elements were evaluated at the regional and company levels. Do companies align with regional strategies for economic growth, or do they choose their way? Can we explain the reasons for following the ecosystem? In the second place, we investigate patterns of company strategies across the twelve different ecosystems. Which combination of elements is seen as important for economic success by the companies? Finally, we inspect the inclusiveness policies that are connected to the different company strategies. Is there a difference if one compares company strategies in terms of inclusive personnel policies and company behaviour? The chapter closes with conclusions, discussion and recommendations.

2.2 Research model and question: the company perspective

2.2.1 Starting at the ecosystem level

BEYOND4.0 applies the entrepreneurial ecosystem model to describe and analyse the economic performance of regions (Dhondt et al., 2022). Stam (2015) uses a neo-Schumpeterian perspective on economic growth in which entrepreneurial activity relates to the capability of a region to improve entrepreneurial behaviour. He sees ten elements as crucial to describe the working of such entrepreneurial ecosystems (see Stam, 2015)[6] (see Figure 1). First, the model distinguishes institutional arrangements and resource endowments that could explain different results in

[6] Oeij, P., van der Zee, F. and Kirov, V. (December 2019), *Research Note WP4-WP8. General document*. Associated Work Package: WP4 and WP8; Informal Working Document 1. Leiden: BEYOND4.0. Based on: Stam, E. (2015), Entrepreneurial Ecosystems and Regional Policy: A Sympathetic Critique. *European Planning Studies 23*(9): 1759-1769.

productive entrepreneurship between ecosystems. The use and development of resources are very much guided by how partnerships within ecosystems can support new entrepreneurial activity. This model of entrepreneurial ecosystems is used in *BEYOND4.0* because a singular focus on technology does not explain regions' economic development and repositioning. Digitalisation may influence development but needs to be understood from the broader working of an ecosystem.

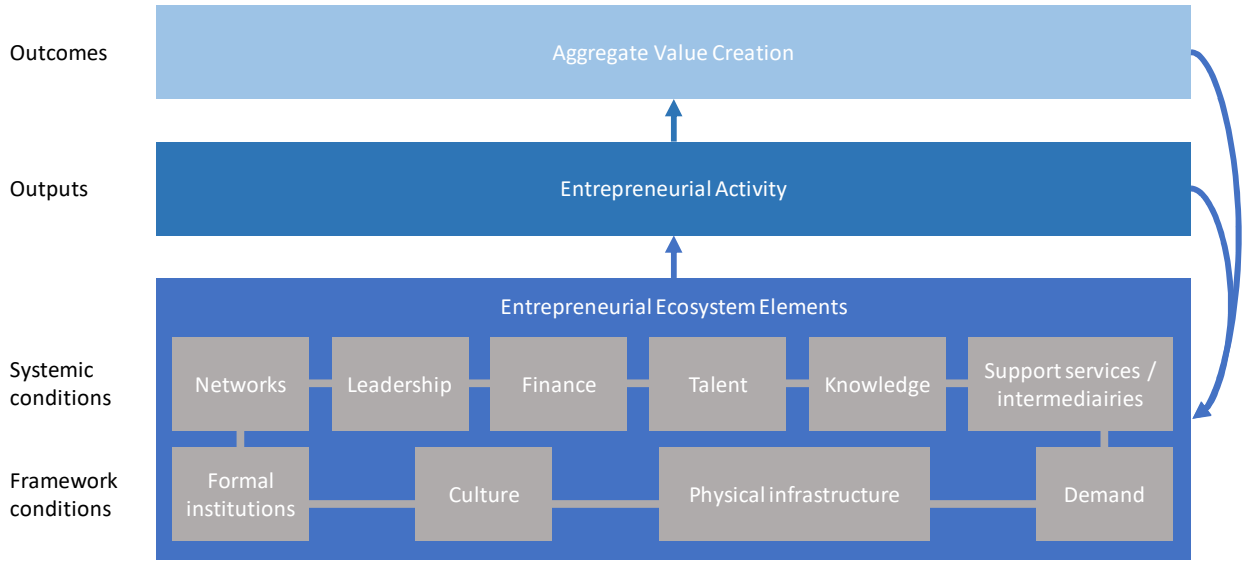

Figure 1. Entrepreneurial Ecosystem model (Stam, 2015)

2.2.2 Relating the ecosystem to the company level

The main question for this working paper is how companies relate to the entrepreneurial ecosystem context. As indicated in the introduction, this relationship is visible in two ways at the company: first, in the perception of what the entrepreneurial ecosystem elements mean for the company, and, secondly, in how the company translates its perception into strategies to achieve more entrepreneurial and inclusive outcomes. In Figure 2, these relationships are visualised.

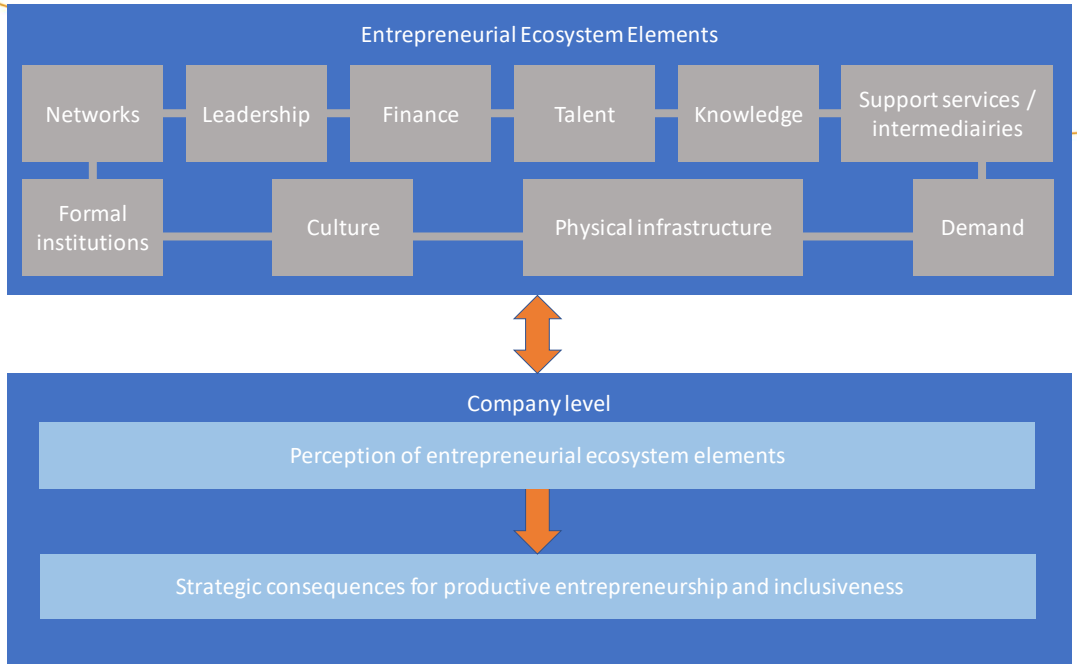

Figure 2. The impact of the Entrepreneurial Ecosystem model at the company level

As indicated, how the entrepreneurial ecosystem is interpreted at the company level is very much a black box in the literature. This working paper provides a first approach to the topic. The research model allows specifying more clearly what we are looking for. This means that this study is explorative in nature.

The model depicts that companies need to understand what is happening at the ecosystem level. This perception will be different between companies. The ecosystem channels a part of the environmental demands to the companies. If ecosystems achieve their productive and inclusive results, then this should be reflected in the perspectives and strategies of the separate companies acting in these ecosystems. The entrepreneurial ecosystem that *BEYOND4.0* applies as a framework – which is described further on - distinguishes ten elements that may explain economic success for a region. Of course, regional strategies and organisational strategies are not of a similar level. Yet, it remains relevant for policymaking to understand which elements that are present or less developed in a region are seen as crucial at the level of companies. In the *BEYOND4.0* perspective, a part of the market uncertainty at the company level is taken away by the ecosystem. For example, if the talent topic is taken care of at the ecosystem level, then this reduces the need for the separate companies to develop their own actions. They can focus more on their performance or inclusive priorities if they see this need. Table 2 provides a description of the ten elements of the entrepreneurial ecosystem model, together with a definition of productive entrepreneurship and inclusive outcomes.

Table 2. Description of the elements of the entrepreneurial ecosystem model for the ecosystem and company

Elements	Ecosystem	Company
Formal institutions	Rules and regulations; enable voice for entrepreneurs; tax regime. Regional-specific elements	Avoiding/overcoming restrictions; having a voice, knowing how to deal with rules and regulations
Entrepreneurship culture	Entrepreneurial activities, start-ups, accelerators, risk-taking culture	Entre/intrapreneurial behaviour, openness to renewal; technology acceptance and innovation adoption; absorptive capacity
Physical infrastructure	Transport/mobility, digital infra, accessibility, educational institutions	Accessibility. Intra-company investment in equipment/machinery; digital platform; IoT
Demand	Regional demand and purchasing power	Regional demand and purchasing power
Finance	Investors, banks, venture capital/angel investors, governmental support for innovation	Own capital/private equity, liquidity, financial independence
Talent	Labour market, enough labour supply, (interregional) labour mobility, skill development	Skills, labour supply and demand; attractiveness as an employer
New Knowledge	Innovative sector; investments in R&D and new knowledge	Innovative company; investments in renewal, esp. in intangibles related to (big) data, AI
Intermediaries	Institutions, supporting and business services for the sector	Business service providers
Networks	Partnerships, co-innovation / co-creation / open innovation in the sector	Access to innovation partners, universities and RTOs, knowledge, willingness to cooperate
Leadership	Vision, technological entrepreneurs present, ecosystem strength compared to other competing ecosystems	(Thought) Leadership in terms of digital renewal (use of platforms, AI, big data), i.e. innovation leadership; leadership in growth rates
Productive entrepreneurship (output)	Economic growth generated by the ecosystem; income and wealth, employment and their growth; 'high road strategy'	Profitability, value-added, labour income, employment; 'good jobs'; gender, minority, hiring of workers with a disability, etc.; number of spin-offs and spin-outs; 'high road strategy'
Inclusiveness	Social cohesion, support for vulnerable labour market groups, generating jobs; 'high road strategy'	Social employership / entrepreneurship, technology vision of employee augmentation instead of employee replacement; 'high road strategy'

The table translates what the ecosystem variables mean at the company level. This table was used during the interviews to explain to interviewees how stakeholders at the entrepreneurial ecosystem level look at these dimensions. The benefits of using the entrepreneurial ecosystem model were that it helped to frame the performance of the companies in their region, given the digital transformation, and it allowed a focus on the formulation of weak and strong points, both in the companies and in the regional support system. The same elements are included in the QCA questionnaire, which the researchers completed.

2.2.3 Performance in economic and inclusive terms

The entrepreneurial ecosystem model has been developed to assess to what degree regions are able to stimulate entrepreneurial activity (Schrijvers et al., 2022). Entrepreneurial activity is usually measured as the number of start-ups within a region or as the number of unicorns that have risen from the activity in a region. The perspective of creative destruction is mainly translated as the creation of a new enterprise. At the company level, the entrepreneurial perspective is somewhat

complicated. For this working paper, entrepreneurial activity has been limited to the company's actual performance in terms of employee growth and profit rate. The question is if this attention to the ecosystem level is supportive of improving their performance. This performance has been assessed as actual economic performance but also as performance in terms of inclusiveness. Do companies see these ten elements of the ecosystem in which they function as crucial for their own economic success? Subsequently, we are interested in assessing the policy of inclusiveness at the company level. By inclusiveness, we mean personnel policies, measures or practices that contribute to the labour participation of existing or new employees. For instance, the proportion of female workers and migrants, job security by fixed contracts, the opportunities for learning, training and education, the presence of a works council and options for employee shares. The assumption is that companies that consciously take the situation of employees into account in terms of learning opportunities, equality and good jobs follow a 'high road strategy', whereas companies that perform poorly in terms of job and income security feature a 'low road strategy' (compare Osterman, 2018).

2.2.4 Operationalisation of the research question

The follow-up question is if a pattern can be identified between the companies and if this pattern reflects national or other differences. Which factors can explain the strategies followed by the companies? Can we identify the institutional differences between the six countries playing a role in explaining strategic choices? Or are differences between the companies explained by other factors such as company size, start-up or network position (i.e. core or satellite company)?

The central research questions in this chapter are:

- What do companies consider important elements in the entrepreneurial ecosystem environment to support their strategy? How does this compare to the actual ecosystem evaluation (see D4.1 report)?
- What do they need from an ecosystem to be successful? How do companies evaluate the presence or absence of specific elements? Can we discover patterns of company strategies to deal with assuring stronger economic performance (economic growth)?
- Can we explain why these strategies are followed or chosen?
- Do companies with a certain strategy develop measures of inclusiveness, and which type, of measures?
- What are the recommendations for stakeholders at the level of companies and regions in dealing with the digital transformation based on the found company strategies?

2.3 Methodology

2.3.1 Qualitative analysis

The basic approach to the research question is comparing the companies' answers. The comparisons are between the companies, the countries, the type of ecosystem and other country characteristics. Several of the variables used in the comparison have been constructed in the working papers included in this report. We will refer to these papers. To clarify certain answers, actual descriptions from the case study reports are used.

2.3.2 The QCA application as a technique of analysis

For the analysis of company strategy, QCA is used as a technique of analysis.

The research model positions two types of performance as outcomes of interest for company behaviour. The objective is to identify several conditions (using the ten elements of the entrepreneurial ecosystem model) to predict these outcomes. Which of the combinations of the conditions lead to the required outcomes? A technique particularly suited to such an analysis is QCA (Ragin, 2008). The importance of QCA is in the first part of this section. Next, the measures and data are explained. With QCA, we assess the outcome of economic growth. The outcome of inclusiveness is carried out qualitatively by comparing the patterns (combinations of the conditions), and groups of companies that are a member of each pattern.

QCA is more and more used in entrepreneurial ecosystem research to identify which conditions are necessary to identify better-performing ecosystems (Roundy et al., 2018). Schrijvers (Schrijvers et al., 2022) used the ***BEYOND4.0*** data to classify the entrepreneurial ecosystems at the EU level. Entrepreneurial ecosystems are complex in the sense that many variables determine how these systems evolve and function. Entrepreneurial ecosystems are perceived as combinations of interconnected organisations, institutions, actors and actions which are arranged in such a way that they facilitate and perpetuate entrepreneurial activity within regional environments (Haarhaus, 2022). Regression analyses cannot explain why ecosystems can be rather different and yet successful at the same time, as they produce linear solutions (single model). To get a better grip on the variability of successful ecosystems, which may differ in nature, we apply another technique to study ecosystems, namely a set-theoretic approach that allows for detecting more than one model in the data, namely different patterns. Set-theoretic methods aim to identify configurations of attributes that are associated with membership in one or more outcome conditions (Täuscher, 2018). The set-theoretic technique applied here is called qualitative comparative analysis (QCA) and examines different combinations of elements of an ecosystem that can all lead to a desired outcome, such as economic growth. As they say, there is ‘no single road to Rome’, and neither a ‘one-best way of organising’. QCA enables the analysis of multiple cases in complex situations. It can help explain why change happens in some cases but not others.

However, the cited analyses are at the ecosystem level. For this working paper, the focus is at the company level, with a perspective at the ecosystem level. The goal is to identify how this higher level permeates the company's lower level. And, do strategies of companies cluster in specific sets

of actions (i.e. how they value the ten elements of the entrepreneurial ecosystem model)? QCA is designed for use with an intermediate number of cases, typically between 10 and 50. It can be used in situations where there are too few cases to apply conventional statistical analysis. The thirty company cases are all investigated to understand the importance of the ten elements of the entrepreneurial ecosystem model for them. All companies are selected because they are at the frontiers of digitalisation. The analysis will unfold different patterns of ecosystem elements that lead to economic growth and can therefore be regarded as different company strategies for how to engage with their ecosystem in their strive for success.

QCA is largely regarded as a comparative, case-oriented approach and aims to capture the complexity of a case while providing a certain level of generalisability (Legewie, 2013; Rihoux & Ragin, 2008). QCA enables the researcher to examine the complex causal relationships within each case and thus uncover its underlying patterns or configurations. The software programme of fuzzy-set QCA (fsQCA) was applied (Rihoux & Ragin, 2008) instead of multiple regression analyses because the latter method is inadequate for capturing equifinal configurations common in asymmetric and non-linear data sets. Moreover, the number of cases was too low to include many variables in the regression. The fsQCA method allows for multiple combinations of variables to produce the same outcome; using fsQCA to analyse data sets that are asymmetrical and non-linear was preferable in our situation (Herrera, 2016; Woodside, 2013). It was expected that different combinations of variables of the entrepreneurial ecosystem model could result in economic growth and inclusive policies.

To conduct the QCA, a questionnaire was developed, and the data collection was supported by desk research.

- QCA questionnaire: Part of the Interview Guide is a short questionnaire for the researchers to assess the significance of the ten elements of the entrepreneurial ecosystem model (Stam, 2015; Stam & van de Ven, 2019) for the outputs/outcomes (i.e. economic growth and inclusiveness) of each studied company case. Each partner reassessed their findings from an expert view perspective (namely: their own expertise), on the basis of ten questions, for example [see 'Interview Guide'], with regard to one of those ten variables, namely 'infrastructure'. *BEYOND4.0* partners completed this for the five companies studied. The researchers had extensive knowledge about these five companies as case study (online) interviews with management and workers (where possible) were done, and websites and company documents were studied. For the QCA analysis TNO collected data from the partners (a dedicated short survey was part of the Interview Guide to be completed by the researchers)

Example of a question in the QCA-questionnaire:

Is the presence of a well-developed infrastructure a crucial factor for the successful digital transformation in this region?

Answering categories: 1=on the contrary, such an infrastructure should be absent; 2=no such an infrastructure is it not crucial at all; 3= it does not matter whether such an infrastructure is absent or present; 4= such an infrastructure is important; 5= such an infrastructure is a necessary, indispensable factor.

and constructed a data file of the companies. The data were used for a QCA analysis. The analysis provided insights into the dominant strategies that lead to economic growth across the 30 companies.

- **Desk research:** In addition, information was derived from websites, annual reports, publications by the companies and other public sources and literature. The desk research and the background case study material was integrated into company case reports. The gathered information was brought together in thirty company case reports. Each report describes the company and its development; the digital transformation and the impact on economic performance and inclusiveness and skills; the position and role of the company in its ecosystem; the role of COVID-19.

2.3.3 Data

The data used for analysis are thirty QCA 'company case questionnaires' completed by the researchers who carried out the company case study. Answering the questions requires knowledge of the entrepreneurial ecosystem (EE) model. To increase the chance of valid answers, the expert judgment of the researchers was chosen over the questioning of the interviewees. It should also be noted that the answers by the researchers are based on a detailed discussion with the interviewees of the companies on the significance of the EE model for the organisation concerned. The questionnaire data are standardised according to the QCA procedure, which is discussed later. To understand and explain the results of the QCA analysis, the company case study reports are used, which give a more detailed description of the findings behind the QCA data. Summaries of the thirty company cases can be found in Annexe 3.

The outcome, economic growth (as indicator of productive entrepreneurship), has been constructed by the combination of personal growth over the last 5 years and profit rate in the last year. This data is gathered from annual reports and interviews within the companies (see also appendix table 2.1_2).

2.4 Analyses and results

2.3.1 Does the evaluation of the ecosystem elements differ between regional and company level?

The first analysis consists of assessing how the companies view their ecosystem environment. In report D4.1, several tables were constructed to evaluate the elements for entrepreneurial outcomes (Dhondt et al., 2022). Table 7 compared results from the Schrijvers-study (Schrijvers, 2020) with the stakeholder reports for the incumbent entrepreneurial ecosystems. Table 18 provides the same results for the emerging entrepreneurial ecosystems. These tables are used as a comparison base of the regional level to the answers of the company level. Tables 7 and 18 provide two values for each elements of the entrepreneurial ecosystem model: either the element is assessed as supportive to entrepreneurial activity (1) or it is not (0). The company assessment used

a five-point Likert score (1 = not performing well; 5 = performing very strongly). The company scores were cut-off at 1-2 = not supportive and 3-5 = supportive to entrepreneurial activity.

The **main result** is the degree to which the answers from the thirty case studies align with the ecosystem scores. Almost two-third (65%) of the cases evaluated the performance of their ecosystem environment the same as the ecosystem score (see Table 3). Most often (58%) the cases evaluated the performance of their ecosystem environment as supportive and as the same as the ecosystem score. Only 6% of the cases had the same score for not being supportive of entrepreneurial activity. In 35% of the cases the performance of their ecosystem environment was not the same as the ecosystem score. In a quarter of the cases (24%), the cases evaluated the performance of the ecosystem as supportive, whereas the stakeholders at regional level were not that positive. The rest of the cases (12%) evaluated the ecosystem as not that supportive, where the stakeholders had a different opinion. This distribution was the same for the incumbent and emerging entrepreneurial ecosystems cases. The cases are very much aligned with the entrepreneurial ecosystems for the dimensions (new) knowledge, physical infrastructure and leadership. The least alignment is seen for demand (50% deviating answers) and finance/financing (57% deviating answers). The Spanish and Finnish cases are most strongly aligned with the entrepreneurial ecosystem answers at the country level. The least aligned are Bulgaria (54% not aligned), the Netherlands (44%), and United Kingdom (42%). The last analysis here was to identify if the correspondence could be explained at the company level. Eleven companies (NL, BG, UK, FI, GE) show 50% or more deviation from the ecosystem evaluation. The companies are diverse in background; no specific identification was possible. Ten companies were 80% or more aligned (FI, GE, UK, ES). Again, no specific explanation could be given.

Table 3 shows the agreement of the scores of the ecosystem level with those of the cases.

Table 3. The agreement between the qualification of the 10 elements of entrepreneurial ecosystems at the ecosystem level and at the company level for the six countries (cell percentages).

	BG	ES	FI	GE	NL	UK	Total
Formal institutions	80%	100%	80%	100%	20%	40%	70%
Entrepreneurship culture	0%	100%	80%	80%	80%	40%	63%
Physical and IT Infrastructure	80%	100%	60%	60%	80%	100%	80%
Demand	80%	20%	40%	60%	20%	80%	50%
Finance / financing	60%	100%	60%	0%	20%	20%	43%
Talent	100%	100%	0%	0%	80%	60%	57%
(New) Knowledge	60%	100%	100%	80%	80%	100%	87%
Services by Intermediaries	20%	100%	100%	100%	20%	20%	60%
(Social) Networks	40%	100%	80%	60%	80%	20%	63%
Leadership	20%	100%	60%	100%	80%	100%	77%
Total	54%	92%	66%	64%	56%	58%	65%

The table presents the results per country as the percentage of agreement between the ecosystem level and company level scores. Overall, for all ten elements, except 'finance', the right total column shows that the agreement per element is 50% or higher. The disagreements between the qualifications of the ecosystems and the degree to which the element is a crucial factor for the companies in that ecosystem are explained with material from the gathered interviews, desk research data, and regional and company case study reporting at both the ecosystem and company level (as carried out in WP4 and WP8).

In Germany, the Netherlands and the United Kingdom, companies see the importance of '**finance**' (43% alignment) differently than how it was judged for the ecosystem as a whole. For the German companies, financing is among the important elements of achieving productive entrepreneurship (i.e. economic growth). But, it is observed that opportunities for financing in their ecosystem were assessed as limited, especially with regard to investments needed to transform the economy. For example, in Germany's studied incumbent ecosystem of the steel industry, there is a high need to transform energy-intensive steel production to low-carbon or CO2-free steel production. This requires large investments beyond the regional funds of financing. The Netherlands's financial situation is well developed in the ecosystem but is not crucial for the companies. These Dutch (multinational) companies are capable of meeting their financial needs in other ways. They are not dependent on the ecosystem's funding. For the United Kingdom, the relevance of finance at the ecosystem and company level differs for the incumbent and emergent entrepreneurial ecosystems. The companies in the incumbent ecosystems are just as the Dutch companies able to meet the demands necessary to boost entrepreneurial activities independent of the ecosystem. The UK companies in the emergent ecosystem are in need of finance for further growth and entrepreneurial activities, and although they receive some funding from the ecosystem to support pilots, for their main source of funding, they depend on a range of national sources, venture capital and foreign direct investments.

For all thirty companies in the six countries, the availability of '**talent**' (57%) is crucial for productive entrepreneurship. We see, however, that this demand for talent has not been sufficiently met by the ecosystems (57% agreement). Especially in Finland and Germany, the element of talent is qualified as poor in the ecosystem, while companies are in need of talent. This indicates, other than in other countries, that the Finnish and German companies have more trouble finding talent. In all countries, there is especially a shortage of highly educated and skilled workers, and in Germany, there seems to be a dwindling talent supply.

The agreement about '**formal institutions**' (70%) at both levels is above average (65%). However, disagreement between the qualification of the formal institutions at the ecosystem level and the level of companies is particularly present in the Dutch and UK incumbent ecosystems. This is partly because companies in the incumbent ecosystems are well developed, often internationally focused, and therefore have limited dependency on regional formal institutions. It might also be that companies undervalue formal institutions for entrepreneurial activities of their companies and take them for self-evident. Specifically for the Dutch situation, companies see formal institutions as moderately important, but during the interviews with some of the companies it was indicated that formal institutions are insufficiently focused on supporting entrepreneurship.

For ‘**entrepreneurship culture**’ (63% agreement), we mainly see disagreements for Bulgarian and UK companies. Entrepreneurship culture is prevalent and important in the Bulgarian ecosystems, but is mainly focused on companies and not at the region's level. The UK companies are well-developed and entrepreneurial, but the ecosystems entrepreneurial culture is reported to be rather traditional and multinational corporations-driven.

The relevance of ‘**knowledge**’ is well recognised for both levels (87% agreement).

‘**Networks**’ in ecosystems and how companies experience them are more often than not aligned (63% agreement). Bulgarian and UK companies have mainly disagreements on the ecosystem level and company level qualifications regarding the importance of networks. Networks in the Bulgarian incumbent ecosystem are not well developed but are still a crucial factor for the companies. The companies solve this through international collaborations and are, therefore, less reliant on companies and other stakeholders in the regional ecosystem. For the UK, two of the three companies in the incumbent ecosystem do not rely on their network for productive entrepreneurship, while this network is well present within the ecosystem. Possibly also because these companies are multinationals with strong international networks. However, the two UK companies from the emergent ecosystem rely on the ecosystems network.

In most countries, there is strong agreement between the qualification of ‘**leadership**’ in the ecosystem and in the companies (77% on average). Little agreement is present in Bulgaria. We mainly see in the companies in the incumbent ecosystem that a clear regional vision is lacking. Entrepreneur-driven leadership is mainly foreign-driven.

There is an agreement concerning the elements ‘**demand**’ in half of the countries (50%) and in ‘services by intermediaries’ there is in 65% of the cases agreement between the qualification of the ecosystem and the importance of that element for the companies. This is mainly because ‘demand’ (for products and services) of companies comes from beyond the regional ecosystem and is often stemming from international markets. ‘**Services by intermediaries**’ is often well-developed in a region but of little use to many of the large companies in these ecosystems. They reason that they do not care if such services are geographically very close. For the UK companies in the emergent ecosystems, the services by intermediaries are not positively evaluated in the regional ecosystem, while the studied companies see those services as somewhat important.

After having investigated the agreements and disagreements between qualifications of the elements of the entrepreneurial ecosystem model at the level of ecosystem and companies, the following observations can be made for **each country**:

- The Spanish companies have a very high agreement between the qualification of the element within the ecosystem and the importance of that element for productive entrepreneurship of the companies. This implies that well-developed entrepreneurship in the ecosystems is well used by the companies for their success.
- The Bulgarian companies in the incumbent entrepreneurial ecosystems make relatively little use of the entrepreneurship-stimulating factors in the ecosystem. These elements are underdeveloped but of importance to the companies. They organise entrepreneurship, networks and leadership in other ways, partly through international collaboration.

- In the United Kingdom, we see that companies in the incumbent ecosystem rely less on the regional ecosystem. While the companies in the emergent ecosystems rely on facilitating entrepreneurial factors for success, these are often unavailable.
- For all German companies, there is a discrepancy between the high demand for finance and talent by companies and the low availability of finance and talent by the ecosystem.
- The Dutch companies seem to use the entrepreneurship culture, talent, knowledge, networks and leadership within the ecosystem, but rely less on regional finance. Formal institutions are moderately important, but, as indicated, these institutions lack entrepreneurial focus according to some of the respondents.
- In Finnish companies, talent is of importance but lacking in the region and also, companies have a hard time extracting knowledge from the ecosystem.

In sum, there is more agreement than disagreement in how the regional analysis assessed the significance of the ten elements of the entrepreneurial model compared to how companies assess the same elements for the business. The company cases are also more positive about how the ten elements contribute to entrepreneurial activity than the regions are. Different factors explain the variation. The strongest alignment exists among Spanish and Finnish cases. Sometimes mature and multinational companies are less dependent on regional facilities because their geographical scope goes beyond the region where they are situated. And sometimes, countries differ in how far certain elements have developed, such as the presence of entrepreneurship and networks. While there are no systematic factors that explain differences between the ecosystem and company level, it can be stated that there is quite some correlation between both levels.

2.5 The results of the QCA-analysis

2.5.1 QCA procedure

The QCA is used to identify patterns in the answers on how the thirty companies position themselves towards the ecosystem elements. The results of the analyses provides insight into what cases think they need to align with the ecosystem level to be successful. The QCA analysis followed a four-step approach. We start with a preparatory step '0'.

Step 0 – Selection of relevant conditions (variables): we selected seven of the ten elements of the entrepreneurial ecosystem model as this is the maximum number of variables that can be considered in a QCA analysis with thirty cases (Rihoux & Ragin, 2008). The element '*Local demand*' was not taken into account as many companies were internationally focused, making this variable irrelevant to consider with regard to economic growth of the companies. '*Services by Intermediaries*' and '*Physical and IT infrastructure*' were not considered because the case descriptions indicated that these factors did not play a major role in most of the company cases. Moreover, the quality of '*Physical and IT infrastructure*' was mostly above average in the regions. The assumption is that this is not an element that will explain differences among the company strategies for economic growth.

Step 1 – Calibration: In fsQCA the original data must be transformed into an interval scale (ranging from 0 = non-membership to 1 = full membership) using the 'calibration method' (Ragin, 2008; each score with .5 was manually changed to .49). First, the values for the anchor points (.05, .5 and .95) are set using the 25th, 50th and 75th percentiles of each variable separately. This is justified by the notion that for this explorative study, we do not always have the theoretical or in-depth knowledge to do otherwise. Although we – i.e., six national research teams - did carry out the case studies ourselves, and, ideally, QCA demands that the researcher moves back and forth between theory and data to retain the value of 'thick case descriptions' for the analysis, we have limited insights in what happens in detail in the companies. For example, company visits were impossible due to the pandemic. However, based on the company case study reports, we manually changed some cases' scores (from 0.49 to 0.51) based on our interpretation of the data with regard to some specific condition variables because these cases scored relatively well on those elements compared to other cases. An inspection of the calibrated data did not lead to the threshold for the outcome variable 'economic growth' being adjusted (manual recalibration).

Step 2 – Analysis of necessary causal conditions: Necessary conditions are variables that should always be present for the outcome to occur. Hence, if the outcome is present in such a situation, so is that particular condition, and if that particular condition is absent, the outcome is absent as well. To see whether the outcome has the necessary conditions, a necessity analysis was performed with all the condition variables, for which a conservative consistency threshold of 0.95 was used (see Ragin, 2008; Schneider, 2018; Schneider & Wagemann, 2012). We chose this conservative threshold because many companies in our sample scored high on many elements. This is explained by the fact that the selection of cases is biased towards good-performing enterprises. The analysis of necessary conditions showed that the consistency scores of all variables were below 0.95 (Table 4), meaning that there are no necessary conditions for economic growth to emerge in most configurations. As Talent with .94 has a high score, it will, however, emerge in many solutions. Entrepreneurship (0.87), (New) Knowledge (0.88), and Networks (0.86) have high consistency scores, which will likely result in them emerging in many solutions as well. By 'solution' we mean a combination of variables (i.e. a pattern) that results in economic growth.

Table 4. Analysis of necessary conditions (Outcome variable: economic growth [Outecon]).

Variables	Consistency	Coverage
Formal institutions (FOR)	0.674067	0.913462
Entrepreneurship (ENTR)	0. 867475	0.824630
Finance (FIN)	0. 608148	0.860985
Talent (TAL)	0. 940490	0.807269
(New) Knowledge (KNOW)	0.884184	0.859973
(Social) Networks (NETW)	0.861295	0.887082
Leadership (LEAD)	0. 512932	0.965116

Step 3 – Truth table analysis of sufficient causal conditions: A truth table consists of all the possible combinations of the seven condition variables (2^7 = 128 combinations). The frequency threshold is 2 (at least two cases must fit in a combination), and the consistency threshold is 0.80 (Ragin, 2008), to regard a combination as a valid condition for the outcome, i.e. economic growth. From the calculated complex, intermediate and parsimonious solutions that fsQCA produces, the last one uses the least number of variables to explain the data, resulting in a lower number of solutions. This means that parsimonious solutions are better to interpret. In our case, the intermediate solution is used as this was the clearest model (the parsimonious solution was similar to the intermediate solution and not calculated in the fuzzy set QCA analysis). The purpose of this step is to keep consistent paths in the final solution, which implies that any combination of variables in such a path is a row that suffices for economic growth (Outecon) to emerge. The intermediate solution for the initial model, i.e. Outecon = f(FOR, ENTR, FIN, TAL, KNOW, NETW, LEAD), produced four consistent paths.

Step 4 – Finalising solutions: The final step in the analysis was to interpret the four paths (combinations or configurations) that lead to outcomes and to conclude which cases correspond to certain solutions (Table 5). The aim is to find the solutions with the highest coverage score (cover as many empirical cases as possible, similarly to explained variance), the highest consistency score and the minimum possible number of conditions (most parsimonious solution).

The model solution consistency is high (0.932), and the solution coverage (0.718) indicates that the model covers 71% of the cases in the analysis. All paths are consistent (more than .91 consistency); a unique path coverage indicates the contribution to the model solution. No path has a highly unique coverage, which indicates that no dominant path leads to economic growth, although the first path has a much higher unique coverage than the other paths. The analysis resulted as said in four solutions or paths, and each path can be seen as a separate company strategy to strive for economic growth.

Table 5. Configurations explaining economic growth (intermediate solution).

Solution	Causal conditions							Descriptives			
	Formal institutions	Entrepre-neurship	Finance	Talent	Knowledge	Networks	Leadership	Raw coverage	Unique coverage	Consist-ency	Number cases > 0.5 member-ship
1 Institutional		●	●	●	●	●		0. 555829	0.189304	0.92342	11
2 Independent	○	●		●	●	●	●	0.459163	0.08145	1	8
3 Free rider	○	●	○	○	●	○	○	0.135153	0.0232714	1	2
4 Rebel	○	○	○	●	○	●	○	0.179906	0.0349072	1	3
	Total										22
Model	Solution coverage	0.706646									
	Solution consistency	0.938763									

Model: Outecon = f(FOR, ENTR, FIN, TAL, KNOW, NETW, LEAD)

Cell: ●=must be present; ○=must be absent (~); no sign=does not matter (ambiguous).

The four paths, which contain 22 cases in total, are consistent and indicate that cases exhibiting a given combination of causal conditions exhibit the outcome of interest. Three cases are present in two solutions. This means that those companies they can follow different strategies to achieve the same goal: economic growth. What do the four paths represent? (Table 6).

Table 6. Entrepreneurial ecosystem elements leading to economic growth.

Solutions (paths)	Elements of the entrepreneurial ecosystem model		Cases	
	Must be present	Element irrelevant for the outcome to emerge*		
1 Institutional	▪ Entrepreneurship ▪ Finance ▪ Talent ▪ Knowledge ▪ Networks		11	FI3, FI4, GE1, GE2, GE3, GE5, ES1, UK2, UK3, ES2, ES5
2 Independent	▪ Entrepreneurship ▪ Talent ▪ Knowledge ▪ Networks ▪ Leadership	▪ Formal institutions	8	GE1, NL1, NL2, NL4, NL5, ES1, BG1, BG4
3 Free rider	▪ Entrepreneurship ▪ Knowledge	▪ Formal institutions ▪ Finance ▪ Talent ▪ Networks ▪ Leadership	2	UK4, UK5
4 Rebel	▪ Talent ▪ Networks	▪ Formal institutions ▪ Entrepreneurship ▪ Finance ▪ Knowledge ▪ Leadership	3	BG2, BG3, GE4

*Formal name in QCA is 'must be absent' for the outcome to emerge, given a certain combination of conditions.

2.5.2 Interpretation and further elaboration (explaining the paths to success)

This section describes the four paths and illustrates each path with two or three company cases. These actions help to clarify what the QCA results actually mean. As explained, the paths are the best combination to achieve the two outcomes.

Path 1: Institutional

Five elements of the entrepreneurial ecosystem model are crucial for eleven of the thirty companies for productive entrepreneurship that leads to economic growth (i.e. measured as economic performance). Such companies have a **well-developed entrepreneurship culture**, **availability of finance or investment capital**, **access to human capital or talent**, a **knowledge structure with R&D investments**, and a **social network** with other companies and stakeholders in the region. The presence of supportive formal institutions and industrial leadership differs across companies and is

not of relevance in this path. The companies in this path are mostly traditional companies, e.g. in the automotive sector, and rely on the presence of historic networks, finance and knowledge: institutional companies. We call this the 'institutional strategy'.

> ***FI1*** *was founded in 2012 as a start-up and has grown from five people to about 100 people now, making a (small) profit each year. The company offers hardware and software solutions and planning for buildings, such as public and private offices, hospitals, and even private homes. The company is a part of the incumbent ICT high-tech ecosystem that has its roots in the knowledge and skill inheritance from Nokia Phones. As a high-tech company, highly skilled and experienced talent is crucial. Simultaneously the company represents emerging innovative high-tech enterprises that form their own emergent ecosystem with intertwined activities and production, making the regional network crucial for their success.*
>
> ***GE1*** *is a large company with about 1500 people employed in the regional division. It has steadily grown in the number of employees and made large profits in recent years. The company supplies the regional media market in the major city it operates in at all levels - from daily newspapers, advertising journals, magazines and radio stations to digital services of all kinds. Within the company, an entrepreneurial culture is important in driving new, innovative ideas. Employees are encouraged to think and act entrepreneurially. The company is very well networked in the ecosystem, cooperates with research institutes, and has open exchanges with other companies to shape ideas. The company has deeply integrated digitalisation into its philosophy and is constantly working to develop innovative solutions for various business areas. Against the backdrop of digitalisation, the company is increasingly looking for new talent, such as data scientists, data engineers or cloud architects. This makes talent increasingly important for the company's success. Although not important for this path, the CEO's leading personality and focus on digitalisation is one of the driving forces of the success of the company.*

Path 2: Independent

The second path that leads to economic growth is largely similar to path 1. Entrepreneurship, availability of talent, knowledge and regional networks are crucial for the success of the companies. Unlike path 1, finance or investment capital availability is not crucial, but well-developed (regional) leadership is. In addition, all these companies have in common that formal institutions play no role in the success of the companies. Leadership may compensate for the absence or irrelevance of finance and formal institutions. Most companies operate in an incumbent and mature entrepreneurial ecosystem, where circumstances like 'the triple helix' seem available. Two of the three companies on this path that operate in an emergent ecosystem are well-developed large companies with a long history. Most companies on this path are multinationals or at least have a strong international focus on their products and services. To them, the regional ecosystem is to a large extent, subordinate to the geographical context in which they do business. That is why we call this the 'independent strategy'.

> ***NL1*** *is a multinational company specialised in advanced manufacturing that grows extremely fast in turnover and in terms of staff, annually several thousand persons. For this, the company needs an ongoing supply of high-skilled talent, which actually hampers even faster growth. The main reason is that product growth is expected to grow even further, driven by innovation in products and in the development of the servitisation strategy. The company is highly entrepreneurial being the world leader in the design and development of very specialised high-tech machines. The company invests a lot in R&D*

investments as their vision is that the newest technology is required for humanity's challenges. Its vision and leadership - through strategic sourcing and a supply chain management strategy built on more buying and less making, and to concentrate on the core business – is crucial for its success. The company, itself an industrial leader, needs a strong regional network with suppliers, but also other stakeholders to educate and attract talent, such as universities and governmental bodies.

***NL4** is a multinational company with a location in the ecosystem under investigation. The company is among others a supplier of **NL1**, and grows in number of employees in line, but less strongly, with the growth of **NL1**. The company is involved with high-tech manufacturing equipment and users of advanced production lines. It is active in the semicon, solar, medical, science & technology, mechanisation and analytical markets. The existing entrepreneurial culture and strong innovation leadership from both **NL1** and the mother company of **NL4**, as well as the strong network where companies collaborate as partners in combination with R&D activities in the region have been the success factor until now and are likely to be so in the future. Their entrepreneurial culture appears as they stimulate regional entrepreneurial activities and start-ups. Just as **NL1**, this company is a digital leader, and relies on sufficient talent to growth further.*

***BG1** is a relatively small company of 40 employees that was established more than 20 years ago. It slowly grows in number of employees and has substantial turnover but a small profit. The company specialises in the development of video streaming solutions, both for mobile applications and as part of complete business solutions in the field of Internet television, providing real-time video to various media devices, video optimisation and security. The entrepreneurship culture of the region is neither good or bad, although there are many start-ups in the region. Talent might be the most important factor for success of the company and the region, with a high concentration of supply of labour by local universities and internal migration. The region where this company is situated is the most innovative in Bulgaria, and **BG1** is a strong innovator with long term traditions in R&D. It has developed its own products and several spin-offs were the result of their innovations. Local and EU wide networks play an important role, the company shares experiences and ideas with other companies. The vision of leading multinational companies is of importance for bringing the region and its companies further as a leader in knowledge-intensive products, services and solutions.*

Path 3 Free rider

The third path that leads to economic growth is characterised by a highly entrepreneurial culture and a good knowledge structure with R&D investments. Other factors, such as formal institutions, finance, talent, networks and regional leadership, do not play a significant role in the success of companies on this path. Two companies from an incumbent ecosystem are part of this path. In other words, these companies seem less dependent on many elements of an ecosystem. The reliance of these companies on entrepreneurship and knowledge seems to fit with the values of liberal economies, making them less reliant on institutions to be competitive. One could say that these companies do not really contribute to the ecosystem, but prefer a form of cherry-picking to their liking. That is the reason we labelled this as the 'free rider strategy'.

***UK4** is a Tier 1 supplier (Original Equipment Manufacturer, OEM) that serves a significant number of major automotive manufacturers. The company has over 200 factories in around 40 countries. An important driver of the company's global expansion is that it 'follows' its customers and produces components near the car manufacturing*

plants of its end users. Although the company's number of employees declined, they made a large profit (>8%).

***UK5** develops industrial software that is a key element of the digitalisation of factory production in the automotive sector. It exists over a hundred years, with 26 facilities in the UK, was stable in number of employees over the last few years but able to make a large profit (>8%). They are both part of the same incumbent entrepreneurial ecosystem. In the ecosystem, there are many of smaller supply chain firms, clusters of R&D intensive firms and a number of globally-renowned specialist centres of R&D, technology, innovation and entrepreneurship. There are well-established collaborations between companies and universities and other R&D centres; and some co-operation between OEMs. Innovation in the automotive sector is primarily focused on repurposing existing production facilities and reskilling workers to enable the transition to electric vehicles. At the case study company most innovation is based on forming strategic partnerships with companies whose technologies are seen as 'enablers' to the business.*

Path 4 Rebel

The economic success of companies in path 4 relies on access to human capital or talent and a strong social network with other companies and stakeholders in the region. Formal institutions, entrepreneurship culture, finance, knowledge and leadership do not play a significant role. The two Bulgarian companies on this path are part of an emergent entrepreneurial ecosystem, and the German company is part of an incumbent entrepreneurial ecosystem. These companies seem to have found their own way to be successful based on talent and their networks without the elements of a more mature ecosystem: rebellious companies. They are rather self-willed, perhaps even somewhat idiosyncratic. This is called the 'rebel strategy'.

***BG2** is a large multinational company established in 2004. in the field of automation of decision making and use of data for "smarter business" in the IT sector and outsourcing industry. Among its main products and services are development of software products, analytical services, financial centre, and customer service unit. The has company steadily grown and makes profit (6% in 2019 over a turnover of 44 million Euro). The development of the ecosystem is taking place despite the formal institutions and not because of the national or regional institutions and their support. The company is among the largest employers in the country and is not subject to support measures.*

***BG3** is subsidiary of a multinational company that provides businesses with digital transformation solutions. In Bulgaria they have about 1400 employees, which has steadily grown over the years. The company made a small profit (3% over a turnover of 94 million Euro's in 2020). Talent availability is vital for the company. It recruits Bulgarian nationals but also foreign citizens in the case of specific language skills required. **BG3** also trains the newly recruited employees from the very beginning and creates talents internally. The company collaborates increasingly with other companies. Sometimes they are competitors and collaborators at same time. Formal institutions and finance play a small role due to corruption and own capital. The entrepreneurial ecosystem is not very entrepreneurial. Leadership is mainly formed by large foreign companies, local leadership is missing.*

***GE4** is a medium-sized enterprise and is family- and owner-managed employing about 100 people and was founded over 100 years ago. The company is stable in number of employees but did make a large profit (>8%). The case is about a German company that specialises in the production of wire. The network structures of the ecosystem are of enormous importance for the company, for example in the form of the steel associations of the ecosystem. This involves agreements with regard to products and standardisation, in which*

producers, processors and customers consult with each other at association meetings. GE4 is very open to accept renewal, especially when it serves their customers. The company relies on in-house training of talent and further education, with the low fluctuation of their employees making it worth for the company to qualify them.

2.5.3 Other paths

Eight cases were not part of one of the four paths, although most had reasonable to good economic outcomes. The eight cases were excluded from the solution because we had set the threshold at minimum of two cases per path. FI1 and FI5 relied on the formal institution for economic success, while this was not a factor of relevance in the paths detected by the QCA analyses. Except for talent, these companies scored relatively low on the other elements. BG5 and FI2 scored relatively low on most or all elements. BG5 made no profit or loss but had a small growth in the number of employees, while FI2 was able to make a profit despite a decline in the number of employees. For NL3, entrepreneurship culture, talent, and knowledge were crucial for success, but the other factors were not. ES3 scored almost the same as the companies in path one but was not part of this path as talent was relatively unimportant for the success of this company. For ES4 formal institutions, entrepreneurship, knowledge and leadership were relatively important, but the other factors were not. Finally, UK1 was similar to the companies in path 2, but in contrast to those companies, regional networks did not play a major role in their success.

2.5.4 Can contextual factors explain the paths?

What does this mean? Among the thirty cases, we found four distinct alignment strategies, covering 22 cases. We could not assess a consistent path for the remaining eight economically successful cases. These companies have a unique strategy. From a policy perspective, this implies that the four paths are recommendable strategies with a relatively bigger chance of success when addressed in policy. The difference between the strategies seems to be from completely aligned to little aligned with the ecosystem context. In path 4, the only alignment is a focus on talent. The first path shows a total alignment with what 'good working ecosystems' require. They are integrated into the working of the broader ecosystem and contribute to the operation of these ecosystems. The benefit is strong economic performance. However, all cases are better performers, so the results may be biased.

Can contextual factors help us better explain the differences between the four paths? For this question, we analysed six factors: the type of ecosystem, company size, the position in the ecosystem, the type of digital transformation, the high/low road character, and the attitude towards vulnerable groups and inclusiveness (see Table 7). The type of digital transformation and low vs high road are typologies developed in section 3 of this report. We refer to Table 12.

Table 7. Company characteristics of the four paths.

	Institutional (11 cases)	Independent (8 cases)	Free rider (2 cases)	Rebel (3 cases)
Type of ecosystem				
• Incumbent	5 (45%)	5 (63%)	2 (100%)	1 (33%)
• Emergent	6 (55%)	3 (37%)	0 (0%)	2 (67%)
Company size				
• Start-up	4 (36%)	1 (13%)	0 (0%)	0 (0%)
• SME	3 (27%)	2 (25%)	0 (0%)	1 (33%)
• Large company	4 (36%)	5 (63%)	2 (100%)	2 (67%)
Type of digital transformation				
• TOTAL	0 (0%)	1 (13%)	1 (50%)	0 (0%)
• AI_ML	3 (27%)	3 (37%)	0 (0%)	1 (33%)
• ROBOTIC	1 (9%)	0 (0%)	1 (50%)	0 (0%)
• LOW-USER	7 (64%)	4 (50%)	0 (0%)	2 (67%)
Low vs high road				
• High road	4 (36%)	5 (63%)	2 (100%)	1 (33%)
• Low road	3 (27%)	0 (0%)	0 (0%)	0 (0%)
• Unclear	4 (36%)	3 (37%)	0 (0%)	2 (67%)
Attitudes towards vulnerable groups				
• Positive	5 (45%)	1 (13%)	2 (100%)	1 (33%)
• Neutral	5 (45%)	7 (87%)	0 (0%)	0 (0%)
• Unknown	1 (9%)	0 (0%)	0 (0%)	2 (37%)
Attitude towards inclusiveness				
Positive	5 (45%)	3 (37%)	2 (100%)	1 (33%)
Neutral	4 (36%)	4 (50%)	0 (0%)	0 (0%)
Unknown	2 (18%)	1 (13%)	0 (0%)	2 (37%)

In path 1 'Institutional', there are eleven company cases, in path 2 'Independent' eight, in path 3 'Free rider' two and in path 4 'Rebel' three. Table 7 shows hardly any significant, systematic differences between the four paths for most of the contextual factors. However, in the case of the Free riders in path 3, these cases differ in several aspects. More often than companies in the other three paths, they are part of an incumbent ecosystem, large in size, high road driven, and with a positive attitude towards vulnerable groups and inclusiveness. Institutional cases in path 1 are relatively often part of an emergent ecosystem and have the position of a satellite company in the ecosystem. Despite the fact that they are often high road companies and large, independent cases of path 2 have more often a neutral attitude towards vulnerable groups and inclusiveness. Rebel cases in path 4 are striking because they are unclear or unmarked in almost every aspect: it remains heterogeneous with respect to high/low road, unclear attitude towards vulnerable groups and inclusiveness, and type of position. Even the technological dimension does not show a particular connection to one of the paths.

Of course, the number of cases (22) is limited. Yet, we cannot conclude that there are striking and strong differences between the companies in the four paths based on these demographic variables. Therefore, we cautiously draw the conclusion that there is much heterogeneity among the studied cases. In addition, we see that the companies on each path – especially on the institutional and independent path – are heterogeneous as well. In the institutional and independent paths, the companies come from incumbent as well as emergent ecosystems, are a start-up, SME and large companies, have low and high road strategies and differ in their attitudes towards vulnerable groups and inclusiveness. Companies differ in strategy, and develop these strategies in very different contexts.

2.5.5 Inclusiveness policies of companies

The last topic that we address in this Chapter is whether company strategies align with inclusiveness policies. Here we compare the four paths. As said before, with inclusiveness, we mean personnel policies, measures or practices that contribute to the labour participation of existing or new employees. For instance, the proportion of female workers and migrants, job security by fixed contracts, the opportunities for learning, training and education, the presence of a works council and options for employee shares.

Per path, the alignment of inclusiveness policies of the companies with the ecosystem level is described.

Path 1: Institutional

Path 1 contains eleven companies in total. Based on the case descriptions, it can be stated that the four large companies (GE1, GE2, UK2, FI4), which are part of this institutional path, can be considered inclusive companies when looking at their personnel policies. These companies have in common that they have a substantial amount of women employed as well as migrants, offer learning opportunities for their employees, and have mixed but mainly permanent contracts. In other aspects, they differ.

> *The large German company (**GE1**) has high retention rate of employees even though many other companies in the sector have not. At the same time, they offer good salaries and good social security for employees. The other large German company (**GE2**) offers specific employment opportunities for pensioners – regardless of their previous qualification and occupation. Above that, for migrants and potentially (long-term) unemployed people it offers employment opportunities in the company's logistics department. Similarly, one of the large English companies (**UK2**) has established equality, diversity and inclusion strategies and practices in place (EDI practices). There are a number of initiatives in place to support equality in the company including flexible working schemes, maternity and paternity schemes, family spaces, support for parents and caregivers, and career development opportunities. A range of resources are available to employees to support them in their role, and to manage their work-life balance. UK2 can be considered a high-road employer as it has a good governance structure, plus strong support and development systems for its employees beyond what is minimally required by law.*

The three SME's in this institutional path seem to be moderately inclusive.

> *One Finnish SME (**FI3**) has a flat organisation, open culture and strongly invests in the development of their employees with both on-the-job as well as off-the-job training. They have relatively few women, but migrants from more than ten different nationalities. Employee voice is however limited, and there is no formal strategy or vision on inclusion of vulnerable groups. The two Spanish cases (**ES2, ES5**) have no low-skilled people or migrants employed, and have few female employees although the technical director is female in one company. While these companies have no low-skilled people employed they do have policies to include vulnerable groups, including the recruitment of vulnerable people.*

These companies seem to benefit their employees in terms of teamwork, learning opportunities, and HR policies for stable employment.

Three start-ups (GE3, GE5, ES1) are part of this path as well and cannot be considered inclusive. This is partly because they are small and 'starting-up' and have no well-developed HR policies. Voice of employees is limited in these companies, and it is too soon to tell whether these companies offer sufficient learning opportunities to employees.

> *One company (GE3) has equal gendered-tasks, and has the objective to have an international mix of employees but lacks attention for vulnerable groups. The other two companies (GE5, ES1) have mainly or even only male employees, and no migrants. The Spanish company (ES1), however, has mainly young employees, which is important considering the youth unemployment rate in the country.*

Overall, the companies in path 1 are, to some extent, inclusive in their personnel policies. Especially the larger companies follow mainly high-road strategies but have little attention to vulnerable groups and inclusiveness. The companies mainly lack jobs for low-skilled people, migrants and other vulnerable groups. This may be a biased effect in the selection of the cases. Only GE5, a 'last mile logistics' service provider, employs many low-skilled workers. Gender inequality seems present in most companies, and the degree of flexible, temporary contracts is still high in some companies.

Path 2 Independent

Five of the eight companies in this multinational path are large, invest strongly in personnel, and involve personnel in organisational changes. They all have works councils installed, jobs for migrants and mainly permanent contracts with good salaries and social benefits. The large German company (GE1) is part of path 1, and as mentioned, it has a high retention rate of employees. Lifelong learning plays a strong role in this company; they invest in the development of their employees. This is even more strongly the case in some of the Dutch companies in this path. Three Dutch companies (NL1, NL4, NL5) of an incumbent ecosystem are growing exponentially and need highly-trained personnel. They invest both in on-the-job as in off-the-job training, and give personal time and budget for personal development. NL5 even allows staff to spend one day per week learning new skills and methodology, favouring the employees as the company, as it stimulates innovation. An example of the involvement of employees is in two companies (NL1, NL 5), highlighted by the fact that employees own shares of the company. These companies work in teams and give employees

relatively much autonomy to excel in performance. Although some of these companies have particular policies to attract and retain migrants, they lack policies and a vision for providing work to vulnerable groups. These companies are mainly male-dominated, and women are underrepresented in management functions.

In this path, the two Bulgarian SMEs (BG1 and BG4) moderately invest and irregularly involve employees. Employees have little voice and no works council, but BG1 has a flat company structure, offers team-building activities, and has HR practices such as flexible working times. BG4 invests in employees to continuously improve their skills and personal development and offers its employees a variety of benefits. These companies have predominately permanent contracts but have no or very few migrants and vulnerable groups employed. In BG4, about one-third is female, which is a high percentage in the sector, and it employs relatively many older workers.

The one start-up (ES1) in this path is part of path one and, as described above, cannot yet be considered inclusive.

Overall, most companies on this path invest in and involve their employees; they follow a high-road strategy. Similarly to the companies in path 1, they have little attention to hiring vulnerable groups and gender equality. For SMEs and start-ups, attention to hiring and retaining migrants is lacking.

Path 3 Free rider

In this rather liberal path, the two large UK companies (UK5 and especially UK4) seem to be highly inclusive and follow high road strategies. Both companies have a strong drive to support career development. Individuals are supported in developing their skills, particularly teamwork and leadership, to retain talent and develop the workforce in-house. In UK4, there is also a culture of inclusivity with much diversity in perspectives and diversity experiences being encouraged and valued. The company's mission statement refers to diversity and inclusion as core values, and it is emphasised that inclusion leads to innovation (the business case for diversity and inclusion). The company has employee network groups for LGBT+ people, women, young professionals and ex-service personnel. These values are also extended to the supply chain: the company expects its production suppliers to share its commitment to ethical conduct and Environmental, Social and Corporate Governance. This focus on inclusiveness by the companies might be quite specific for the UK context as this ethical conduct may partly drive it.

Path 4 Rebel

The two large companies and the SME in this fourth rebel path seem to involve and invest in employees moderately. The two large Bulgarian companies (BG2, BG3) have little employee voice and no works council, and BG3 has a high proportion of flexible contracts. BG2 has relatively few migrants, while BG3 has a moderate proportion of migrants employed. Both companies seem to have no specific policies or vision on diversity and inclusion. Gender distribution in both companies seems to be 50/50, which is relatively good. Both companies have good social and health benefits and invest in the development of their employees. BG2 seems to replace routine work with machines, yet creates new and more interesting tasks and roles for their employees. This requires constant training, which an internal academy executes. BG3 also offers different learning options, including three online training platforms and coaching/mentoring programs.

The German SME (GE4) in this path has mainly male employees with permanent contracts. They have a works council and offer extensive in-house training and secondary education; the low fluctuation of their employees makes it worth it for the company to qualify them. Although they employ a relatively high proportion of migrants, they lack integration of disadvantaged labour market groups.

In conclusion, it can be stated that in each of the four configurations, there are inclusiveness policies present to a certain extent. Apparently, there is a relationship between paths with economic growth and inclusiveness policies. Overall, one can observe that larger companies more often have inclusiveness policies. Company size seems to be more influential than the incumbent or emergent ecosystem type. Understandably start-up companies often lack formal inclusiveness policies but it does not mean they can be receptive to representatives of labour market segments of a diverse nature.

2.5 Conclusion and discussion

2.5.1 Conclusion and summary

This study investigated the company strategies to improve economic growth (company's economic performance) and inclusive policies. The applied point of view was to research how companies perceive the entrepreneurial ecosystem's ten elements in terms of their usefulness and quality of their own goals. Throughout the *BEYOND4.0* project, the entrepreneurial ecosystem model is applied as a framework to understand the empirical practice at the level of the ecosystems (in WP4) and at the level of companies situated in these ecosystems (WP8). The entrepreneurial ecosystem model is, however, focused on entrepreneurial activity within a region. This perspective is less feasible with a company analysis. The implications will be discussed further.

Companies can differ in how they weigh the ten elements compared to the region (i.e. regional stakeholders). For instance, a region can consider formal institutions as a crucial element for economic success in the region, but a multinational company may prefer to use institutions that go beyond the regional level, such as international investment banks or supranational laws and regulations. For most of the ten elements (on average 65%), regions and companies were aligned in importance for their economic goals. There is a 'moderate' relationship between the ecosystem and company level. If we look at the disagreements, then in about two-thirds of the disagreements, the companies rated the ecosystem dimension as performing better than what the stakeholders did. In general, more than 80% of company scores are positive about the dimensions. Much agreement existed between both levels regarding the physical and IT infrastructure, leadership and (new) knowledge. More disagreement was observed with regard to finance, services by intermediaries and talent. But this difference was not always interpretable in a straightforward way. Talent, for instance, showed an agreement of only 57%, suggesting a substantial discrepancy between both levels. Yet, talent, especially a shortage of talent, was a major issue in all countries. But companies differed in how successful they were in meeting their needs within the ecosystem or, how dependent they were on the regional labour market. Several multinational companies, for example, were successful in recruiting new staff from abroad, indicating that the way the regional

ecosystem tackled the element of talent was of less importance to them. In other words, there is a relationship between the two levels, but it is not a very strong relationship between the quality of a regional ecosystem, and how companies use what the region has to offer. Companies often develop strategies that are partly disconnected from what a region is doing. If we interpret the ecosystem dimensions as the 'environment' in which these cases operate, then the overall image is positive. However, this bias is a result of selection too. The ecosystems were selected as high performers, they were evaluated as high performers (Schrijvers et al., 2022), which is reflected in the company case scores. At the ecosystem level, stakeholders are more critical about how they are stimulating entrepreneurial activity.

In the next step, we investigated if companies used combinations of the ten elements to configure their company strategy in the search for better economic performance. There proved to be four paths or combinations of elements that resulted in better company performance, which were labelled as institutional, independent, free rider and rebel. The institutional path accommodated companies that made well use of several of the elements of the entrepreneurial ecosystem model, showing some alignment between the two levels. In the independent path, another kind of strategy appeared, namely one in which companies showed to operate largely independent of the ten elements of the ecosystem. The free rider strategy seemed to indicate that companies use the ecosystem wherever they can, but do not necessarily contribute to it. And lastly, the rebel type of strategy is used by companies which, to a certain extent, go their own way, more or less disconnected from what the regional ecosystem does. Of course, these paths are based on a limited number of cases, but they nonetheless offer useful patterns of understanding how companies operate in different ways, which all lead to economic growth.

In an additional step, inclusiveness was analysed. In each of the four configurations inclusiveness policies were present, such as taking into account job security, learning opportunities, employee representation, and equality and diversity measures. There appeared to be a relationship between strategies of economic growth and inclusiveness policies. Overall, one can observe that larger companies more often have inclusiveness policies.

An analysis of contextual factors made clear that the four paths are not easy to pin down in a characteristic set of differences, such as type of ecosystem, position in the ecosystem, size, technology and type of inclusive policies. There is much heterogeneity, which requires looking deeper into possible agreements and disagreements among the thirty company cases, as will be done in the coming chapters. The main message is that companies select a limited set of combinations to support their performance. Not anything goes.

2.5.2 Discussion and recommendations

In this working paper, we have proposed a new perspective on analysing entrepreneurial ecosystems. Up to now, research on entrepreneurship has only focused on the level of the individual manager or on the level of ecosystems (Haarhaus, 2022). But how do companies actually operate within the context of ecosystems? We have suggested a research model that focuses on the alignment between business models and what occurs at the ecosystem level. This new view yields some remarkable insights, but there is still more way to go to refine these initial qualitative results.

The main result is that companies moderately align with the elements of an ecosystem. This result indicates that ecosystem research is certainly valuable. However, the results of the thirty case studies can only be called exploratory. The fact that 65% of the companies align with the strategy at the ecosystem level is not straightforward to interpreted. The sample is biased because we are looking at well-performing ecosystems. More variation in ecosystems and a larger sample size is needed to really produce statistics. The study does indicate that this alignment between companies and ecosystems is an overlooked issue. There is alignment between the entrepreneurial ecosystem elements of companies and ecosystems, and good explanations why there is sometimes disagreement. For example, because companies use resources that go beyond the region. The limited number of companies limits the insight into the contextual variables that can help explain the choices made by companies.

Another weakness of the study is the criterion used to conduct the QCA. We have focused mainly on companies' performance, not on productive entrepreneurship, as indicated by the entrepreneurial ecosystem-model (Stam, 2015). The choice for company performance is perhaps a weak indicator for productive entrepreneurship. Nonetheless, it is important to realise that ultimately stimulating entrepreneurship is not only about creating new competitors for existing companies. It is also about creating new products and innovations within the existing companies. And this starts with economic success to accumulate capital. Follow-up analyses should focus more on productive entrepreneurship and its relationship with performance. In this way, a broader view of the phenomenon of creative destruction can be gained.

Does the research have any policy relevance? The answer is that what is thought at the ecosystem level apparently also drives the agenda of companies. This is visible in the QCA result, which indicates that the institutional path is the most dominant strategy followed by companies. When companies align with what is happening within an entrepreneurial ecosystem, this provides opportunities for policymakers to exert influence. This is the case for inclusive policies, among others. As yet, more attention must be paid to that influence.

Which ecosystem elements should policymakers respond to? Although the four paths differ in their combination of elements, and not all elements were necessary factors for success, four elements of the entrepreneurial ecosystem model seem crucial for the company strategies that lead to economic growth: the presence of *networks* (for collaboration), an *entrepreneurship culture*, availability of *talent* (on the labour market) and (new) *knowledge* as basic to innovation. The main recommendation is that regional stakeholders, to strengthen their ecosystem, should consider supporting the development of networks, an entrepreneurship culture, availability of talent, and (new) knowledge. A combination of these elements is expected to enhance chances for economic growth and inclusiveness, but the optimal combination differs per region and per company. Since companies can follow different strategies, this requires made-to-measure support at the company level and specific policies for start-ups, SMEs, larger organisations, and emergent and incumbent ecosystems. However, specific recipes could not be deduced from the information because of the heterogeneity. Regions that want to improve equality, diversity and inclusiveness are advised to consider broad collaboration among institutions and companies as this requires a common effort. Alignment between company strategies and entrepreneurial ecosystems policies is, however, an

interesting finding of this analysis. It opens the door for policymakers to guide companies towards new policies such as, for example, Industry 5.0.

. A final point of discussion is whether this ecosystem research now opens up new avenues for research into digitalisation and its impacts on labour. Perez and Murray Lynch (2022) question whether we are able to see omens of the future of work. Their development model indicates that there is a correlation between technology, public policy and an entrepreneurial agenda. This working paper indicates that this connection can become visible at the ecosystem level. Suppose Industry 5.0 (Breque et al., 2021) aims at human-centric, sustainability and resilience, and we want companies to align with these goals. In that case, the ecosystem level can be taken as the starting point. However, more research is needed into the process by which companies see this alignment and bring it about.

Annex D2.1: Additional tables

Table D2.1_1. Mean calibrated scores for all elements of the entrepreneurial ecosystem model.

Case	Ecosystem	FOR	ENTR	FIN	TAL	KNOW	NETW	LEAD
BG1	IEE	0,25	0,51	0,25	1	0,75	1	0,75
BG2	EEE	0,25	0,49	0	1	0,49	1	0,25
BG3	EEE	0,49	0,49	0,49	1	0,49	0,75	0,49
BG4	IEE	0,25	0,51	0,49	1	1	0,51	0,75
BG5	IEE	0,25	0,75	0,49	1	0,49	0,49	0,49
ES1	EEE	0,49	0,75	0,75	0,75	0,75	0,75	1
ES2	IEE	0,49	0,75	0,51	0,75	0,75	0,75	0,49
ES3	IEE	0,49	1	0,75	0,49	0,75	0,75	0,49
ES4	EEE	0,75	0,75	0,49	0,49	0,75	0,49	0,75
ES5	IEE	0,49	0,75	1	0,75	0,51	0,75	0,49
FI1	IEE	1	0,49	0,25	1	0,49	0,25	0,25
FI2	IEE	0,25	0,25	0,49	0,49	0,49	0,49	0,25
FI3	IEE	0,75	1	0,75	0,75	1	0,75	0,49
FI4	IEE	1	1	1	1	1	0,75	0,75
FI5	EEE	1	0,49	0,49	1	0,75	0,49	0,49
GE1	EEE	0,49	0,75	0,75	0,75	0,75	0,75	0,75
GE2	IEE	0,75	0,75	0,75	1	0,75	0,75	0,75
GE3	EEE	0,75	1	1	1	0,75	0,75	0,49
GE4	IEE	0,49	0,25	0,49	0,75	0,25	0,75	0,49
GE5	EEE	0,49	1	0,75	0,75	0,75	0,75	0,49
NL1	IEE	0,49	1	0	1	0,75	1	1
NL2	EEE	0,49	1	0,25	1	1	1	0,75
NL3	IEE	0,75	1	0	1	0,75	1	1
NL4	IEE	0,49	1	0,25	1	1	1	1
NL5	IEE	0,49	1	0,25	1	1	1	1
UK1	IEE	0,49	0,75	0,49	1	1	0,49	0,75
UK2	EEE	0,25	1	1	1	1	0,75	0,25
UK3	EEE	1	1	0,75	0,75	0,75	0,75	0,75
UK4	IEE	0,25	0,75	0,25	0,49	0,75	0,25	0,49
UK5	IEE	0,25	0,75	0,25	0,49	0,75	0,25	0,25

Table D2.1_2. Uncalibrated and calibrated scores of the outcome: economic growth.

	Profit	Personnel growth	Sum score economic growth	Calibrated score economic growth
BULCS1	3	3	6	0,75
BULCS2	3	4	7	0,875
BULCS3	4	3	7	0,875
BULCS4	4	3	7	0,875
BULCS5	2	3	5	0,625
ES1	2	3	5	0,625
ES2	4	2	6	0,75
ES3	4	3	7	0,875
ES4	4	3	7	0,875

ES5	4	2	6	0,75
FIN1	3	4	7	0,875
FIN2	4	1	5	0,625
FIN3	3	3	6	0,75
FIN6	3	3	6	0,75
Fin7	3	3	6	0,75
GE1	4	3	7	0,875
GE2	3	1	4	0,49
GE3	2	4	6	0,75
GE4	4	2	6	0,75
GE5	3	1	4	0,49
NL1	4	4	8	1
NL2	3	2	5	0,625
NL3	3	4	7	0,875
NL4	4	4	8	1
NL5	3	3	6	0,75
UK1	3	2	5	0,625
UK2	3	2	5	0,625
UK3	2	2	4	0,49
UK4	4	1	5	0,625
UK5	4	2	6	0,75

* Personnel growth: 1= Decline; 2 = Stable; 3 = Growth; 4 = Strong growth (>5% per year). Profit: 1 = loss (>1%); 2 = stable (-1 to +1%); 3 = profit (2-8%); 4 = large profit (>8% per year).

Table D2.1_3. truth table of 15 paths.

FOR	ENTR	FIN	TAL	KNOW	NETW	LEAD	number	raw consist	PRI consist	SYM consist
0	1	0	1	1	1	1	6	1	1	1
0	1	1	1	1	1	0	4	0,979286	0,932085	0,990055
0	0	0	1	0	1	0	3	1	1	1
1	1	1	1	1	1	1	3	0,953279	0,882086	0,989822
0	1	0	0	1	0	0	2	1	1	1
1	1	1	1	1	1	0	2	1	1	1
0	1	1	1	1	1	1	2	1	1	1
0	0	0	0	0	0	0	1	1	1	1
1	0	0	1	0	0	0	1	1	1	1
0	1	0	1	0	0	0	1	1	1	1
1	0	0	1	1	0	0	1	1	1	1
0	1	1	0	1	1	0	1	1	1	1
1	1	0	0	1	0	1	1	1	1	1
0	1	0	1	1	0	1	1	1	1	1
1	1	0	1	1	1	1	1	1	1	1

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3. Study 2: Digital transformation, organisational practices and impacts in thirty cases

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Abstract

This working paper focuses on thirty cases on the digital frontier. Four types of digital transformation could be identified: companies that have invested in nearly all technologies (the 'TOTAL (digital)-category); companies that have invested in AI/Machine Learning as the main distinguishing trait; companies that have invested in robotics, next to other technologies (ROBOTIC type); and companies that have some digital technologies but have no AI/ML or robotics (LOW-USER type). The most important motives for digitalisation were improving quality and serving the customer better. The organisational practices differed significantly between the cases. Still, the high investment, high involvement model with 13 cases stands out. The TOTAL type only shows high investment – high involvement practices, which suggest an association between organisation and technology practice. Employment has not suffered because of digital transformation. Rather, all cases show important investments in the training and development of personnel at all educational levels. High involvement – high investment organisational practices mediate the relationship between technology and employment in different ways: it helps to make the companies more attractive in the labour market; the HR measures need to be optimal to recruit, select and retain talent; the current workforce needs to be motivated to work with the technologies and develop their expertise, and organisational measures are needed to create cross-over learning and redevelopment of the workforce in the case markets fall out. The main shift in employment is further upskilling in technological and digital skills. The COVID-19 crisis is an important (unforeseen) event that allows us to assess how companies deal with technology and organisation. COVID-19 has initiated major technological and organisational changeovers, but they were a long-time coming. Companies did not implement those changes in the past, fearing several impacts such as productivity loss. The pandemic shows that more technological and organisational changes are possible. This requires different expectations among management.

Keywords: digital transformation, case studies, organisational practices, workplace innovation, COVID-19 pandemic

3.1 Introduction

3.1.1 The BEYOND4.0 cases on the digital frontier

What do companies do when confronted with digital transformation? This is the main question for this qualitative study, part of the ***BEYOND4.0*** project, on the impacts of digital transformation with actual data from thirty company cases. The study looks at which technologies are used by the

companies, what investment plans are, and which personnel and organisational policies are used. With this information, technology profiles are created and related to personnel and organisational policies. This allows assessing the impacts of technology and organisational strategy on the performance of companies and employees. The main impacts are skilling and digital skilling strategies. With this qualitative analysis and comparison between thirty companies, we try to understand what it means for companies to work on the digital frontier. This study is limited to what is happening in the companies, with insights from management and employees. The companies selected for the *BEYOND4.0* project are exemplary cases for their role and position in several entrepreneurial ecosystems in Europe (Dhondt et al., 2022). Most of the company cases are leaders in their sector in the use of digital technologies, i.e. these are core companies in the studied ecosystems in a particular industry. Other companies in our selection are at best users of digital technology. These are often suppliers or network partners of the core companies in the studied ecosystems. The differences in practices allow us to understand better which specific company policies are adopted to deal with these digital technologies. The cases present a first understanding of what companies do when confronted with digital transformation. The COVID-19 pandemic offers an extra perspective on digital transformation. This 'shock' happened during the data collection, and in some cases, it was possible to assess if the pandemic altered the stakes with technology and employment in the cases.

3.1.2 Technology and employment levels

The context for this study is that over the past decade, several claims have been made about the future impact of digital technologies (robots, AI, platforms) on occupations and labour markets (e.g. Brynjolfsson and McAfee 2015). Researchers predicted significant and strongly negative outcomes for occupations and the labour market for the coming two decades (e.g. Frey and Osborne 2017). Heald, Smith, and Fouarge (2019) predicted that the major unemployment impact of digital technologies will be visible between 2030 and 2050. Autor (2015) was critical of this perspective, posing the question of why we still have so many jobs today. He concluded that technology is only part of the equation and that there is a need to look at how labour markets function and check the ever-increasing demand for products. Fernández-Macías, Klenert, and Antón (2021) indicated that part of the overestimation of the impact of digital technologies resides in the fact that most of these technologies have already been around for some time, in other forms. These technologies' labour-destructive impact on employment was mainly felt in the 1990s. Current technologies do not have this impact. Other studies are also sceptical about the negative effects of the newest technologies on employment. For example, Graetz and Michaels (2018) found that increased robot use by companies in Europe increased annual labour productivity growth but did not significantly reduce total employment. So, robot use did reduce low-skilled workers' employment share. There is a relationship between the type of company and robot use. According to Koch, Manuylov and Smolka (2021a), better-performing firms are more likely to adopt robots. However, more skill-intensive firms are less likely to do so. Robot adoption generates substantial output gains, reduces labour cost-share, and leads to net job creation. Low-skilled workers are more likely to be affected by automation since they perform the less complex tasks which are automated. At least, this is the case with work tasks that can be standardised. Low-skilled workers can profit from more productive work situations if their work is not fully robotised. Up to the current date, the stark predictions

about unemployment impacts have been quite inaccurate. At the beginning of 2022, European countries experienced the highest job vacancy rates in more than ten years (Eurostat, 2021). This is ten years after the first predictions by Frey and Osborne (2017). It is time to inform the debate with more insights of what is happening in companies dealing with the digital transformation. Research on the employment effects of past technological introductions, for example, micro-electronics, has shown that expected rising unemployment was mitigated by several compensating factors, such as wages and consumer demand (Whitley & Wilson, 1982). Indeed, each time that techno-anxiety has been stoked, for example in the 1960s when companies first started installing computers, more jobs have been created than destroyed ("March of the Machines," 2016). The question is also to what degree digital technologies really transform company practices. In the 1990s, a series of studies investigated the impact of the microelectronics and software revolution on work (Huys et al., 1995a; Schumann et al., 1994). Based on sectoral case study research, one of these studies found that the microelectronics and software revolution did not dramatically impact work practices. The 'technological transformation' seemed to be postponed (Huys et al., 1995b). We are confronted with the same context of strong predictions about the impact of technological change. The question is, in line with Schumann et al. and Huys et al.: what transformation can we see happening in companies at the technological frontier, in our case, the digital frontier?

3.1.3 High-performance work systems and skills impacts

An explanation why the direct impact of digital transformation on work may not be as expected is that much depends on the organisational practices deployed by the companies. Companies need to create environments that help job occupants shape their roles and have jobs that improve their skill sets. This is called the 'AMO' approach; workers have the 'ability', 'motivation' and 'opportunity' to expend the discretionary effort that supports company innovation and competitiveness (Appelbaum et al., 2000). Companies need to know how to help individuals expand their skills during their careers. This requires companies not reducing work to small specialised tasks but to create real T-shaped organisations. Team environments are needed that integrate individuals with overlapping high-tech skill profiles (Dhondt & Van Hootegem, 2015). Employment levels and changes in skills composition require intervention by company management. Companies have different approaches to achieving these changes. The question is also if the digital transformation changes the balance in the companies towards 'high road' organisational strategies such as workplace innovation. Workplace innovation companies allow greater discretion from better-skilled employees (Batt, 1998), which has morphed into 'High-Performance Work Systems' (HPWS) (Appelbaum et al., 2000). These HPWS are defined as an 'approach to managing organisations that aim to stimulate more effective employee involvement and commitment to achieve high levels of performance' (Belt & Giles, 2009: 17). Appelbaum et al. (2000) argue that HPWS provide the optimal environment to elicit discretionary effort, underpinned by AMO. There is room for policymakers to block off the low road through legislation and/or pave the high road by encouraging environments that generate better jobs (cf. Carré et al. 2012). This fits with the workplace innovation movement that already exists at the national (Oeij et al., 2017) and EU levels (e.g. EUWIN network).

The mediating impact of organisational practices may explain why other occupational changes occur rather than those predicted. It could be that, rather than job losses or job gains, the current technological transformations might result in jobs being reconfigured. As Dunlop stated, the future

might be 'less that the robot will take your job than the robots will redefine what we understand by a job' (2016: 109). This redefinition points to the fact that we may need to check which skills are required of workers. The call for higher-level skills to overcome future employment disruption also connects to renewed discussion about the role of lifelong learning to help foster workers' adaptability to changing labour markets over their working life (Barnes et al., 2016). There are serious digital skill deficits amongst some workers. However, there are other skills needed too. The different tasks identified by Fernández-Macias and Bisello (2016) map onto different skill sets, for example, technical, analytical, behavioural, transversal, leadership and T-shaped skills (see also Kohlgrüber et al., 2021).

3.1.4 Research questions

Suppose technology itself is not the main factor influencing what is happening with employment. In that case, a study is needed to understand the mediating impact of organisational policies on the relationship between digital technologies and employment impacts. Do digitally transformed companies with highly automated production systems also invest in high-road company policies? Or, do such companies opt for low-road strategies and models for producing cost-driven services? Do we see different impacts of digital technologies? As Wilson and Hogarth (2003) have pointed out, there is nothing wrong with some companies choosing the low road. Organisations may be perfectly successful in operating such a strategy. However, long-term difficulties arise for Europe as a whole if too many companies choose this option. Eurofound and Cedefop (2020a) found that at least 21% of European companies choose the road to low investment, low involvement organisational practices. However, mainly companies using high road strategies seem to be investing in digital technologies.

3.1.5 Outline paper

This chapter is structured around seven sections. We start with developing the concepts for our analysis (section 3.2). This study is based on thirty case studies. The methodology to analyse these cases is presented in section 3.3. The section discusses the selection of cases and the procedure to collect information and conduct the comparative study. The results sections describe the technology situation among the thirty companies (section 3.4). The comparison leads to a typology of digital technology companies, which is the basis of further analysis. The section looks into the motives for investing in these technologies and possible barriers to change. It also discusses technical transformation and workplace innovation practices (3.5). The second part of the results section is focused on understanding how to analyse the organisational development of the cases and the relationship with the technology typology (section 3.6). The last part brings technology and organisation together in the analysis of the impacts on employment and work. The separate impact of the COVID-19 pandemic is assessed. In section 3.7, conclusions are formulated, and the overall results are discussed.

3.2 Main concepts

This section explains the core concepts used to analyse technology impacts within the company case study, including the technology situation (the 'digital transformation'), organisational practices, the performance of companies, and the employment and skill situation. The changes in these factors are examined. The relationship between technology and impacts is seen as mediated by the organisational context and personnel practices.

3.2.1 Digital transformation

For the definition of digital transformation, we refer to the European Commission study on the digital transformation of SMEs (European Commission, 2021, p. 2): "*Digital Transformation (to be denoted as DX across this literature review), is the profound and accelerating transformation of business activities, processes, competencies and models to fully leverage the changes and opportunities of digital technologies and their impact across society in a strategic and prioritised way, with present and future shifts (i.e. socio-economic, environmental, technological etc.) in mind. DX, in the integrated and connected sense of the term, requires, among other factors, the transformation of business models; activities/functions; processes; ecosystems; asset management; organisational culture; ecosystem and partnership models; and customer, worker and partner approaches (i-SCOOP, 2021).*"

The report sees digital transformation (DX) as the next step after the digitalisation of products and production processes. The focus is on changes in the company's business model, products, processes and organisational structure. "*DX is about using digital capabilities (such as big data, IoT and cloud computing) to revolutionise the customer experience, to outdo the competition and to create an innovative business model adapted to this digital era* (Westerman, 2011)" (European Commission, 2021, p. 3). The company perspective is helpful for this study.

Here, we examine whether companies use AI, machine learning, robotics, high-speed infrastructure, Cloud systems, and blockchain to drive their operations. The digital transformation happens next to or on top of existing mechanisation and automation efforts. The application of such technologies is used to enhance the network relationships between technologies (cyber-physical systems; IoT), but also between technologies and company strategies (data-enabled production), and between the company and its environment (suppliers, customers, others). This changeover is sometimes referred to as Industrie 4.0 (Perez & Murray Leach, 2021; Chris Warhurst et al., 2020). The SME report (European Commission, 2021) is useful because it functions as a reference point to assess where the company cases are in the digital transformation. It helps in understanding the external validity of this study. As Genz et al. (2022, p. 1) indicate, there is a "scarcity of datasets that provide measures of the usage of advanced technologies at the firm level and accompanying workers' outcomes". In their own study (Genz et al., 2021), they find that 22% of German companies use Industrie 4.0-level technologies. Their observation is that the spread of these technologies in these companies ('depth of transition') is also quite limited. Missing from their perspective is the translation of the Industrie 4.0-technologies into a digital strategy. For our study, we will be reducing

the technological complexity to a limited set of technological strategies. This will be done in the results section.

3.2.2 Workplace Innovation and 'high road' practices

The SME study identified several internal and external factors that can act as key determinants of digital transformation (European Commission, 2021). The internal factors include managerial ability, access to talent and digital skills deficits, ability to connect a digital strategy with a concrete business model, and behavioural characteristics at the individual level. These factors, it can be argued, seem to be disconnected from each other, making it hard to operationalise in the case studies. However, in practice, organisational measures tend to come in 'clusters', with some clusters leading to superior organisational performance and higher quality of working life (Subramony, 2009). Brynjolfsson and Milgrom (2013) indicate that organisational and HR measures tend to be complementary. An organisation with a specific set of practices will also tend to have complementary measures (Brynjolfsson & Milgrom, 2013: 11). The question is, then, which measures are connected. Modern Sociotechnical thinking (MST) (Kuipers et al., 2020; Mohr & Van Amelsvoort, 2016) identifies, on the one hand, the structural dimensions of an organisation (production organisation; control structure) and the way work is divided between organisational units. On the other hand, there are the HR dimensions. MST argues that these last dimensions should be aligned with the first dimension. Workplace innovation is then seen as an organisational practice in which organisations focus on reducing complexity in operational processes by allowing employees maximum control (Høyrup, 2012). Reducing the operational overload of management gives them the opportunity to deal with strategic and tactical decision-making (Kuipers et al., 2020). Using HR measures, the focus can be on the AMO-approach as indicated earlier (Appelbaum et al., 2000). Workplace Innovation collects these approaches that allow for high performance of organisations and superior involvement of workers (Oeij et al., 2017). Companies confronted with digital transformation need to rely on sets of measures to deal with knowledge shortages, employee involvement and employee capacity issues. Well-developed policies allow mitigating measures to be developed for any workplace issue, work process disturbance or control problems that may arise.

The focus of the case studies was to map 'high road' employee practices. The European Company Survey (ECS) (Eurofound & Cedefop, 2020b) provided a typology of organisational practices that is useful for our study. The ECS typology is constructed from nine variables. However, we do not have all the statistical information Eurofound has about the companies. We do not have reliable information on workplace behaviour and motivational levers, nor on the use of part-time contracts. We did not include 'job complexity and autonomy' as an indicator in the workplace innovation construct because we see this as a job level indicator and not an indicator of organisational practices. Therefore, it is important to indicate what we see as the core characteristics of the Eurofound/Cedefop types. The first type is the *high involvement, high investment* type of company practices, which differentiates itself from the other types mainly because of more possibilities for employees to voice their concerns, more comprehensive training, more open-ended contracts and more collaborative supplier relationships. This type is most comparable to what we have defined as workplace innovation company practices. The *selective investment and moderate involvement* type identifies itself as using more selective training opportunities and more part-time working arrangements. This last arrangement is more gender-focused and can be qualified as a gender-

sensitive arrangement. The *moderate investment and irregular involvement* type has one distinguishing characteristic: the use of open-ended contracts. The *low investment and low involvement* type also uses open-ended contracts and is less focused on external collaboration. We use these main characteristics to identify the dominant organisational practice among the company cases.

3.2.3 Inclusive technological impacts

As indicated in the ***BEYOND4.0*** Guidance Paper (D2.1), it is important to identify those routes followed by companies in the digital transformation, where technologies are used as a resource complementing human work and those where humans come as an appendix to the machines (Chris Warhurst et al., 2020). Next to the fact that these technologies do not necessarily target employment levels, inclusive technologies enhance skills and skill utilisation. To develop insights into these inclusive impacts, we need to examine equality, diversion and inclusion (including gender practices in personnel policies), with particular attention to vulnerable groups.

The Eurofound/Cedefop-typology does not cover the inclusive personnel practices that we want to be mapped in our study. In the survey and the interviews, we collected information on equality, diversion and inclusion (EDI practices) with particular attention to vulnerable groups ("Is the use of "vulnerable groups" an explicit part of your establishment's mission?", "In the past two years, has your establishment deliberately employed people from one or more 'vulnerable groups', such as the long-term unemployed, early school leavers and young or partially disabled?"). For gender practices (a part of EDI practices), we focused on what companies said they were doing, whether task division was gendered, and if women had equal pay and/or access to management positions. For diversity, we only had the possibility to assess if migrant workers were recruited. This inclusive dimension is notably missing in the high investment – high involvement typology. If we add this dimension, we have five organisational practices, with the extra type of *inclusive high investment – high involvement* organisational practices.

3.3 Cases and methodology

This study uses a case study approach to understand the technological and organisational situation in the companies. The qualitative approach is exemplified by trying to reduce the different situations in the thirty companies to a limited set of types of technological and organisational practices.

3.3.1 Cases

We conducted in-depth qualitative research into 'incumbent' and 'emerging' ecosystems in six countries: Bulgaria, Finland, Germany, the Netherlands, Spain and the United Kingdom) (Dhondt et al., 2022). Each of the six research teams selected cases from the (incumbent and emerging) ecosystems. In discussion with the stakeholders in each of the ecosystems, example companies were identified and selected. Stakeholders looked for companies that represent the leading technological and organisational practices. They selected 'core companies' in the ecosystems and suppliers or customers to these core companies. A total of thirty companies have been retained. Not for all companies do we have all the required information. Table 8 shows the main descriptives for these companies.

Table 8. Descriptives for the 30 cases

		Number of cases	Comment
Country	Bulgaria	5	
	Finland	8	Analysis limited to 5 cases
	Germany	5	
	The Netherlands	5	
	Spain	5	
	United Kingdom	5	
Size	Large	14	> 250 -15000 employees
	SMEs	8	> 30 – 250 employees
	Start-up, small	6	< 30 employees
	Missing	2	
Date of establishment	<1899	2	
	1900 -1999	14	
	2000 - 2009	8	
	2010+	5	
	Missing	1	
Main sector	Advanced manufacturing	12	
	Software, digital health	15	
	Logistics and maintenance	3	

Half of the cases (18) belong to major corporations with multiple locations around the world. We limited the investigation to one geographical location of such major corporations. Interviews and surveys were conducted in each of these companies. Managers and employees needed to describe the situation for this location. The companies have very different historical backgrounds, allowing us to understand different reactions to external changes. Some companies have a long history; about half are younger than twenty years old. The sectors show that the cases reflect the situation in Industrie 4.0-type of companies (advanced manufacturing), but also digitalisation from the perspective of software producers and users.

Our sample allows us to describe how digitalised the companies are. Managers and employees have reflected on the motives to implement digital technologies and barriers to the implementation. Because the core companies have been selected as advanced in the six countries, the answers are biased towards digital 'survivors' and 'winners'. However, the start-ups are in the first phases of their development and may ultimately still fail. The database is thus quite heterogeneous and

selective at the same time. To allow us to understand how the cases perform, we use the FLASH-Eurobarometer as a comparison base (European Commission, 2021).

The companies and interviewees have been promised that they remain anonymous and unidentifiable. Company summaries and survey material are available but with no possibility of identifying the actual cases.

3.3.2 Methods

Development of interview guides and case reports. As indicated, several surveys and interview protocols were developed to conduct the study. Two company surveys were used: one to map the perspective of management on the ecosystem dimensions relevant to the company; a second survey was used to map the digital technologies in the companies, based on the Eurobarometer Flash survey (European Commission, 2021). The advantage of this second survey was that the results of the thirty cases could be compared to an external source. The interviews mapped technology, organisational practices, and the perspective of the company on employee outcomes. The interview guides enabled a standardised approach to be adopted between the six research teams. These interviews were integrated into company case study reports. These case reports were verified by the companies who gave approval for the reports to be used as data; only the two-page summaries of these case reports are publicly shared (see Annexe 3). These approved reports have been the basis for developing the comparative dataset used for this report. All teams used the same approach to ensure the comparability of research findings.

An important context for the research is the COVID-19 pandemic. This pandemic limited our ability to undertake company visits and map the technology situation in practice. The surveys provided this insight. The majority of interviews were conducted using online tools or by telephone, reducing the possibility of engagement with different actors at the companies.

Desk research. Where possible, the information on the companies was enhanced with desk research material. Annual reports and websites were used to complete several dimensions of the organisational practices and company performance.

Integration of findings. Integrating the findings from all countries was a joint endeavour of all partners. While TNO, as the leading partner, laid out the headlines and format and principal author, the partners provided their case study reports and added their information to the report. The main results were mapped into overview tables and used for coding and comparison. These tables also provided the case fragments that are used in this working paper to illustrate several results.

3.3.3 Comparative analysis

Comparative tables for the thirty companies are the main input for this working paper. These basic tables were further reduced by inductive coding to the core content (core variables), for which we compared the cases (Miles et al., 2013). For several research questions, technology and organisational practices were reduced to several typologies. The typologies were compared with the qualitative reports. For each typology, several cases provided information. To enhance the reliability of these typologies, we used several researchers to evaluate the results. The researchers

discussed the different eventual classifications of cases and tried to obtain a consensus. 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 have high validity and reliability of our research material by using multiple sources and different stakeholders, comparing a great number of cases, and including responses from the company managers and employees.

3.4 Qualifying the digital transformation among the cases

To understand what the digital transformation means for the thirty cases, three steps have been taken: assessing the depth of the digital transformation and identifying the path the companies follow; identifying the motives to invest in the digital technologies; and identifying possible barriers in investing.

3.4.1 Depth of the digital transformation?

To assess the digital transformation in the case studies, the depth of transformation was assessed with several questions on the type of technology situation, type of digital technology and the number of these technologies implemented. The combination of these variables allows us to assess the depth of the digital transformation.

The FLASH-study (European Commission, 2021) used several questions to map the technology situation of SMEs in Europe. These questions were advanced to the thirty cases of the *BEYOND4.0* study. Table 9 compares the two studies for the self-qualification of the type of technology situation.

Table 9. Comparison cases with the FLASH-Eurobarometer – SME-results (European Commission, 2021): type of technology situation

Answer	Number of cases	% of total	FLASH (all)
A 'Your enterprise has adopted or is planning to adopt basic digital technologies such as email or a website but not advanced digital technologies'	1	3%	33.13%
B 'There is a need to introduce advanced digital technologies but your enterprise does not have the knowledge or skills or financing to adopt them'	1	3%	7.89%
C 'There is a need to introduce advanced digital technologies and your enterprise is currently considering which of them to adopt'	4	13%	10.40%
D 'There is a need to introduce advanced digital technologies and your enterprise has already started to adopt them'	23	78%	25.23%
E Your enterprise does not need to adopt any digital technologies	1	3%	1.12%

Three-quarters of the cases have already started **adopting advanced digital technologies**. Only two cases did not see the need to adopt these technologies. One case is a technology consultancy firm, and the other case is a last mile-logistics deliverer mainly using software to plan operations. Overall, the cases are technically more advanced than the SMEs in the Flash-study.

Table 10 provides an overview of the actual technologies implemented.

Table 10. Comparison of presence of digital technologies cases and FLASH-study

	Number of cases reporting use	% of cases	FLASH (all)
2A_Articial Intelligence_Machine Learning (AI_ML)	14	46%	6.26%
2B_Cloud_computing	27	90%	45.58%
2C_Robotics	14	46%	7.84%
2D_Smart_devices	20	66%	25.14%
2E_Big_data_analytics	22	73%	12.35%
2F_High_speed_infrastructure	20	66%	31.19%
2G_Blockchain	4	13%	2.87%
None, don't know	-	-	33.77%/1.45%

About half of the cases have introduced AI/ML or robotics, compared to only 6-8% of the SMEs in the FLASH-study. Cloud computing, smart devices, big data analytics and high-speed infrastructure seem to be quite common technologies in the cases as well. Blockchain applications were seen in a few cases, but still more often than in the FLASH-study. In one case, blockchain was used to map parts that were delivered to customers. The technology was used to maintain a stable database of these parts.

Table 11 lists the **number of digital technologies** used in the cases.

Table 11. Number of technologies present in the cases

Number of technologies present	Present
7	3
6	3
5	6
4	8
3	5
2	2
1	3

Only three companies can be classified as a basic digital technology adopters; all others can be classified as advanced digital technology adopters (in Flash: 28% basic; 19% advanced; rest is no technology). Twelve cases had five or more of the listed technologies. The main conclusion that can be drawn from the comparison between the cases and the FLASH-SMEs is that the cases represent far more digital technological situations. They were selected for this reason which can explain this bias.

The presented evidence is however too crude to understand the different technological paths among the cases. Two steps have been taken to identify specific technological strategies of the cases. The first refinement was to assess if the cases are digital transformers. SMEs that use digital technology to transform their business model are classified as digital transformers (DX). SMEs that only use digital technology as a tool are called digital users. Our analysis has identified companies that develop servitisation strategies and direct or support their operations towards customers in a digital fashion. Table 12 shows that one-third of the cases in our study can be classified as users and two-thirds as digital transformers. A second refinement was to understand if different digital paths are deployed. With the AI/ML and Robotics criteria, we distinguish four types of digital transformation (see Table 12):

- companies that have invested in nearly all technologies (TOTAL (digital)-type);
- companies that have invested in AI/ML as the main distinguishing trait (AI ML type);
- companies that have invested in robotics, next to other technologies (ROBOTIC type); and
- companies that have some digital technologies but have no AI/ML or robotics (LOW-USER type).

The following table relates this distinction to DX/user.

Table 12. Four types of digital transformation among the cases (n=30).

	Digital transformers	Digital users
TOTAL	4	2
AI_ML	7	
ROBOTIC	5	3
LOW-USER	3	6

Most of the LOW group are 'users of digital technology'. Most of the other technology strategies are digital transformers. Table 12 allows distinguishing between four significantly different technological strategies or situations: if the 'users' and 'low' categories are classified under one label, this delivers the strongest distinction between technology situations: TOTAL (4 cases), AI_ML (7), ROBOTIC (5) and LOW-USER (14). The following examples illustrate how these cases are different.

> ***NL3***[7] *belongs to the TOTAL group and is an example of a company that has been investing in all types of technology. The company sees technology as an important means to deal with customer demands. Internal logistics and production activities have been automated to the highest degree. Robots and AGVs support advanced manufacturing in this plant. The company does everything to avoid manual operations. To be able to use technology in all operations,* ***NL3*** *avoids being dependable on external technology suppliers: all software that drives robots and other tooling has been developed internally. This allows the company to understand better how to progress faster than their competition. The company uses low-code programmes for software so most employees can adapt products and processes.*
>
> ***GE1*** *is transforming into a major digital services company and is in the AI_ML (DX) category. To optimise its logistics operations, it has mapped the geographical characteristics of the whole region in great detail where it delivers its product. This allows very precise planning of deliveries and response to the very diverse customer demands. Machine learning tools and planning software have been the cornerstone of this strategy. Cloud computing and big data analytics are now the core driver of the business.*
>
> ***ES3*** *is a producer of heavy tooling requiring the highest precision and performance. It can be classified as a ROBOTIC DX company. To achieve this performance, the company needs robotics to assist in precision manufacturing and big data analytics to understand the production processes and the maintenance of its products once delivered.*
>
> ***BG5*** *is a small software developer exclusively working for the Bulgarian market. It does not compete with the larger, more internationally focused software developers in its own region. The specific position makes the company unable to pay the high wages the other software developers pay and relies on sufficient new talent to support its further development. The company uses a set of standard software tools to deliver to its customers. An ERP system drives the different projects for the company. Even if the type is not as advanced as the three other types, these companies rely on many digital competencies of their personnel. We classify it as LOW-USER, even if it is an ICT company, mainly because it is a user of ICT-tools, rather than a developer.*

[7] Cases are identified by their country (NL, GE, ES, BG, FI, UK) and by a separate number.

3.4.2 Comparing the motives for the digital transformation

The FLASH-Eurobarometer identifies eight possible **motives to invest in digital technologies**. The analysis of the cases shows that there are two additional motives: to develop new business models and to better serve the customer. This last motive has been integrated with 'quality', because improving quality comes down to better serving the customer. The cases have been asked to rank-order their motives from 1 to 6, with 1 as the most important rank. If cases did not rank a motive, then this motive was rated as 6. Table 13 shows the average rank scores for each technology type.

Table 13. The priorities of companies to implement digitalisation during the past two years.: average score per type of technology situation (1 = highest priority; 6 = lowest priority) (n=29; 1 missing)

	LOW-USER	AI_ML	ROBOTIC	TOTAL
N =29	14	6	5	4
Labour_costs	4,0	5,2	3,4	3,0
Higher_production	3,4	4,3	2,8	1,3
Work_less_physically_demanding	4,2	5,8	5,2	2,5
Work_mentally_less_demanding	3,9	4,7	5,4	4,3
Quality/better serving the customer	1,9	2,8	1,8	1,3
Image_stakeholders	4,6	4,0	4,2	2,8

Quality and better serving the customer are the most important motives identified across the cases to implement digitalisation. Even the LOW-USER cases rate this as an important motive. The TOTAL and ROBOTIC types also rate higher production as an important motive. The TOTAL type rates more motives as important in comparison to the other types. These companies use digital technologies for multiple objectives. LOW-USER and AI_ML are mainly focused on quality/better serving the customer. ROBOTIC cases also stress higher production as a motive to invest. The other motives are not seen as driving the implementation. Labour costs are only of some importance for ROBOTIC and TOTAL cases.

The cases were also asked if their **priorities or strategy with digital investments changed** over the past two years. Only three companies have indicated that their motives to implement digitalisation have changed over the past years. Two companies are start-ups with shifting tasks and priorities. The third company is an advanced manufacturer which indicates that the pace of change has become slower. All other companies indicate that priorities have remained the same. It is relevant to indicate that the companies were in the midst of the COVID-19 pandemic when responding to this question.

The overall picture is that the motives are different between TOTAL and the other types. The three other types mainly invest in improving the quality or the services to the customer. TOTAL companies have a broad set of motives for their strong technological strategy. The strategies were embedded some time ago.

3.4.3 Barriers to investing in the digital transformation

The FLASH-Eurobarometer identifies eight possible barriers to introducing digital technologies (Table 14). This study focused on understanding why SMEs may not have any digital technologies. For this working paper, comparing the answers between the thirty cases and the SMEs helps to map

the different investing contexts. From the answers of the cases, an additional barrier was suggested: the availability of sufficient personnel.

Table 14. In introducing digital technologies, have you been confronted by the following barriers to digitalisation?: count (n=30; no missing)

	LOW-USER	AI_ML	ROBOTIC	TOTAL
N =30	14	7	5	4
Financial	5	3	2	1
Skills	5	4	2	2
Managerial_skills	3		1	
IT_infrastructure	2	2	1	
Regulatory_obstacles	3			1
IT_security_issues	7	5	2	
Uncertainty_digital_standards	2	1	1	
Internal_resistance	3	3	3	
Personnel availability				1
Average number of barriers	2,1	2,5	2,2	1,2

Four companies did not report any barriers to implement digital technologies. AI_ML cases, on average, see the most barriers, mainly to IT security and skills. The LOW-USER type sees barriers to IT-security, available personnel skills and finances. ROBOTIC and TOTAL have very few cases that report barriers, making it less reliable to specify a specific barrier. Internal resistance to digitalisation seems to play a role in all types except the TOTAL cases. One example of this resistance was that older employees did not feel comfortable with the new technologies and needed to have new workplaces without these technologies.

Again, it seems that the TOTAL type sets itself apart from the three other types: not only having a broad set of motives to implement digital technologies but also reporting the least barriers to digitalisation.

3.5 Technological transformation and workplace innovation practices

Organisational practices were identified during the interviews and desk research. The companies verified the case study reports with the qualification of organisational practices. The information was recoded according to the Eurofound-typology of organisational practices (Eurofound & Cedefop, 2020b). For the coding, two coders used the same information for the classification to assess the inter-rater reliability. Their scores showed a high (87%) correlation. A final discussion was needed to agree upon the full classification. Table 15 shows the distribution of organisational and technological practices among the company cases.

Table 15. Comparison of organisational and technology practices (n=29; 1 missing)

	LOW-USER	AI_ML	ROBOTIC	TOTAL
low investment, low involvement	5	2	1	
moderate investment, irregular involvement	2	1	1	
selective investment, moderate involvement	2	1	1	
high investment, high involvement	5			2
high investment, high involvement, inclusive		2	2	2

The company cases are spread across all organisational practices. Not one practice is dominant, even though the high investment, high involvement with 13 cases stands out. The low investment, low involvement is an important category. As expected, the results are biased towards size of the company: the larger companies rate more favourably towards high investment, high involvement. The TOTAL type only shows high investment – high involvement practices, which suggest an association between organisation and technology practice.

Again, the case of NL3 is exemplary with the company investing a lot into comprehensive and continuous training of all of its personnel. Half of the employees do not have Dutch nationality.

Low investment-low involvement practices are more common among the LOW-USER, and even among some AI_ML and ROBOTIC companies. The moderate investment – irregular involvement is also quite dominant among the LOW-USER type of companies. Even if there is some spread in organisational practices among the technology types, it seems that the more technology-focused companies are supported by more investment-type organisational practices.

3.6 Impacts of the technological transformation and workplace innovation on company performance and skills

Two main impacts of the digital transformation are considered in these case studies: the impact on employment levels and on skills. The impact of the COVID-19 crisis is added as a separate topic, mainly to understand how the companies dealt with this sudden impact. The analysis is done on the available performance data and illustrated with case study material. The development in employment levels is the starting point of analysis.

3.6.1 Current growth and future growth of employment

The expectation from Frey and Osborne (2017)) and subsequent research is that digital technologies will render a whole set of jobs obsolete, whilst others suggest that certain tasks disappear. Even if the idea is that only some tasks would disappear, the overall net effect should be a reduction in employment. What do the cases provide as information? For the cases in this study, the actual development of employment levels in the period 2015-2021 has been analysed, and the expectations about the future development of employment have been checked during the interviews, company surveys and desk research (in some cases, annual reports).

Seven companies have experienced decreases in employment in the surveyed period, even if this is only for a part of the tasks or jobs. Only in two cases has this led to an overall reduction in total employment.

> ***GE5*** *saw an important customer disappear, which nearly forced the company to close its entire business. In two years, the company bounced back to a third of its previous employment level.*

In another German company, further productivity increases have led to overall declining employment. For the other companies, overall employment has remained stable or even increased. Six of the seven companies with employment losses see productivity increases as responsible for the declining tasks.

> *For two companies (**FI1** and **NL3**), certain tasks have been eliminated, but a general increase in employment has offset employment reduction. **NL2** has seen the same effect, but the total employment has remained quite stable.*

The logic among these six companies to reduce the tasks or occupations is not straightforward.

> ***NL3*** *focused on eliminating the most expensive tasks to create higher productivity. **UK4** only focused on tasks that engender many safety issues. **FI2** adds to safety issues also a reduction of highly specialised manual tasks and, to a lesser extent, the most expensive workplaces and workplaces requiring the most creativity. **NL2** and **UK5** reduced tasks that are the most expensive or routine knowledge tasks. **FI1** had a myriad of reasons for reducing tasks.*

The reasons for reducing specific workplaces are quite heterogeneous, and only three cases are driven by the need to be more productive. Reducing safety risks is a driver for (digital) investments in three companies. For these six companies, we cannot see that companies use the Frey and Osborne-logic to reduce employment, to focus on the low-skilled manual jobs or routine knowledge tasks. For routine knowledge tasks, these are only reduced if they are also quite expensive.

Our second analysis focuses on technology and organisational contexts for past and future employment growth. Table 16 maps all the technology types according to both dimensions: past and future growth of employment. Strong growth (decline) is seen as changes of five per cent or more in employment levels.

Table 16. Technology type: change in current (>2015) and future employment levels (next five years). Interviews and secondary material (box = growth quadrant)

Employment development at plant level in period 2015-2021	Expected future employment development			
	Decline	Stable	Growth	Strong growth (>5%)
Strong growth (>5%)			1 TOTAL	2 LOW-USER, 1 AI_ML, 2TOTAL
Growth			3 LOW-USER, 3 AI_ML, 1 ROBOTIC	1 ROBOTIC, 1 AI_ML
Stable		4 LOW-USER		1 LOW-USER
Decline	1 LOW-USER		1 LOW-USER, 1 ROBOTIC	

The table shows that the cases seem to relate future performance to their own past performance. Only six cases show a different rating between past employment performance and future expectations. Seventeen of the 25 cases are in the growth quadrant and expect at least a continuation of past performance. It is mainly the low-users of technology that do not see that much growth in the future. The AI_ML, ROBOTIC and TOTAL cases all foresee strong future growth in employment.

When looking at the same results in the organisational context of the cases, the spread in organisational contexts seems somewhat stronger than according to technology type. Table 17 provides this information.

Table 17. Organisational type: change in current (>2015) and future employment levels (next five years). Interviews and secondary material (box = growth quadrant)

Employment development at plant level in period 2015-2021	Expected future employment development			
	Decline	Stable	Growth	Strong growth (>5%)
Strong growth (>5%)			1 HH+	1 LL, 1 SI, 2HH, 1 HH+
Growth			3LL, 3MO, 1 SI, 1 HH+	1 SI, 1 HH+
Stable		1 LL, 1 MO, 2HH		1 HH
Decline	1 HH		1 LL, 1 HH+	

Key: number indicates the number of companies in this cell;

- HH = high investment, high involvement
- HH+ = high investment, high involvement, plus inclusive policies
- LL = low investment, low involvement
- MO = moderate investment, irregular involvement
- SI = selective investment and moderate involvement

High involvement-high investment cases seem to be located along the axis decline – growth. Low involvement, low investment cases are mainly situated in the growth-growth cell.

Comparing the two tables, it seems technology type shows a clearer employment performance than the organisational context of a company. From these tables, it is helpful to explain the positioning with more background information from specific cases.

> ***GE2**-LOW USER represents the '**decline-decline'** cell in the table. This is a major German company that has been restructuring itself over the past twenty years. Employment has been declining steadily by the closure of several production departments and increasing efficiency in all other parts of the company. All digital technologies are developed for this purpose. This efficiency is possibly going to be accelerated, given the power of the different digital technologies that are implemented. The markets still show growing competition, mainly from China. Here, the HR- and organisational measures are used to dampen the impact of this restructuring. The company has a broad range of plans to redeploy the current workforce and to school its workforce into new tasks. The company does, however, experience significant shortages in skills to use these new digital technologies.*
>
> ***FI2**_ROBOTIC represents the '**decline-growth'** cell. In this case, one of the main departments needed to close because of a shift in consumer demand. The corporation to which the case belonged decided to close the plant and redeploy the workers to other parts of the company or to help workers find re-employment elsewhere. The high involvement-high investment context supported workers to find new employment within the same company.*
>
> ***BG4**-AI_ML has seen **slow growth** over the past years and predicts the same for the future. It has been integrated into the 'mother holding' and performs very specific tasks and services. The case carefully manages its business, mainly because of the type of client it is working for (European defence industry). The company has a selective investment – moderate involvement organisational context. The company does invest in the learning and personal development of employees. The recruiting policies are, however, not that focused on inclusiveness. Future growth is expected but may be difficult to achieve if the company does not change its methods drastically. The company saw its major growth in employment more than ten years ago.*
>
> ***NL1**-TOTAL represents the other side of the spectre. This is the core company in the Dutch entrepreneurial (incumbent) ecosystem and expects **major growth** for the future. The case has seen its employment double in size in the past years. Digital technologies are everywhere in this company and require continuing training and personnel development to keep up with the changes. The case invests in all dimensions of workplace innovation to make this happen. The recruitment is done at a global scale to support future growth. The new focus is on Big Data specialists, mainly because the company's future depends on better use of data and guiding the advanced machines with software. The physical limits of the product technology can now be circumvented with more software possibilities. For this, the case is investing heavily into HR- and organisational instruments.*

The cases show that all companies are investing into digital technologies and in ways to deal with the knowledge and skills needed to work with these technologies. The main result is that more digital technology does not mean less employment; on the contrary. What is not visible in these results is if these changes also mean that employment in other companies suffers from the developments within these cases. The selected cases all see digital technology as a driver of more employment. Organisational measures such as high involvement-high investment are no guarantee for strong growth. However, high involvement-high investment helps companies in certain economic contexts to better and more quickly adapt the employment levels, with less negative

impacts on the employed. Workplace innovation (high involvement – high investment) therefore mediates this relationship in different ways: it helps to make the companies more attractive in the labour market; the HR measures need to be optimal to recruit, select and retain talent; the current workforce needs to be motivated to work with the technologies and develop their expertise, and organisational measures are needed to create cross-over learning and redevelopment of the workforce in the case markets fall out. More technology seems to be connected to higher employment growth, but the organisational context provides the buffer to deal with decline and growth situations.

3.6.2 Technical and digital skills

The cases in this study operate differently on the digital frontier. For instance, the cases are variously ensuring that skills follow the changing tasks, changing skills requirements, polarising skills structures, and managing digital skill requirements. The skill requirements are not a direct function of technological changes but also how the companies organise their processes and change personnel practices.

Table 18 shows that about half of the companies (16) indicate that their personnel mainly has an academic skill level. This means that even technicians are operating at the academic level. For the ROBOTIC companies, the technical skills are more engineering related. These cases report that mechanical skills are being replaced by electrical and electronics skills. In the other technology types, programming and data skills are essential. Most companies see a shift towards data skills. Nine companies have a majority of vocationally schooled personnel, mainly LOW-USER and ROBOTIC companies. Only two LOW-USER companies mainly operate with low-skilled personnel.

As most companies already have their personnel working at the academic level, upskilling of this personnel was undertaken in the past. Even so, seven cases do report that they see further upskilling of tasks and see only some shifts in the type of skills.

> *For example, **BG2** requires more analytical skills from its employees.*
> ***GE3** requires new recruits to be able to work in a team and have well-developed social skills.*

But it is not as if the technical skills are on the way out.

> ***NL1** acknowledges that it is all about technical abilities. The rest of the skills can be trained on the job. "We cannot do anything with skills such as creative, emotion skills, '21st century skills', as you sometimes see. Courses at our academic institutions sometimes go completely wrong: instead of professional skills, they insist on soft skills. We do not support such policy changes. As a training experience, it may be good to insist on soft skills. But technical skills remain the foundation of what we need in the company. And these technicians must be excellent at what they do.".*

Table 18 shows some association between technological situation and the degree the companies see their personnel have adequate skills. ROBOTIC companies, on average, see 80% of their

employees as qualified or adequately experienced for their work. Among the other types, they are above ninety per cent or more.

Table 18. Association between technology type and current dominant skill level of personnel (dominant = +50%); percentage of advanced academic skills

		LOW-USER	AI_ML	ROBOTIC	TOTAL
Main skill level	Academic	5	5	2	4
	Vocational	6	1	2	
	Low skilled	2			
% advanced digital skills		54%	83%	75%	100%

Regarding **digital skills**, workers in seven companies mainly have basic digital skills. Five of these companies are LOW-USER type of companies. Twenty companies show that most employees have advanced digital skills. About half of the companies indicate that the (limited) **availability of digital skills is a barrier to further digitalisation**. This does not really affect the percentage of staff that is not qualified or adequately experienced for their work. Nine out of ten employees are seen as qualified for their work, and there is no significant difference between those who do not and those reporting digital skills as a barrier.

The cases do not report polarising skills structures. The main shift is upskilling. There are no remarks about 'leaving' groups behind or letting specific groups go because of digitalisation.

All cases report that they have **serious difficulties in finding new talent**.

> *This is clearly reflected in the answer of **GE5**, which indicates that the war on talent is costing them rising recruiting time and effort. As a very small company, they cannot afford to spend too much time on recruiting alone.*

GE5 is a very specific case in dealing with the demands, and we will come back to how they are an outlier compared to the other cases.

In dealing with these technical and digital skill demands, the cases use very **specific organisational, recruiting and training methods** or have changed these measures over the past years. Most companies have shifted their recruitment demands upwards, in line with their perception of upskilling demands. This pushes the companies to broaden their recruiting areas.

> *For example, **NL3** now looks at academic schooled personnel, and then mainly from countries they expect are not in the recruiting areas of their main competitors or customers, such as Iceland and Bulgaria.*
> ***GE3** has followed the same strategy with regard to software developers and IT specialists: first trying to use the local talent, then shifting towards talent coming from the capital, and now looking at the international scale. Nevertheless, ideally, the company prefers recruiting talent that is geographically close to the company.*

However, some companies do not follow this path, rather continuing to recruit any talent they can attract and then training these employees to perform the right tasks.

ES2, ES3 *and* ***NL04*** *recruit students from VET-schools and then train them. ES3 indicates that the machines they use are so complex that no school system is able to prepare the workers for such tasks.*

In fact, all cases deal with the upskilling requirements by heavily investing in internal training systems.

Interestingly in this respect is that all Bulgarian cases report that they need internal schooling and training systems to bring the talent to the required skill level. ***BG2*** *explains that they have developed an internal academy specifically for this purpose. They even engage external consultants to come in and train the new colleagues.*
BG4 *recruits any person with data skills and then retrains them to understand and use the technologies they use in the company. They cannot afford to be picky.*

Some companies have unique methods to deal with skill shortages.

ES4 *tries to follow the changing technological frontier by outsourcing tasks to companies or experts who are able to perform the (digital) tasks. Then, ES4 tries to learn how these tasks are performed and then invests in the abilities to perform the tasks themselves.*

The cases all report that they need to continuously train new and current employees to keep up with technological and digital changes. However, training approaches have evolved over time. Several companies still have most of the training on-the-job, sometimes under the guidance of specific senior mentors. At least four companies shift training to self-training systems in which personnel needs to keep up-to-date with online or e-learning modules.

BG5 *reports that they use a system of internships to find the right talent, but once selected, these interns switch over to on-the-job training.*
GE1 *also reports an apprenticeship model, with walk-in-training of new talent guided by experts.*

The difference between training approaches used is how the skill development of the employees is monitored.

NL3 *has a very extensive system in which a Resource and Responsibility Matrix is used to monitor changing skill levels. This provides a 'Living CV' of someone, which shows which skill levels a person controls, what ambitions a person has, so they know what they want to develop, and in what topics they can train themselves.* ***NL3*** *lets new employees start from their own talent so that they can grow into specific processes and workflows. The idea is that the employee gets involved in specific (technology/product) programs and then can apply the competencies. 'Coaches' ensure that employees develop their competencies in both directions.*

There are, in fact, some outliers in training practices.

GE5 *is the only company that invests in standardising work to such a degree that training time is reduced - the company requires low-skilled profiles, as they are looking for drivers*

for the mail order business. Where the standard training period for its type of work is two weeks, the training period for new employees is only around 2-3 days in GE5. Digital tools have been designed in such a way that practically every driver can drive in every area. Training and on-the-job learning are undertaken within the company itself.
***ES1** is also a specific company, limiting its recruiting opportunities by only relying on new talent that is recommended by colleagues or externals. They build on existing experience. There is no capacity in the company to start training employees for new tasks.*

Both companies are small and cannot afford longer development times. However, the overall picture is that all employees, even managers in all cases, need continuous retraining to deal with ever-changing technologies. When looking at organisational measures that companies use to deal with the upskilling tendency, we describe four cases. The first case shows how a high involvement-high investment case uses a whole arsenal of instruments to deal with technological and digital transformation.

***NL4** is a major supplier to the core-company in the region. It is itself part of a major technological concern and a leader in advanced manufacturing. The workforce is for 80% of vocational or higher levels, mainly a technical and trained workforce. The main reason why this company does score as a more selective workplace innovation type of company is mainly for only partly achieving inclusive policies. The workforce is predominantly male and local. It scores as LOW-USER because it has only invested in the cloud, big data, smart devices and high-speed infrastructure. It is not yet investing in robotics or AI/machine learning. Other companies in the corporation have done so, but not the supplier facility in this study. The company does have a learning culture with investments to redevelop the workforce (for example: training mechanics to become electricians). Skills are not seen as a barrier to the implementation of digital technologies, but this is mainly because the company still needs to take this leap.*

The second company is an example of a low involvement-low investment type of company.

***GE3** is a start-up in the logistics domain. It relies heavily on its AI/machine learning technologies for its delivery service. The profit margins are thin, and the only way to win in the market is to secure timely and on-demand delivery. The company is very dependent on the skills of its developers. For this purpose, the company has broadened its recruiting base to other countries, even if the company is still only a start-up. The current workforce is 100% suited to the task, but there are too few of these specialists. The company is too young to have well-founded personnel policies. A lot of decisions are made on an ad hoc basis. The future will tell if the company can scale-up to profit from its technologies.*

The third company shows that organisational measures can help employees to use their skills and to remain knowledgeable in different organisational settings.

***FI2** is a plant of a major Finnish corporation. The corporation has conducted major transformations in the regions, after closing down one of its nearby plants. FI2 experiences no skill problems: it profits from more skills and personnel coming from the closed-down plant, even profiting from the downfall of a major microelectronics concern in the region. These opportunities allow it to have access to sufficient skills to deal with the major digital transformation it is undergoing. It has invested in all digital technologies, except for*

AI/machine learning. The corporation runs an accelerator programme in which it supports start-ups that support the company with the whole range of digital technologies (also AI/Machine learning). The plant itself uses packaging robots. The whole production process is measured and monitored to a great degree with robotic process automation. To keep the knowledge of all employees updated, a specific online academy has been developed to achieve that all workers feel knowledgeable about using digital technologies at work. Organisational measures (e.g. cross-organisational workstreams) are also applied for this purpose. The deployment of digital technologies is linked to the workplace innovation practices the plant has implemented.

FI1 shows that organisational measures in a high involvement-high investment environment help to broaden its recruiting base.

***FI1** is another Finnish company in the same region as FI2. Where FI2 has a technician workforce (70% academics), FI1 has a workforce of engineers and academics (80%). Since the company is operating at the (digital) technological frontier, it has difficulty finding sufficient talent to support its growth. It also means that the current workforce is seen as sufficiently qualified. Further growth in developing new products and technologies depends greatly on the input of the current workforce and on finding sufficient talent. To do so, the company recruits far over the borders and manages inclusive personnel policies to guarantee multicultural and -national workforces. FI1 has special services for foreign employees and their families coming from 40 different countries. For each position, FI1 starts from the current skill set of the employee/applicant. If the person has the skills FI1 needs, then (possible) disability can never be a problem. FI1 adapts the work process and working environment according to the need of the employee. Twenty per cent of the staff is women. The company ensures that women conduct the same work as men and has abolished any gender pay gap.*

These cases suggest that there is a need to manage digital transformation with specific HR and organisational practices. Recruiting issues are linked to dealing with digital transformation. The growth of a company such as FI1 is limited by finding sufficient talent. This company is in an expansive period, pushed by digital technologies. GE3 is also confronted with high demand for personnel and new skills. The company is still in its start-up phase and has not yet implemented all HR- and organisational measures to develop its own growth. It depends a lot on finding new specialists to keep 'alive' and 'growing'.

NL4 and FI2 are on similar trajectories in dealing with digital transformation, where FI2 has taken the lead. NL4 is focused on machining complex mechanical components for the core company in the region. It is fast developing the digital competencies of its workforce but is not there yet. The difference with FI2 is that FI2 put digital transformation on the agenda of the company in 2017, supporting all (VET-level) employees to follow the company in its footsteps. They now profit from this previous investment and are keeping up the needed growth. This does not protect parts of the company from closure, as was seen by a sister plant. Changing customer demands can have a major impact on operations.

3.6.3 Dealing with the COVID-19 pandemic

Half of the cases (15) responded to our question on the impact of COVID-19 on company practices. The main focus was to understand how companies mitigated the impact with technological and organisational measures, how they implemented remote working solutions, what drivers and barriers they needed to consider with these measures, and what the eventual employment and other impacts were on the company and employees. The COVID-19 crisis is an important (unforeseen) event that allows us to assess how companies deal with technology and organisation. The impact is still in its early stages, but the analysis allows us to check if COVID-19 is a trigger for change.

Companies reacted differently to COVID-19 outbreak. They all wanted to protect their employees. Remote working was the clear option. One Bulgarian case preferred to wait for enacting measures (e.g. in Bulgaria, no lockdown was imposed), others reluctantly moved with the flow, and others moved quite swiftly to react to the new situation. In the end, only three companies did not implement any remote or hybrid working procedures.

> ***ES3*** *does not see working remotely as an option for the company. To limit the health risks to its personnel, it outsourced tasks, so its own personnel was not infected.*
> ***NL3*** *tried to keep employees working at the location and implemented measures to reduce the risks for infection to employees. COVID-19 impacted financial results only to a small degree.*
> ***BG4*** *only slowly changed towards a hybrid model after their system with daily testing for COVID-19 did not work. Working at the office was seen as a necessity for decision-making and smooth workflow. In the end, some form of homework was allowed, but BG4 left any decision to work at home to the individual employees.*

In one case, technology is seen as a barrier to implementing remote working.

> ***GE4*** *reports that their company infrastructure is ready for remote working, but data bandwidth in Germany is too limited to make remote working easily applicable.*

The companies BG1, BG2, NL1, NL5, BG5, GE1, and GE3 implemented some form of remote working for all employees. In the hybrid models (nearly all other cases), management still required a part of their workforce to come to the company. Sometimes this was for specific activities, mainly to ensure continuity in arrangements, training and commitments.

> *For example,* ***BG3*** *requires work at the office for training purposes.*

In most cases, current technology and organisation were seen as a precondition for implementing remote working.

> ***BG4*** *reports that company practices were already fit for remote working with cloud databases and remote working procedures available. Homeworking was not implemented mainly because of concerns in organising and connecting activities. COVID-19 changed the equation for the company.*
> ***NL5*** *says that its' IT infrastructure and entrepreneurial culture proved to be instrumental in smoothing over the transition to remote working.*

***GE1** sees the success of remote working implementation as the consequence of long-term planning. The cloud was implemented five years ago, chatbots and AI were already integrated, and now their use is accelerated by COVID-19.*

These cases show that COVID-19 was the trigger to use their technological environment's potential. Remote working could have been implemented years ago, but management did not really explore the possibilities. The organisational change was made possible by the pandemic.

Even if some cases indicate that the technology needed to be in place for remote working to succeed, the COVID-19 crisis also triggered more technological change.

***GE3** only fully integrated web communication services and the provision of the company's internal network at the start of COVID-19.*
***NL4** has used the crisis as a further push for automation to reduce the number of needed executive staff, but still, the demand for new employees keeps on increasing.*
***ES3** implemented new technologies to allow remote support for tasks carried out at a distance.*

Remote working technologies do not themselves protect employees. Companies needed specific person-focused or organisational measures to help their employees adapt and stay connected to the company.

***BG2** offered a free consultation with a psychologist for mental support to its employees to deal with COVID-19.*
***BG4** mainly focused on the integration of remote workers by providing remote virtual games and informal online gatherings.*

Such support to employees is seen as positive.

*For example, in **BG5**, our respondent has been Covid-19 sick and has received full support from the company management. The employee got the positive feeling that the company cared for him.*

Remote working technologies do not themselves provide sufficient conditions for workable arrangements. Five cases supported the change with specific organisational measures.

***NL4** made use of internal transfers of personnel from one plant to another to help out. Remote working was organised for those departments that could allow it. The facilities that relied on production work needed to continue with this work with strict measures to reduce infections.*
***NL2** reduced the number of shifts to limit the risk of spreading possible infection.*
***ES3** continued to work as normal, but implemented working groups to improve work processes in general: groups had the tasks of discussing health at work and developing proposals for process improvement.*
*The COVID-19 pandemic forced **NL5** to take quick, decisive action and make clear choices. They accelerated the efforts to simplify the organisation. New cost savings were introduced in March 2020, and this helped to improve the margin of operations.*

The future of remote working was also probed. The cases are, however, unclear on the subject. Two cases expect that the remote working model will only be temporary, but the rest of the cases (mainly IT companies) sees remote working as a permanent solution.

A specific trigger for changes was the possibility of using public funding to deal with the impacts of COVID-19. In the Netherlands, for example, companies could apply for financial support to pay for the wage bill (the NOW-funding[8]). Eventually, the companies will need to repay the government for this financial support. It was unclear for a lot of companies if they needed to rely on public funding support. It seems that only Finland and the Netherlands implemented specific funding for the companies. The cases in our studies were already well-functioning organisations for which such public funding, at first hand, does not seem to be a necessity to survive the COVID-19 pandemic. In these cases, we can see that funding really intended for the survival of the companies was rather used for different purposes not intended by the public authorities.

> ***NL4** used nearly ten million euros in public funding to deal with possible personnel disruptions at the beginning of COVID-19. They did not experience main disruptions but continued to submit requests for funding.*
> ***NL2** applied for NOW-help for two main units, for a total of 2,5 million euros.*
> ***NL3** did not apply for the NOW subsidies but did use the possibility to defer of taxes. In total, some 11 million euros in wages and VAT were deferred. They will be repaid from 10/2021 in 36 months. In this case, the financial facility functioned as loans with fewer restrictions.*
> ***FI6**, one of our 'extra' cases, reported the use of financial support. This was not directly funding for their own operation, but rather funding that their customers received. It is this funding which helped FI6 to increase the sales of its products.*

The COVID-19 pandemic could have been a moment for the company cases to undertake mass lay-offs and introduce work-reducing technologies. Some companies have pushed for more automation, but this was not the norm. However, in all cases, remote working solutions were mainly used as a new way to operate. The question was why these solutions were not implemented earlier. One reason was that the cases were expecting negative productive and operational impacts of remote working. In practice, remote working is seen to have negative and positive impacts. The impacts on the organisation and labour markets have been divided.

> *In **UK4**, COVID-19 has been a limiting factor for implementing a major change in the training systems needed to improve operational processes.*
> *Remote working has pushed **NL1** to look differently at work in general. Working from home can be good, but it can also be a threat to serendipity and innovation. It has impacted recruitment in the sense that NL1 is becoming less dependent on the local region on the one hand, but people are less willing to be mobile because of the uncertainty and restrictions in travelling on the other hand. NL1 reports a change in company culture because remote working was not a widespread norm. A last positive impact for NL1 was a reduction of attrition because of COVID. A negative impact is that NL1 experiences fewer people applying for university education in the labour market. They expect fewer academics in the future. NL1 monitors where the talent pools are strong or not in the future.*

[8] Noodmaatregel Overbrugging Werkgelegenheid (NOW): Emergency Measure Support Employment

__NL5__ indicates that remote working has slowed down recruitment activities, mainly needed to deal with high rates of attrition at its country offices. COVID-19 has lowered the overall attrition rate. This impact counter-balanced the situation of more difficult international hiring. Other topics became more challenging to manage during the COVID-19 pandemic, like driving innovation and sharing knowledge.
__BG5__ sees a positive labour market impact of COVID-19 because remote working allows to keep Bulgarian employees to work for Bulgarian companies.

The same can be said of the impact of company performance. BG1, BG2, NL1, BG5 and GE1 all report that remote working and COVID-19 did not affect productivity or company results. COVID-19 rather created more opportunities, more markets for their (IT) solutions, or created more demand in general.

The longer COVID-19 had influence, the more it slowed down the business of __NL5__. The company scaled down investments accordingly. The COVID-19 pandemic has mainly impacted the short-term secondment activities. The long-term projects proceeded well, and the nearshoring activities (subcontracting within EU context) were even able to benefit from growth opportunities.
__NL3__ reported that COVID-19 had small negative impacts on results.

In summary, COVID-19 initiated major technological changeovers in the tasks that lend themselves to remote working. However, for the period that we have discussed with the cases, there has not been a major impact on employment levels. However, organisational practices have changed. Companies did not implement those changes before COVID-19, fearing several impacts such as productivity loss. The shift to cloud technologies has supported the quick change over to remote working, with some companies needing to catch up during the COVID-19 pandemic. For those activities that did not fit with remote working, organisational measures were implemented to reduce infection risks but only in a limited fashion to improve processes in general. Only one case of remote support of operational activities ('digital twinning') was found, but we may expect more of this in the future. The pandemic is starting to alter some elements of the personnel situation. Personnel attrition was reduced, but it is now known that this was a temporary phenomenon. In 2022, attrition levels have risen considerably for all companies. Recruitment started to change during the pandemic, with remote work providing companies with a unique opportunity to find new types of recruits who are not necessarily geographically close. Those groups of personnel that either did not want to stay in a country (e.g. Bulgaria) or that did not want to move to another (e.g. the Netherlands) are now using the changing working situation to change their habits. The technological and organisational measures are part of the digital transformation, and the pandemic has accelerated these. The cases in this study have not seen negative employment impacts but rather a continuation of the employment shortages they already experienced before the pandemic. For most companies, the pandemic did not affect demand for the products. Exceptions were those companies supplying the aviation industry, as there was a fall in demand.

3.7 Discussion and conclusion

The thirty cases allowed an assessment of technology use, work and impacts among thirty companies on the digital frontier. The cases provided information on the impact of the COVID-19 pandemic. The pandemic provided an additional perspective on how the companies dealt with technology, organisation and personnel. Even if the results have limited generalisability to other companies, they can be seen as representative of what leading companies are experiencing with digital transformation. These cases give a perspective on several discussions on the impact of digitalisation.

First, there is no one strategy for dealing with digital technologies. Four digital strategies were visible, going from using all technologies (4 companies), AI and Machine Learning (7), robotics (5), to low-use of digital technologies. The small size of these companies mainly explains the low-use situation. These small companies are confronted by a lot of barriers in digitising their operations.

A second result is that to understand the impact of digital technologies, more understanding of the organisational practices is needed. Organisational practices are focused on delivering more internal training and using training methods to deal with the high demands of digital transformation. The cases did not see dealing with digital transformation as an impossible hurdle to take. However, recruiting sufficient new talent was challenging in all cases. The information of the cases rejects the idea that digital technologies will lead to the unemployment of a great number of personnel. Technologies are far from 'autonomous' and require a lot of technical expertise to manage digital transformation.

A third result is that all companies are dealing with upskilling impacts and the need to attract more talent. There is no sign that digital technologies are leading companies to reduce employment levels. The cases are not expecting any downfall in employment levels in the near future. Skill sets are shifting towards electronics and data analytic skills. Only two companies showed negative employment impacts but these impacts were driven by market factors and not technology. The cases did not show any polarisation in their skill structures. The upskilling of their personnel is not a recent phenomenon. Companies have been recruiting at higher educational levels over some time.

The last result is that the COVID-19 pandemic has exemplified how companies deal with technology and organisation. The pandemic has been a trigger for change. A technology environment that allows remote and hybrid working (in this case, cloud technology) supports a fast technology and organisational changeover. The pandemic also shows that the cases have been quite reluctant over the past years to implement these changes. The pandemic has forced them to change. Such external incidents show how management is hesitant to invest into change, mainly because there is a lack of trust in employees' commitment. The pandemic made clear that employees can be trusted and that technological change can be successful. The question is whether management will use this example to change technology and organisational practices broadly. The challenge of finding new talent will pressure companies to adapt, also technologically.

The cases only provide information from the comparison between the technology and organisational types. The cases could have shown more information about what is happening with

the different skill levels, but the information remained too limited to come to a precise conclusion. Future research should delve even deeper into the company settings for such understanding. The complexity of managing thirty cases at the same time is demanding. In the future, the use of QCA may be helpful in refining the strategies the companies are using. To answer the question that Schumann et al. (1994) and Huys et al. (1995a) posed, digital transformation is real in the cases. However, the predicted impacts have not come through. Digital transformation pushes for more upskilling of personnel, which requires companies to be attentive to HR policies to remain inclusive.

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4. Study 3: Workplace Innovation, digital transformation and impacts. Lessons from thirty cases across Europe[9]

Steven Dhondt, Peter Oeij and Gerben Hulsegge[10]

Abstract

The organisational context mediates the relationship between technology and work impact. This reality is not recognised in much research. However, the European Company Survey 2019 (Eurofound & Cedefop, 2020b) has revealed this relationship in European companies. This mediating role has not yet been sufficiently explored. Thirty cases performing at the digital frontier were examined about their organisational model, technology, decision context and handling of work impact. Companies with a workplace innovation model ensure that the impact of digital technology on employees is channelled differently from companies that follow a model of low investment, low involvement.

Keywords: workplace innovation, organisational context, digital transformation, work

4.1 Introduction

4.1.1 The context

The European Company Survey (ECS) 2019 found that establishments that highly involved their personnel and at the same time were prepared to invest strongly in their personnel showed a high prevalence of 'high digitalisation'. Establishments that did neither (the ' low investment, low involvement' group) show 'limited digitalisation' (Eurofound & Cedefop, 2020b). The *high involvement, high investment* type of company practices differentiates itself from other company practices mainly because of more possibilities for employees to voice their concerns, more comprehensive training, more open-ended contracts and more collaborative supplier relationships. In the previous European Company Survey, Eurofound had called the high involvement – high investment practices, workplace innovation (Eurofound & Cedefop, 2020b). The central question in

[9] A version of this chapter will be published in the book Oeij, P., Dhondt S., McMurray, A. (planned 2022) A Research Agenda for Workplace Innovation: The Challenge of Disruptive Transitions. Cheltenham: Edgar Elgar Publishing. This book is also a result of the H2020 Beyond 4.0 project. Several chapters are direct products of the project. The other chapters have been delivered by researchers from Australia, Vietnam, Japan, South Korea and Europe. The book provides a state-of-the-art assessment of workplace innovation and inclusive organisational practices. It complements our work in this report D8.1.

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this chapter is what kind of organisational practices are prevalent among digital leaders in Europe and how these organisational practices are supportive of digitalisation.

The digital transformation in Europe is a new phase in the automation efforts of companies. The application of digital technologies is used to enhance the network relationships between technologies (cyber-physical systems; IoT), between technologies and company strategies (data-enabled production), and between the company and its environment (suppliers, customers, others). This changeover is sometimes called Industrie 4.0[11] (Perez & Murray Leach, 2021; Chris Warhurst et al., 2020). Hermann et al. (2016) indicate that companies now live in the Industrie 4.0 technology era. Digital technologies such as (collaborative) robots, machine learning, artificial intelligence (AI) and connected technologies change the way companies shape tasks and jobs (Frey and Osborne 2017). Researchers predicted significant and strongly negative outcomes for occupations and the labour market for the coming two decades (e.g. Brynjolfsson and McAfee 2015). Heald, Smith, and Fouarge (2019) predict that the major unemployment impact of digital technologies will be visible between 2030 and 2050. Autor (2015) remains critical of this perspective, posing the question of why we still have so many jobs today. His answer is that technology is only part of the equation, with the need to look at how labour markets function and check the ever-increasing demand for products. Fernández-Macías, Klenert, and Antón (2021) indicate that part of the overestimation of the impact of digital technologies resides in the fact that most of these technologies have already been around for some time, in other shapes. The impact of these technologies on labour markets has mainly been felt in the 1990s. This result is confirmed for the US situation by Handel (2022). Other studies are also sceptical about the negative employment effects of the newest technologies. Increased robot use by companies does add to annual labour productivity growth but did not significantly reduce total employment in a major study in European industry. Robot use does reduce low-skilled workers' employment share (Graetz & Michaels, 2018). Koch et al. (2021b) see a relationship between the type of company and robot use. Better-performing firms are more likely to adopt robots. However, more skill-intensive firms are less likely to do so. Robot adoption generates substantial output gains, reduces the labour cost-share, and leads to net job creation. Low-skilled workers are more likely to be affected by automation since they perform the less complex tasks which are automated . At least, this is the case with work tasks that can be standardised. Koch et al. indicate that low-skilled workers can profit from more productive work situations if their work is not fully robotised. This assessment underpins the idea that it is not technology itself that starts the change in jobs and tasks, but that the organisational practices are certainly guiding how technology has its impact. This result runs counter to the technological determinism has become an orthodoxy in discussions today (Pfeiffer, 2016). The question is also to what degree the digital technologies really transform company practices (Schumann et al., 1994).

Given that there are strong predictions about the impact of technological change, the question is, what can we see in companies on the digital frontier? Can we relate what happens on the shopfloor of these companies to the organisational practices of these companies? The study by Eurofound/Cedefop (2020b) is cross-sectional and cannot determine the direction of the

[11] The German spelling "Industrie 4.0" (Industry 4.0) stems from a national strategic initiative from the German government through the Ministry of Education and Research (BMBF) and the Ministry for Economic Affairs and Energy (BMWI). It aims to drive digital manufacturing forward by increasing digitisation and the interconnection of products, value chains and business models.

association, but it seems that organisations that invest heavily in learning environments and HR practices see more implementation of new technologies. More longitudinal approaches are needed to untangle this association. The influence of organisational practices and technology on skills was investigated in a recent panel study by Dhondt et al. (2022). Technology does not itself impact skills development. However, the organisational model does show strong impacts on skill use. Workers shifting from an integrative ('workplace innovation') to more tayloristic organisational models are restricted in skills use, and vice versa.

Oeij and Dhondt (2017, p. 66) define workplace innovation as an integral set of participative mechanisms for interventions relating to structural (e.g., organisational design) and cultural aspects (e.g., leadership, coordination and organisational behaviour) of the organisation and its people with the objective to simultaneously improve the conditions for the performance (i.e. productivity, innovation, quality) and quality of working life (i.e., wellbeing at work, competence development, employee engagement). In this definition, workplace innovation is seen as a specific cluster of organisational and HR measures leading to superior organisational performance and higher quality of working life (Subramony, 2009). The hallmark of workplace innovation is employee involvement and engagement. Employees have a say in organisational change and innovation (like digital transformation), and their quality of work is conditional for good performance by people and the organisation as a whole. Research on digital transformation tends to see organisational practices as disparate HR measures. A recent European Commission (2021) study tried to identify among the European small and medium-sized (SMEs) which internal and external factors act as key determinants of digital transformation. As internal factors are listed, managerial ability, access to talent and digital skills deficits, ability to connect a digital strategy with a concrete business model, and behavioural characteristics at the individual level. Brynjolfsson & Milgrom (2013) indicate that organisational and HR measures tend to be complementary. An organisation with a specific set of practices will also tend to have complementary measures (Brynjolfsson & Milgrom, 2013: 11). Companies need to create environments that help job occupants shape their jobs and have jobs that improve their skill sets. Team environments are needed that integrate individuals with overlapping high-tech skill profiles (Dhondt & Van Hootegem, 2015).

4.1.2 Research questions

Companies confronted with the digital transformation need to rely on sets of measures to deal with skills and knowledge shortages, employee involvement and employee capacity issues. Well-developed policies allow the development of mitigating measures for any workplace issue, work process disturbance or control problems that may arise (Oeij et al., 2017). The question is, then, which measures are connected. Modern Sociotechnical thinking (MST) (Kuipers et al., 2020; Mohr & Van Amelsvoort, 2016) identifies, on the one hand, the structural dimensions of an organisation (production organisation; control structure) and the way how work is divided between organisational units. On the other hand, there are the HR dimensions. MST argues that these last dimensions should be aligned with the first dimension. Workplace innovation is then seen as an organisational practice in which organisations focus on reducing complexity in operational processes by allowing employees maximum control (Høyrup, 2012). Reducing the operational overload of management gives them the opportunity to deal with strategic and tactical decision-

making (Kuipers et al., 2020). The mediating impact of the organisational practices may explain why other changes occur to occupations than predicted by more technology determinist thinkers (Frey and Osborne 2017). It could be that, rather than job losses or job gains, the current technological transformations might result in jobs being reconfigured (Handel, 2022). This redefinition points to the fact that we may need to check which skills are required from workers. The call for higher-level skills ('21st century skills', see Van Laar et al., 2017) to overcome future employment disruption also connects to renewed discussion about the role of lifelong learning to help foster workers' adaptability to changing labour markets over their working life (Barnes et al., 2016). There are serious digital skill deficits amongst some workers. However, there are other skills needed too. The different tasks identified by Fernández-Macias and Bisello (2016) map onto different skill sets, for example, technical, analytical, behavioural, transversal, leadership and T-shaped skills[12].

For *BEYOND4.0*, to understand the association between organisational policies and digital technologies, we need to develop an understanding of the technologies implemented and how organisational policies help shape the choices. Do digitally transformed companies with highly automated production systems also invest in high-road company policies? Or, do such companies opt for low-road strategies and models for producing cost-driven services? Do we see the different impacts of digital technologies? A high-road strategy implies investing in people and seeing them as a critical resource, while a low-road strategy has no room for good quality of work, and is contrary to workplace innovation interventions.

This study is based on thirty case studies. The methodology to analyse these cases is presented in section 2. We describe the organisational practices in section 3 and the digitalisation strategies in section 4. Section 5 looks into the association between the digital transformation in these cases and the organisational practices. We look into the prevalence of digital technology and organisational practices, motives to invest in and barriers to implementing digital technologies, and how organisational practices support the development of the required skills needed for digital transformation. Finally, in section 7, conclusions are formulated, and the overall results are discussed.

4.2 Methodology

4.2.1 Case study approach

This study used a case study approach to understand the technological and organisational situation in thirty company cases at the digital frontier. The focus is to extricate the logic the case companies follow to adopt and implement digital technologies and which organisational practices they follow. How do they deal with the knowledge requirements the digital technologies bring along? The qualitative approach is exemplified by trying to reduce the different situations in the thirty companies to a limited set of types of technological and organisational practices. For the methods, we refer to the case study report (Oeij et al., under preparation). The following typologies are used:

[12] In their taxonomy, they identify tasks in terms of content (physical tasks, intellectual tasks, social tasks) and in terms of methods and tools of work (methods: autonomy, teamwork, routine; tools: digital, non-digital).

- *Workplace Innovation practices:* the European Company Survey (ECS) (Eurofound & Cedefop, 2020b) provides a useful typology of organisational practices. The ECS typology is constructed from nine variables. We do not have all the statistical information Eurofound has about the companies in the case studies. For example, we do not have reliable information on workplace behaviour and motivational levers, nor on the use of part-time contracts. We did not include 'job complexity and autonomy' as an indicator in the workplace innovation construct because we see this as a job level indicator and not an indicator of organisational practices. Therefore, it is important to indicate what we see as the core characteristics of the Eurofound/Cedefop types. The first type is the *high involvement, high investment* type of company practices, which differentiates itself from the other types mainly because there are more opportunities for employees to voice their concerns, more comprehensive training, more open-ended contracts and more collaborative supplier relationships. This type is most comparable to what we have defined as workplace innovation company practices, because it emphasises employee involvement which is the core of workplace innovation (see Oeij & Dhondt, 2017). The *selective investment and moderate involvement* type identify itself as using more selective training opportunities and more part-time working arrangements. This last arrangement is more gender-focused and can be qualified as a gender-sensitive arrangement. The *moderate investment and irregular involvement* type has one distinguishing characteristic, namely the use of open-ended contracts. The *low investment and low involvement* type also uses open-ended contracts and is less focused on external collaboration. We use these main characteristics to identify the dominant organisational practice among the company cases.

- *Digital transformation*: digital transformation is discussed quite extensively (Hermann et al., 2016b). However, as Genz et al. (2022, p. 1) indicate, there is a "scarcity of datasets that provide measures of the usage of advanced technologies at the firm level and accompanying workers' outcomes". (Genz et al. (2021) found that 22% of German companies used Industrie 4.0-level technologies and that the spread of these technologies ('depth of transition') was quite limited. The ECS (Eurofound & Cedefop, 2020b) reported that 28% of European companies (>10 employees) are highly digitalised. The definition of digitalisation is somewhat broader than the Genz-study. For the case survey, we used the typology of technologies used by the European Commission (2021) in their SME-study mapping technology adoption and organisational practices. This report focused on digital strategies deployed by SMEs. Their definition of digital transformation was broader than just a set of technologies (European Commission, 2021, p. 2):

"Digital Transformation is the profound and accelerating transformation of business activities, processes, competencies and models to fully leverage the changes and opportunities of digital technologies and their impact across society in a strategic and prioritised way, with present and future shifts (i.e. socio-economic, environmental, technological etc.) in mind. DX, in the integrated and connected sense of the term, requires, among other factors, the transformation of business models; activities/functions; processes; ecosystems; asset management; organisational culture; ecosystem and partnership models; and customer, worker and partner approaches (i-SCOOP, 2021)."

The report sees digital transformation (DX) as the next step after the digitalisation of products and production processes. The focus is on changes in the company's business model, products, processes and organisational structure. The company perspective is helpful for this study.

The main elements of these typologies were recorded in comparative tables for the thirty companies. These basic tables were further reduced by inductive coding to the core content (core variables), for which we compared the cases (Miles et al., 2013). For each typology, several cases provide information. To enhance the reliability of these typologies, we used several researchers to make the qualifications. The researchers discussed the different eventual classifications of cases and tried to obtain a consensus. 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).

4.2.2 Cases

The cases are selected from the entrepreneurial ecosystems in Europe, which were studied in Workpackage 4 (Dhondt et al., 2022). We conducted in-depth qualitative research into 'incumbent' and 'emerging' ecosystems in six countries: Bulgaria, Finland, Germany, the Netherlands, Spain and the United Kingdom). In discussion with the stakeholders in each of the ecosystems, example companies were identified and selected. Stakeholders looked for core companies, suppliers and customer companies that represented the leading technological and organisational practices in the ecosystems. Many of the company cases are leaders in their sector in the use of digital technologies. Other companies in the selection are at best users of digital technology. These are often suppliers or network partners of the core companies in the studied ecosystems. Not all companies provided all the required information. Table 19 shows the main descriptives for these thirty companies.

Table 19. Descriptives for the 30 cases

		Number of cases
Country	Bulgaria	5
	Finland	5
	Germany	5
	The Netherlands	5
	Spain	5
	United Kingdom	5
Size	Large (> 250 -15000 employees)	14
	SME (> 30 – 250 employees)	8
	Start-up, small (< 30 employees)	6
	Missing	2
Date of establishment	<1899	2
	1900 -1999	14
	2000 – 2009	8
	2010+	5
	Missing	1
Main sector	Advanced manufacturing	12
	Software, digital health	15
	Logistics and maintenance	3

Half of the cases (18) belong to major corporations with multiple locations around the world. We limited the investigation to one geographical location of such major corporations. Interviews and surveys were conducted in each of these companies. Managers and employees needed to describe the situation for this location. Half of the cases (16) have been established before 2000, the rest after this date. This distribution indicates that start-ups and mature companies with long tradition are compared. Start-ups have been selected that are in the first phase of their development. They may ultimately still fail to scale up. The sectors show that the cases reflect the situation in Industrie 4.0-type of companies (advanced manufacturing), and digitalisation from the perspective of software producers and users.

The companies and interviewees have been promised that they remain anonymous and unidentifiable. Company summaries and survey material are available but with no possibility of identifying the actual cases. The study's design is such that we have high validity and reliability of our research material by using multiple sources and different stakeholders, comparing a great

number of cases and having the answers from the management and employee side. However, the database remains quite heterogeneous and selective.

4.2.3 Analytical approach

The cases present a first understanding of what companies do when confronted with digital transformation. To understand the relationship between digitalisation and organisational practices, we focused on three analyses: (1) the prevalence of organisational practices and digitalisation; (2) the motives to invest in digital technologies and the barriers the cases encounter in these investments (these motives and barriers provided insights into why companies select specific organisational practices); and (3) if the organisational practices between digital leaders and followers were different and why. Managers and employees reflected on the motives to implement digital technologies and the barriers to their implementation. Because the core companies were selected as advanced in the six countries, the answers are biased towards digital 'survivors' and 'winners'.

To understand how the cases perform, we use the FLASH-Eurobarometer (European Commission, 2021) and the European Company Survey (Eurofound & Cedefop, 2020b) as a comparison base. These comparisons help to understand the external validity of the results. To illustrate our results, we describe the examples of the actual organisational practices of the cases.

4.3 Workplace Innovation practices among the cases

Using the Eurofound/Cedefop classification, we can identify the degree to which the organisational practices are characteristic for workplace innovation. Table 20 compares the cases to the Eurofound/Cedefop distribution.

Table 20. Organisational practices among the casestudies (n=27; 3 missing)

Organisational type	Count (%)	Eurofound/Cedefop 2020
1. low investment, low involvement	6 (22%)	21%
2. moderate investment, irregular involvement	4 (15%)	27%
3. selective investment, moderate involvement	4 (15)	32%
4. high investment, high involvement ('workplace innovation')	13 (48%)	20%

The table shows that half of the cases (13) are in the high investment, high involvement group. This is more than double the percentage in the Eurofound/Cedefop study. This overrepresentation of this type is expected with major companies that already outperform their competition. Still, six cases – and a similar percentage to Eurofound/Cedefop - are categorised as low investment, low

involvement. Five companies are small, start-ups with no focus on managing human resources. These companies are completely focused on gaining entrance into their market. The companies in the different organisation types show differences in practices in employee involvement, the core of workplace innovation. The following table provides two examples per type.

Table 21. Comparison of organisational practices among two cases per organisational type

Organisational type	Cases
1	We have two cases that illustrate different contexts and practices for the low investment, low involvement type. **ES1** is also a very small start-up with engineers trying to launch a new technological product. The company cannot assess new recruits and relies on referrals by colleagues or externals. They build on existing experience. The company has no capacity to start training employees for new tasks. They work with funding from one Venture Capital company and need to show their success in the short term. A lot depends on finding markets for their technology. There is no attention to the internal organisation. **GE5** delivers last-mile logistics for its customers. The company survives by using low skilled, low paid personnel. It is organised for 'personnel attrition'. Not only is GE5 confronted by high personnel turnover, but it can also not secure long-term employment prospects for its personnel. Over the past years, it went from 60 persons to 15 persons. Now, recruiting has started again. The main focus is to reduce the learning time of its (constant) changing workforce. They use digital planning software to reduce the learning times to a quarter of what their competitors need and eliminate any workforce dependency. GE5 is 'organised for attrition', and ES1 needs to prove it can survive the start-up phase. ES1 can develop itself into a different organisational model. GE5 specialises in a market niche and needs its low investment-low involvement strategy to survive. It will not develop this model into another type.
2	For the moderate investment, irregular involvement type, two other cases illustrate different contexts and practices. **ES2** recruits students from VET schools and then trains them for positions in manufacturing. The company applies teamwork in a project-driven environment. ES2 reports that training remains limited, even though each product is unique, so each project requires some retraining. The company does have a works council. Personnel consists mainly of VET-trained men. There are no flexibility measures, which puts them into the moderate investment-irregular involvement category. **BG1** also seem to have moderate investment in its personnel. It works with a flat structure and has 'open-minded' hiring practices and activities focused on team building. Also missing is employee voice, and does not have a trade union present.
3	The distinctive feature of selective investment, moderate involvement type is the lack of employee voice. **FI3** is classified under this type mainly for this reason. The company has been growing quite steadily, mainly with the support of private equity funding. The company is selling very specific technology-based products and needs rapid development. It does invest in on- and off-the-job training, open culture and personal development. However, the possibilities for employees to express their voice seem limited.

	BG2 is part of a global company. The office has grown into a major player in the Bulgarian context. It is organised for 'attrition' in this sense that personnel turnover is 16 to 20% on a yearly base. Employee voice is not channelled in the organisation: it depends on the 'courage' of the employee to act. As the figures show, personnel rather chooses an exit. The companies need internal schooling and training systems to bring the talent to the required skill level. BG2 explains that they have developed an internal academy specifically for this purpose. They even engage external consultants to come in and train the new colleagues.
4	The high investment, high involvement type also consists of different companies. ES5 is a company owned by its personnel after a worker buyout. It is a small company and masters its products and marketing. Workers are very involved in all domains of company policy. NL3 is a producer that has shown significant growth in personnel over the past decades. Even with this growth, the company has managed its personnel consistently. Knowledge management is a core element of its strategy, focusing on mastering all knowledge and skills needed for its production. Workers are continuously trained in the newest technologies and software. They have a voice in different ways: workers council and employee ownership.

4.4 Qualifying the digital transformation among the cases

Table 22 assesses how the cases see themselves in their technology development and compares the results with the FLASH-study.

Table 22. Comparison cases with the FLASH-Eurobarometer – SME-results (European Commission, 2021): type of technology situation

Answer	Number of cases	% of total	FLASH (all)
A 'Your enterprise has adopted or is planning to adopt basic digital technologies such as email or a website but not advanced digital technologies'	1	3%	33%
B 'There is a need to introduce advanced digital technologies but your enterprise does not have the knowledge or skills or financing to adopt them'	1	3%	7%
C 'There is a need to introduce advanced digital technologies and your enterprise is currently considering which of them to adopt'	4	13%	10%
D 'There is a need to introduce advanced digital technologies and your enterprise has already started to adopt them'	23	78%	25%
E Your enterprise does not need to adopt any digital technologies	1	3%	1%

Table 23 provides the specific technologies used.

Table 23. Comparison of presence of digital technologies cases and FLASH-study

	Number of cases reporting use	% of cases	FLASH (all)
2A_Artificial Intelligence_Machine Learning (AI_ML)	14	46%	6%
2B_Cloud_computing	27	90%	45%
2C_Robotics	14	46%	7%
2D_Smart_devices	20	66%	25%
2E_Big_data_analytics	22	73%	12%
2F_High_speed_infrastructure	20	66%	31%
2G_Blockchain	4	13%	2%
None, don't know	-	-	33%/1%

Three-quarters of the cases have already started adopting advanced digital technologies. Only two cases do not see the need to adopt these technologies. One case is a technology consultancy firm, and the other case is a last mile-logistics deliverer mainly using software to plan operations. Overall, the cases are technically more advanced than the SMEs in the FLASH-study.

Table 24 provides an overview of the actual technologies implemented.

About half of the cases (46%) have introduced AI/ML or robotics, compared to only 6-8% of the SMEs in the FLASH-study. Cloud computing, smart devices, big data analytics and high-speed infrastructure are also quite common technologies in the cases. Blockchain applications are seen in a few cases, but still more often than in the FLASH-study. In one case, blockchain is used to map parts that are delivered to customers. The technology is used to maintain a stable database of these parts. The main conclusion that can be drawn from the comparison between the cases and the FLASH-SMEs is that the cases represent far more digital technological situations. They have also been selected for this reason.

The material above is too crude to understand the different technological paths among the cases. Two steps are taken to identify specific technological strategies for the cases. A first refinement is to understand if the cases are digital transformers. SMEs that use digital technology to transform their business model are classified as digital transformers (DX). SMEs that only use digital technology as a tool are called digital users. Our analysis has identified if companies develop servitisation strategies and direct or support their operations towards customers in a digital fashion. Table 24 shows that one-third of the cases in our study can be classified as users and two-thirds as digital transformers. A second refinement is to understand if different digital paths are deployed. With the AI/ML and robotics criteria, we distinguish four types of digital transformation: companies that have invested in nearly all technologies: the 'TOTAL (digital)-category'; companies that have invested in AI/ML as the main distinguishing trait; companies that have invested in robotics, next to other

technologies (ROBOTIC type); and companies that have some digital technologies but have no AI/ML or robotics (LOW-USER type). The following table crosses this distinction with DX/user.

Table 24. Four types of digital transformation among the cases (n=30).

	Digital transformers	Digital users
TOTAL	4	
AI_ML	7	
ROBOTIC	5	
LOW-USER	3	11

Most of the LOW-USER group are 'users of digital technology'. The other cases are identified as digital transformers. The table allows us to distinguish between four significantly different technological strategies or situations: if we classify the 'digital users' and 'low-user' under one label, we have the strongest distinction between technology strategies: TOTAL (4 cases), AI_ML (7), ROBOTIC (5) and LOW-USER (14). We give four examples of how these cases are different.

> ***NL3*** *belongs to the TOTAL group and is an example of a company investing in all types of technology. The company sees technology as an important means to deal with customer demands. Internal logistics and production activities have been automated to the highest degree. Robots and AGVs support advanced manufacturing in this plant. The company does everything to avoid manual operations. To use technology in all operations, NL3 avoids being dependable on external technology suppliers: all software that drives robots and other tooling has been developed internally. This allows the company to understand better how to progress faster than their competition. The company uses low-code programmes for software so most employees can adapt products and processes.*
> ***GE1*** *is transforming into a major digital services company and sits in the AI_ML category. To optimise its logistics operations, it has mapped the geographical characteristics of the whole region in great detail where it delivers its product. This allows very precise planning of deliveries and response to the very diverse customer demands. Machine learning tools and planning software have been the cornerstone of this strategy. Cloud computing and big data analytics are now the core driver of the business.*
> ***ES3*** *is a producer of heavy tooling requiring the highest precision and performance. Therefore, it can be classified as a ROBOTIC company. To achieve this performance, the company needs robotics to assist in precision manufacturing and big data analytics to understand the production processes and the maintenance of its products once delivered.*
> ***BG5*** *is a small software developer exclusively working for the Bulgarian market. It does not compete with the large internationally-focused software developers in its region. The specific position makes the company unable to pay the high wages the other software developers pay and relies on sufficient new talent to support its further development. The company uses a set of standard software tools to deliver to its customers. An ERP system drives the different projects for the company. Even if the type is not as advanced as the three other types, these companies rely on many digital competencies of their personnel. We classify it as LOW-USER, even if it is an ICT company, mainly because it is a user of ICT-tools, rather than a developer.*

The four cases represent the variation in technology strategies. NL3 is a high tech company with robotics, AI and Machine Learning in all its operations. GE3 is mainly focused on using AI and

Machine Learning for its delivery strategy. ES3 uses robotics and big data analytics to assist its precision manufacturing. BG5 is a software supplier to a whole range of national customers.

4.5 Technological transformation and workplace Innovation practices

In this section, we follow the analytical approach described in 4.2.3.

4.5.1 Prevalence of digital technology type

Table 25 shows the company cases' prevalence of organisational and technological practices.

Table 25. Prevalence of organisational and technology practices (n=28; 2 missings)

	LOW-USER	AI_ML	ROBOTIC	TOTAL
low investment, low involvement	4	2	1	
moderate investment, irregular involvement	2	1	1	
selective investment, moderate involvement	2	1	1	
high investment, high involvement	5	2	2	4

The table shows that the company cases are spread across all technology types and organisational practices, except for the TOTAL technology type. The TOTAL type only shows high investment – high involvement practices, which suggests an association between organisation and technology practice.

We can point to the case of NL3, in which the company invests into comprehensive and permanent training of all of its personnel to deal with all the technologies it invests in. Every person in the company has a technical coach. NL3 is focused on attracting more VET-level personnel from all parts of Europe. Half of the employees do not have Dutch nationality. The use of technology requires a dedicated strategy for personnel.

Low investment-low involvement practices show more cases of LOW-USER technology, but even some AI_ML and ROBOTIC cases. The moderate–irregular and selective-moderate types show a spread of technology types. Even if there is quite some spread in technology types among the organisational practices, it seems that the more technology-focused companies are supported by more high investment-type of organisational practices.

4.5.2 Comparing the motives for the digital transformation

The motives to invest in digital technologies can shed light on the demand for organisational practices. The FLASH-Eurobarometer identifies eight possible motives. The interviews with the cases uncovered two additional motives: to develop new business models and to serve the customer better. This last motive has been integrated with 'quality'. The cases have been asked to rank-order their motives from 1 to 6, with 1 as the most important rank. If cases did not rank a

motive, then this motive was rated as 6. Table 26 shows the average rank scores for each technology type.

Table 26. The priorities of the cases according to organisational type (1 = highest priority; 6 = lowest priority) (n=26; 4 missing)

	Low-low	Moderate – irregular	Selective - moderate	High-high
N =26	6	4	3	13
Labour_costs	4,8	3,5	4,0	3,3
Higher_production	3,1	2,2	2,3	3,2
Work_less_physically_demanding	4,3	5,2	4,3	4,0
Work_mentally_less_demanding	3,6	4,5	4,3	4,3
Quality/better serving the customer	3,5	1,7	1,3	1,3
Image_stakeholders	4,8	3,7	4,6	4,4

Quality and better customer service are the most important motives for the moderate-irregular, selective-moderate and high-high organisational types. Only for the low-low type, this is not the most important motive. Higher production is the most important motive for the low-low organisational type, and rates as high in the other organisation types. The table also shows that the low-low type has no clear preference, all motives rate above 3. The other organisational types are much more clear in their priority. The focus for these companies is more on the customer. For the low-low, higher production is the most important motive to invest. For the hi-hi, quality is the most important motive to invest. For the two other types, it is the combination of quality and higher production. In none of the types, labour costs, less demanding workplaces and image stakeholders are prioritised as a motive.

The cases were also asked if their priorities or strategy with digitalisation changed over the past two years. Only three companies have indicated that priorities in motives to implement digitalisation changed over the past years. Two of them are start-ups with shifting tasks and priorities. The third company is an advanced manufacturer that indicates that the pace of change has become slower. All other companies indicate that priorities remained the same. It is relevant to indicate that the companies are in the midst of the COVID-19 pandemic when responding to this question.

The overall picture is that the motives for low-low types of organisational practices are not that pronounced. This aligns with the idea that such companies do not invest strongly in their organisational practices. The other types are clearly more focused on serving their customer and achieving higher production. This requires more investment into organisational practices.

4.5.3 Barriers to investing in the digital transformation

The comparison of barriers to investing in the digital transformation between organisational types adds extra information on organisational issues. The FLASH-Eurobarometer identifies eight possible

barriers to introducing digital technologies (Table 27). One extra barrier was added after analysing the cases: the availability of sufficient personnel.

Table 27. In introducing digital technologies, have you been confronted by the following barriers to digitalisation?: count (n=30; no missing)

	Low-low	Moderate – irregular	Selective - moderate	High-high
N =30	6	5	4	15
Financial	2		2	5
Skills	3	2	1	5
Managerial_skills	1	1	1	1
IT_infrastructure				2
Regulatory_obstacles			1	2
IT_security_issues	2	4	1	4
Uncertainty_digital_standards				3
Internal_resistance	1	1		5
Personnel availability	1			

Four companies did not report any barriers to implement digitalisation. For low-low cases, skills (of employees) are the most reported barrier to digitalisation. Financial resources and IT security issues are an issue. For the moderate-irregular cases, IT security issues are an important barrier. Half of this number are manufacturing companies. Financial resources are most cited for the selective-moderate type, but a clear picture of barriers does not arise. For the high-high group, three main barriers are cited: financial resources, skills shortages and internal resistance. The last barrier is important because it is precisely the 'voice' factor that is characteristic of this type of organisation. Internal resistance is allowed and is present in these cases. One example of 'internal resistance' that was given was that older employees did not feel comfortable with the new technologies and needed to have new workplaces without these technologies.

The barriers of skill and internal resistance are linked to the organisation of processes. IT security is more of a technical matter. It seems that low-low and high-high organisation models report more organisational issues. Probably because the organisation is lacking for the low-low situation, and the organisation is complex for the high-high situation.

4.5.4 Organisational practices to manage skills

The technological and organisational transitions affect the skill use in the cases. The way the cases describe how they deal with skills can indicate how technology and organisation relate to one another. High investment, high involvement type of companies are expected to make better use of skills. The context is that almost all cases employ personnel with academic and technical skills. Most cases work with a workforce that possesses advanced digital skills. The challenges of all these cases are attracting new talent and keeping skills up-to-date. In dealing with these technical and digital skill demands, the cases use very specific organisational, recruiting and training methods or have changed these measures over the past years. Most companies have shifted their recruitment demands upwards, in line with their perception of upskilling demands. This pushes companies to broaden their recruiting areas and invest heavily in internal training systems. All cases (27) report that they need to continuously train the new and current employees to keep up with the technological and digital changes. All employees, even managers in all cases, need continuous retraining to deal with the ever-changing technologies. All cases report that they have **serious difficulties in finding new talent**.

The four organisational forms approach their skills and the challenges of digital transformation differently. A part of this has already been touched upon in Table 21. The question is how different the approaches to skills really are. However, the main divide in practices is between low-low and the rest of the organisational types. The latter part of the cases differ in the degree of investment in the measures and the voice is given to the shop floor workers.

The *low-low company practices* of ES1 and GE5 were already described in Table 21. Practices at GE3 resemble those of GE5, but the skill-level is very different. GE3 is a start-up in the logistics domain. It relies heavily on its AI/machine learning technologies for its delivery service. The profit margins are thin, and the only way to win in the market is to secure timely and on-demand delivery. The company is very dependent on the skills of its developers. For this purpose, the company has broadened its recruiting base to other countries, even if the company is still only a start-up. The current workforce is 100% suited to the task, but there are too few of these specialists. The company is does not yet have well-founded personnel policies. A lot of personnel decisions are made on an ad hoc basis. The future will tell if the company can scale up to profit from its technologies. It is clear that these low-low companies expect to find employees that are directly productive. In GE5, this is achieved by reducing the learning time of new drivers. Technology is in support of the organisational model. Training and on-the-job learning are undertaken within the company itself. ES1 limits recruiting time by strictly relying on referrals. New candidates need to bring high-level experience. There is no capacity in the company to start training employees for new tasks. For as far as there is specific training, it remains mostly training on the job, sometimes under the guidance of specific senior mentors. BG5 reports that they use a system of internships to find the right talent, but once selected, these interns switch over to on-the-job training.

The practices among the *three other organisational types* are the other extreme. The high-high case NL3 only recruits academically schooled personnel, and then mainly from countries they expect are not in the recruiting areas of their main competitors or customers, such as Iceland and Bulgaria. The growth of the high-high case FI1 is limited by finding sufficient talent. To do so, FI1 recruits far over the borders and manages inclusive personnel policies to guarantee multicultural and -national

workforces. FI1 has special services for foreign employees and their families coming from 40 different countries. GE3, as moderate-irregular case, has followed the same strategy: first trying to use the local talent, then shifting towards talent coming from the German capital, and now looking at the international scale. However, some companies do not follow this path, rather continuing to recruit any talent they can attract and then training these employees to perform the right tasks. ES2 and ES3, both moderate-irregular type of companies, recruit students from the local VET schools and then train them. ES3 indicates that they are forced to do this since the machines they use are so complex that no school system is able to prepare the workers for such tasks. BG4, in the same type, recruits any person with data skills and then retrains them to understand and use the technologies they use in the company. They cannot afford to be picky.

The training systems in these high-high cases varies quite significantly. However, central to the training systems is the fine-grained approach to follow-up the skills of their employees. The last step in the development of their training systems is the possibility of using self-training systems. For example, the high-high case FI1 starts for each position in its processes from the current skill set of the employee/applicant. If the person has the skills FI1 needs, FI1 adapts the work process and working environment according to the need of the employee. NL3 goes even further. It uses a very extensive training system in which a Resource and Responsibility Matrix is used to monitor changing skill levels. This provides a 'Living CV' of someone, which shows which skill levels a person controls, what ambitions a person has, so they know what they want to develop, and in what topics they can train themselves. NL3 lets new employees start from their own talent so that they can grow into specific processes and workflows. The idea is that the employee gets involved in specific (technology/product) programs and then can apply the competencies. ‘Coaches’ ensure that employees develop their competencies in both directions. GE1 also reports the use of an apprenticeship model, with walk-in-training of new talent guided by experts. FI2 keeps the knowledge of all employees updated through an online academy specifically developed to achieve that all workers feel knowledgeable about using digital technologies at work. Organisational measures (e.g. cross-organisational workstreams) are also applied for this purpose. The deployment of digital technologies is linked to the workplace innovation practices the plant has implemented. These high-high cases support these training systems with team- or project-based organisational models and flat hierarchies. BG2, selective-moderate, has also developed an internal academy specifically for training. They even engage external consultants to come in and train the new colleagues. Most of these cases are shifting training to self-training systems in which personnel needs to keep updated with online or e-learning modules. The difference between companies is how they monitor the skill development of the employees.

Some companies have unique methods to deal with skill shortages. ES4, a selective-moderate type of case, tries to follow the changing technological frontier by outsourcing tasks to companies or experts who are able to perform the (digital) tasks. Then, ES4 tries to learn how these tasks are performed and invests in the abilities to perform them. This is probably not specific to the organisational type but shows that ES4 relies on the capacities of other organisations to move forward.

4.6 Discussion and conclusion

The key question in this chapter is what is the connection between digitisation and organisational practices? Does a company that chooses to digitise benefit from WPI? The research focuses on thirty cases, half of which can be classified as WPI. The prevalence of digital technologies is high in all cases but highest in these WPI companies. This is not surprising because the cases are selected on the prevalence of digital technology. However, it was not clear beforehand which digital technology this would be and whether it fits within the company's digital strategy. In the end, we see that 19 companies can be classified as digital transformers.

What do our research results tell us? Digital technology is also used in low-low companies. In these cases, we see that digital technology is used as a management tool. Algorithms help to reduce the complexity of the work of the employees. The cases organise the work in such a way that a high turnover of personnel is taken into account. The knowledge of the employees is in the technology itself. Think of the knowledge of the delivery area at logistics providers: every square meter of the delivery area is in the software. In other low-low cases, there is simply a lack of development strategy for the employees. There, the new employees must be immediately employable. There is no time to develop knowledge. This kind of staff deployment is risky because the departure of one person can immediately frustrate the growth ambitions of the case. The lack of a development strategy further limits the growth of this type of company at the outset.

Among the high-high type companies, we see more applications of digital transformation strategies. Although all companies, including the low-low companies, report staff shortages, it is clear that digital transformation strategies require a lot of new knowledge and skills. Most cases focus on the recruitment of academic, technically skilled staff, but this is not always the case. There are several companies with VET employees who survive on the digital front. All companies indicate that they have to source their talent from further and further afield. Recruiting on an international scale is an issue even for very small companies. Although we have not looked at it specifically here, international recruitment makes companies more focused on including different cultures and languages.

However, recruiting on an academic level only is a specific choice of companies. It is not necessary to be successful. More important is the development perspective that the companies offer to existing and new staff, and that for all education levels. Only the low-low cases in our research employ unskilled or low-skilled staff, and they limit the training opportunities and development perspectives of this staff. Especially in workplace innovation cases, there is no single strategy for the development of existing and new knowledge. The cases apply a broad set of measures. The aim of this research is to develop a method that helps organisations to diagnose and improve their knowledge productivity. In the workplace innovation cases, it is striking that these high-high cases go to great lengths to map all the available knowledge in order to organise new development paths on the basis of this knowledge. An important organisational context here is that these organizations should not be overly hierarchical. The cases show teamwork and project-driven work as models.

Workplace innovation cases let employees play a role in shaping the digital transformation. The fact that these cases identify employee resistance as an obstacle to transformation does not reduce

digital transformation at all. The opinions of the employees are channelled into improvements in the organisations. Apparently criticism is not punished, but staff is stimulated to speak up to improve learning and innovation (Edmondson & Harvey, 2017).

The cases come from six different countries and different institutional contexts. These contexts have an impact on business practices. Especially for the Bulgarian cases, it is clear that the input of the employees in the companies is not organised. Employees should take the initiative themselves to bring their opinions. What is visible in that in three cases, employees leave earlier than express their voice. The turnover rate remains very high (16-50% per year) in Bulgarian companies, despite the higher pay rate compared to other sectors.

The digital transformation does not lead to reduced staffing requirements or even plans for staff reductions in any company. All companies need staff growth to keep up with demand. What we do not fully understand is whether the growth of these companies is at the expense of jobs at competitors in the sector. This does not seem to be the case in practice. In the example of the Dutch core-company, we see that even though they benefit from a monopoly situation for their product, the demand for their product is so high that their personnel growth rate is increasing by ten percent annually. None of the companies sees the digital transformation as a threat. On the contrary, they need this transformation to meet the quality demands and wishes of their customers.

Organisational policies help companies get the most out of their employees: some do this better than others. There are still large differences in practices, indicating that even for most workplace innovation companies, there are still opportunities to develop and better use their staff. The choice of measures, and thus the opportunities to make better use of technology, depends on the extent to which employees can participate. The situation in Bulgarian companies is that they are experimenting with all kinds of measures, but there is no participation from employees. Only the external option seems to make sense for employees if they have a different opinion. There is still a world to be won in that context.

The thirty cases remain a biased sample. As a result, the external validity of the results seems limited. Nevertheless, it is important that this material, in particular, provides insight into what is happening at companies on the digital front. The material shows that not only technology but the organisational context must be included in understanding the effects at the employee level. In broad surveys, more attention should be paid to workplace innovation as a driver of digital transformation.

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5. Study 4: Working on the digital frontier

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Abstract

The German technology programme Industrie 4.0 has been a leading sociotechnical imaginary for industrial policy for over ten years. This perspective does not only indicate what technological investments are needed, how industrial policy should be designed, but also what labour market policy should be, and what employees in companies should use as a perspective for skills development and work content. This perspective is mainly driven by what employers want but is not informed by the worker's needs. This paper expands on the sociotechnical perspective of workers working on the digital frontier. The analysis shows that workers from four countries cluster into two groups. Both groups think differently from the Industry 4.0 perspective. The most important item for the employees is that they think they can handle the digital transformation but are not sufficiently involved in its development. The discussion of the results connects this contradictory feeling with the new sociotechnical imaginary of Industry 5.0, which the European Commission is now promoting.

Keywords

Automation, skills, technology, organisational change, skills use, technological change, sociotechnical imaginary, industry 5.0

5.1 Introduction

5.1.1 Industrie 4.0 versus Industry 5.0

The German initiative Industrie 4.0 was launched as a new narrative for redirecting investments into science and technology in the European context (Hermann et al., 2016a). In the sociotechnical imaginary of Industrie 4.0, a new view on work and technology was promoted with high degrees of autonomous technology and high risks of mass unemployment. Any remaining work would be highly skilled (Frey & Osborne, 2017; Jasanoff & Kim, 2015). The concept of Industrie 4.0 is being contested not only in research (see Autor, 2015), but also in the political arena with the launch of Industry 5.0 as a new vision by the European Commission (Breque et al., 2021). In terms of Jasanoff and Kim (2015), the attractive vision within the Industrie 4.0 is being contested in such a way that, as a vision, it may not achieve a permanent embedding in our social practices. However, as a vision, it does have normative implications for company behaviour, investments and practices to employ and develop workers. In the body of emerging research on Industrie 4.0, too little attention is directed at what precisely happens with technology and work within Industrie 4.0 companies (Leonard &

Tyers, 2021). The Industrie 4.0 imaginary is mainly informed by what employers think about technology and employment (Schwab, 2016).

This paper examines how technical experts working on the digital frontier perceive their work practice and that of their immediate colleagues. Do they share this understanding of technology and work that employers have? These technical experts have been selected from companies in several European countries that are dealing with robotisation, Artificial Intelligence and Machine Learning, connected technologies (cloud computing, smart devices, high-speed infrastructures), Big Data and Data analytics. These companies are pioneers in advanced manufacturing or supply software products to industry and healthcare, and are leading in the entrepreneurial ecosystems they have been selected from (Dhondt et al., 2022).

5.1.2 Impacts of autonomous technology

Frey and Osborne (2017) predicted that autonomous technology would lead to mass unemployment within two decades, and low-skilled workers would mainly pay the price of technological advances. The focus of this paper goes beyond the employment effect when implementing new technologies and looks at the newest technologies that do not only substitute work by technology. As Autor et al. (MIT Work of the Future Task Force, 2020) point out, these autonomous technologies also allow workers to be supported or augmented in what tasks they perform in their jobs. Handel (2022) estimated that for the same occupations cited in the Frey and Osborne study, there would be no further decline in employment levels by 2029. If any threat exists for workers from these autonomous technologies, then it is more likely to arise from the threat where technology increasingly erodes the quality of work (Spencer, 2018). It is evident that robots, artificial intelligence (AI), and other intelligent technologies are changing the content of work (Bailey & Barley, 2020; Frank et al., 2019).

However, most of the attention in the Industrie 4.0 imaginary is directed at skill changes. Autonomous technology would change the required skills of employees (Frey & Osborne, 2017). According to Statistics Finland's 2018 Quality of Work Life Survey, which provides a telling example of what happens in modern economies, 90% of wage and salary earners use digital applications at work. Most of them cope well, but about 10% of employees are in the 'user gaps', i.e. they neither have the proper skills to handle the digital transformation nor do they use digital tools at all (Tuomivaara & Alasoini, 2020). In the Industrie 4.0 imaginary, the responsibility to adapt to the impacts of new technologies is placed on the shoulders of the individual workers in the form of 'upskilling' (Schlogl et al., 2021).

5.1.3 A more realistic perspective

The question is if such a perspective is realistic. Appelbaum et al. (2000) question the ability of employers to adequately assess the skills required from workers. Moreover, it is important to consider the organisational context in which employees work to understand which skill demands will prevail. Dhondt et al. (2021) show that the organisational context is a more important factor

influencing the type of skills that can be developed in the workplace rather than the technology itself.

Bailey and Barley (2020) show that a broader perspective is needed on the design and use of technologies. Engineers and managers have broader strategies when using these digital technologies than Frey and Osborne think possible. The power relations between shopfloor workers, trade unions, technologists, and managers also influence relationships in the workplace.

The nature of these Industrie 4.0 technologies is also more and more being questioned. Acemoglu and Restrepo (2019) estimate that in many companies, the objectives of automation are rarely achieved. They label technology that does not contribute to higher productivity as 'so-so-technologies'. In an ethnographic case study, Leonard and Tyres (2021) found that the take-up of new digital technologies was slow, mainly because management itself was sceptical that technology could deliver on its promises.

5.1.4 The worker perspective

The current Industrie 4.0 imaginary needs to be questioned. Robots are still not taking over the work of employees (DeCanio, 2016; Genz et al., 2021). Even AI does not seem to be able to automate every aspect of work (Erik Brynjolfsson & Mitchell, 2017). There is a large divide between the potential of current new technologies and the reality of what happens once these new technologies are implemented (Dhondt et al., 2020). The perspective of the workers is needed to understand what is happening in the companies. As examined in this study, the context of the digital transformers allows greater importance to be placed on answers provided by employees, as it is they who are working on the digital frontier. Thus, they have a unique perspective which is rarely canvassed as most surveys on skills are completed at the company level by managers or HR staff. Cascio and Montealegre (2016) indicate that research on technology, work, and organisations is currently still in its infancy. It is striking that the opinion of the employee is only rarely considered. As Berkers et al. (2020) point out, more attention needs to be paid to the meaning employees give to new technologies. Given that the introduction of new digital technologies does not always seem to deliver the benefits as intended (Acemoglu & Restrepo, 2019), it is important to seek insights on the employee side to guide decisions around the selection and implementation of any technologies. Belloc et al. (2021, p. 4) see that employee participation in designing jobs and workplaces may enable the adoption of rich job designs, retraining policies, and complementary technologies that confer large productivity gains. Technology adoption theory predicts that employees are more likely to adopt new technology if it is understandable, makes work easier and produces results, in addition to showing that management cares about its use (Oeij et al., 2022). Gekara and Nguyen (2018) also see digital technology as having other unforeseen positive impacts. Upskilling and a shift in the importance of soft skills alter the debate in their example of Australian employees in the context of the container terminal industry.

5.1.5 Research questions

The purpose of this study is to explore how workers closest to the newest technologies (i.e. those working on the 'digital frontier') evaluate their work situation and that of their immediate colleagues. This exploration will enable the debate around the impact of technology on work to be progressed. The study aims to answer the following research questions:

- What does working on the digital frontier entail for workers?
- How do those working on the digital frontier assess their skills situation in terms of keeping up with digital transformation?
- To what degree do these workers have a grip on technology, on organisational change? Are they powerless in the face of the latest technologies?
- Do they see their employment relationship threatened by the digital transformation?
- How do workers on the digital frontier perceive the work situation of their colleagues? Does it deviate from the assessment of their situation?

From the analysis of these questions, an assessment can be made about whether these workers at the digital frontier have the same perspective on Industrie 4.0 as managers. By conducting an international survey, it was possible to explore whether there are differences in the perceptions of employees by country of origin and/or according to their type of job or occupation group. Is there a difference between what these workers think about their work vis-à-vis their immediate colleagues?

There are several advantages to focusing the research on the work situation of the workers and their colleagues at the digital frontier. This study does not suffer from the limitations of existing surveys on work: these data usually reflect the past and are pre-COVID-19. There is only a limited view of the latest digital technologies. This is often because these digital technologies (Industrie 4.0 technologies) are typically reported to be in very limited use when the sample is drawn from across all sectors and companies (Genz et al., 2021). It is difficult to extrapolate much about the work situation on the basis of the limited material in existing surveys. The connection between the employer's business situation and how the workers experience the impacts is also usually not captured (Greenan & Napolitano, 2022). In addition to the perspective on one's own work situation, it would be useful to also look at the situation of one's colleagues, at least according to what the employee thinks about it. The sociotechnical imaginary of the workers can be deducted from the description of their work setting but also from what they imagine their colleagues are experiencing. Most research tries to assess an employee's work situation based on a comparison with others. However, how do they themselves see the difference from those colleagues? This within-comparison helps to determine whether they really view their work situation as different to the situation faced by their colleagues. Using the perspective of the practice approach developed by Leonard and Tyres (2021), the theoretical debate on technology and work is extended. Learning from the perspective of the workers at the digital frontier, a better understanding of why companies appear to be slow in adopting change, next to what already is known from a management perspective, can be developed (Leonard & Tyers, 2021).

5.2 Method

5.2.1 The context

This research was conducted in twelve companies in advanced manufacturing and software development (see Table 28). These companies were selected because they have already invested in robots, AI, big data and data analytics, and connected technologies. The companies are part of a broader sample of thirty companies from six business ecosystems in six countries in the period 2021-2022 (Dhondt et al., 2022). In these thirty companies, discussions were held with management and workers. Because workers could not always be approached independently, companies were asked to provide workers with a survey that they could then complete and send directly to the researchers. Twelve companies cooperated with this specific request. The companies were selected from different entrepreneurial ecosystems in Finland, Netherlands, Spain and the United Kingdom. These companies were asked to select leading workers, defined as key workers working in departments that have implemented technologies including robotics, sensors, data sciences, machine learning/artificial intelligence (AI), Internet of Things (IoT). In line with the theoretical sampling method of Eisenhardt and Graebner (2007), the sample was restricted to those workers in companies working on the digital frontier.

Table 28. Overview of companies and types of jobs included in the survey (n=52)

		Type of jobs			
Company	Technologies present	Robotics, automa-tion	Data sciences, data analytics, IoT	Software, program-ming	Other technical expertise (1)
Finland1	AI, Big data & analytics	X	X	X	X
Finland2	AI, Big data & analytics			X	
Finland3	Cloud, Big data & analytics, High speed			X	
Netherlands1	All technologies		X		
Spain1	Robotics, AI	X		X	X
Spain2	All technologies	X	X		
Spain3	Cloud			X	
United Kingdom 1	Cloud computing, Robotics, Smart Devices, High speed	X			
United Kingdom 2	AI, Cloud computing, Smart devices, Big data & analytics, High speed		X		X
United Kingdom 3	Cloud computing, Smart devices, High speed				X
United Kingdom 4	Cloud computing, Robotics, High speed				X
United Kingdom 5	AI, Cloud computing, Smart devices, Big data & analytics, High speed	X			
Total participants		9	7	27	9

(1) Expertise are: engineering (electronics, industrial, mechanical); technical operator (not robotics); research & development; IT infrastructures and network

The main group of participants in the study performs software and programming work. This work concerns the programming of machines and devices in the production environment or in digital health. It is striking that despite some of the companies have introduced machine learning or AI, none of the respondents in this study had specific work in roles directly involving AI or Machine Learning. Whilst such functions exist in some companies, it is possible that survey respondents included these types of technologies under the broader category of data analytics. In addition to this survey, members of the research team had various discussions with such specialists, but they did not complete the survey.

5.2.2 Procedure

In each organisation, the contact person was asked to forward the survey to one employee in every major department that was currently using the main digital technologies of interest to our study.

The contact person was asked to identify an employee who they felt had the best overview of operations and use of technology. In one of the organisations, the survey was piloted with two respondents to see how they would respond to the questions. In some companies, the contact people distributed the surveys to several departments, while in others, the questionnaire was only sent to an employee in one department. Having followed this approach, a total of 52 surveys were returned from across the twelve organisations. It was not the aim of the survey to be representative, rather, the theoretical approach to sampling meant that we were interested in gathering views from workers who, in their current job, are directly involved in dealing with one or more of the abovementioned new technologies. Although the sample was rather small, it deliberately aims to represent the views of workers at the digital frontier, where the results are indicative rather than confirmative.

The survey asked the employee how they perceive their own work and the impact of digital technologies, and how they believe their colleagues perceive the work.[13] The surveys were translated by partners where necessary.

The following figure depicts the structure of the survey, showing the topics and flow of the survey.

Figure 3. Overview of the topics in the questionnaire

The selection of topics is not random. The topics follow the main line of reasoning in the Industrie 4.0 sociotechnical imaginary. In this imaginary, only high-skilled are able to keep up with technology (Frey & Osborne, 2017). The new work situation would put more stress on non-technical skills (Van Laar et al., 2017). Industrie 4.0 technologies would require mainly external help rather than being a collaborative effort (Schwab, 2016). Workers should be more focused on developing a perspective of moving from one firm to another to develop their labour market security (Molloy et al., 2014). The survey is focused on testing if workers at the digital frontier share this perspective.

[13] Because the workers were deliberately targeted by the contact in the organisation as being the 'best representative', it was expected that their own situation would be seen as more advanced than that of their colleagues.

5.2.3 Data analysis

The data from the workers was analysed in several steps.

In a first step, a thematic analysis of the data was undertaken around the three main themes that compose the sociotechnical imaginary. The first main theme was concerned with skills to deal with the latest technology, where findings were grouped into three sub-themes: the ability to keep up with technology; collaboration with workers with other technical expertise to themselves; comparing skills for the digital transformation (3.1). The second main theme was around dealing with digital and organisational transformation (3.2). The third main theme was around technology, jobs and the employee relationship, where findings were grouped into two main sub-themes: job mobility and technology and job security (3.3).

In a second step, a cluster analysis was undertaken to see how homogeneous the worker group actually is. Two groups were identified on the basis of the different questions. The background of these groups was compared. The perception of these groups was compared to the Industrie 4.0 imaginary of work at the digital frontier.

The last step was to inform the perspectives of the two clusters with their perceptions of their 'colleagues. Jasanoff and Kim (2015) indicate that the methodology to map sociotechnical imaginaries is still under development. Most of these imaginaries are built on historical data or on personal histories. This paper explores if the description of the personal situation can also profit from how these workers, or group of workers, on the digital frontier interpret their position in relation to their co-workers.

Background details, including the gender and age of the respondents, were not collected, and company details were anonymised. This approach was not made to map the situation of the 'other' colleagues but to provide their perception of working on the digital frontier.

5.3 Results

The survey makes it possible to describe the perception of what digital work means for workers at the digital frontier. Next to describing the individual answers, the clustering of answers between the workers was checked. The survey also enables the answers of the workers to be compared with those of their colleagues. The constructed clusters of workers are used in this analysis.

5.3.1 Skills to deal with the latest technology

Keeping up with technology. The survey asked workers at the digital frontier to rate, using a scale, whether they feel they can keep up with the changes arising from digitalisation. The respondents were also asked to make an assessment about whether their educational background remains appropriate for the work that they currently do. Additionally, respondents were asked to provide details on what kind of education and training they felt they needed to keep up with changes related to digitalisation.

Almost two-fifths (38%) of workers on the digital frontier indicated that they felt they could easily keep up with the technology necessary for them to perform their job. However, three-fifths (62%) reported that they felt that it was difficult to keep up with technological developments. No workers indicated that they would find it impossible to keep up.

Less than 10% of the workers at the digital frontier felt that their previous education fitted perfectly with the requirements of their current work. Half (50%) of the respondents felt that their previous education was adequate for the requirements of the job they currently perform. However, two-fifths (40%) felt that their prior education was not adequate for them to perform their current job. The better the previous education fits the job, the easier it is for the employee to keep up technically. In this survey, the best fit between education and work can be seen among software specialists (74% perfect and just right fit), less so among robot specialists (44%) and data scientists (43%).

Collaboration with other technical expertise. The workers were then asked whether they mainly worked within their own expertise or whether they were required to collaborate with workers with technical expertise different from their own, the vast majority (90%) of the workers indicated that they worked with colleagues with other technical expertise, either somewhat or a lot. This finding is particularly noteworthy because it exemplifies how working on the digital frontier requires a significant amount of inter-disciplinary collaboration between workers with different types of expertise.

Comparing skills for the digital transformation. To assess the skill sets required for dealing with the digital transformation, workers were asked to rate the importance of technical skills compared to their social and communication, and critical skills. For this purpose, technical skills are understood as those skills specific to their own job.

Over half (52%) of respondents reported focusing mainly on their technical skills, while just over two-fifths (42%) reported focussing on their social and communication skills in addition to their technical expertise. In contrast, just one-in-20 (6%) reported focussing mainly on their social and communication skills (Table 29). A higher proportion of people working in software programming (67%) felt that focussing on their technical skills was more important than focussing on their social and communication skills as well as their technical skills (67%), compared to those in roles involving robotics/automation (56%) or those in data science/data analytics/IoT roles (43%). A higher proportion of those working in roles in data sciences/data analytics/IoT reported focussing on social and communication skills in combination with technical expertise (57%), compared to those in robotics/automation (33%) or software programming (33%).

All of the respondents reported a focus mainly on their social and communication skills working either in robotics/automation (11%) or other roles (22%). That is, none of those working in data sciences/data analytics/IoT or software programming reported focussing mainly on their social and communication skills, which in itself is telling.

Table 29. Given the digital transformation, compare the importance of technical versus social and communication skills, according to the expert area.

	Robotics, automation	Data sciences, data analytics, IoT	Software, programming	Other technical expertise	Total
N =	9	7	27	9	52
I focus mainly on my technical expertise	56%	43%	67%	11%	52%
I focus on social and communication skills and technical expertise	33%	57%	33%	67%	42%
I focus mainly on social and communication skills	11%	0%	0%	22%	6%
	100%	100%	100%	100%	100%

Chi-square = 13.092; p=0.042 (2-sided)

Respondents were then asked to consider whether they focussed mainly on their technical skills, on both critical thinking and their technical expertise, or mainly on critical thinking. Just over half of all respondents (52%) reported focussing on both critical thinking and technical expertise. The vast majority (86%) of those in roles involving data science/data analytics/IoT reported focussing on critical thinking and their technical expertise, which was much higher than among the other specialist categories of workers.

Only a small number of workers indicated that social and communicative skills or critical skills are sufficient on their own. Where, for example, only those in 'other' roles reported focussing mainly on critical thinking (22%) (Table 30).

Table 30. Given the digital transformation, compare the importance of technical versus critical skills, according to the expert area.

	Robotics, automation	Data sciences, data analytics, IoT	Software, programming	Other	Total
N =	9	7	27	9	52
I focus mainly on my technical expertise	44%	14%	56%	33%	44%
I focus on critical thinking and technical expertise	56%	86%	44,%	45%	52%
I focus mainly on critical thinking	0%	0%	0%	22%	4%
Total	100%	100%	100%	100%	100%

Chi-square = 13.949; p=0.03 (2-sided)

A comparison of the results on social and communicative skills (Table 29) versus critical skills (Table 30) suggests that, in addition to their technical expertise, workers at the digital frontier may place greater importance on their critical skills than their social and communication skills. This result is somewhat unexpected given that these workers report they are required to undertake a high level of collaboration with workers from other areas of expertise.

The final question in this section of the survey asked workers about what kind of education or training they thought would help them to develop their careers. While more than two-thirds (70%) of workers reported having faith in their technical training, one-fifth (20%) considered training in social and communication skills important and a further one-in-ten (10%) viewed training in critical skills to be important.

5.3.2 Dealing with the digital and organisational transformation

The workers showed strongly divided opinions about the extent to which they think they are able to shape the direction of the digital and organisational change in their companies. One-in-three (33%) of the workers believed that technology is a given, so their role in driving technological change is very limited.

While nearly half (46%) of them felt that their ideas about technological change are sometimes used and implemented by their companies. Only one-fifth (21%) believe that they have a great deal of influence and control over changes in the technological environment in their organisations. It was not possible to disaggregate these results down to the level of specific organisations, and there were no discernible differences by country. The results for influence on organisational change are similar.

While there were only a small number of surveys completed by people working in the same organisation, where this did occur, workers within the same organisation reported different experiences, ranging from reporting having no control over shaping company direction around digitalisation and organisational change to having sufficient influence over this.

While robotic specialists register the highest proportion reporting being 'sometimes in control' for technology (57%) and organisation (56%), software programmers register the highest proportion who say they have 'no control at all' (37% technology; 41% organisation). It is important to indicate that over two-fifths (42%) of these technical specialists see digital transformation or organisational change as given. This is quite high if you consider that these workers are the core workers involved in translating the plans from management into workable solutions on the shop floor.

Table 31. What role do you see yourself playing in driving this digital transformation or this organisational change? (descriptive)

Role in digital or organisational transformation …	Technological change	Organisational change
N	52	52
A given, my role is very limited.	33%	29%
Sometimes my ideas are used and implemented.	46%	44%
I have a great deal of influence and control.	21%	27%
	100%	100%

5.3.3 Technology, job and employee relationship

Job mobility. The last series of questions in the survey concerned job mobility and job security connected to technological developments.

In 2021-22, there was no evidence among workers at the digital frontier to support the idea that they should be more committed to mobility between companies and even professions (Molloy et al., 2014; Schmid, 2017). To this end, over two-fifths (44%) of these workers indicated that it was particularly important for them to remain in their current job with their current company for the duration of their working careers. Insofar as they want to be 'mobile', they might be open to the idea of changing jobs within the same company (25%). Just under 10% were open to the idea of job-hopping between companies and positions, while one-fifth (20%) thought that job-hopping between companies was important. There were no discernible differences in responses to this question by country or job type.

Considering these findings, it appears that mobility between professions and companies is not a very attractive option for many of these workers who are engaged in jobs at the digital frontier. This is in contrast to the underpinning logic common to many labour market policies, where labour market mobility is conceived as a 'no regret' action that functions to smooth labour market matches (Erken et al., 2014). Of course, workers at the digital frontier may be confident about their labour market employability. Nevertheless, the findings suggest that because many rule out the idea of changing companies or professions, they may not optimise their future career development.

Table 32. For which technical area do you consider yourself an expert? (Please tick the box closest to your expertise)

	Robotics, automation	Data sciences, data analytics, IoT	Software, programming	Other	Total
N =	9	7	27	9	52
Staying in current job - company for the rest of your career	11%	29%	56%	56%	44%
The rest of your career in your present function, possibly in more companies	22%	14%	11%	11%	14%
To stay in the company for the rest of your career	33%	43%	19%	22%	25%
Not staying long in one job - company, but learn by going to different companies	33%	14%	15%	11%	17%
Total	100%	100%	100%	100%	100%

Chi-square = 7.622; p=0.573 (2-sided) (n.s.)

Technology and job security. Related to the previous issue of mobility, respondents were asked whether they saw the digital transformation as a threat to their current job security. Only two people (4%) viewed the digital transformation as a threat to their job security. Over half (56%) did believe that digital transformation influenced their job security, however, they saw other factors (such as company financial position) as having a greater influence on their perceived job security.

Interestingly, despite working on the digital frontier, as many as two-fifths (40%) of those surveyed did not see any connection between the current job security and the digital transformation.

In general, despite working in jobs at the cutting edge of technology, the digital frontier workers were surveyed maintained traditional views about the employment relationship.

Table 33. Do you see the digital transformation as a threat to your current job security?

	Robotics, automation	Data sciences, data analytics, IoT	Software, programming	Other	Total
N =	9	7	27	9	52
They see no link between their current job security and the digital transformation	22%	29%	44%	56%	40%
The digital transformation influences job security, but they see other factors as more important for their job security	56%	71%	56%	44%	56%
The digital transformation influences their job security to a great extent	22%	0%	0%	0%	4%
Total	100%	100%	100%	100%	100%

Chi-square = 11.671; p=0.07 (2-sided) (n.s.)

5.3.4 Is the group of workers homogeneous?

The group of workers is not homogeneous. A K-means cluster analysis was conducted to identify if the workers' answers were clustered in distinctive perspectives. First, those variables that showed little spread were excluded from the analysis. These are questions about keeping up with technological developments, most important skills, and digital transformation as a threat to current job security. All workers provided the same answers. Using the questions on collaboration with other technical expertise, type of future education and training needed, role in digital and organisational change, a most important element for own job security, and quality of the educational degree. Table 34 shows what the core answers are for two clusters.

Table 34. Main answering categories for the two clusters (final cluster centres)

	Collaborative cluster	Technical cluster
N (100 %)	23 (44%)	29 (56%)
Collaboration	3 = I **collaborate** a lot with other technical expertise	2 = I collaborate with other technical expertise, but not much
Type of future education and training	2 = Mainly more training or education in **social and communication skills**	1 = Mainly more **technical** training or education

Role in digital transformation	2 = Sometimes their ideas about what technology should change are used and implemented.	2 = Sometimes their ideas about what technology should change are used and implemented.
Role in organisational change	2 = Sometimes my ideas about what should change are used and implemented.	2 = Sometimes my ideas about what should change are used and implemented.
Most important for job security	To stay in the **company** for the rest of your career	The rest of your career in your present **function**, possibly in more companies
Quality of educational degree	3 = The knowledge I have learnt in my (school) education is **not at all adequate** for my current job	2 = The knowledge I have learnt in my (school) education is **just right** for my current job

Two clusters or groups are identifiable. The collaborative group insists on collaboration with other technical expertise and requires more social and communication skills training or education. They see previous education as not adequate at all. The group rather wants to stay in the company they are now working for. The technical group insists more on working within their own group, needing more technical training or education, is more focused on the job title, not so much on the company, and sees previous education as adequate. Both groups only see their ideas about technology and organisation sometimes implemented.

The clusters do not resemble the expectation formulated in the Industrie 4.0 imaginary as described earlier. Two-fifth (44%) of the workers belonged to the collaborative group and the rest (56%) to the technical group.

The two groups can be found in all companies and in all countries. Software and programming experts are likely to be in the technical group. The title 'technical focus' may be misleading but refers more to the expertise orientation of this group. Both groups are present in all technical expertise.

Table 35. Technical expertise of the two groups

	Robotics, automation	Data sciences, data analytics, IoT	Software, programming	Other	Total
N =	9	7	27	9	52
Collaborative group	67%	57%	30%	44%	23
Technical group	33%	43%	70%	56%	29

Chi-square = 5,4; p=0.15 (2-sided) (n.s.)

5.3.5 How do they position their colleagues to their situation?

The workers at the digital frontier were asked the same questions about how they thought their colleagues experienced their work situation at the digital frontier. The perceptions of the two groups that were identified in the previous section are compared in Table 36.

Table 36. What do the two groups think that their colleagues find important?

	collaborative group	technical group
Can they keep up with developments in your technical field?		
• **'Almost all colleagues can easily keep up with developments'**	36%	52%
• **'Only half of the colleagues can keep up easily'**	41%	24%
• **'For most colleagues, it is a challenge'**	23%	24%
	100%	100%
Do you find that the technology they need for their work requires them to collaborate with other technical expertise?		
• **'They work mainly within their expertise'**	27%	17%
• **'They collaborate with other technical expertise, but not much'**	23%	45%
• **'They collaborate a lot with other technical fields of expertise'**	50%	38%
	100%	100%
For their current job, which skill is the most important?		
• **'They focus mainly on their technical expertise'**	73%	59%
• **'They focus on social and communicative skills and technical expertise'**	23%	38%
• **'They focus mainly on social and communicative skills'**	5%	3%
	100%	100%
For the digital transformation they are experiencing:		
• **'Mainly more technical training'**	59%	62%
• **'Critical thinking and technical expertise'**	36%	34%
• **'Especially more training in critical thinking'**	5%	3%
	100%	100%
Which type of education or training will most help them develop your career?		
• **'Mainly more technical training or education'**	68%	86%
• **'Especially more training or education in social and communication skills'**	18%	10%
• **'Especially more training or education in critical thinking'**	14%	3%
	100%	100%
What role do you see them playing in driving this digital transformation?		
• **'Technology is given'**	27%	48%
• **'Sometimes their ideas what technology should change are used and implemented'**	55%	41%
• **'They have great influence control over any change in their technological environment'**	18%	10%
	100%	100%
What role do you see for them in driving this organisational change?		
• **'Organisation is given '**	23%	55%
• **'Sometimes their ideas about Organisation are used '**	59%	41%
• **'They have great deal influence control over Organisation'**	18%	3%
	100%	100%
What do you think your colleagues find important for job security? (missing = 2)		
• **Staying in current job - company for the rest of their career**	18%	45%
• **The rest of their career in your present function, possibly in more companies**	18%	24%
• **To stay in the company for the rest of their career**	27%	17%

• **Not staying long in one job - company, but they learn by going to different companies**	36%	7%
	100%	93%
Do your colleagues see the digital transformation as a threat to their current job security?		
• **'No link between current job security and the digital transformation'**	24%	46%
• **'The digital transformation influences job security, but other factors are more important for their job security '**	71%	50%
• **'The digital transformation influences their job security to a great extent'**	5%	4%
	100%	100%

The two groups have different and concurring opinions about what they think their colleagues find important. The differences reflect their own situation. For example, the technical group was more optimistic about the capabilities of their colleagues. In total, a quarter of both groups see keeping up with technology as a challenge, whereas they do not have this challenge themselves. The collaborative group saw their colleagues as more collaborate with other expertise. The two groups were also split on what they think their colleagues find important as a development perspective. The technical group further though that colleagues should remain in their current role in one company. The collaborative group saw more flexibility (within jobs and companies) as important.

On the other topics, the two groups think alike. Both groups insisted that their colleagues mainly needed to focus on technical skills, and less on non-technical skills. In line with this, both groups saw their colleagues mainly benefitting from technical training or education rather than from training or education in non-technical skills. In terms of influence on digital transformation and organisational change, the collaborative group saw their colleagues sometimes having an impact. The technical group was more pessimistic and sees technology and organisation more as a given for their colleagues. Both groups were convinced that their colleagues do not see digital transformation as a great threat to their job security.

The overall picture from the comparison of answers of what their colleagues experience in their own situation is that the workers at the digital frontier see their colleagues have less leeway than themselves.

5.4 Discussion and conclusion

5.4.1 Summary of findings

The objective of this study was to assess the perception of workers working in advanced manufacturing and software service companies that operate on the digital frontier. Within these companies, targeted workers were selectively surveyed to obtain a picture of perceptions about their own work situation and that of their colleagues. The survey made it possible to compare the answers between workers from different companies and countries. The answers of the workers were then clustered to see if different groups of opinions could be identified. These perceptions are contrasted to the main tenets of the Industrie 4.0 concept of working on the digital frontier, as

identified at the end of section 2.2. These perceptions cluster into what Jasanoff and Kim (2015) call a 'sociotechnical imaginary'.

The findings contribute to a better understanding of the relationship between digital transformation and its impact on work, as Cascio and Montealegre (2016) recommended. Workers at the digital frontier have strong confidence in their own technical competencies and in dealing with technological change. Despite surveying 52 workers from 12 different companies located in four different countries, there were no discernible differences in the opinions of workers by job type, company or country. Answers of these workers cluster into two groups: a group of workers that stress collaboration at work and the development of non-technical skills; and a group of workers giving priority to technical skills and the development of these skills. When comparing what these two groups think of their immediate colleagues, it can be seen that both groups saw themselves as having greater control over their work situation than their colleagues. They also considered themselves better skilled than their colleagues. However, in many respects, the image of their colleagues reflects what they think is important in their own work.

Both groups of workers only partially reflect the Industrie 4.0 imaginary of working on the digital frontier. The workers did not report being fearful about their own situation in the digital context, perhaps holding opinions that viewed their colleagues as at greater risk than themselves. An important observation was that almost two-fifths (40%) of these technical specialists viewed technological change as given, perceiving limited capacity for them to drive or influence technological change in their companies. This suggests that the ideas of this group about technology or organisation are not taken into consideration by their senior management teams. This is surprising because one would assume that these companies rely on these specialists to translate production ideas into reality and make technological progress. It points to a potential problem whereby senior managers show reluctance in letting their leading technology specialists participate in this progress. Such participation proves to be helpful for companies to become successful in innovation, as is shown by companies with workplace innovation practices (Eurofound, 2015).

Although the study did not capture all aspects of the work situation, knowledge development, participation, and job security are important aspects of the work. These workers still showed a preference for traditional employment relationships, being less open to occupational or firm mobility during their careers. The sociotechnical imaginary that workers at the digital frontier have still reflects traditional values important for work: technical skills, collaboration, further education and training in the company context, a long-term perspective in the company context, and no fear of engaging with technology. However, their imaginary also reflects the limited power they experience at work. The conflict with management is present in this thinking.

5.4.2 Limitations and follow-up research

The survey was purposefully limited in focus on workers working on the digital frontier, nevertheless, none of the respondents worked in AI and ML. In the interviews conducted as part of the broader research project (not reported in this paper), conversations were held with such workers, and it was found that companies predict increasing opportunities for these types of jobs. Among the workers who completed the survey, there was a general consensus that neither they

nor their colleagues felt particularly threatened by emerging new technologies. It is difficult to judge whether these positive beliefs about their employability are well-founded or overly optimistic.

As indicated in the introduction, the perspective of workers is missing in many surveys and studies. While providing a range of useful insights from a selective group of workers on the digital frontier, these results have limited generalisability to other contexts. It is not known, however, whether there is a bias among workers according to age, gender or other characteristics. The studies concern workers actively using variously robotics, automation, data sciences, data analytics, IoT and software, and programming. In any follow-up research, it would be important to identify whether employee demographics and/or specific educational qualifications would influence perceptions.

5.4.3 Conclusion

This exploratory study on work at the digital frontier has made it clear that workers see many opportunities for themselves but also for their colleagues. It selected the practice perspective that Leonard and Tyres (2021) advocated and positioned this within the sociotechnical imaginary of Jasanoff and Kim (2015). By asking the workers at the digital frontier to relate their situation to their colleagues, the within-comparison adds an interesting perspective for building the sociotechnical imaginary. It helps to understand the views of the work being undertaken by a group of workers that are uniquely placed at the forefront of technological change. From their responses, it seems clear that workers at the digital frontier do not feel challenged with problems associated with keeping up with the digital transformation. What is important is that there is sufficient technical training available to maintain and develop both knowledge and skills. They also mainly work across technical disciplines with colleagues to master technologies. However, a considerable number of technical experts indicate that their ability to influence the digital transformation and organisational change underway in their companies is limited. This perspective appears to arise mainly as an individual assessment as it was not possible to discern any particular differences between the company, job title or country that may explain these views. More research is needed to clarify this situation. If having greater participation by workers is important to select better technologies in the workplace (Acemoglu & Restrepo, 2019; Belloc et al., 2021), then this study indicates that many workers in roles central to digitalisation are not included in decisions being made about steering technology.

Finally, while the workers in our sample do not appear to see digital transformation as a threat to their job security or to that of their colleagues, there seems to be much greater scope to include workers in the ongoing processes of technological transformation. Adding to the commentary of Leonard and Tyres (2021), in addition to managers often being slow or hesitant in adopting new technologies, when they do, they may not sufficiently engage with their workforce during any technological transformation.

5.4.4 Policy Implications

Various lessons can be drawn for policy.

Workers indicate that they attach primary importance to developing and maintaining their own technical skills as the main way to develop their careers. Technical skills are those related to their jobs, be it robotics, data analytics or software programming. They also consider this orientation to skills development as similarly important for their colleagues. While the development of social and communication skills or critical skills are important, it seemed acutely apparent that developing these other types of skills was not considered as important as maintaining the domain-specific technical skills. This finding seems at odds with the finding that the workers viewed collaboration with colleagues with expertise from other disciplines as an important characteristic of their work. It does not lead them to shift their skilling perspective to broaden the types of skills they need to develop, which has been identified in other studies (e.g., Gekara & Thanh Nguyen, 2018). According to the respondents, critical skills are needed in combination with technical skills.

Workers indicate that the update of their knowledge does take place at the workplace and that their former education and training are important, but staying up-to-date with further developments within the company is at least more important.

Many policy initiatives over the past decades were aimed changing the employment relationship and reduce employee protection. Despite the direction of policy, most workers surveyed expressed a clear preference, above all, to be able to develop further within their current company context and job. This finding was consistent across the four countries where the surveys were conducted. On a positive note, at the EU-level, the new narrative of Industry 5.0, with its focus on human-centred technology (Breque et al., 2021), offers the potential to go beyond the limitations of Industrie 4.0, but for a human-centric approach to work, the humans (that is workers) that do the work need to be consciously and more actively involved in future processes of technological transformation.

Workers working on the digital frontier in leading digital companies are not particularly fearful of the digital transformation. It can be argued that their grip on technological and organisational change is not the same for everyone. However, regardless of what role an employee works in, It is important to let workers have a grip on digital technology in the preliminary phase of technology as well as in the implementation (Meylemans et al., 2019) so that they can participate in, and benefit from, digital transformation. If workers perceive the new digital technology as beneficial, they are more likely to adopt it.

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6. Epilogue: beyond the Technology Trap

6.1 The context

The H2020 Beyond4.0 project title indicates that we must go beyond the Industrie 4.0 technology perspective to understand changes in work and employment. The sociotechnical perspective of Industrie 4.0 (Jasanoff & Kim, 2015) is defined by some contrasting messages. On the one hand, there is talk of promising productive technology. Industry 4.0 was launched in Germany in 2013 (Hermann et al., 2016a) as the building block of a new industrial strategy for the country. Instantly, almost all European countries adopted this same perspective. Industry 4.0 technology would become autonomous, able to function independently of people and thus free companies from all kinds of human boundaries. On the other hand, the perspective implied that humans would become superfluous in companies implementing this technology. This idea was central to the working paper by Frey and Osborne (2017). Almost half of the professions would become redundant in the short term. Brynjolfsson and McAfee (2015) envisioned a second 'machine age' in which the only thing to think about would be what to do with all those unemployed workers. This was the rise of the idea that Universal Basic Income (UBI) could help as a new social security system (Hiilamo, 2022). Less positively formulated policy documents on Industrie 4.0 indicated that the employees would be responsible for their 'upskilling' (Schlogl et al., 2021).

Opposition to the conclusions soon arose in the scientific field (e.g., Autor, 2015). But the alternative narrative has not really caught on in recent years. What was important was the effort by the OECD to redevelop the Frey and Osborne method to calculate the development of the size of unemployment loss in occupations (Arntz et al., 2016; Nedelkoska & Quintini, 2018). Hard data and the OECD systematics have started many follow-up projects supporting the narrative of Industrie 4.0 and a strong rise in productivity. For example, the sister H2020 project Technequality[14] has estimated the range for future unemployment as between 8 million and 106 million unemployed (Heald et al., 2019). Frey (2019) has also entered the debate and doubled down on his earlier message: not only is mass unemployment looming in half the occupations in the future, but workers' resistance to this development will undermine the Industrie 4.0 strategy. He considers a return to the pre-industrial era possible (the 'technology trap') wherein technological innovation would be impossible.

The main premise for *BEYOND4.0* is that technology, and certainly digital technology, is not deterministic but socially negotiated by key social actors at various levels: firms, industry, regional, national and EU (Warhurst et al., 2020). Decisions and situations in companies require more than simply adapting to technology. Resistance to technology is possible and does occur. That is not to say that Industrie 4.0 is not a useful strategy. Industrie 4.0 is still a promising technological journey

[14] https://technequality-project.eu/. The BEYOND4.0 team was awarded the Horizon2020 project. At the same time, and in the same research programme, our colleagues from the University of Maastricht were awarded the H2020 Technequality project. We collaborated on tasks but have different perspectives on the topics.

and offers opportunities for companies to adapt to autonomous technology. However, it is more about looking at what is happening in the companies before we start extrapolating all kinds of trends.

BEYOND4.0 has conducted several studies to find out what is 'beyond Industrie 4.0'. Different methodologies have been used to make visible how companies deal with technology. The core of *BEYOND4.0* is a Schumpeterian perspective of creative destruction, in which it is important for companies to achieve continuous innovation (Perez & Murray Leach, 2021). Therefore, the research initially focused on entrepreneurial ecosystems and how companies develop within them (Dhondt et al., 2022). To find out what exactly takes place within the companies, various approaches could be followed. This report focused on leading entrepreneurial ecosystems and frontrunners companies within them. *BEYOND4.0* is convinced that this is the approach that will provide more insight into the process of creative destruction. Frontrunner companies within leading ecosystems are best placed to map the actual working situation at the digital frontier.

As emphasised several times in the working papers in this report, the thirty companies sketch the technology and work situation of frontrunners. It is by no means a representative survey of all companies dealing with digital transformation. The studies are explorative. Despite the fact that we were looking for the frontrunners, there are a few companies in the analysis that are certainly not technological frontrunners. This concerns three companies. These companies do serve as a test for the findings of the other companies. Because the core companies of our research can certainly be seen as pioneers in Industrie 4.0, we believe that these companies indicate what many companies are now undergoing or will undergo. The same observation applies to our research material at the employee level. The worker-survey focused on employees in charge of the shop floor in the frontrunner companies. They are not managers but people who work with the various technologies and can indicate how they experience digital transformation. Again, not a representative picture for all employees but an explorative preview of what employees can expect. The results do not visualise ‘average work situations’ but sketch what the digital frontier actually entails. We see how companies and employees are innovating within Industrie 4.0.

We can then derive various conclusions from this report. In this section, we do so by answering the following five questions.

- How do companies operate within entrepreneurial ecosystems?
- What does digital transformation in these cases mean? How are companies applying Industrie 4.0 technology?
- What does 'socially negotiated' mean? How do organisations channel technology and its impacts?
- What does this mean on an employee level?
- What are the signs of the future of work?

6.2 How do companies operate within entrepreneurial ecosystems?

Applying the entrepreneurial ecosystem model with its ten elements (Stam, 2015) and comparing how regional stakeholders and companies evaluate those ten elements, an agreement was observed concerning 65% of those elements, especially regarding the (new) knowledge, physical and IT infrastructure, leadership and formal intuitions. More disagreement than agreement is on the element of finance. The overall picture is that there is quite a strong alignment between the level of the region and the level of companies.

Companies in these ecosystems seem to use four different strategies to achieve economic growth (economic company performance). They find four elements of the entrepreneurial ecosystem model important to their company strategies: the presence of *networks* (for collaboration), an *entrepreneurship culture*, availability of *talent* (on the labour market) and (new) *knowledge* as basic to innovation.

To strengthen their ecosystem, regional stakeholders should consider supporting the development of networks, an entrepreneurship culture, availability of talent, and (new) knowledge. A combination of these elements is expected to enhance chances for economic growth and inclusiveness. Since companies can follow different strategies, this requires made-to-measure support at the company level and specific policies for start-ups, SMEs, larger organisations, and emergent and incumbent ecosystems. Regions that want to improve equality, diversity and inclusiveness are advised to consider broad collaboration among institutions and companies as this requires a common effort.

6.3 What does digital transformation in these cases mean? How are companies applying Industrie 4.0 technology?

Two-thirds of the cases studied apply advanced Industrie 4.0 technologies. Four companies can even be called ‘poster companies’ for Industrie 4.0 (the TOTAL-companies). They work with the latest technology and continuously invest in it. Yet, it is striking that even in these companies, a lot of 'manual' work still needs to be done. Autonomous production and lights-out-manufacturing are a distant future for these companies (Autor et al., 2020). One of the cases applies lights-out warehousing. No worker is allowed to enter this warehouse. Technology takes care of itself in this hall. It is striking that the companies have far-reaching forms of automation, but some of these forms of automation already date from more than ten years ago. AI and Machine Learning are clearly still in the experimental phase. Insofar as there is any evidence of it, it is more likely to be in the software companies that are experimenting with it. Nineteen companies have also taken a step towards digital transformation (Dx), whereby their business model is driven by new developments such as servitisation and software technologies that 'steer the business'.

What is striking is that the companies are not investing in the technologies to automate cheap and simple work in the first place. This is the logic that Frey and Osborne (Frey & Osborne, 2017) see as

dominant. On the contrary, in the cases we examined, automation projects go hand in hand with better serving the customer. In addition, and maybe this is because we are in the Industrie 4.0 sector, it is not so much about being cheaper but delivering better quality. We see that companies in the low technology situation (the LOW-USER companies) indicate that they see more obstacles to making the technological leap. As shown in other research (Andrews et al., 2016), it is not easy for most companies to find the right path to far-reaching technologisation. The distance between low-users and high-tech companies is significant and will remain so.

Another interesting fact is that IT security, skills and internal employee resistance are major barriers to digitalisation among the frontrunners. The last two factors have to do with the employees.

6.4 What does 'socially negotiated' mean? How do organisations channel technology and its impacts?

The choice to invest is not always a simple cost-benefit consideration. The clearest example that this is not the case is the study of the impact of the COVID-19 pandemic in the cases. The companies were forced to invest head-over-heels in protective measures for their employees (sometimes with considerable reluctance) or in remote working. The latter would actually have been possible for most companies years ago. Cloud solutions and other IT infrastructure, important facilitating technologies for remote working, were in place at ninety per cent of companies. The pandemic helped break through management's resistance to letting employees work remotely. The technology was there, but management and organisations were not ready. This situation applies to more technologies: a lot is technically possible, but organisations are not all up to speed with the technology. There are many reasons for this. One of the companies was a victim of hostage software just before our research, which meant that operations had to be shut down until all software was replaced. Many cases are concerned that internal practices and habits are not in place to go fully digital. Managers themselves have limited faith in the possibilities of Industrie 4.0 technology (Leonard & Tyers, 2021). The main example that technological choices are socially negotiated is that all TOTAL companies are also high investment-high involvement companies. The companies are not only technologically advanced but have elaborate systems for recruiting, training and developing employees. We cannot derive an association or correlation from this. However, this result is in line with the Eurofound/Cedefop study ECS2019 (2020). These high road companies also appear to have invested more in digitalisation. High-tech environments make great demands on personnel. None of these TOTAL companies opts for maximum outsourcing of specialists.

On the contrary, one of the cases shows a complete reversal of a past decision to work with a buffer of flexible contracts. The upshot is that these frontrunners cannot approach technology as merely a technical issue. There are many organisational measures and views on how best to deploy people involved in the design of high-tech environments. Designing an organisation in which employees help with technology requires considerable investment in the organisational context. But we are not quite there yet.

6.5 What does this result mean at an employee level?

For this research, we used the perspective of Jasanoff and Kim (2015) on sociotechnical perspectives. Industrie 4.0, as a technological and organisational concept, is also a normative concept that guides what managers and employees should do. To date, the concept has only been informed to a limited extent by employees' opinions. In Germany, there is talk of Work 4.0 (Avogara, 2018) alongside Industry 4.0. However, both are designed so that the world of Work 4.0 only influences the technology-driven concept to a limited extent. The main result is that the frontrunner workers have a different image of what working at the digital frontier entails than that expected by management. The employees do not all have the same picture. We distinguish two perspectives: a group of employees who see more in cooperation and a group that follows a more technical perspective. Technology is not something that frightens these employees. On the contrary, they firmly believe in the possibilities of that technology. Yet only one-fifth of these frontrunner workers have much influence on technology decisions. The rest see their own influence on technology and the organisation as limited or non-existent. This is strange because precisely the employees were 'hand-picked' by our contacts as the people to listen to. Therefore, these employees do not really see Industrie 4.0 as a promising future for themselves. Here, the perspective of Industry 5.0 (Breque et al., 2021), in which human-centred work is crucial, may offer a solution. Again, when developing this perspective, care must be taken to ensure that it does not become a mere palliative. Genuine cooperation between the shop floor and management is needed to make Industrie 4.0 technology workable and successful.

6.6 What are the signs of the future of work?

Frey (2019) indicates that the omens for employees' dealings with technology are not positive. If the technology takes its course, he expects mass unemployment and further erosion of employees' future prospects. However, the company cases show that none expect large-scale employment loss. Whether this will be the case in the non-frontrunner companies, we cannot confirm with our data. An erosion of middle-level jobs is not visible in our case. Only in one of the low-user cases, digital technology was used to standardise the work and thus significantly reduce the learning time. This is not the case with the rest of the companies. On the contrary, in many ways, companies are dealing with skill shortages and investing in bringing all employees up to a higher standard.

The technology, as seen in the thirty cases, is one of steady progression, with the continuous development of new tasks and jobs. Half of the personnel in the four TOTAL companies are R&D personnel. That percentage of R&D personnel also appears to be growing steadily. This indicates how difficult it is for these companies to innovate. The cost of R&D also appears difficult to control. The situation is that companies need more and more technology, are moving more and more towards software, and therefore need to develop their staff strongly. Employees feel that they should be more involved with what is happening at work. This is not a general dissatisfaction with technology, and certainly not one that leads to a decision to put the brakes on technology innovation, as Frey (2019) fears.

On the contrary, more work needs to be done to create a perspective in which employees gain insight into their roles and autonomy. It is as Perez and Murray-Leach (2022) observed for the Luddite conflicts of the 1800s. Contrary to tradition, these Luddites were not against technology but opposed the destruction of their autonomy and future prospects. Children and women were used as the 'robots' of the time. The research among the thirty frontrunner companies and their employees confirms this perspective: employees want that autonomy and a future perspective. The difference with the 1800s is that Industrie 4.0 technology needs the employees' input to be successful. Ten years of Industrie 4.0 in the industry has not led to the expected productivity increase (Moss et al., 2020). Further productivity improvement is needed in all sectors. The input of the employees is crucial in this respect. Workplace innovation solutions are, therefore, a needed perspective.

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Annexe 2. 30 company CASES

Country code	Ecosystem	Industry	Employees (at location)	Main product / service	Year	Type in EE
BG1	IEE	ICT, software production	40	video streaming software, defence software	1998	core
BG2	EEE	Outsourcing, IT sector	875	software products and services	2004	core
BG3	EEE	Computer and IT services	1.400	IT outsourcing solutions	2005	core
BG4	IEE	Software development	77	software development, computer programming	2021	sat
BG5	IEE	Software development	30	development of software, apps, websites	2009	sat
ES1	EEE	Power engineering	5	Electronic components	2020	sat
ES2	IEE	Machine tool	8	vertical lathes	1972	core
ES3	IEE	Machine tool	250	milling and boring machines	1960	core
ES4	EEE	Mobility – IT	30	IT transport systems	2008	core
ES5	IEE	Machine tool	45	steel cutting and processing knives	2011	sat
FI1	IEE	ICT electronics	2.300	telecommunication equipment	1865	core
FI2	IEE	Wood processing	375	paper and cellulose, kraftliner production	1935	core
FI3	IEE	IT products	220	locks and access control systems	2003	core
FI4	IEE	IoT products	100	various IoT products	2012	sat
FI5	EEE	R&D in IT services	30	IT solutions	2017	core
GE1	EEE	Logistics media company	in logistics 1.500	various print media	1870	core
GE2	IEE	Steel production	12.000	steel production, material solutions, material services	1899	core
GE3	EEE	Logistics media company	17	logistics concepts, software	2015	sat
GE4	IEE	Steel processor	75	wire manufacturing	1920	sat
GE5	EEE	Logistics	14	last mile delivery, courier express parcel	2019	sat
NL1	IEE	Advanced manufacturing	14.500	machines for chip production	1984	core
NL2	EEE	Aerospace	285	aircraft maintenance	1996	core
NL3	IEE	Advanced manufacturing	2000	hardware & software, mechanical and electronic parts	1993	sat
NL4	IEE	Advanced manufacturing	850	production automation components	1953	sat
NL5	IEE	IT services	100	IT solutions	1980	sat
UK1	IEE	Automotive	500	R&D in automotive manufacturing	1980	core

UK2	EEE	Digital health	580	digital healthcare (diagnostics, analytics, services)	2000	core
UK3	EEE	Digital health	unknown as dig. network	digital healthcare tools	2016	sat
UK4	IEE	Automotive	1.300	automotive interior components	1993	sat
UK5	IEE	Digital technology / engineering	8.500	industrial digital products and software	1843	sat

Annexe 3. 30 company case study two-pagers

1.Case BG1

1.Small and Versatile

The company is part of the Bulgarian ICT incumbent ecosystem. This small company is a characteristic for many players in the ecosystem. The impact of the digital transformation on the company is important, as it is a part of the digital ICT sector. The study of Norbio Soft (the company name has been changed for anonymity). in the context of entrepreneurial ecosystems provides insight into the Entrepreneurial Ecosystem (EES) development, the digitalisation process and its impacts. It is a small but versatile company instantly implementing various digital technologies that favour it to serve its clients rapidly and qualitatively.

2.The company

Norbio was established in 1998 by Bulgarian entrepreneurs, more than 20 years ago, and is considered as one of the oldest in the EES. However, it is a relatively small company with 40 employees. It is part of ICT (software production), more concretely producing video streaming software, and software solutions for the defense industry. It provides professional software and consulting services to clients from ICT and digital media. The focus is mainly on the US market. Gradually, the company develops a thematic specialization. Its company's strategy is focused on the projects with high value-added. Pursuing its strategy to engage in high value-added projects, the company maintains a working cooperation with many other companies from the ecosystem.

Norbio's innovation strategy is to create a special R&D unit to develop all its own products, which the company presents on the market, as well as the search and implementation of new solutions that improve the efficiency of the engineering team. The focus on the development and sales of own products is part of the strategy for future development of the Company and the holding group as a whole and is closely related to the development activity.

3.Position in the entrepreneurial ecosystem

The study of Norbio Soft in the context of entrepreneurial ecosystems provides insight into the development of the EES and the digitalisation. The company is a well-known local company, one of the oldest in the ecosystem. In the context of the EES growth, companies such as Norbio have opted for thematic specialization, establishment of R&D departments and gradual upgrade in order to acquire projects with high value added. Norbio has been introducing and applying the digital transformation for its clients and itself for many years. The company management considers that all the internal processes are digitalized, and at present it is constantly trying to optimize them.

4.Digital transformation

The digital transformation affects the production system of Norbio in different ways. Norbio Soft is far ahead in its digitalisation, due to the nature of the business. The company is currently optimising the processes and tools they use.

The company employs a highly qualified staff. In the context of competition for talents, the company underlines its strategy to attract and retain people with the pleasant working environment. The company plans to gradually increase the staff, as well as to adapt the management structure, according to the needs and in connection with the development of the services offered by the subsidiary.

The company's activities are already digitalised. According to the respondents, they have to be, since it is vital for the being of the company. The remote work is not new, Norbio implements immediately new products that facilitate the development. It was one of the first companies in Bulgaria to support and introduce the idea of teleworking. The company believes that "the members of our team are extremely responsible and we unconditionally trust them to work from home when necessary". Depending on the specific commitments, workload and projects' specifics, each employee has the opportunity to work from home. Whether it is a few days a month or a completely remote work - for us the end result is important.

The company could be considered as a 'high road' employer: Norbio Soft employees are favourable to all possible benefits; the Company is obliged to provide all kind of benefits to their employees to keep them. When necessary, they use HR consulting companies as intermediates for personnel hunt – companies that offer workforce selection and negotiation. When working on an important project, the Company hires people temporarily. Every employee's contract becomes unlimited after the 6th month. Company's clients are more dependent on digitalization since they must adapt it.

2.Case BG2

1.Technology Nearshoring in Support of the Future (WisetechWide)

WisetechWide is among the leading technology companies in Bulgaria within the BPO. The logic of the company production follows the process of turning data into information by monitor market trends and evaluates client needs. The strategy of the company combines elements of low and high road development, attempting to preserve the quality of work of its employees. One of its main directions is in terms of nearshoring, outsourcing services that serve the whole company within the company in terms of outsourcing of business processes. COVID19 crisis proves to be a driver for the company's progress.

2.The company

WisetechWide is a core company from the emergent entrepreneurial ecosystem. The company is a subsidiary of one of the biggest international companies, which operates in 44 countries employing globally 17, 800 persons in 2021. One of its largest office centres is in Bulgaria. It is a technological organization in the field of automation of decision making and use of data for “smarter business” in the IT sector and outsourcing industry. Among *WisetechWide* main products and services are development of software products, analytical services, financial centre, and customer service unit. The office centre in Sofia was established in 2004. The company has benefited from regional policy support, e.g. from a measure called “Project-investor class A” and this is evaluated very positively by the management. In 2021 the company employed 875 people (51% male / 49% female). The average age of most employees is 20+, and of managers 40+. Sofia city was chosen for the Europe region for the following reasons: tax preferences; cheap labour and talent on lower price.

3.Position in the entrepreneurial ecosystem

Bulgaria has a long, rich tradition in the IT and electronics sectors (dating back to the Communist era) and is still known as the ‘Silicon Valley’ of Southeastern Europe. Bulgaria is home of 60 global ICT companies, 80 percent of which are only exporting (BASSCOM, 2021). Among the other main technology companies of the ecosystem with which the examined company is in good cooperation are VMware; SAP; Software AG; Paysafe; Visteon; Uber and Progress.

The ICT sector is the fastest growing sector in Bulgaria (growth of nearly BGN 600 million/EUR 306 million in 2019). The industry is highly export-oriented – almost 80% of revenues are generated by export. Revenues of the industry continue to outpace GDP growth and in 2019 reached 3.3%. Despite the COVID-19 crisis, forecasts are for 10% revenue growth in 2020 with a 5.5% decline in the country's GDP. In 2019 over 34,300 are employed in the industry.

The ICT sector in Bulgaria, concentrated mainly in Sofia, has been the best paying in the country for years. In 2019, the average monthly salary per employee in the industry (EUR 1.636) remains at a level over 3 times higher than the national average (EUR 642) (BASSCOM, 2021).

The examined company (*WisetechWide*) collaborates with rival companies to plead their common business interests/positions to social partners - government and business organizations. Also, *WisetechWide* organizes recruitment forums with them. It partners with various universities from a

knowledge perspective - company employees deliver lecture courses at some university programmes to share up-to-date knowledge and know-how with students. Meetings with students are also a channel to attract recruits to the company.

According to the SWOT analysis the opportunities are: the available talent, the physical infrastructure and the developed networks. The threats are the formal institutions as well as the demand purchasing power.

4.Digital transformation

The technologies that have been adopted by the company include 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, and 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. At the same time the technologies could negatively affect some of the routine jobs. For example, in 2021 a chat bot is expected to be implemented in the Bulgarian subsidiary for the needs of human resources management and for the benefit of employees, according to the respondents. However, in the company in general the process of digitisation and automation does not lead to job cuts, i.e., to hire fewer people, but on the contrary. The company introduced a strategy for dealing in the pandemic crisis. It includes the transition to working hours with flexible boundaries (implemented since a year ago, the start of the pandemic), as well as remote working possibilities (home office). The flexible working hours program is available for each occupation within the company, as well as the opportunity to work from anywhere (geographically), during the most personal productive hours for every person and thus achieve a better work-family balance.

WisetechWide provides social and health benefits (incl. home office option), as well as an internal training centre (academy) of its employees, which are highly evaluated by the staff. Concerning the management approach, the company is hiring and developing people in 'game-changer' roles; ensuring a supportive, flexible and inclusive environment that attracts talent; establishing a high-performance mind set throughout the organisation and creating employee experiences.

3.Case BG3

1.The Local Multinational Company

ITools (the company name has been changed for anonymity) is a Sofia-based subsidiary of a multinational company that provides digital transformation solutions. The services provided by ITools target the digital transformation of its clients, global companies in a variety of sectors, such as automotive, transportation, banks, manufacturing, and energy and so on. The company provides services exclusively at the global market, as the local market is too small. Its employees have both technical and language skills, as they should serve the clients in their native languages. The personnel is relatively young. The company is inclusive employer, providing multiple benefits and specific, human oriented culture. ITools internal processes have already been digitalized, but ITools functions also as an important player in the digital transformation of its clients.

2.The company

ITools is the non-core company of the BPO emerging ecosystem. ITools offers technology and digital engineering consulting, customized and outsourcing project solutions, and professional staffing services. The company serves large companies from automotive, transportation, environmental, energy, internet and communication, industrial manufacturing, software, and financial services sectors. ITools clients include some of the largest technology businesses in the world, and the company's office in Sofia is the largest service delivery centre for the company in Europe.

On a global level, ITools offers professional solutions in the areas of IT and engineering. In Bulgaria it specializes in providing a comprehensive IT outsourcing solutions in the areas of IT Service Desk and Data Centre support, network management and maintenance services, end-user device support, software application development and maintenance and BPO solutions for leading companies worldwide.

ITools employs about 1400 people in three office locations in Sofia and Plovdiv. Globally, the company employs about 30 000 persons. The company's expertise is in IT and digital engineering solutions that accelerate innovation and digital transformation Tech Consulting, Tech Talent Services and Tech Academy Solutions.

Its core business is IT-related and focuses on the digital transformation of their clients. In the post-pandemic context, ITools has gradually returning to a hybrid model of work, combining remote work and some presence in the office. The digital transformation makes possible the transition first to a remote mode of work during the pandemic and to a hybrid model after it. According to the interviewed manager of the company, the presence in the office is vital, as employees could be easily trained and able to interact, to create and train soft skills that are vital for the company.

3.Position in the entrepreneurial ecosystem

ITools has been developing in a competitive environment. It provides IT-related services to the global market. During the last years it has developed partnerships with other providers from the country in order to serve better its global clients.

ITools does not depend much on the local institutions, works closely with the local authorities, and universities. It is a member of AIBEST – branch organization of the BPO companies in Bulgaria. ITools collaborates increasingly with the other companies within the EES. Sometimes they are competitors and collaborators at same time. The role of AIBEST is important.

Talent availability is vital for the company. It recruits Bulgarian nationals but also foreign citizens in the case of specific language skills required. ITools also trains the newly recruited employees from the very beginning and creates talents internally.

4.Digital transformation

The continuous development of IoT, Big Data and Machine Learning segments, as well as robotic services stimulates ITools to invest in the development of software engineers, Java, Android and iOS developers in the company. ITools provides various processes and services, supporting the digital transformation of its clients.

The company's operations are closely dependent on digitalization. Internally, all digitalization processes are developed according to the needs of the local company, but in compliance with the requirements of the parent company, B group. ITools transferred its digital knowledge to the other branches of the parent company to improve their processes via digitalization.

ITools is a 'high road' employer. Employees have been offered a variety of benefits, as usual in the ecosystem. ITools is completely transparent from a social security point of view, as most of the BPO companies. The main bonuses that the company provide to its employees are: additional health insurance, food vouchers; entertainment and discounts: sports cards, game rooms, discounts in various retail outlets; professional development: certification courses, in-house training, and coaching/mentoring programs. In summary, the company is inclusive employer, providing multiple benefits and specific, human oriented culture. The company's internal processes have already been digitalized, but ITools functions also as an important player in the digital transformation of its clients.

4.Case BG4

1.Data Mining Worldwide

The examined company SemSoft (the name has been changed for anonymity) is one of the global niche leaders in the domain of non-relational data bases. It belongs to one of the core companies in the Sofia ICT ecosystem. The company emerged as a spinoff. Its development has been based of an own technology supported by internal R&D. The R&D development has been always the most important element of SemSoft strategy. The company has developed its own technologies and competes with global giants such as IBM or Oracle as well as with few niche companies.

The company is a major player in the domain of the digital transformation of its clients at global level, proposing AI based data mining solutions. It has an advanced level of digitalisation itself.

So far the company has been impacted positively by the digital transformation. It is growing and operating in several key markets, pushing its internationalisation.

2.The company

SemSoft is the AI development venture of Big Soft Holding (anonymised). The holding was created around BigSoft Company, one of the biggest and oldest Bulgarian private IT companies, developing a large variety of own IT products and solutions. SemSoft develops and provides various AI based data mining services based on an own technological development. It is a part of the, where its umbrella, Big Soft Holding is one of the core companies. SemSoft is a medium-size company, with some characteristics common for many players in the ecosystem, but also has some unique features, e.g. its focus on R&D. The impact of the digital transformation on the company is important, as it is a part of the digital ICT sector.

SemSoft main activity is the development of software based on the Semantic Web languages and standards, in particular RDF, OWL and SPARQL. SemSoft was established in 2000 as a R&D department in the top 3 Bulgarian Software company BigSoft. In 2008 SemSoft has spun off the mother company to become a separate company. In 2010 SemSoft registered a subsidiary in the US and successfully established a customer network comprised of leading world class organizations. In 2019 BigSoft AI, a unit of BigSoft Holding, acquired SemSoft.

SemSoft has become a global leader in enterprise knowledge graph technology and semantic database engines. Its highly coupled integration of text analytics and big knowledge are spread worldwide across the value chain of the most knowledge intensive enterprises in Financial Services, Media and Publishing, Healthcare, Life sciences, Pharma, Industry and Public sectors.

The main products of the company include SemSoft Platform – A cognitive content analytics technology supporting cognitive reading machines vision and dynamic semantic publishing application pattern and SemDB. In addition to its products, the company proposes solutions to its clients.

3.Position in the entrepreneurial ecosystem

Unlike other companies in the ecosystem, that need mainly software engineers, SemSoft employs a considerable number of data engineers and scientists and according to the respondents, these profiles are rare and difficult to find at the labour market.

The company has been developing without a specific support by the formal (state) institutions. However, it has benefitted from EU funding schemes and some national funding from the EU structural funds. The local infrastructure has been favourable for the development of the project of SemSoft, mainly the access to high quality internet and to the universities in the city.

The company works for the global demand, so the local demand is without significance.

The availability of talent has always been the strongest element, supporting the development of the company. It recruits nationally, but also internationally, attracting Bulgarians with academic achievements abroad.

4.Digital transformation

SemSoft is far ahead in its own digitalisation, but also that it is sufficiently large to control its own digital strategy. There is no need for further optimization since the company's activities are digitalized; the employees don't use any paper and use ERP tools. The company is a major player in the domain of the digital transformation of its clients at global level, proposing AI based data mining solutions. It has an advanced level of digitalisation itself. For the moment the company has been impacted positively by the digital transformation. It is growing and operating in several key markets, pushing its internationalisation.

The main solutions include Semantic Technology Consulting, Semantic Data Modelling, Text Mining and Text Analytics, Support and Maintenance and Semantic Technology Trainings. More precisely, SemSoft targets the development of solutions for: Healthcare and Life Sciences – in order to develop knowledge graph powered AI solutions quickly and easily; Financial Services – aiming to get deeper and provide interconnected understanding of the client's data and assets; Media and Publishing – to improve engagement, discoverability and personalized recommendations and the Public Sector - Unlock the potential for new intelligent public services and applications.

SemSoft is a 'high road' employer. Employees have been offered a variety of benefits, as usual in the ecosystem. There is only a limited turnover. Employees are satisfied with their job, because they are involved in a state-of-the-art technological development, combining R&D and development of business solutions for some of the world leader in a couple of sectors. Unlike other companies in the ecosystem, the employees of SemSoft are also women and older software engineers. Another specific feature is that employees do not work under pressure, as in the cases where venture capital funds seek immediate returns.

5.Case BG5

1.Small Company with a Plan

Expressoft (the name was changed due to keep the company anonymous) is relatively small, specializing in Fintech after ten years of development without particular focus. The company has emerged around a software project for educational tools. Its development has been based on several technologies, combining backend technology of financial institutions and knowledge about the development of mobile apps. Its development has been based on strategic partnership with financial institutions and the internal skilling of young employees.

For the moment, the company has been influenced positively by the digital transformation. It is growing and operating in the local market. Its development plans include further growth and specialisation in the Fintech field.

2.The company

Expressoft is a small independent software development company headquartered in Sofia. It belongs to the Sofia ICT ecosystem. It offers solutions mainly for Bulgarian corporate clients. After a period when the company's specialisation so far has not been fully clarified, during the last few years it specialises as a Fintech company. The company's team consists of 30 software and computer engineers at the time of the research (November – December 2021). The company case study is based on five interviews and documentary research.

In contrast to the situation in the ecosystem, Expressoft works mainly for Bulgarian clients. So far, it has had only a few foreign clients. Expressoft does not have any domestic competitors. The personnel is an issue as it is difficult to find high-level specialists. The remuneration proposed by Expressoft is not competitive, compared to the market expectations within the EES.

3.Position in the entrepreneurial ecosystem

This small-size company is characteristic for many players in the ecosystem, but also has some unique features, e.g. the focus on domestic clients, while most of the companies in the ecosystem work for global clients. In addition, Expressoft combines experience in both Fintech and mobile applications. The impact of the digital transformation on the company is important, as it is a part of the digital ICT sector.

The company development has been based on strategic partnership with financial institutions and the internal skilling of young employees. Its products and services include backend solutions that serve the mobile and web apps, mainly for financial companies, AI/Machine learning for management and sorting of accounting documents, websites for online education, e-commerce, or other areas that the clients of the company needed and development of applications for Android and iOS mobile devices.

The company is about to become an important player in the digitalisation of the financial institutions in Bulgaria. However, the focus on the internal market is also related to some inconveniences, as local companies are not very keen to invest in digital solutions and are often not aware about what

to expect and require. The demand for its services and solutions is mainly local, the company complains for the low digitisation level and the lack of concrete requirements of its clients.

The company has been working successfully mainly for private companies; it has some discontent in relation to the work done for the public administration. The well-developed internet infrastructure is vital for its activity.

Expressoft still has no formalized HR policy. However, within the examined ecosystem it has been pushed to develop practices that maintain employees. First of all, employees appreciate the working time flexibility. There are no strict rules about working time and leaves.

4.Digital transformation

Expressoft does not have any formal innovation strategy. It is a small company with limited capacity to invest in R&D activities. It uses already existing technologies to provide software and hardware solutions to its customers. However, the use of both Fintech software and mobile apps development could be perceived as an innovation allowing Expressoft to conquer new markets. Other innovations include the development of educational digital tools.

Expressoft has improved and digitalised its internal processes by adapting to their particular requirements an existing bug-discovering platform and using it as an ERP system. The system has decreased bureaucracy within the company and has improved the working process by adding flexibility, and easy reporting, and general rules. The communication is via chat (Google Meet), all software is coded and tested on computers or computer simulators. The company uses a special communication programme aimed at business and programmers.

It has its own office, but since the beginning of the Covid-19 pandemic, employees work from home. The wages of the employees are below the average for the sector, and this means that Expressoft cannot afford to hire high-level software specialists. The team consists of young people; the average age of the personnel is below 30 years.

The personnel of Expressoft is predominantly male and young, as it is the case in general in the ICT ecosystem of Sofia. Most of the employees are with university degree, but some are still students. The company HRM philosophy is to keep employees, both experienced and newly recruited, away from the routine work and to provide them with challenging and changing tasks. The company has invested in internal skills development especially for those recruited at intern level.

6. Case ES1

1. *Electric power: the rise of electric mobility*

The automotive sector is one of the sectors with the greatest economic impact in the Basque Country. This economic activity is composed by a large number of auxiliary companies that need to adapt to the irruption of producing new components for electric mobility. The automotive auxiliary industry in the region is made up of 300 companies with a turnover of 10,000 million euros per year, employing 40,000 people (EVE, 2018). In addition to the automotive sector, the transport and logistics sectors represent 12% of Gipuzkoa's GDP and employ 37,000 workers. There is an important issue that has to do with taking advantage of the opportunities offered by the territory. The are good conditions for the creation of new projects and initiatives. To this, the opportunity and the technological momentum must be taken into consideration as key aspects. The added value of the products and services allow the company to make a difference in the sector, as it mainly works on customised projects, which generate competitive advantages.

2. *The company*

The company is a start-up company founded in 2020 providing engineering and product development services for electric mobility solutions. In particular, it focuses on power conversion applications; the company offers customised software and hardware solutions and develops products and services applicable to motorbikes, light vehicles, heavy vehicles, off-road and maritime transport. Within the entrepreneurial ecosystem of the Basque Country two companies are strongly positioned in Gipuzkoa. On the one hand, Irizar Group, a centenary bus & coaches manufacturing company founded in 1889, which leads customized coach and buses, adapted to smart mobility solutions through Irizar E-mobility. And, on the other, CAF Group, with its subsidiary Vectia, which focuses on hybrid and electric buses since 2013, and more recently through the acquired Poland-based company Solaris.

3. *Position in the entrepreneurial ecosystem*

The company is part of the emerging ecosystem of electric, smart and sustainable mobility in the region. The company has received support from the Business Innovation Centre of Gipuzkoa, a public business incubator and accelerator. In addition to public promotion and aid, the company has the support of private venture capital and has successfully participated in several rounds of financing, allowing it to accelerate the growth of the company as well as the development of specific products for electric mobility and energy management applications. The company is currently based at MUBIL, a reference and innovation centre focused on smart mobility that is promoted by several public administrations (Government of Gipuzkoa, San Sebastian City Council and EVE - Basque Energy Agency), and which acts as a dynamic agent in the electric mobility ecosystem, promoting collaboration, specialisation and excellence. MUBIL is a strategic project within the programme led by the Government of Gipuzkoa known as "Building the Future". In this framework has to be noted thay smart mobility is framed within the regional strategy for smart specialisation (RIS3) of the regional Basque Government. Although the value chain of electric and sustainable mobility, and specifically power electronics, in which the compamy takes part, is led by technology centres, the start-up is oriented towards the application of solutions with a clear market/industry orientation.

This differentiates it from other business models and strategies, such as those used by the research centres described above. The company is looking to develop as an OEM supplier.

4. Digital transformation

Electrification has generated a transformation in the automotive sector. The company develops power inverters (devices that change or transforms a DC input voltage to an AC output voltage with the magnitude and frequency desired by the user or designer) and DC/DC converters (type of power converter that transforms DC current from one voltage level to another) for light mobility applications in GaN technology (gallium nitride chargers, considered the future of charging devices). These fields are key in battery- or hydrogen-powered electric vehicle architectures.

At company-level, the starting point of the entrepreneurial experience has to deal with the identification of new services to be provided to Original Equipment Manufacturers (OEM). The digitisation of work is mainly identified in areas related to business management. The administration of tasks, especially those related to the management of the company, is carried out through the application of ITC technologies.

7.Case ES2

1. High quality machine tooling: a total makeover

The manufacturing industry is undergoing changes driven mainly by the increasing use of artificial intelligence, robotics, the Internet of Things, and additive manufacturing, among others. According to data provided by the European Association of the Machine Tool Industries and related Manufacturing Technologies, 35% of the machines produced are manufactured in Europe. However, 80% of machine tool manufacturers in the EU are SMEs. Compared to large corporations, SMEs face more challenges in undergoing digital transformation processes.

The company employs more than 100 people, a third of whom are involved in technological development and R&D. The unique character of the company resides in the type of product it manufactures; machines with high levels of performance, productivity, precision and reliability, specialising exclusively in "vertical lathes". The company markets products for, specifically, two sectors; aeronautical/aerospace, and energy in general (with a predominance in the wind energy sector).

2. The company

The company is specialised in the design, manufacture and installation of heavy and ultra-heavy machine tools. Five partners founded it in the early 1970s. Until the end of the 1980s, the company focused on rebuilding CNC machines and then began to manufacture new machine tools. In the mid-1990s, it began to design and manufacture multi-process machines (specialising in vertical and horizontal multitasking lathes). During this phase, the company acquired a highly specialised know-how in the design and manufacture of specific machinery. It is important to mention that in the early 2000s the company went bankrupt, a capitalisation took place and one of the partners acquired 100% of the shares. In this new scenario, the company became a family- owned business. The process of internationalisation and the search for new markets began in 2006, when the company's business activity grew due to the levels of exports in international markets. In 2010, the company opened a sales office in China, and in 2017, in Germany. Currently, almost the company's entire turnover comes from international markets; Russia, Germany, China, USA, Canada and France account for most of the orders, although there are important customers in the region where it is located.

3. Position in the entrepreneurial ecosystem

The regional sector has a high concentration of manufacturing companies, ranking sixth in the world by volume. The regional ecosystem is one of the largest machine tool manufacturers in Europe. It is important to consider the exporting nature of the sector, given that 90% of the national machine tool producers are Basque factories. The importance of the machine tool sector in the ecosystem is reflected in the region's industrial policy. The regional ecosystem is in good shape, with positive workloads; however, profitability (considering turnover levels) is low. Technological value needs to increase, competing on price. The perception of the national/regional product abroad is of a product that competes on price, unlike German or Italian products, which are perceived as value-added products.

4. Digital transformation

Today, within the framework of Industry 4.0, new generation machine tools have a wide implementation of cyber-physical systems, Internet of Things, sensors, computer technologies incorporating connectivity. In relation to digital transformation, the company recognises the need to introduce advanced digital technologies; specifically technologies associated with Artificial Intelligence and its applications to machine tools. The application of this type of technology is framed in the field of machine maintenance, specifically in aspects related to the replacement of defective components in which the adoption of technology helps to carry out predictive maintenance, among other things. In this case, the combination of data generated by machine operations incorporates learning systems that allow the performance and use of the machine to be evaluated by means of algorithms. The business strategy advocates concepts such as flexibility and the ability to customise machines. Product specialisation must be understood in the context of research and development. In 2010 the company created the R&D unit for the development of new machine tool products and the improvement of machining processes. The unit accounts for 20% of the company's workforce. In 2018, the research activity is integrated in the technical office where around 30 engineers work. Faced with this reality, the company's digitalisation strategy focuses on the Systems and Applications Department. This department, made up of 4 electronic engineers and 3 applications engineers, works on product automation and digitalisation processes. In the field of Industry 4.0, the "virtual commissioning" and "total predictive maintenance" work stands out. The former allows the machine to be available virtually (even before it is completely manufactured), enabling testing and training for end users. The second allows data to be obtained on the situation of the machine in a predictive manner. However, with regard to the latter, the difficulty of the digitisation process lies in two aspects; on the one hand, in the capacity to process all the information generated by the machine, and on the other, in the aspects related to cyber-security.

8.Case ES3

1.Cooperative Machine Tooling (CMT): collaborate to deal with digitalisation

The machine tool sector is one of the significant subsectors of the industry. CMT is a leader in the design and manufacture of machine tools. Innovation is the main vector, which positions the company as a pioneer in technologies that drive the sector. The company is integrated in a cooperative industrial group of machinery manufacturing; one of the main European producers. The industrial branch has a wide multi-technology offer for high-tech sectors and customers. The group is highly internationalized with 16 production plants. It also has Centres of Excellence in strategic countries, as well as its own research center specializing in advanced manufacturing technologies.

2.The company

Located in the Basque Country (Spain), the company leads the machine tool sector in milling and boring technologies. It employs 370 workers, 250 at its main plant in the region, with an annual turnover of 82 million euros. The company is part of the incumbent regional business ecosystem; a strategic industrial sector that has been described as resilient. Around 90% of Spain's machine tools are built in the Basque Country.

Throughout its more than 50 years of history, the enterprise has been able to maintain a high competitive level in international markets, with innovation, research and development being the main driver for the production of high precision and high performance machines. The challenge for the machine tool sector (specially for SMEs) is to position in "Industry 4.0", which stems from the multiple opportunities of the increasing digitalisation of products and processes. Advanced manufacturing is part of the region's Smart Specialisation Strategy (RIS3), which includes the key lines to be developed along the value chain (materials, processes, resources and systems).

3.Position in the entrepreneurial ecosystem

The company is part of the machine tool division of a cooperative corporation; the largest business group in the Basque Country and the tenth largest in Spain. It has a turnover of 260 million euros and employs 1300 people, making it one of the leading manufacturers of machine tools and production systems in Europe.

The importance of the sector in the business ecosystem is exemplified by the existence of a strong cluster of companies, technology centres, universities and specialized vocational training centres. Although the regional ecosystem stands out for its specialization, it faces continuous technological change; openness to foreign competition, globalization and internationalization. Demand has varied over time, starting from a local market to international markets. Given the relationship of the sector with other industrial activities, the incidence of business cycles is high. The most notable aspects, in addition to networking, are anchored to elements such as financing and specialization, based on new knowledge and talent.

4. Digital transformation

In the 2018-2020 period, the business group undertook the digitization process. In this scenario, digital transformation is defined as follows:

"Digital transformation is the process of changing something completely with digital tools and describes the adoption of technology and possible cultural changes as less to improve or replace existing resources. Digital transformation is not a product or a solution to buy, it encompasses everything related to IT in all sectors".

The digital transformation affects two axes; on the one hand, to reinforce the positioning and maintain the leadership in the offer of products and services; and, on the other hand, optimization in the management of resources and the construction of the governance model. This digital transformation process incorporates, among others, the strategic management of talent and financial resources; the creation of a value office with the capacity to follow up and monitor progress; and the construction of a new digital architecture to face the challenges of the industry of the future.

Digitalisation and automation does not have a direct impact on the quantity of employment; not in quantitative terms. The new employment intake for 2021 amounts to 36 persons. The evolution is clear; in 2010 there were 189 people employed, rising to a total of 253 in 2021. As a cooperative, the company's philosophy is to increase the creation of quality jobs by making employees members.

The new generation machine tool (Industry 4.0) is characterised by a widespread implementation of digital technologies. The most observed effect of these technological innovations is the increasing demand for technological skills; however, soft skills and communication skills are expected to be of greater importance in the digital transformation.

9.Case ES4

1.Intelligent Transport Systems (ITS): small but powerful

The ITS company was founded by two entrepreneurs back in year 2008. 5 years later, it became part of one of the core business groups within the smart and sustainable mobility regional ecosystem. The "new mobility" is part of an emerging regional strategy with a high capacity for growth. The presence of business groups in the region, together with public institutional support, determines an area, which is included in the regional smart specialization strategy. Smart and sustainable mobility is a revolution and an unprecedented opportunity for the regional business ecosystem. Autonomous (driverless), cooperative (intelligent) and collaborative (shared) systems will promote radical change. Technologies such as robotics, sensors, big data or artificial vision will contribute to this, which places Intelligent Transport Systems (ITS) at the center of the new, smaert and sustainable mobility.

2.The company

The company designs and develops technological applications (ITS; Intelligent Transport Systems) for both rail and road transport. Company´s key product provides intelligent assistance systems by capturing data generated by vehicles. Expertise in artificial vision and deep-learning enables the company to offer fleet management systems, preventive and predictive maintenance and autonomous driving. In addition the company provides information for passengers and passenger-oriented multimedia management services.

Although it is an SME, the company is part of a leading group in the bus and coach sector and a reference in the electronics vehicles industry. Within the framework of Industry 4.0, supply chain digitization is the core process towards digital transformation.

3.Position in the entrepreneurial ecosystem

The company is positioned in an economic activity with increasing demand from transport operators and vehicle manufacturers. In this regard, current technology trends point to vehicles having the ability to produce data. However, the key issue is to generate information from the data collected.

There is an important regional business sector dedicated to this field in the regional ecosystem; from startups and entrepreneurs developing and commercializing their own innovative technologies, to consolidated companies. In particular, digital technology-based innovative projects driven by companies and technology centers are identified, along with a strong network of universities and vocational training centres.

4. Digital transformation

The company states the need to introduce advanced digital technologies and that in some cases it has already started to adopt them. The reasons for the adoption of these new technologies lie in aspects related to the improvement of production; or, the improvement of quality in the production process, among others.

At company level dfferent technologies such as Big Data and Internet of Things (Machine learning; Datal Analytics; Mobile Communications; and Edge Computing) are employed. In addition, other type of digital services and technologies are bought on the sell (Google or Amazon). When the technology is provided by a supplier, the company acquires the technology mainly from nearby companies. Later on, if the technology is of interest, the outsourcing is managed by a member of the team and the company adopts it. However, the relationship varies according to the company's capacity to absorb knowledge.

Since the company is used to working with the latest technologies, it can be said that the management strategy is employee-oriented. Although the company consider itself to have a hierarchical style, the high autonomy, discretion over work and the ability to learn and solve task-related problems point to a "high road strategy". However, some issues regarding the lack of skills at operational level arise, in particular due to the adoption of digital technologies.

Work autonomy is high, with task discretion over the work. The impact of new technologies does not seem to be direct, in terms of labour substitution. This is why the only changes in human resources policy seem to be associated with the search for increasingly specific profiles. According to EUROSTAT, 55% of EU companies have problems filling vacancies for ICT specialists. Problems are identified in lack of applications, lack of relevant qualifications and experience, and high salary expectations. Training of the workforce emerges as the main strategy to provide ICT-related skills upgrading.

10.Case ES5

1.Labour Machine Tooling: the employees have a strong voice

Founded in 1953, the company has a history of more than 60 years in the machine tool industry. Production is dedicated to the manufacture of industrial blades for cutting metal, wood, paper and plastic, as well as precision guides for machine tools. In 2011, faced with the imminent closure due to the lack of generational change in the ownership of the company, the enterprise reinvented itself through the participation of 30 workers in the company's capital (workers buy out). The workers took up the challenge by transforming it into a worker-owned company, i.e. a legal scheme in which the workers are partners and owners, known as “Labour Companies” (Sociedades Laborales in Spanish). A clear example of resilience and business transformation; in this case, at the hands of the workers themselves.

2.The company

The differentiating aspect of the company is the feeling of belonging. In the company's strategic thinking, this is referred to as a "shared project". Employee participation creates stability. Small working groups are organised in which different departments come together. Improvement projects (depending on the size) are led by one or two people. It is a classic research and development model but highly participatory. This helps to reduce resistance. Improvement or change projects involve all stakeholders from the beginning. Early participation helps to deal with typical resistance.

One aspect to be highlighted in the transformation process concerns decision-making. In other words, when purchasing a machine, the opinion of the operators is also taken into account, as they are the ones who will be using the machine. By section, monthly meetings are held to share financial data. Weekly meetings are held to organise the work. The company informs about economic aspects twice a week (by means of newsletters).

3.Position in the entrepreneurial ecosystem

In terms of the ecosystem, both formal institutions and intermediary services are very important elements for business. The presence of actors such as ASLE (association for the promotion of worker-owned companies, i.e. those in which the capital is held by the workers) is a driving force. Proximity to and collaboration with vocational training centres is another important aspect: market volatility is high, and mobility to larger companies in the sector is a threat. This is why the company has an active policy for the integration of workers as partners of the company. In addition, despite the small size, the leadership is clear, which underlines the ability to cooperate in networks and to lead projects.

4.Digital transformation

The pace of digitalisation at company level is slow. The company recognise the need to face this process but requires more knowledge on how to adopt and adapt the required technology. Regarding skills and development it is worth mentioning that the company has a competence matrix. This matrix is individual; each level has a salary and competence level. It is carried out every

two or three years for each employee. This matrix assesses three areas (first is productive; second is managerial; and the third area is attitudinal). The increase in competences is carried out in an agreed manner.

11.Case FI1

1.The giant is still standing there

Shutting down the mobile sector did not cease FI1's activities in Oulu. The company continued in Oulu concentrating on planning, developing, and producing network and base station devices and services that are currently an important part in FI1's worldwide production. Currently, FI1Solutions and Networks still employs over about 2,500 people and it is still one of the most important employers in Oulu. FI1 has its own global ecosystem that is partially in Oulu.

2.The company

FI1 is a Finnish multinational telecommunications, information technology, and consumer electronics company, founded in 1865. FI1's main headquarters are in Espoo, in the greater Helsinki metropolitan area. In 2021, FI1 had 100,000 employees in different parts of the globe. The number of FI1 employees in Finland is 6,000 and out of them 2,300 are working in Oulu.

The FI1 production has a long history in Oulu. In 1960, the FI1-owned company Pohjolan Kaapeli (Nordic Cable) was established in Oulu. In addition to the cable business, FI1 initially concentrated on production of radio technology. In 1975, the company decided to locate its network operations in Oulu and begin manufacturing radiotelephone base stations. The company had expertise in both mobile phones and base stations. After the collapse of FI1 Phones, the company continued its activities and specialised on telecommunication (telecoms equipment or communications equipment). During 2018-2020, FI1 hired around 1,200 new permanent employees in Finland and in 2021 has hired an additional 500 employees. The vast majority of these new positions are in R&D. Oulu is considered as the key R&D site for FI1. In January 2021 the company announced that it will build a new campus in Oulu. The campus will be completed during 2025 and it is expected to enable FI1's innovation and development at the forefront of 5G and 6G technologies. Thus, the giant still is in Oulu and seems to firmly stand on its technological feet in its new premises.

3.Position in the entrepreneurial ecosystem

FI1 is an ecosystem! As a global company, its ecosystem is mainly outside Oulu, in fact, it is everywhere in the world. The Oulu FI1 factory designs and manufactures various products – infra, equipment, services – for telecommunication processes. The products comprise a wide variety of articles, such as base stations, future 5G (and 6G) products, autonomous intelligent (AI) vehicles, AI-driven air interface design, etc. But FI1 is an essential part of the ICT ecosystem in Oulu. The new FI1 campus is in between the University campus (housing the University, University hospital and University of Applied sciences) and Technology Village housing most of the SME high tech companies in Oulu. Thus, the giant and smaller actors will be more closely located also geographically. The University, FI1, Ericsson and a number of local SMS enterprises are participating in the 6G Flag-ship research funded by the Academy of Finland.

Accessible markets are mostly global. Funding is not a problem for a company like FI1. Collaboration with the university is important partly in research and development (however, as a rule, almost all the R&D activities take place within the company) and partly due to access to skilled-labour force. The company is complying national, EU and international legislations.

The city of Oulu is sees the value of the company for the municipality. Therefore, the municipality is willing to carefully listen to FI1's wishes as exemplified by the promise to build a new road systems for the FI1 campus. (The road systems will be completed during the summer of 2022.)

4. Digital transformation

Digital transformation is the core of the company. This applies both the R&D and manufacturing for example base stations. Manufacturing in the company is highly digitalised and based on robots.

FI1 follows the high-road. The educational background that is required is mostly related to engineering, diplomas achieved either at universities or universities of applied sciences. 95% of FI1 Oulu staff have lower or higher university degrees. The company does not have a explicit inclusivity programme for people with physical disabilities. In its strategy, FI1 puts it other way round: If a person has the proper qualifications and skills, adaptation of working hours or working environment is not a problem. The company also houses university students do their internship in the company and write their theses on some question that is topical for the company. Oftentimes such students then say in FI1. New employees with basic engineering knowledge will get their further training for more difficult and more specialised tasks. Every employee has his or her own path and pace in their career, and their personal skills and enthusiasm plays a role in how the path develops in the company. There is an imbalance between genders. Only one fifth of the professionals are women. A urgent problem is to find employees in Oulu, where all the skilled professionals are hired quickly. FI1 has vacancies open all the time. The company tries to be as visible and as attractive as possible for the youngsters and representatives of the company are doing lots of school and university visits to tell about the technology industry in general and about FI1 in particular.

12.Case FI2

1.The wooden leg of Oulu

Finnish national economy is small, open and highly export oriented. Traditionally, the Finnish national economy has been one-sided and mostly based on wood. Not until the 1980, the value of export of metal and engineering industry exceed the value of forest products. The economic ecosystem generated by the wood processing industry in Oulu covers entire Northern Ostrobothnia (NUT-3 area) and beyond. The forest industry is going through a rapid transformation. There is a transition towards a sustainable circular bio-economy and a move away from fossil-based materials. Companies in the forest industry are researching and developing renewable materials. The company is an excellent example how an incumbent, old and well-established ecosystem is adapting its production to correspond changes in the surrounding world and ways of seeing the world. The company also is an example of intelligent manufacturing and digitalised information systems in the wood procurement process that is highly digitalised.

2.The company

The company was originally established in Oulu in 1935 to produce cellulose and paper. The focus of the forest industry gradually switched from sawmilling to paper and board production which, in turn, led to an increase in the use of pulpwood. In the 2010s the company has invested in the production of cardboard and other packaging materials in Oulu. The change from paper to kraftliner production had several repercussions. It is said that in the transformation of the production line, Oulu lost and the province won. Regarding Oulu, the company reduced its staff by 350 employees (to 400 employees) working in the Oulu plant. Regarding the province, kraftliner production needs more raw material (wood), and therefore, the transformation has significant spill-over effects on the regional economy in terms of selling, harvesting, and transporting wood. This process benefits forest owners, forest machine owners, and transportation companies. The example shows that the decisions made (whatever they are) in the core of the incumbent ecosystem have spill-over effects on its surroundings and may generate new economic activities and new ecosystems. The spill-over effects are economic and they change the economic ecosystem around the core company / companies.

3.Position in the entrepreneurial ecosystem

The company plays the major role in the wood processing ecosystem in Northern Ostrobothnia and also world-wide. The company itself is a global actor and in its production is its more or less self-sufficient. The company is a global actor, and therefore, it is not as dependent on the local circumstances as smaller, emergent companies that oftentimes have problems in establishing themselves in the markets and obtaining the funding needed for the expansion of activities.

As regard the wood procurement process (buying wood from the forest owners, harvesting and transporting) there are several sub-contractors involved. The company has an important role for the whole Northern Finland. The company needs sub-contractors in harvesting and logistics. Thus, the spill-over effects of the core company in the Ostrobothnia are wide-spread. There are smaller

sub-contractor companies taking care of harvesting wood, transporting the raw material to the factory and further to the world market. The company has its own port and stevedoring services.

Accessible markets are world-wide. The company operates globally. The company is expanding its products from traditional paper production to new areas (biomaterials, medical applications of wood-based materials, green technology etc.). Research and development are highly dependent on collaboration with universities and technological research centres. For a global actor, funding is not a problem. As regard the Oulu, the fate of the site is dependent on the headquarters' decisions as the closure of the factory (with 700 employees) 100 km to the North from Oulu exemplifies. World markets are volatile and company's decisions on different production sites depend on the demand of the company's production in world markets.

The company is a global actor, and therefore, it is not as dependent on the local circumstances as smaller, emergent enterprises that oftentimes have problems in establishing themselves in the markets and obtaining the funding needed for the expansion of activities. Smaller companies are also more dependent on local infrastructure, municipal decisions, and support provided by BusinessOulu, local polytechnics, and the university. In a way, Oulu is more dependent on the company than the company is on Oulu. A global actor has its own global networks and it is not necessarily deeply involved in the local business ecosystems formed by other enterprises. Although some local ICT enterprises provide ICT / digital services to the company, there is not much collaboration with them. The company is more or less self-sufficient in this respect.

4.Digital transformation

The wood processing in the paper mill is highly digitalized and the whole process represents intelligent manufacturing. The impact of the digitalized work processes is directly mirrored in the number of people working in wood industry. In the 1970s, there were about 65,000 employees in paper industry, By now, the number is down to 13,000. Salaries for the paper mill workers are rather good (€5,000 to €6,000 per month). The production strategies of the company have changed partly due to digitalisation partly for other reasons. The digitalization of newspapers has diminished the demand of paper and internet-based shopping has increased the demand of backing material. Therefore, the company has reduced its paper output and instead, invested in cardboard production as it did in Oulu. Recently, the company's production has expanded from pulp, paper, packaging, and wood to the 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, and granules, i.e. wood-fibre bio-composite. There also is promising research going on in bio-medical and medical sciences, for example how to utilise cellulose in producing artificial veins and intestines.

13.Case FI3

1.From steel to digi – clever access control systems

In the Oulu region, there is a longer tradition of enterprises producing mechanical high-tech devices. One of them is the 1977 founded Polar Electro company that manufactures sports watches and training computers and wireless heart rate monitors. There are several examples of similar companies (e.g., Oura producing OuraRing collecting information on daily activities or QuietOn producing the smallest anti-noise ear-plugs). The company in question produces digitalised access control systems that will replace traditional locking systems. Keys and locks made of steel will be replace with digitalised keys and systems. In the beginning, there were 2 to 5 persons working in a garage testing their ideas and producing prototypes.

2. The company

The company was established in 2003 and the first product was ready 2007. The company produces locking and access systems with mobile and digital solutions for access sharing and management. The company has rapidly grown and it is operating in eight different countries. The company has has about 200 employees, most of them are in Oulu.

The initial ideal of the company was linked to issue how to bring the traditionally mechanical locking systems (a key and a lock) to the digital age. How to develop a digital locks that could be managed without batteries. This initial idea was further developed in the cooperation between the fledgling company and the university. The result of this cooperation was a system where the lock cylinder contains a generator and a small computer. The power needed to open the lock is generated by the motion of inserting the key into the lock cylinder. No batteries are needed. Both the lock cylinder and the key are programmable to admit access and the administrator can control up-to-date information on the keys, locks, access rights. All access events are stored in the cloud for future utilisation (if needed).

3.Position in the entrepreneurial ecosystem

The company belongs to the high-tech R&D and manufacturing ecosystem that partially is an incumbent but also emerging and expanding ecosystem of SMEs in the Oulu region. The company benefits from the co-operation and researching activities between the university, the Technical Research Centre of Finland (VTT) and other high-tech companies in Oulu. Also the role of BusinessOulu in enhancing the collaboration of SMEs and bringing different actors together and facilitating the formation of the economic ecosystem is crucial. The Oulu site of the company is specialised in research, planning and development. In product development, majority of the employees are from the local universities, only a few of them have studied somewhere else. Thus the role of the university and technical university is essential for the company. The outspoken strategy of the company is to keep all the product development in one place, and also have all possible partners around the corner.

The company has about 30 sub-contractors producing both the soft- and the hardware. The company applies two different ways to sub-contracting: 1) There are subcontractors that work in the company's projects under the supervision and management of the company in the same way

as company's own employees. 2) There are sub-contractors work in their own facilities and the company buys the end-result. Thus, in production and in logistics in particular, the company uses hired labour which is regarded to bring flexibility in quickly changing situations. The company also carries out small-scale prototype production in Oulu, but the major focus in Oulu is on research and product development. The subcontractors in Malaysia and Romania do the actual manufacturing of the hard-ware (sub-contractors in the 2nd category).

4.Digital transformation

Digital transformation is the core of the company. The whole idea of the company is based on R&D how to replace keys and steel in locking systems by digitalised systems that use kinetic energy instead of batteries. The company is following the high-road case in Oulu, whereas it may be the low-road followed in the sub-contracting countries.

As regard human capital the educational level varies. Most of the planning and development personnel are engineers with tertiary level / university level education. New systems are being introduced at an accelerating pace and therefore the importance of digital skills has grown significantly. Data big analytics and programming is a requirement in the R&D tasks. The company is rather male dominated (about 80% of Oulu personnel are males).

As regard the facilitating factors that have helped to company to expand the role of the university and technical university is crucial. They provide educated and skilled workforce. In Oulu, the competition of skilled personnel is quite harsh, of software developers in particular. The company has not that much suffered from the situation. As an employer, it seems to have a good reputation and people want to work there. In the beginning and expansion the role of BusinessOulu was important by bringing all the relevant actors together.

Accessible markets are both in Finland and outside Finland. Domestic demand is important. in the beginning of the company but enlargement takes place in the global market. The company complies national regulations and tax policies. The municipality of Oulu is very flexible and supportive for the evolvement of new innovative enterprises. The entrepreneurial 'Spirit of Oulu' is an important factor in the emergence and functioning of the ecosystem. The slogan of the company could be "From a garage in Oulu to world markets".

14.Case FI4

1.An IoT company from the ashes of Nokia

When Nokia Phones closed its activities in Oulu, a group of fired engineers gathered around a glass (or two) of beer. As Ostrobothnians, they had a realistic view on their situation: Nobody will come from the South to save us. Therefore, lets save ourselves! They had expertise, they had visions. A new company was born in that evening at that beer table.

2.The company

The company was founded in September 2012, the company started out as a start-up of five people, a group of experts from Nokia's top product development team. Currently, the company employs about 100 persons in Oulu. Most of them are engineers, either with lower or higher tertiary educational attainments. The company started as a product development and design and later, the company has specialised on various IoT products and it delivers appliance and system designs to start-up companies worldwide. The company offers hardware and software solutions and planning for buildings, such as public and private offices, hospitals, and even private homes. The company has its own IoT platform, which makes it possible to implement easy connections for smaller and bigger uses, from a toilet towel dispenser to a hospital IoT system.

3.Position in the entrepreneurial ecosystem

The company is a part of the incumbent ICT high-tech ecosystem that has its roots in the knowledge and skill inheritance from Nokia Phones. Simultaneously the company represents emerging innovative high-tech enterprises that form their own emergent ecosystem with intertwined activities and production. The company was, among other things, involved in planning the Oura health ring, the QuietOn earplugs and it also is a part of the emerging Oulu digital health ecosystem.

Oulu is hub of reals estate management enterprises. The company is also involved in property technology (prop-tech) real estate technology, providing applications information systems to real estate markets to help customers rent, sell, buy, build, and manage real estate.

The company delivers to the ecosystem know how in IoT system planning and development of equipment for the digitalisation of work. The development and most of the manufacturing are carried out in the Oulu region. The company uses subcontractors to manufacture high-tech appliances for many other companies, mainly for foreign enterprises. In the Oulu area, and in the ecosystem of 'Nokia hairs', there is a solid co-operation network, which gives resources to scale, even internationally.

Accessible markets are both local and increasingly abroad. About 70% of the company's production goes abroad.

When the company started it, was rather easy to get skilled labour force but since that recruiting has turned out to be more difficult. Most of the employees are experienced, although the company hires younger people to learn, specialise, and bring in fresh information and new ideas. The base education takes place at the university, but the profession is learned at work. Situations and job descriptions can change throughout the years, so the most important prerequisite is the ability and

enthusiasm and ability to learn new things. The university is important and in the long run it is the base for the whole wellbeing and technological ecosystem in Oulu. Thus, for the company, the university is both the catalyst of ideas and source of skilled labour.

4.Digital transformation

The company is expanding and its strategy aims to be innovative and produce completely new things. The company applies-high road approach. In its strategy is tries to support learning by doing to facilitate the employee's skill formation. When comparing production, tasks and skill requirements, they are different in a SMS enterprises at the company or in a giant like Nokia Phones was. The strategy of the company is that manufacturing only digital appliances will take the company and business nowhere. The company need to have broader solutions and complete service chains to succeed. Therefore, compared with Nokia, the actual job description in the company concentrates more on a holistic picture. Whereas Nokia had a lot of highly specialised people on some specific tasks, employees in the company are less specialised and they should rapidly learn the new skills needed in rapidly changing digital environment.

15.Case FI5

1.Fledgling high-tech in Salo

The preconditions for the Schumpeterian creative destruction were highly different in Oulu and Salo. Although there was planning and development of Nokia mobile phones in Salo as well, Salo was used more as a site for assembly lines and manufacturing than research and genuine product development. Salo's economic ecosystems were more dependent on Nokia than Oulu's ecosystems. Salo lacked the tradition of medium-sized high-tech enterprises that Oulu had along with Nokia's imperium. Furthermore, Oulu had University that was specialised in high-tech research and education. These factors had important repercussions for later development of digital ecosystems in Salo and Oulu. In Oulu, there was a surge of high-tech SMEs and emergence of digital ecosystems, whereas in Salo, only a handful of small IoT enterprises were developed. Instead, manufacturing

2.The company

The company is a Salo-based research and design company with a team of about 30 employees – who are also co-owners – with experience with embedded software, mobile and web apps, cloud services, design, and preparing and testing prototypes. The company was established in 2017. It produces it services in the geographic triangle Turku-Tampere-Helsinki. Thus, its clients are in Southern Finland. For the company, the developing ICT ecosystem in Salo is based on the know-how Nokia Phones left behind. All the founders of the company have Nokia background and they knew each other for their Nokia time.

3. Position in the entrepreneurial ecosystem

The company is a part of an ICT ecosystem in Salo (and partially in Turku, too. They have an another office in Turku). The ecosystem consists of SMEs specialised on different things. This differentiation and specialisation means that the company does not need to produce everything by itself but it can use sub-contractors. The companies complete each other in different ways. Companies and persons employed in those companies know each other (usually from the Nokia time), so there is an atmosphere of trust, and with smaller cases, a phone call without an official contract can be enough. There are two companies in the Turku-Tampere-Helsinki triangle that specialise in mechanics that the company uses, whereas the company focuses on planning and delivering software. They cooperate and buy services from each other.

The company operates in domestic markets, mainly in the Southern part of the country. As such funding & finance is not directly an issue for the company. But indirectly it is an issue. Many smaller enterprises have problems is buying and paying for the services the company produces. Companies comply with national regulations and tax policies. The municipality of Salo has been active in enhancing new enterprises. The municipality is the co-owner of the Salo IoT Campus, and it provides locations and basic services for enterprises establishing their activities in the Campus. The problem in Salo is that there is no university, and the local University of Applied Sciences (polytechnics) is more specialised in social and health care education than on technology. Changes in the curriculum are underway and the newly established university level engineer education in Turku helps the situation. When the Valmet Automotive is expanding in Salo, the company as well the ICT ecosystem

may grow in Salo, too. Salo is rising on its feet again, but in contrast to Oulu it is more manufacturing than digital based industry that will be blossoming in Salo.

4.Digital transformation

Digital transformation is the core of the company. The company is specialised on IoT and digitalisation is sufficient and necessary condition for the company. The company follows the high-road way. A telling example is that all the employees are co-owners of the company. The company could recruit directly from the technical universities / universities but it does not do that. As small company, the employee to be recruited must have a wide bundle of skills. Often the target group of the recruiting process are the experts that the people in the company known to be good enough for the purposes. It is not enough that the employed person has excellent digital / technical skills, but the person must also have social skills and ability to promote and sell the products and services the company offers. Thus, many-sided skills are demanded and technical skills are not sufficient.

16.Case GE1

1.The anchor company of the logistics ecosystem: A digital frontrunner

In a way, the logistics anchor company is an example of how the increased use of digital technologies can lead to business models becoming obsolete. The company is undergoing a digital transformation process, in two respects: On the one hand, the core product is no longer selling as well as it used to due to the influence of digitalisation, so the offer is being changed into more digital business models. On the other hand, digital technologies in the area of logistics, especially with regard to data evaluation and data sovereignty, play a decisive role for the company and have clearly found their way into the corporate philosophy. In this sense, the company is setting new digital standards in the region in the field of media logistics, especially with regard to the use of data.

2.The company

After all, the anchor company is not a classic logistics company, but primarily active in the field of media. Accordingly, the company's mission is to supply the regional media market in the city of Dortmund at all levels - from daily newspapers, advertising journals, magazines and radio stations to digital services of all kinds. Although logistics has always played an important role for the company in the delivery of print media, new logistics business models are now also being realised, also through the use of digital technologies. Therefore, companies like the anchor company are sometimes also referred to as media logistics providers.

As a subsidiary of the anchor company, the company's logistics area which in the past was officially referred to as press distribution, is responsible for all transports concerning the company. The entire print edition and print circulation of the company is delivered through this division. A total of 1400 people are employed here - so the total number of employees in the logistics and delivery division exceeds the number of employees in the (media) company itself, which is about 1000, whereby administrative areas and the company's printing plants are considered. The company has a tradition of over 100 years, especially in the city of Dortmund, and is very well networked and well-known in the ecosystem.

3. Position in the entrepreneurial ecosystem

Due to the company's long history and its publishing activities, which include the development of various print media, the company has a high profile, especially in the city of Dortmund and in the surrounding area (being part of the administrative district of Arnsberg). Especially the daily newspaper developed by the publishing house with its high circulation has been one of the leading newspapers in the region since the 1970s and enjoys great popularity.

As part of a digitally ambitious company, the IT experts interviewed criticised the inadequate digital infrastructure of the ecosystem, which makes future projects difficult in some cases – the experts thereby refer, for example, to the lack of fibre-optic connections. However, these are not so much region-specific problems, but rather conditions that are criticised throughout Germany. In the case of the anchor company, insufficient digital infrastructure may also have a negative impact on the possibilities for evaluating large amounts of data, which is a central part of the company's digitisation strategy. With regard to the use of its own logistics structures, the company ultimately

operates in a new field and tries to work out new business models in order to utilise the existing structures. Cooperation with other companies in the ecosystem also plays a role in this regard. The idea is to use the anchor company's logistics structures to deliver other products and print media. This adds another area to the company's already extremely solid position in the ecosystem.

4.Digital transformation

The digital transformation plays a crucial role for the anchor company: on the one hand, the advance of digital offerings has an impact on the company's core business, print products such as daily newspapers. The latter are no longer purchased to the same extent, as apps and smartphones often take the place of traditional offerings here. In this respect, the company is undergoing a transformation of its business models, digitising many of the existing models for readers and customers. With regard to the development of new business models, digital technologies and digital opportunities, mainly with regard to data evaluation and data sovereignty, are used to optimise products and services for the customers of the distribution area. Logistics also plays a decisive role in this, as the aim is to provide readers and customers with new products, for example from the print sector, on a daily basis. At the same time, digitalisation is used to improve internal processes and to make the work of the various departments more effective and efficient.

The company, and thus especially the management, seems to be characterised by an enormous openness with regard to digital technologies. Accordingly, digitalisation is firmly anchored in the corporate philosophy. Digital topics are thus approached proactively. At the same time, there is an open exchange between employees, department heads and the management in order to continue to promote innovative ideas. Especially in the area of logistics, existing structures are to be used to enable new business models. Through years of experience in newspaper delivery, the company has developed a detailed picture of the delivery area that goes far beyond the accuracy of established mapping systems. Digital geo-information systems were also used and further developed in the development of these precise geographical descriptions. The resulting precise logistical data represents an important resource in the realisation of new business models and for the cooperation with other enterprises.

17.Case GE2

1.A major steel company and its digitisation efforts

This case describes a company that is considered the flagship of the German steel industry. As such, the company is also a frontrunner with regard to the digital transformation, while the digitalisation is deeply embedded in the corporate strategy. It is evident here that it is above all gains in effectiveness and efficiency that make investments in digital technologies worthwhile for the company. The case study was able to take a closer look at the strategy, but also at the effects of such a technological transformation, for example on employees.

2. The company

The company can be regarded as one of the world's leading manufacturers of flat steel and employs around 27 000 people altogether, with around 12 000 employees at the Duisburg location. With a production volume of approximately 11 million tonnes of crude steel annually, the company is the largest flat steel producer in Germany. The company comprises numerous plants within Germany and other countries. At the same time, the company also has various subsidiaries, including logistics service providers or, for example, subsidiaries that produce packaging steel for the construction industry. The anchor company is considered a multi-layered company, which, despite its classification in the rather conservative metal sector, is characterised by great innovative strength and progressiveness in many areas. For various reasons, the last decades have been marked by a strong decline in jobs in the steel sector and at the anchor company – a trend that seems to be continuing for the time being. However, this is not only due to crises related to the steel sector, but also to enormous productivity increases and automation potentials, which have already been harnessed in the course of the third industrial revolution. Nevertheless, the company is still characterised by a low fluctuation rate and thus a high retention rate of employees. At the same time, good salaries and good social security for employees are prevalent in the company. As a major transformation topic, digitalisation offers further potential for the company to increase productivity, optimise processes and make decisions more efficiently and effectively.

3. Position in the entrepreneurial ecosystem

When attempting to describe the company's position in the ecosystem, the regional importance of the steel manufacturer, especially with regard to the city of Duisburg, should be emphasised. In addition to the long tradition and the decisive role the company has played in the formation of Germany's largest conurbation, the Ruhr region, the company is still the largest employer in the city of Duisburg, and at the same time, the steel industry is the city's strongest sector in terms of employees. Also due to the presence of the steel anchor company, Duisburg can be considered one of the largest steel locations in Europe, while the anchor company is considered the flagship of the region. A crucial point for the regional steel ecosystem is the element of networks: Thereby, it is worth mentioning the anchor company's involvement in various networks, as well as cooperation and partnerships, which also illustrate the importance of the company in the steel ecosystem. The company also supports many educational and social projects at its locations and thus contributes to positive developments. Especially regarding digitalisation and highly specialised technology and

IT systems, the anchor company partly also relies on cooperation and partnerships with research institutes and innovative start-ups.

4.Digital transformation

Generally, the majority of digitisation efforts in the company are based on the collection of data, the networking of data, the harmonisation of processes and the goal of digitising processes end-to-end on integrated platforms. Most of the digital technologies implemented in the company are aimed at optimising internal company processes, as digitalisation can contribute to simplifying and speeding up processes in various areas. The SAP system, for example, in which data can be fed, is helpful for this. Internet of Things platforms and, in some cases, artificial intelligence are also part of the anchor company's digital toolbox. The company's development and application of digital technologies is primarily oriented towards existing challenges. Accordingly, the main focus is on developing solutions that optimise processes and thus make certain areas of the company more efficient and effective. The digital transformation is making itself felt in the company in many ways, also for the employees. Ultimately, new roles and job profiles are emerging, but above all individual activities and tasks are changing.

Summed up, digitalisation is an important means of enabling future competitiveness and efficiency gains for the company. Despite the product steel being a physical, analogue one, the digital transformation plays a role in many areas of the company. From the automation of production facilities, to sensor technology, which in turn is used to obtain data, to logistics processes, to the digitalisation of administration and other company areas with the help of SAP or the Internet of Things.

18.Case GE3

1.A Prime example for a modern, digital enterprise

In the case of the presented company, digitalisation does not stand as a transformation topic, but has been deeply anchored in the young company's philosophy and business model since its founding. The company serves as a prime example for the interface between IT and logistics, which is particularly characteristic of the logistics ecosystem in Dortmund - not least because of the high importance of logistics research in the region. Accordingly, there are fewer profound processes of change for the employees as is the case with established, long-standing companies. Nevertheless, new challenges arise for the company, which are primarily related to finding the right, digitally capable skilled workers - especially in the technology development area.

2.The company

The case revolves around a young company that was founded in the mid-2010s in the administrative district of Dortmund, with under 20 employees. Broadly summarised, the company's focus is on the development of innovative solutions for last-mile logistics and thus inner-city delivery. Thereby, the core product of the company is an app that enables private customers, in this case also referred to as recipients, to collect their own ordered parcels (which were ordered by different stores and providers) in bundles or have them delivered all at once. At the same time, services, for example in the form of software development, are also offered for logistics service providers. In line with the business models, digital technologies and the development of digital solutions have played a major role since the company was founded. The company emerged from a research project of one of the leading research institutes of the Dortmund logistics ecosystem. Consequently, the company symbolically embodies the synergy of IT and logistics and, through a modern and innovative corporate philosophy, also qualities that are characteristic for the research landscape in the emerging logistics ecosystem in the Arnsberg administrative district.

3. Position in the entrepreneurial ecosystem

The company was founded in the logistics ecosystem and has its headquarters in Dortmund. In line with its business models, the company represents an important partner for established and emerging logistics service providers and focuses primarily on innovative solutions for the last mile. The company also maintains close relations to the ecosystem’s research institutes. Above that, there are close ties between the company and Dortmund University as well as other universities in the region, with TU Dortmund University in particular having a focus on logistics research. Contact to universities play an important role for the company with regard to recruitment. At the same time, the company cooperates with regional CEP service providers in the form of classic transport companies. Moreover, subcontractors of larger CEP service providers can realise their own business models through cooperation with the company. The company also enables regional start-ups that focus on sustainable delivery, for example with cargo bikes. Challenges arise especially in the area of talent recruitment in the ecosystem, particularly in the area of IT development.

4.Digital transformation

The company is not undergoing a digital transformation in the classic sense, as digital technologies are firmly anchored in the business model, while digitisation permeates all areas of the company. The business model of the company itself ultimately only comes about through the influence of the flourishing internet trade - with shippers in the form of online shops on the one hand, deliverers in the form of CEP service providers and subcontractors for the last mile on the other, and also recipients in the form of private customers who have ordered products on the internet. At the same time, the company supports other companies from the logistics sector in the development of software, while all of the company's administrative processes seem to be digitalised. Accordingly, with digitalisation being a core topic of the company from its beginning, one can speak less of a transformation process with regard to digitalisation. Deep in the corporate structure is a mindset of willingness to change. Since the topic of digitalisation does not occur as a change process in the young company, but is an integral part of the business model and the corporate philosophy, there are no cases of established employees who now have to acquire new digital skills - which is not least due to the short time in which the company has existed. On the contrary, the topic of digitalisation and, above all, the skills associated with it, are already extremely important factors in the recruitment process. This is not just about administrative staff, for example, who need the corresponding digital skills. Since the company can also be understood as a software company, technological developments and thus also the corresponding IT staff to get these developments off the ground take centre stage.

19.Case GE4

1.Integrating the SME perspective

The company presented in this case in particular succeeds in conveying a realistic picture of the actual use of digitisation and technology in a small and medium-sized enterprise in the steel sector. It shows that the incentives for investing in digitalisation technologies and the development of a digitalisation strategy are subject to completely different logics than is the case in large corporations in the steel ecosystem. At the same time, resources are more limited, not only financially but also in terms of research. This results in a new perspective with regard to challenges in the course of the digital transformation. Furthermore, the company case study shows in considerable detail the new demands on factory workers in the industry.

2. The company

The case is about a company that specialises in the production of wire. It can therefore be assigned to the first processing stage of the product steel. The company can be classified as a German medium-sized enterprise and is family- and owner-managed. It employs under 100 people and was founded over 100 years ago in the Rhein/Ruhr area.

As a steel processor, the company is not only part of the steel ecosystem of the administrative district of Düsseldorf, but as a customer it is also directly affected by the price developments of the large steel groups in the ecosystem. Above all, the analysis of the company provides an important function for a better understanding of Industry 4.0 in SMEs. The company is not a pioneer in terms of digital technologies, yet, the company case study provides exemplary qualitative insights into digitisation processes and strategies of small and medium-sized enterprises in the incumbent ecosystem steel.

3.Position in the entrepreneurial ecosystem

The company not only has its headquarters in the steel ecosystem of Düsseldorf's administrative district, but also sources its steel from steelworks in the region. At the same time, as a steel processor, the company supplies steel companies and subsidiaries in the region and beyond, as well as supranational. Developments in the regional and national steel industry are of great importance to the company, as price fluctuations of the product steel ultimately affect the company, with the purchase of materials making up an important share of its costs in the production process.

The infrastructure of the Rhein/Ruhr area is also an important locational advantage for the company. In particular, the function as a logistics location and the trimodal shipping possibilities of the region are used to the full extent by the company. At the same time, the network structures of the ecosystem are also of enormous importance for the company, for example in the form of the steel associations of the ecosystem. This involves agreements with regard to products and standardisation, in which producers, processors and customers consult with each other at association meetings. Furthermore, the company also competes with steel manufacturers and steel processors in the region for skilled workers and trainees.

4.Digital transformation

The company can be considered a digital novice. Yet, there are various company processes and other areas, for example in sales and logistics, that have potential for digitalisation, some of which are already being implemented and used in the company. It can be stated that the driver of the vast majority of the company's digitisation efforts is the customer. One of the company's goals is to standardise and break down processes and procedures to such an extent that they can be translated into digital workflows. In the process, the worker should also be enabled to map processes that were previously understood as typical office skills. All findings considered, digitalisation does not seem to be an integral part of the corporate philosophy and does not play a direct role in the company's core business. Digital potentials are mainly used against the background of direct added value and against the background of customer requirements. At the same time, digital technologies are mainly used to simplify processes and make them more efficient and effective. However, the technologies used so far seem to be rather rudimentary. Innovation therefore plays a purpose-bound role within the company. Even if the company does not claim to be a pioneer in innovation technology, it is open to new applications and technologies and prepared to fulfil customers' demands quickly.

20.Case GE5

1.Digitalisation in last mile delivery

The company impressively demonstrates the importance of using digital tools for last-mile delivery. Not only with regard to route optimisation, but also with regard to the parcel overview, digitalisation seems to be indispensable. Digital technologies are thereby used to relieve delivery staff and make their work easier and clearer, while demands for delivery staff should rather decrease through the use of digital tools. The company analysis also shows the peculiarities and challenges of last mile logistics and the special client-customer relationships between large CEP service providers on the one hand and companies that focus on inner-city delivery on the other. All in all, it gets clear once again that IT and logistics are an important interplay and that digital technologies are of upmost importance for the delivery of parcels.

2.The company

The company case revolves around a young company, founded in 2019, mainly operating in the city of Dortmund. It specialises in climate-friendly delivery, using electric cars accordingly. The company is managed by a single entrepreneur, who was also the founder of the company. The company is also headquartered in the city of Dortmund, where it has moved into an office in one of the most important start-up and competence centres of the Dortmund logistics ecosystem. Currently, the company employs a 12-person delivery staff. However, the delivery volume is increasing, or in other words, more delivery trips are being made, so that the company is currently trying to recruit more delivery staff and is growing accordingly.

3.Position in the entrepreneurial ecosystem

The main cooperation and networks that the company has entered into and which are of utmost importance for the company's existence take place in Dortmund. For example, the parcel centres of the most important clients are located in Dortmund and in surrounding cities of the Ruhr region. The company's main parcel delivery also takes place in Dortmund. At the same time, the company is striving for further cooperation with CEP service providers for the Dortmund area and the surrounding region. Dortmund location is well suited as a location, also because other logistics distribution centres and distribution areas in Ruhr valley cities can also be easily reached from here via the motorway connections of the A45, A40 and A42. The company also has its headquarter and offices in one of the most important competence and start-up centres of the Dortmund logistics ecosystem. Thereby, the managing director and entrepreneur of the company was able to make further contacts in the logistics ecosystem and expand his network in the said competence and start-up centre. An interesting finding is that the company has not yet used any support structures from other intermediaries, such as the employment agency, for example on the topic of recruitment.

4.Digital transformation

Digitalisation is used in the company primarily with a view to optimising processes, so that the delivery staff in particular use various tools against the background of route optimisation and parcel overview. Digital tools thereby lead to a better overview, which in turn has a positive effect on the

performance of the individual suppliers and thus the company. Digitalisation has been an integral part of the company from the very beginning. The aim for the company is to achieve paperless, flexible working, where both the managing director and the employees are no longer tied to a specific location. For example, all content can be accessed via cloud systems on smartphones as well as laptops. This is particularly important in logistics, where motion plays an important role and all company employees are always on the move. Ultimately, the use of digital technologies and tools has a positive effect on employee satisfaction, he says. On the one hand, digitalisation is a way to bind employees to the company and to enable smooth, efficient and satisfying work. On the other hand, the use of digital technologies can also prevent signs of wear and tear among employees: The overview provided by digital tools makes it possible to assess exactly how much individual employees can do, so that they do not have to go beyond their limits. As the managing director puts it - the use of digitalisation and the accompanying process optimisation are necessary to keep the business running.

21.Case NL1

CCAM indicated that the data on the company can be used in the project. However, the two-pager still allows the company to be identified and gives too much information on its strategies. Therefore, the two-pagers has been excluded from the report.

22.Case NL2

1.Seeking an ambitious role in the ecosystem

AMC is one of a dozen aircraft maintenance company in the Netherlands. It is capable to maintain numerous types of aircraft and repair all components of aircraft. As part of a new company strategy, AMC changed its strategic emphasis to becoming a major MRO (maintenance, repair and overhaul) service provider in the world. This strategic change opens up the way to become a dominant player in the Dutch aerospace entrepreneurial ecosystem.

2.The company

AMC operates at two Dutch locations. It cooperates with the Dutch military.

AMC distinguishes three main elements in its production system. Maintenance is based on a project approach. Warehousing has the strategy in keeping a minimum stock, yet be able to deliver immediately. Efficiency is key for supply chain management. Predicting customer demand is crucial, in order to control costs in the operational MRO process and in balancing volume and speed of delivery in warehousing and logistics. The AMC production system is able to handle a large variety of aircraft types, and the project structure offers the needed flexibility.

3.Position in the entrepreneurial ecosystem

The ecosystem is characterised by differing interests and silos, which hinders a clear direction for its future. As part of its new strategy, AMC wishes to take a leading role in the ecosystem in the maintenance activities, but cannot do it alone. Reliable cooperation between the military and civilian partners is conditional; more businesses and start-ups should be attracted. The aerospace knowledge infrastructure goes beyond the local region. The ecosystem encounters talent scarcity, a lack of leadership, and a dependency of governmental formal institutions. For AMC to become a leading company in the ecosystem, it requires having partnerships for further investing in scaling up, such as suppliers, or an important customer. COVID-19 affected civil aviation hard. A significant portion of aerospace staff at the location went to other industries.

4.Digital transformation

The company is on its way to become a digital transformator. The company regards digital technologies as a means to improve their processes and servicing clients. It is experimenting with AI and blockchain.

The innovation and digitalisation strategy of AMC is being redeveloped. Aircraft design, parts management, maintenance work, and supply chain management are slowly being digitalised. AMC is jumping on that train. For that purpose, AMC is working on different digital technologies, such as Blockchain, 3D printing, improve real-time data logistics processes. The case focused on the digitisation of the customer quotation process for spare parts, the so-called ‘autoquote process’.

The autoquote process automatically generates ‘automatic’ offers based on automatically processed questions (for information) by prospects. AMC has a huge number of spare parts of aircraft in its warehouse. The quotation process had become rather unstructured. Requests came

in from customers (i.e. airlines) in different ways: by email to many people, on different portals. There was no overview of what was being picked up and the workflow was hard to control. Whether or not something is addressed, that depends on the people. The aim of the digital process was to centralize, structure and streamline this process. Machine learning helped AMC gain more insight in the customer behaviour. Different types of quote request could now be classified to different customer categories. Machine learning made the process more transparent, and resulted in four clearly distinguishable streams of order types. The result is that 40% of the incoming questions is automatically processed and 60% is assigned to the account managers. Although this also reduces the workload, autoquote is not intended to reduce people, but to make more quotes as possible. Account managers now have more time for solving difficult quotations. It improves efficiency, a better process, a higher turnover, and learning opportunities for employees.

Employees in the sales department are positive about the 'autoquote' technology. It seems that employees adopt these innovations, because it makes them more productive (which is pleasant), it enhance their job security (which is crucial), and they can still feedback improvement into the system (which gives a sense of craftmanship). One observation is that these employees cooperate with new specialists in the company like data scientists. In the view of the operating employees both disciplines need each other. For themselves, they see both technical skills and social skills as important, but they weigh technical skills and training as most important.

AMC wants to be a transparent employer, to engage employees and to enhance collaboration. AMC is looking at inclusiveness and diversity and making new people feel welcome, that they are really allowed to participate. They want to develop employees' soft skills more, in addition to safety and quality. AMC also ensures that employees have fixed contracts. Technical skills are of key importance, "but soft skills have been underexposed, that's where the profit lies to do more with them", says an HR professional. Employees feel very connected to the firm and its products. Turnover is low, but the workforce is ageing.

23.Case NL3

1.A digital frontrunner with a societal mission

CTS aims to be a digital frontrunner in many ways: it is a paperless company, operates fully automated production facilities, and developed several methodologies to develop and produce things better and cheaper. The digital approach applies to its production philosophy to apply the newest technologies to its own business. It relies on a growth strategy with self-developed innovative 'building blocks', a production system that integrates its own digitalisation and robotisation, and a logistics system that applies its own innovations in automation. With its production, CTS aims to contribute to a better world with innovations, for example, for health care, sustainability and a greener economy. The production strategy puts people central because they are the ones developing the innovations.

2.The company

CTS is a financially independent maker of products for several high tech markets, mechatronics, and industrial automation. The focus of the case study was on its work for the semiconductor markets and its role as supplier for the core company in the incumbent ecosystem. CTS controls the design and production of its technological solutions. Everything is kept in-house to better manage the boundaries of technology and innovation. In all it does, it aims to contribute to sustainability by reducing the use of energy, raw materials and plastics, and by the endeavour to continually optimise, automate and apply robotics. CTS sees itself as an extremely flat organisation, consisting of self-coordinating teams, and striving to continue eliminating bureaucracy while growing strongly in employment and turn-over. Management roles are limited in the company. The policy is that privileges for management levels are non-existing. Instead of seniority, the CTS criteria for responsibility and rewards are ability and ambition. CTS has a growth strategy based on, for example, re-using proven technology as building blocks (Ready-to-use-Products, RTUP), the vertical integration of expertise and experiences and a combination of capabilities. This 'full control of all design and production steps' creates a shorter time-to-market and scalable revenues, supports synergy, and requires less overhead and indirect costs. CTS manages several plants over the world. These plants are 'global copy exactly' of the Dutch plant. Every single process, way of working and adjacent element of their model all over the world is the same, which eliminates learning costs when setting up new subsidiaries, and leads to economies of scale. For CTS-employees are their most important asset.

3.Position in the entrepreneurial ecosystem

CTS HQ is a highly innovative firm in the entrepreneurial ecosystem under study, where its sales, R&D, manufacturing, supply chain and services are located. There are branches of the company over the globe. R&D is only located in The Netherlands. The company strategy of CTS is to manage all crucial production steps 'in-house'. The internal organisation is also an innovation. CTS shifted the structure from departments to an increasingly uniform structure of projects that are connected via processes, resources, programs and customers. The work organisation is a flat non-hierarchical structure, with clear responsibilities, and aimed to facilitate young talents' possibilities and ambitions. The organisation is centred around the CTS specialist, a talented person with an attitude

that underlines the company values is driven by ambition, takes the initiative and is customer conscious. The members of the Board no longer have departmental responsibilities but align holistically with growth and productivity objectives, QLTCS criteria and support to personnel. CTS was founded in the 1990s and started a relationship with the core company, which is today a major customer of CTS's products and services. CTS sees itself as a research, development and production partner to the semiconductor and electronics equipment industry. CTS supplies three types of products to the core company: standard interfaces in competition with other suppliers; specifically developed products to request, where CTS has its own IP rights; and build-to-print: products produced according to exact specifications. CTS is also included in several technical roadmaps of the core company. “In this relationship with the core company, CTS has chosen to have from the start an independent position. CTS has never wanted to deliver exactly what the core company wanted but has always chosen the role of 'challenger'. This allowed CTS to contribute and develop its own entrepreneurship.”, explained the CEO. The company has a solid position in the ecosystem. It shares the same challenges as other core companies in the ecosystem: a shortage of talent, limited infrastructure concerning mobility and housing of new talent, and limiting governmental rules and regulations.

4.Digital transformation and employment impacts

CTS can be called a ‘digital transformer’ (DX). It has largely automated its manufacturing and logistics. Manufacturing automation is realised by using standardised building blocks (RTUP). They developed applications to automate assembly operations (such as sealing, heat staking and automated inspection). Logistics automation is achieved by developing integrated logistics solutions to provide the right things at the right time at the right place in the correct quantities. They use solutions such as AGVs and local buffer centres to achieve this. The digital technologies are helping it change its business model, more focusing on product lines and less on manufacturing services. CTS is fully responsible for its own R&D. Innovation is kept in-house. It is a technology and digital leader. It uses digital capabilities (big data, automation, IoT and cloud computing) to improve customer experience, outdo the competition and create new business models adapted to the current competitive environments. CTS is known for its strive to maximise the automation of its production processes. CTS is a ‘digital factory’. CTS works with all the new technology that is available. To a large extent, they are steering their own technological revolution and are not dependent on other suppliers. Even in the domain of software, CTS finds its own developments. The digital transformation has only strengthened fast employment growth. All employees get fixed contracts. Technology is mainly 'augmenting' what employees can do and not just eliminating tasks. New technology leads to new possibilities with which more can be done. An example is Low Code Software. Instead of an employee coding a lot of lines, a programmer can focus on the intellectual challenge of combining software blocks (modular chunks). CTS highly values ‘entrepreneurship’ and ‘conceptual thinking’ as competencies. “We are known for our young and bright designers and engineers that look at things from a different angle. They come up with ideas to solve complex problems with fewer parts, simpler and more robust structures and better maintainability”. According to the Annual Report, gaining on cost, quality, and functionality is often the result of the fundamental choices that are made in the design of a product, module or system.

Some characteristics of a high road perspective are that CTS aims to increase diversity, high work autonomy, flat hierarchy, many learning opportunities, the possibility for employees to become a shareholder, contribute to ‘meaningful innovation’ and support sustainability and inclusiveness.

24.Case NL4

1.A a family business of professionals. On the way to digital transformation

SIT is a company that is part of an international industrial family business with more than 50 operating companies, spread throughout 20 countries with thousands of employees. About 3,000 are located in the Netherlands. The mother company is a major player in subcontracting and semi-finished products sectors. It produces its own finished products in advanced manufacturing.

2.The company

The case study is one separate company, a Supplier in technologies (SIT), and part of a division that is a tier-one design and contract manufacturing partner, with customers having a leading role in high-tech manufacturing equipment and users of advanced production lines. It is active in different markets. The semicon part is the largest as most of its production is done as a supplier for CCAM, the core company in advanced manufacturing in the Dutch studied incumbent ecosystem.

The focus of the investigation is on SIT and its relationship as a supplier of CCAM. SIT makes complex mechanical parts in-house, delivers modules to customers or fully integrated and tested systems, both built to spec and built to print, which include the entire engineering. For CCAM the ratio of built-to-print products (products according to CCAM's exact specifications) and and built to spec products is about 50/50. SIT also makes products for CCAM's competitors. SIT has more than 800 employees, and this is likely to increase to 1000 employees in the near future. Of all SIT-employees, about 75% works for CCAM projects / products. CCAM and SIT are interdependent of each other.

The products SIT produces for CCAM become more and more complex, and have to be made ever more quicker. Traditionally, SIT received complete and finished drawings for new products for review on which they had relatively little voice, and limited time for testing in pilots. Today, they participate more often already from the design phase for faster development and production. They do not always pilot separately anymore, but make drawings and do engineering tests/simulations at an early stage. The development of new products or the introduction of new technology is also becoming more complex, which demands that project teams are embedded in the entire organisation and work in close collaboration. Due to the speed and complexity, the work process changes continuously. Instead of separate teams doing separate tasks, the process changes into a more integrated cooperation of different people: interdisciplinary teamwork.

3.Position in the entrepreneurial ecosystem

Looking at the entrepreneurial ecosystem model from the perspective of SIT, the existing entrepreneurial culture and strong innovation leadership from both CCAM and the mothercompany of SIT, as well as the strong network in combination with R&D activities in the region have been the success factor until now and are likely to be so in the future. Two related elements crucial for future success need more attention: the presence of enough qualified staff to grow; and, to attract staff from abroad, an infrastructure of housing, international schools and urban facilities. In addition, with the growing importance of IT, cyber security is also a potential risk and a growing point of attention.

SIT's mother companies' policy is geared towards continually improving and renewing products and production processes. They are convinced that, in order to keep the high-quality manufacturing industry in Western Europe competitive on a global scale, they must continue to fully work on innovation. SIT also sees leadership and vision, entrepreneurship and knowledge institutes as the most important elements of the ecosystem-model for their success. They, for example, work closely together with technical universities and start-ups.

4.Digital transformation and impacts

Digitisation of production and business processes is one of the spearheads SIT's mother company across all divisions. Some divisions work with large production batches, but this is not the case for SIT. SIT is, for example, in the middle of the process of digitalising all work instructions, where people used to make their own notes and now read work instructions from tablet or computers. SIT is now looking how to make the digital work instructions more interactive. These are first steps in digitalisation of work processes, which are believed to be needed for the future when digitalisation and automatisation will become more important: "organise first and then automate". SIT already for many years uses automated machining centers whereby the current focus is to minimize the manpower dependency, and is exploring other technologies to expand the automation like robot welding and 3D printing. This will improve machine utilization, optimize processes and help to deal with the shortage of professionals.

A major digital effort for SIT is to align their digitalisation strategy with that of CCAM. A major transformation would the ability of CCAM to directly place orders in a portal for SIT. Such a relationship requires a major improvement of cyber security and guaranteed data quality.

Digitalisation projects are also initiated by SIT to improve work processes and gain efficiency. An example is the 'logistics project', which was triggered by three reasons: 1) CCAM and SIT have a large stock of end products, which is expensive to hold and still is not sufficient to meet the demand; 2) there are a lot of quality escalations that need to be handled at high costs; and 3) there is a long delivery time. The Logistics project became rather successful, it is now possibly to reduce stock and reduce delivery time, resulting in millions of euros of efficiency gains. CCAM would like SIT to move quicker on digitalisation initiatives, but SIT deems it important to follow a more cautious approach. Interviewees indicate that digitalisation has not shifted practices to such a degree that new functions had to be created or other people had to be attracted. Nonetheless, most employees need to develop at least some news skills due to digitalisation. Most employees need to be capable to work with data and have more analytical skills. And because work is becoming more complex more people with higher education levels are recruited.

As an employer SIT gives priority to health and well-being. SIT finds "strength through cooperation" a central value and wants to improve equality, diversity, and professional development of its employees.

25.Case NL5

1.From managed services to the core supplier as a digital transformer

The IT Firm department under study mainly provides services to major companies in Europe. This summary focuses on the relationship to one such major company. The tasks are to maintain and develop software for the main systems and, at the same time, deliver innovative solutions. The IT Firm's digital strategy is to outsource standard services to a foreign subsidiary it has and develop in-depth products with local highly educated and motivated professionals. These professionals must have broad and deep skills, technical and software skills, and excel in problem-solving, teamwork or team leadership.

2.The company

The IT Firm is a major European industrial technology solutions provider. The IT Firm offers its clients project-based and managed services as well as consultancy, training, software development and recruitment & staffing services. One part of the IT Firm supplies information technology solutions to a core company in the studied entrepreneurial ecosystem. The solutions are for the highly technical business. Roughly 75% of the employees of this department work on projects for this core company. Much of the work consists of dealing with 'farm-out' orders outsourced work of the core company in the ecosystem to IT Firm. The IT Firm has a specific way in supplying these services. The core idea is that as a supplier, it wants to be more selective in its projects. The expertise of core teams is leading in this selection.

3.Position in the entrepreneurial ecosystem

Two elements characterise the position of IT Firm in the entrepreneurial ecosystem: a specific reliance on the ecosystem, and a changing relationship in the business ecosystem, as part of the entrepreneurial ecosystem.

Of all the core elements of the entrepreneurial ecosystem, the main success of IT Firm depends on the presence of enough qualified staff to grow; and infrastructure of housing, international schools and urban facilities that help attract sufficient future employees from abroad.

In the relationship with the core company, initially, IT Firm was 'just' a supplier. It has recently grown towards a partnership relationship with the core company with a growing portfolio. 'Bulk work' of programming and coding on maintenance for the tooling and data migration are largely done by the IT Firm-subsidiary abroad. The IT Firm is focusing on getting more involved in the innovation strategy of its customer. 'The company is starting to invite us to think with them out-of-the-box', says the BU-manager. The work for the core company is 'fixed budget'-driven. The core company closely monitors it. But compared to other IT solution providers, it is unique due to its domain knowledge of the core company. 'It is more like a partnership rather than being a supplier', as the work of IT Firm is deeply embedded in the core company's process. There is a close collaboration, and at the same time some interdependency between both firms. However, a large part of the work is carried out for other customers in the industrial sectors. The experience with complex projects done for the core company is an ability that can be used to acquire orders from other companies.

The relationship can be described as more and more symbiotic, also favouring the development of IT Firm as a supplier.

4.Digital transformation

IT Firm can be called a DX-company (digital transformer), working in the heart of the digital transformation. It has an advanced level of digital competencies in software development, machine learning and AI. Its services are attuned to these competencies. The digital transformation implies more work and business opportunities because prospects invest more in automation, like in manufacturing industries in the region, and there is an increase in investments in cyber security. Companies also increase remote working, partly as a consequence of COVID-19. For IT Firm it is important to be able to deliver state of the art solutions and ensure they have enough qualified people.

IT Firm recognises that IT is of growing importance for equipment built by the core company, given that multiple computer languages are required (legacy software, high-level software, low code software). In its services, it concentrates on opportunities for innovative projects for the core company, on the one hand. Whilst on the other hand, the need to maintain and develop legacy programming languages is carried out by the IT Firm-subsidiary abroad, which works cheaper. Over time, the digital transformation has only led to more tasks, more work and more employment.

The work at the Dutch location is 'low volume, high complexity and multidisciplinary', which implies that the IT engineers must have a broad orientation with knowledge of other disciplines than IT. Formerly, work was carried out individually; now, it is more teamwork. Project managers and lead engineers need to be good leaders. In terms of skills, there is both more complex programming and the need to maintain skills in older programming languages. IT Firm must anticipate changes and software innovation, and the average required education level is rising. Skill must be both broad and deep. Roles become important compared to job descriptions. Process managers (scrum masters) and product owners must work together in synergetic teams that are able to solve problems.

The digital revolution poses three skills challenges for IT Firm: Finding sufficient new talent?; How to manage to change tasks, acquire new skills, and maintain knowledge of old programming languages? How to retain and keep employees? IT Firm recruits internationally and helps talents thrive by providing 'job journeys'. By offering the opportunity to rotate in disciplines and roles, employees can broaden their perspective and personal growth and development opportunities and unleash their full potential. Attracting and retaining the right people is a key driver of growth. The firm invests in its people and encourages them to be entrepreneurial. COVID-19 did not significantly impact the inflow and outflow of employees. It has, however, become more difficult to attract employees from abroad.

IT Firm wants to be an attractive employer, and puts a focus on well-being, flexibility, learning, and diversity, and an equity participation plan, much in line with a 'high-road' perspective.

26.Case UK1

1.R&D anchor supporting digital transformation in SMEs

SMEs are an integral part of the automotive supply chain in the West Midlands. However, their ability to explore and integrate digital transformation is limited by the resources and capacity within the organisation. The R&D anchor, Beauclerc R&D, has been supporting the adoption and implementation of digital technologies in a number of SMEs to increase their competitiveness in an increasingly digitalised market. Support has been provided in collaboration with a range of organisations (from Original Equipment Manufacturers (OEMs) and Tier 1, 2 and 3 companies. It is an interesting case as companies have come together in a competitive environment to share learning and support digital transformation and innovation in the sector.

2.The company

Beauclerc R&D can be considered an anchor firm in the region as it is hub of training and R&D with strong networks and ongoing relationships with a number of multi-national and regionally based organisations in the sector. It is located in the West Midlands county, but through its networks and partnerships beyond the region it also undertakes other work in the automotive sector. This case study is focused on its business within the West Midlands county supporting SMEs improve their digital manufacturing processes.

Beauclerc R&D has been based in the region for over 40 years and has always worked with and supported those in the broad automotive sector. There are a number of interconnected departments which have particularly specialisms and expertise. It has around 500 staff across a range of roles with industry experience and higher level qualifications. The company's R&D activity is led by their digitalisation and green strategy and aimed at all automotive vehicles. R&D work is focused on the development of robotics in manufacturing (particularly co-bots), supply chain digitalisation, autonomous systems for vehicles, battery technology and systems, automation software and systems, and the electrification of vehicles.

3.Position in the entrepreneurial ecosystem

In the UK, the Automotive Sector Deal in 2018 established an industry-government collaboration to support future growth and provide long-term opportunities (Automotive Council UK, 2018). This provided a foundation and roadmap for growing the sector in terms of: ideas by increasing R&D funding; people by establishing a technical education system to support the skills system; infrastructure by supporting investment in transport and an electric charging infrastructure, housing and digital infrastructure; business environment to drive investment and innovation; and places by setting up local industrial strategies.

As Beauclerc R&D is a well-established company in the region it is at the heart of supporting the sector growth in the region and part of the larger network of companies operating in the region. There are a number of large, well-established private sector 'anchor' firms headquartered in the West Midlands metropolitan county: Jaguar Land Rover (JLR); Tata Motors (Indian parent company of Jaguar Land Rover, with R&D facilities located in the region); and Aston Martin. Other OEMs and Tier 1 companies in the automotive sector with operations in the region include GKN Automotive,

Rolls-Royce and Dennis Eagle. There are thousands of smaller supply chain firms, clusters of R&D intensive firms and a number of globally-renowned specialist centres of R&D, technology, innovation and entrepreneurship located in the West Midlands Metropolitan county. Beauclerc R&D works with a number of SMEs in the region on various projects.

Beauclerc R&D sits within a ecosystem with a traditional entrepreneurial culture where R&D is required. The company has well-developed physical structure and a highly skilled workforce which is drawn from across the sector. It is a strong collaborator and has good public and private networks within the region and internationally, so it is well-placed to support digital innovation and learning in the sector. However, R&D is often driven by the MNCs so there is a challenge on how to address the needs of SMEs. The company has had a positive impact in the region evidenced by digital transformation in SMEs. The company (whilst impacted by the pandemic in terms of working processes) has continued to perform well driving a number of developments particularly in terms of CAV and battery technology. The work with SMEs is seen to support growth at the regional and company level.

4.Digital transformation

Digitalisation at Beauclerc R&D is driven by the aim to improve quality through automation and to reduce labour costs in the companies they work with. Projects and programmes are set up to address this aim. Within Beauclerc R&D, their digitalisation strategy is focussed on driving technology and engineering advances in the broad automotive and manufacturing sector. Their R&D aims to support businesses with new technologies, products and materials in order to increase competitiveness, agility and security. The drive to net zero across the automotive and manufacturing sector is fundamental to the company's innovation strategy; net zero with the products manufacturer, but the R&D projects are designed to be net zero from the start. The company's work with the SMEs is to support the development of innovative manufacturing process and support the required knowledge and skills development for companies to increase) their productivity and competitiveness.

The company could be considered a high road employer as it is well-invested in the economic, social and environmental needs of the region. It has a strong developmental culture and supports its workforce skill and learning needs.

27.Case UK2

1.Eden Health: Delivering digital services to support the health sector (Case UK2)

Digital healthcare has been identified as an emergent ecosystem in the West Midlands and there is a growing cluster of both large and small firms operating within the region. Eden Health undertakes R&D in the development of digital healthcare services, but also supports the piloting and implementation of these services in practice. As a collaborative organisation, Eden Health is part of a number of networks at the local and regional level in order to support knowledge sharing activities with the aim of driving digitalisation of the health sector. As a result, the workforce has a range of opportunities to engage with SMEs and the public sector in order to develop knowledge and identify what skills they may need to address the challenges of the future.

2.The company

Eden Health in one of a number of companies operating in the West Midlands digital healthcare sector. Its main business is R&D with a focus on telehealthcare (telecare and telehealth systems that support and assist clinicians provide care at a distance using ICT and the remote exchange of clinical data between patients and their clinicians); and health analytics (software solutions and analytical capabilities needed to assimilate big data). The company's R&D activity is led by their strategy to address global healthcare challenges. It is located in the West Midlands metropolitan county. It has strong local networks and informal international collaborations and partnerships developed as part of their knowledge sharing networks. The company has been based in the region for over 50 years undertaking R&D in the health sector, but it has only recently expanded into digital healthcare in response to the drive to digitalisation as set out in The Topol Review (Health England, 2019).

Collaboration with the public and private sector at the local, regional, and national level is a key part of Eden Health's strategy to developing knowledge for the field with an emphasis on sharing practice – *'we are outward looking and want to engage with the public and those in practice'*. Engagement is seen as key to improving their services.

3.Position in the entrepreneurial ecosystem

In the UK, the National Health Service (NHS) is a publicly funded medical and healthcare service for the UK public under the Department for Health & Social Care. It is a complex system comprising a range of organisations providing primary, secondary and tertiary care services free of charge to those living in the UK.

The national healthcare system has strong governance structure which feeds into regional services which are commissioned and delivered by partners. This provides a strong foundation for the region's healthcare sector which has a number of strengths. These strengths include: a long history of well-established companies and service providers; an internationally recognised centre of R&D and innovation in companies and universities; plus well-established collaborations between universities, and the public and private sector.

Eden Health sits within the national healthcare system working to support the NHS long term plan particularly in terms of its digital aspirations. Within the regional ecosystem, the company collaborates with the public and private sector to develop and implement digital services aligned to this plan. At a local level, Eden Health is working with Clinical Commissioning Groups to implement and support digital services in primary and secondary care. The company has been working with local GP practices to develop and implement digital services, which support triage systems, online booking systems, access to digital records, prescription orders and online consultations.

In the West Midlands, there is a growing cluster of both large and small firms operating. SMEs in the region working on digital applications to support service delivery collaborate to develop 'whole' systems (front-end and back-end developments). Eden Health works with these SMEs to share knowledge and experience, as well as support the testing and implementation of the new digital tools/applications. The company supports those in practice embed the digital systems. Within the company there is a general ethos of trying to support the healthcare sector and support those working in the sector so they can do their job more effectively.

4.Digital transformation

Over the last few years, the pandemic shifted not only access to digital healthcare services and improved IT infrastructures (partly due to the accelerated upgrades to rural infrastructures), but also uptake in services at practice level and demand at service user (patient) level.

As the digital healthcare sector has developed, reskilling the operational workforce at the company to deal with digital transformations has been key. Digital skills developed in other sectors have been translated to fill gaps in the current workforce.

Eden Health recognised that the shift to digital health meant that all health professionals needed to possess digital skills and digital literacy skills to ensure effective communication. This not only impacted the health sector workforce more generally, but their own workforce who needed to understand the healthcare workforce skills when developing and implementing services. Knowledge and understanding of data protection and security was also noted to be needed by the company workforce as systems have to be built with UK GDPR requirements in mind. The future workforce, it was reported, will also require specific ICT technical skills in areas including big data analytics, information security, software engineering and database development.

Eden Health can be considered a high-road employer as it has a good governance structure, plus strong support and development systems for its employees which exceed those required by law. It is also a recognised living wage employer; therefore, it pays a wage that is based on the cost of living rather than the minimum wage. In addition, there are number of initiatives and practices in place that are designed to support an inclusive work environment

28.Case UK3

1.Simmons Warwick Alliance: Regional networking for digital transformation in healthcare

This case study has focused on the Simmons Warwick Alliance (hereafter, the Alliance), a network which is part of an emerging digital healthcare ecosystem in the West Midlands metropolitan county. Established in 2013, the Alliance supports, develops, tests and helps accelerate the adoption and spread of innovative ideas and technologies in the West Midlands to deliver benefits to the UK National Health Service (NHS) and its patients. It is an interesting case study because it demonstrates the important function played by networks in leading and catalysing collaboration digital innovation in healthcare. This case study discusses the positioning of the Alliance in the emerging entrepreneurial ecosystem in the West Midlands county: Digital Healthcare.

2.About the Alliance

The Alliance is a membership-based network that operates in the West Midland's emergent digital healthcare ecosystem. The network aims to drive collaboration between local NHS trusts, Integrated Care Systems (ICSs), universities, industry, healthcare providers, growth hubs, and other inter-connected networks. As such, it can be considered one of the anchor organisations in the ecosystem. It is one of 15 similar networks across England, has a secretariat of approximately 50 staff and plays a coordinating role in the region's emerging digital health ecosystem. The number of members and partner organisations in the Alliance is large, yet dynamic.

3.Position in the entrepreneurial ecosystem

Within the regional health ecosystem, the Alliance brings together major actors, including NHS trusts, their Clinical Commissioning Groups (CCGs), healthcare IT and medical device companies (including start-ups), health regulators, and local authorities to develop, pilot and implement digital products and services in primary and secondary care.

The West Midlands Local Industrial Strategy identifies data-driven health and life sciences as a major market opportunity for the region, while the West Midlands Regional Skills Plan aims for more inclusive regional growth by trying to improve the match between the skills of the region's residents and future skill requirements of business.

There is a growing regional cluster of data-driven healthcare firms in the West Midlands, many of which are members of the Alliance. R&D is supported by local universities, teaching hospitals and centres of clinical excellence. There are two main clusters within the open innovation system centred around the innovation districts found in the region's two largest cities. Specialist healthcare hubs and accelerators in each cluster were established to support new digital healthcare start-ups and those trying to scale-up.

Rather than coming from individuals, leadership in the West Midlands ecosystem is best characterised as institution-led. It might be said that the culture emanates from the NHS, as the public provider of healthcare. While the NHS and university research facilities typically lead investment, although some smaller firms and spin-offs are accessing R&D funding to innovate new healthcare related products and services.

4.Digital transformation

Using digital information and technology to deliver healthcare and improve the well-being of individuals is central to the work of the Alliance. It plays an important networking role to help deliver digital health solutions at various maturity levels (from lab-based innovation to product development). The potential for digitalisation in healthcare is prolific, however, the region's healthcare sector has yet to fully capitalize on the opportunities arising from digitalization.

The NHS has struggled to adopt digital innovations in the past, but with government support, the ecosystem is beginning to mature. Three strands of digital R & D/innovation are now underway across the Alliance: development and deployment of digital monitoring and prognostic medical devices; identifying ways to improve the management and analysis of health data; and using Big Data/AI and imaging technologies to improve diagnosis and treatment.

With the shift to digital health, the need for digital skills across the entire healthcare system is clear. The future workforce will require specific ICT technical skills in areas including (big) data analytics, Artificial Intelligence (AI), Cloud computing, information/cyber security, software engineering and database development. The interface between technology and healthcare has seen the emergence and growth in new jobs, particular in the area of health data analytic but there is a lack of specialist IT staff who understand the complexities of the health system. In addition, all health professionals will need to possess digital literacy skills to effective communication and protect patient data.

Many of the jobs at the digital frontier in healthcare require similar skills sets to those in other more highly paid sectors (such as ICT itself, banking & finance, and precision manufacturing). The supply of digital talent is mainly from other sectors as there is no educational pathway directly into the digital healthcare sector. Upskilling those who are implementing the digital services and silos between disciplines, such as developers not working with clinicians, are barriers hampering digital transformation in healthcare.

In terms of skills initiatives, curriculum in the Higher Education (HE) system needs to be updated so that all healthcare workers are familiar with digital health solutions. Problems in the Further Education (FE) system have contributed to skills shortages in many technical and vocational areas. as most of the colleges and providers deliver a limited range of qualifications, despite there being a much broader range of jobs in the sector. While digital re-training schemes do not appear to targeted specific sectors, rather digital skills training offers generic skills such as coding training or digital cafes to traditionally disadvantaged groups.

Overall, training the region's future healthcare workforce is important to the development of the digital healthcare sector, where digital skills will be important. While the Covid-19 pandemic has been a driver of change with digitalization, there is an underdeveloped supply of skills in the field generally but it is anticipated that the education sector will respond to the emerging digital skills and other skills requirements emerging in the sector, where Alliance members will play an important role.

29.Case UK4

1.Clayton Manufacturing: Driving innovation through strategic partnerships R&D anchor supporting digital transformation in SMEs (Case UK4)

Driven by their end-users, Clayton Manufacturing was encouraged to start its digitalisation journey. Digitalisation at Clayton Manufacturing is driven by the aim to improve quality through automation and to reduce labour costs. Automation is seen as an enabler in reducing production costs, so it makes UK-based production competitive. Strategic partnerships with companies whose technologies are seen as 'enablers' to the business provide the foundation for innovation at Clayton Manufacturing. The company identifies early stage technologies as they are being developed and supports them through venture capital firms, accelerators, and incubators.

2.The company

Clayton Manufacturing is a Tier 1 supplier (Original Equipment Manufacturer) that serves a significant number of major automotive manufacturers. The company has over 200 factories in around 40 countries. An important driver of the company's global expansion is that it 'follows' its customers and produces components near the car manufacturing plants of its end users. Another driver of geographical mobility is that the company is trying to establish manufacturing facilities in 'low cost' countries. The company's UK operations started in the 1990s and considered an incumbent company in the ecosystem. The company has several sites in the UK, including two factories, offices and a 'technical centre' in the West Midlands metropolitan county. The annual turnover of the UK business is over $20 million.

The company manufactures car interior components, electronic capabilities (complex wire harnesses) and develops software that is integrated into interior components. Interior components are based on modular sub-assemblies, produced in different factories around the world and shipped to the factories where the final assembly takes place. There are some 're-shoring' initiatives underway to reduce the carbon footprint and enable a closer co-operation and co-design car interiors with the end users. Automation is seen as an enabler of this because it reduces the cost of production and makes UK-based production competitive. At Clayton Manufacturing most innovation is based on forming strategic partnerships with companies whose technologies are seen as 'enablers' to the business. Innovation is primarily focused on repurposing existing production facilities and reskilling workers to enable the transition to electric vehicles. The company also identifies early stage technologies as they are being developed and supports them through venture capital firms, accelerators, and incubators. The company has a global 'Innovation Team' that is based in the UK.

3.Position in the entrepreneurial ecosystem

Automotive manufacturing is one of the major industries in the West Midlands county, with large, well-established private sector 'anchor' firms. As a Tier 1 supplier, Clayton Manufacturing is connected to all carmakers in the local ecosystem and it benefits from the local and regional automotive sector in a number of ways: proximity to its customers; good supply of engineering

talent; access to academic and industry-based R&D centres; good physical and IT infrastructure with transport links to automakers (customers), companies in the local and global supply chain.

Clayton Manufacturing has a well-developed physical structure and a highly skilled workforce which are well-supported with skills training and development opportunities. It is a good strategic partnerships and networks across the sector in the region and internationally. The weaknesses of the local and regional automotive sector include: relatively low level of digitalisation, especially below Tier 2 and the low level of co-operation between suppliers and OEMs within a supply chain. Clayton Manufacturing challenges this context by working with suppliers and OEMs across the ecosystem to drive innovation in the company. In this respect, the company has had a positive impact in the region driving entrepreneurial activity and innovations in the sector to support productivity and reduces operating costs. As an established company in the ecosystem, it is well placed to take advantage of the strategic partnerships it has developed.

4.Digital transformation

Digitalisation at Clayton Manufacturing is driven by the aim to improve quality through automation and to reduce labour costs. The end-users of their products encouraged the company to start its own digitalisation journey. Digital transformation is impacting production, including the final assembly of car interior components; the 'end-of-line' processes, such as quality testing and packaging; other non-value-added processes, such as material handling, logistics and warehousing and back-office activities. There is also a trend to collect and analyse the data generated in the manufacturing process. The digital technologies currently used include: automation in logistics and warehousing; digital twins in manufacturing process design; cobots and robots on the assembly line; digital technologies in quality control; automation (robots) in packaging and palletising (end-of-line process); and data analytics. The effect of digitalisation is likely to be complex on the quality of jobs. Manufacturing process engineers and IT specialists are currently developing new digital skills in digital twins and data analytics.

In terms of the number of jobs, there is evidence that the use of digital technology in warehousing and in end-of-line processes has replaced jobs. In the production processes, it is too early to tell whether jobs will be replaced or changed, however, it is expected that the introduction of automation will replace some manual operative jobs. The company has recruited workers into new occupations that focus on the design and implementation of digital technologies.

Clayton Manufacturing can be considered a high road employer. It has a strong governance strategy with a number of longer-term goals in terms of innovation and R&D; strong sustainability goals using green technologies, reducing energy, minimising carbon emissions and protecting water resources. In terms of the workforce, the company has a strong drive to support career development and collaboration providing international working opportunities to individuals. There is also a culture of inclusivity with diversity in perspectives and experiences encouraged and valued. Individuals are supported in developing their skills, particularly teamwork and leadership, with the aim of retaining talent and developing the workforce in-house.

30.Case UK5

1.Lee Engineering: Upskilling and workforce development for digital transformation (Case UK5)

Lee Engineering is a well-established company with ties to a number of sectors. Its digitalisation activities include the development, production and sale of software and related services that enable automotive manufacturing companies in the West Midlands to progress towards becoming 'digital factories'. The company's longer term innovation strategy is to transition from manufacturing to technology development and services, and increasingly, to software as a service (SaaS). Central to this transition is supporting its current workforce with upskilling, training and development opportunities.

2.The company

Lee Engineering is the UK subsidiary of a global company that is the conglomerate of technology development and manufacturing businesses, with a particular focus on the automotive sector. The company is well established in the UK having operated in the country for over a hundred years. It has 26 facilities, including offices, R&D centres and manufacturing plants in the UK, including three sites in the West Midlands metropolitan county and a fourth site in the broader West Midlands government office region. The company's activities in the West Midlands metropolitan county are focused on industrial software development and R&D related to the electrification of transport.

Lee Engineering develops industrial software that is a key element of the digitalisation of factory production in the automotive sector. Its own factory is powered by the company's own digital factory systems and automation components. The large portfolio of software is relevant to industrial processes ranging from mechanical to simulation of functionality and controlling machinery. Closely linked to the software is the development and the manufacturing of digital industries hardware, e.g. operator controls and dashboards (human machine interface) that are used in the factories that run the company's software.

The company's longer term innovation strategy is focused on transitioning from manufacturing to technology development and services, and increasingly, to software as a service (SaaS). Part of this shift focuses on upskilling and developing the workforce to support their transition with the company. The company aims to identify early-stage technologies as they are being developed internally and externally by start-up businesses. The initiatives that focus on digitalisation aim to 'scale up' the production of electric and autonomous vehicles, including the production of batteries. The company is also collaborating with industry partners in the development of automated charging technology and an infrastructure in the West Midlands for charging electric vehicles. This partnership and others are seen to bring several benefits to the company including support with workforce upskilling and knowledge sharing opportunities.

3.Position in the entrepreneurial ecosystem

Lee Engineering is a global engineering company that is connected to the automotive industry and the West Midlands metropolitan county in complex ways. The company is established in the ecosystem as it is the main supplier of digital industry software and hardware (controls and human-machine interface) and related services to OEMs and Tier 1 companies in the region. It also provides

technology products and services to companies in the automotive sector supply chain, Tier 2 and lower. It is also collaborating with industry partners on electrification projects in the automotive sector, including the development of software to support electric vehicle batteries, charging technology and infrastructures. It is a key player in supporting innovations in the automotive sector in the region.

As an international company, it has a skilled and mobile workforce. Talent is drawn from the international labour market, which supports knowledge sharing and development. It also provides career development opportunities for the workforce for those wishing to develop in their role to those who wishing to learn new skills. Lee Engineering has a well-developed IT and physical structure. It is well placed in the ecosystem with strong networks and substantive funding to innovate.

4.Digital transformation

The company is undergoing a digital transformation, moving away from manufacturing towards becoming a digital services business. Key technologies include software development and manufacturing data analytics. Software development supports the manufacturing production line process from a customer personally-configuring an online order, which is converted to a work order, sent to a scheduler and then to the production line. The manufacturing data analytics development supports the collection and interpretation of data enabling productivity, faults, etc,. to be monitored. A data collection and analysis system is essential for creating the right manufacturing conditions in the automotive sector which operates a just-in-time process. This digital transformation has resulted in a certain groups of workers with specialist skills, for example, IT specialists needed to develop new skills, particularly around cloud computing and data analytics. In the UK there is a shortage of engineers, IT experts and other staff with high levels, specialist digital skills. For Lee Engineering, this has significant impacts at a local level with high demand and the need to address shortages with in-house training.

Lee Engineering has a strong governance strategy, and its inclusivity and diversity policies all lead by its international head office. The company is a ‘high road’ employer with clear longer-term plans towards digitalisation and workforce development as they shift their processes to software as a service. As workforce skills will need to be addressed, measures are underway to support this upskilling. New talent will likely be recruited to address the gaps but to also support workforce development. The company’s current production strategy is based on digitalisation and full automation to reduce the cost of labour in the UK.

Annexe 4. Tables and figures

Tables

Figures