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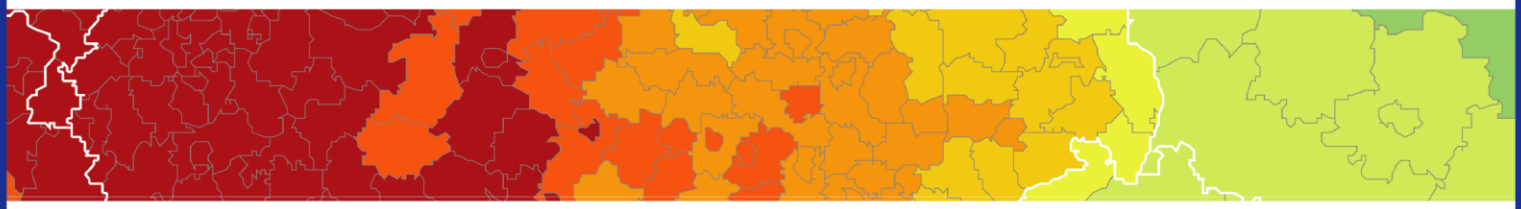

T^4 – Territorial Trends in Technological Transformations

Applied Research

Draft Final Report – Case Study Annex B
Synthesis of Case Studies

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Synthesis of Case Studies

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Authors	**responsible for**
Technopolis Group (TG) – Reda Nausedaite and Olga Mikheeva	Section 1
Technopolis Group (TG) – Karine Lanoix and Patrick Eparvier	Section 2
University of Warsaw & EUROREG (UW – EUROREG) - Agnieszka Olechnicka and Maciej Smętkowski	Section 3
Economics University in Bratislava (EUBA) - Miroslav Šipikal, Štefan Rehák, and Martina Džubáková	Sections 4 and 6
MCRIT – Laura Noguera, Oriol Biosca, Rafa Rodrigo and Andreu Ulied	Section 5

Advisory Group
Project Support Team: Marinko Ajduk, Wolfgang Pichler, Christine Wallez Cuevas
ESPON EGTC: Martin Gauk, György Alfold

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Contact: info@espon.eu

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Final Report – Annex B

T^4 – Territorial Trends in Technological Transformations

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This document is a draft final report.

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The final version of the report will be published as soon as approved.

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Setting the scene	
Regional baseline	ICT sector in Estonia accounts for 20% of exports and ICT equipment and knowledge-based capital have contributed ca 7.4% of labour productivity growth in Estonia during 2000-2014. Labour productivity in ICT sector is about 30% higher than in the rest of the business sector, which is only 60% of OECD average. At the same time, business R&D investments are low and productivity gap in manufacturing remains the largest, as compared to more advanced EU Member States. The overall technological development (total factor productivity) was still only 70% of EU average and was the weakest contributor to GDP in 2013. The two regions – **Northern and Southern Estonia** - are different in terms of intensity of industrial structures (significantly more in the North), their diversification, presence of ICT industry (more vibrant in the North), activity of ICT cluster organisations (more active in the North), population density (higher in the North), among of high-skilled and knowledge intensive jobs (higher in the North). Meanwhile, the regions are comparable in terms of quality of education and training (each has one-two major universities, and a number of applied schools), connectivity and digital literacy/readiness of population. Both regions demonstrate similar structural characteristics: industries are dominated by lower-productivity micro-enterprises, lack of sector-specific skills and shortage of industrial employees. Wages are higher in the North and technical competences are also concentrated in the North.
Adopted 4.0 technologies in the sector in the region	Based on interviews with industry associations, two industries that have been faster in adopting Industry 4.0 technologies are metal-processing and machinery as well as forestry and wood-processing. The choice also owes to their region-specific concentration: metal-processing industry in the Northern region and wood-processing industry in the Southern region. The two sectors are export-oriented, score good in terms of application of ICT technologies in production processes but the value-added produced domestically is substantially higher in the wood-processing sector. Both sectors are dominated by SMEs but in the case of wood-processing, almost entire value chain is located in Estonia whereas Estonian metal-processing companies are mainly sub-contractors to larger, often foreign-owned firms. Industry-specific analysis is based on interview materials and latest sector-specific reports. All digital technologies used by industrial firms in Estonia are foreign made. Both, wood-processing and metal-processing, are not the technology-producing sectors. Both sectors have adopted ERP systems, digital supply chain systems, digitised machinery and production lines and some robots. Metal-processing sector (**Northern** region) has been less successful in the wider adoption of such practices. Wood-processing (**Southern** sector) has a larger share of more digitally advanced firms. This is because the metal industry has been traditionally been rather low value-added, but wood-processing has formed a well-performing cluster with firms exporting finished goods with higher value-added. Wood-processing also has a positive spill over effects onto related sectors, such as furniture, wood-based biofuel, etc. Southern region benefits from such positive externalities directly. There are no such developments in the metal-processing in the Northern region.
Preconditions for transformation	
Regional preconditions	**Northern** region might provide stronger and better facilities for digital transformation due to a larger number of competence centres, digital infrastructure in terms of knowledge exchange, various experts, etc. and also due to strong presence of foreign-owned large manufacturing corporations. Wood-processing cluster (**Southern** region) has been very successful in gaining a good position in international markets (especially in Scandinavia), the actual location might no longer matter in terms of region-specific preconditions because the demand for higher standards comes from foreign customers and not local. This is the example of how

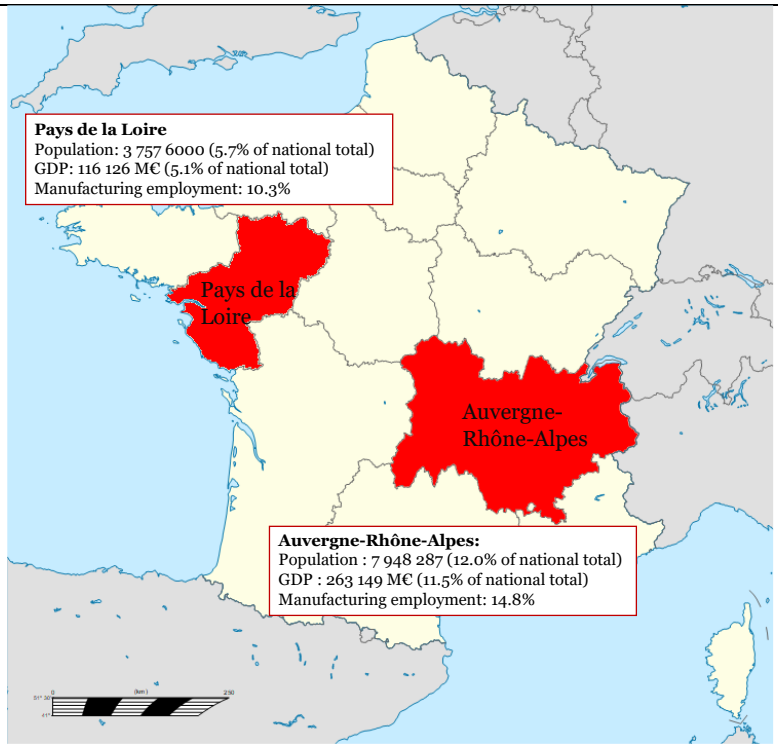
	more remotely located areas can 'leap-frog' if to take digitisation as a tool to build a stronger international competitive advantage.
Sectoral preconditions	Metal-processing sector is significantly less ready for digital transition due to historically low-value added firms. However, both regions (and country as a whole) is characterised by business demographics and structures that are not favourable to digital transformation: too many micro-firms, few clusters, too many sub-contracting jobs. The **Southern** region with wood-processing industry can be better positioned since the cluster has already formed and many firms further upgrade towards own product development.
Social preconditions	Greater interest among the younger generation in jobs in more traditional sectors and in working with digital technologies in more traditional sectors is lacking. The technological readiness of population is nevertheless very much in favour of digital transformation due to a wide use of digital financial and public services. **Southern** region has a lower technological readiness relatively to the **Northern** region due to more active traditional sectors that dominate the regional production structure. **Northern** region, due to many more industries, make switching between high-skills jobs faster. Northern region provides significantly more information/knowledge infrastructure (trade fairs, seminars, conferences) which can also affect technology readiness of population and of firms. ICT cluster located in the **Northern** region is also very active in Industry 4.0 popularisation and very few of such activities are happening in the **Southern** region.
Policy preconditions	Application of ICT technologies in industrial sector is mentioned in a footnote in 'Made in Estonia 3.0' strategic document as an example of horizontal application of ICT across economic sectors: automatics and robotization, software development and cyber security. The strategy recognises the need to increase productivity and attract foreign investments, to which end ICT can contribute by 'making industries more efficient. More explicit notion of Industry 4.0 and the potential of ICT technologies to increase industrial competitiveness is made in the first industry strategy document, published in December 2017. The Industrial Strategy Green Paper has a rather broad wording and does not specify targeted sectors or any sector-specific strategies. Digitisation of industry is increasingly regarded as a policy priority and as a tool to increase national competitiveness. It is explicitly acknowledged that as a small and open economy, Estonia can no longer compete based on factor costs, such as skilled and cheap labour. A number of strategic and programme documents identify the limitless potential of ICT sector to spur productivity increase in other sectors and industries, including public sector. In doing so, ICT sector can leverage on already existing notable achievements in digital public services (i.e. eGovernance and eHealth) as well as digital financial services (e.g. online banking). Application of ICT in the industrial sector and services features in a number of strategic documents but it has been considered as part of a broader 'digital society' or 'digital economy' agenda, where ICT is perceived as a set of horizontally deployed technologies.
Actual transformations in the region	
Economic transformation	The deployment and use of enabling ICT technologies and infrastructure has been fast and successful. This is reflected in high penetration of broadband internet, mobile telecommunications and widely used online and mobile banking services. In addition, Estonia has been successful in building a robust and effective digital governance infrastructure, including provision of a large variety of digital public services. Despite these positive dynamics, the private sector scores generally low in the use of ICT for doing e-commerce, marketing and other business- and trade-related services. The regions differ in terms of economic and technological performance due to composition of regional industrial base: the lion share of industrial output is produced in the **Northern** region. The only higher education institution specialising in engineering and technology – Tallinn University of Technology – is also located in the **Northern** region. Firms with higher productivity are located also in the Northern region, although higher productivity of Tallinn-based and Tartu-based firms are comparable. This

	speaks of stronger urban/rural rather than regional divide when comparing economic transformation of the Northern and **Southern** regions. The **Northern** region is the most dynamic and its economic structures are most diversified. The share of services in the regional economy in the Northern region is the highest (over 75%) and has been growing. This share is comparable with similar levels of the tertiary sector in Tartu county but not with the **Souther**n region as a whole, where it is lower. The Northern region demonstrates higher internationalisation of business firms and therefore highest share of total exports. The growth of regional GDP per capita is nevertheless similar between the regions during 2012-2017: 34.3% for the Northern region and 33.6% for the Southern region. Entrepreneurship indicators are the highest for the Northern region: 136 business units per 1000 inhabitants while for the rest of Estonian regions the share is 62/1000, as of 2018. The only exception is Tartu county, which makes the indicator slightly higher for the **Southern** region but still far lagging behind the Northern region. In other words, the growth of entrepreneurship activity has been confined to the two urban centres – Tallinn and Tartu – and reflect urban/rural divide with no active rebalancing effects stemming from regional development.
Social transformation	**Northern** region and Tallinn have been experiencing population growth: +6.2% during 2007-2013 while all other regions in Estonia have been experiencing decrease in population. Tallinn is the centre for higher international education and work mobility: there are many more large international companies and more international degree programmes offered in English in the **Northern** region. The share of employment in industrial sector in the Northern sector has been slightly decreasing during 2007-2013. At the same time, the total level of employment in the counties of the **Southern** region has been growing for the last three years and the highest growth of participation in the labour market was registered in the **Southern** region (over 10%). Although some of Southern counties demonstrate the highest levels of unemployment (8-9%).
Actual and potential impacts	
In the sector in the region	There are more high-performing and digitally advanced firms in wood-processing than in metal-processing in Estonia overall. But since wood-processing is located in the South and has a more significant impact / importance on the **Southern** region and metal-processing has on the **Northern** region, there are greater risks of unemployment (if less digitised companies will go out of business) in the south than in the north. But wood-processing workers can easier switch/retrain for related sectors such as forestry, furniture, etc. In metal-processing the switch is less easy. Therefore depending on policy support measures (retraining, digitisation support), these processes can offset potential negative effects. The potential effects of Industry 4.0 in the southern region might be more visible due to smaller density of production on the whole. In the North, industry 4.0 can help create linkages between large foreign-owned firms, create more KET jobs, help reorient more of ICT firms towards the needs of local industrial firms. Technology-induced unemployment risks are higher in the South than in the North. Both sectors and in both regions require similar skills: production managers and line operators with a greater variety of digital skills (CAD, product design and related adjustments in production, ability to understand and work with tech specifications of products and production). Sector-specific digital skills are needed.
In other sectors in the region	In the **Northern** region, at the moment Industry 4.0 contributes to polarisation of productivity and value-added between large subsidiaries of foreign manufacturing companies and small local companies; it also makes local ICT companies sell Industry 4.0 services abroad rather than domestically. It is creating more niche, sector-specific digital skills and demands more of such professionals. It creates pressure especially on applied education institutions but also on higher education institutions to produce managers with sector-specific digital competences. This is visible on both regions. In the south region the shortage of these skills is more visible because of few industrial sectors. Especially in metal-processing the divide between manual operations and digital becomes more apparent, as

	well as between digitising and non-digitising firms. Therefore, so far, most important impacts of Industry 4.0 have been related to polarisation of skills, profitability, local-foreign capacities. This is especially seen in the North. In the **Southern** region, wood-processing sector contains a higher share of truly innovative firms and firms with higher value-added finished goods (e.g. log houses), which makes polarisation of skills and markets less apparent.
In the region	Loss of markets, firms, and downgrading of skills is more probable in the **Southern** region on the whole due to fewer industrial activities and a greater number of traditional industries operating in the region. More high-skilled jobs are located in the North and therefore productivity growth, employment is more pulpable in the **North**. Further polarisation between the regions is therefore very plausible, unless more active sectoral and regional policies will take place.
Future outlook on 4.0 technologies	In the ICT sector there will be further polarisation: more of Estonian ICT companies will be selling products and services to foreign industrial firms; but if domestic digitisation in industrial sector will be happening faster, there will be morel links between domestic ICT and domestic (non-ICT) industry. In case smaller local firms in metal-processing start digitising, there might be more links between large foreign companies/subsidiaries operating in Estonia and local small firms. This will further create within-industry demand for small firms to digitise. In wood-processing sector, digitisation can bring even stronger position on international and regional markets, and to increase the sector's contribution to the upgrade of other related sectors (materials, furniture, etc.).
Best practices	Estonia is a very small country and therefore practices applied in one region can be applied in the same sector in another region. In wood-processing, high-tech greenfield investments and managerial decisions to invest more into own product design can be easily adopted in the neighbouring region of Central Estonia, where wood-processing is similarly important economic sector and employer. In metal-processing sector, a more strategic approach towards optimisation of production through digitisation and attracting high skilled engineers can be easily adopted in other regions in Estonia, such as Eastern Estonia, which experiences high rates of unemployment due to post-Soviet de-industrialisation.
Operational policy recommendations	Operational policy recommendations include the following • Re-assessment of industrial policies and developing a more strategic take on facilitating structural transformation, increase in productivity and value-added. • Developing a strategy for increasing digital skills of the business sector and a set of indicators for monitoring the use of digital governance services and other digital services, including e-commerce, among business firms. • More accurate operationalisation of what Industry 4.0 means for Estonia, in terms of more narrowly defined sector-specific applications (groups of technologies, services, etc). • Reforming teaching and training curricula in industrial professions (including retraining programmes) in order to incorporate automation and sector-specific digitisation knowledge. • Popularisation of jobs in traditional sectors (such as wood-processing) among the youth. • Developing new sets of technical standards for product development and production processes to incorporate modern digital methods and technologies. This would help both, companies and education establishments. • To re-consider technological impacts, both positive and negative, on regional development and incorporate digitisation and automation into regional strategies with targets, sectors and goals set.

2 Summative table for France

	Key messages by country
Setting the scene	
Regional baseline	**Pays de la Loire region** The Pays de la Loire region has more than 1.5 million jobs in 2015, spread over nearly 320,320 establishments (5.0% of the national total). The region has some sectoral specificities. Agriculture accounts for 3.8% of jobs in Pays de la Loire, compared with 2.4% in metropolitan France. Industry, which accounts for 16.4% of jobs, is also more represented in the region than at the national level (12.2%), unlike some service activities. Regional employment is concentrated in a few companies, many of which are active in industrial production. The region's productive capacity is structured around a core network of medium-sized companies. The region also stands out for its recovery from the economic crisis, thanks to its diversified economy and industries, the recent redeployment of its production capacities, and its trend towards servitization. With a GDP of 106.7 billion euros in 2014, it is also the eighth richest region by GDP in France and accounts for 5.1% of the national added value. Between 1994 et 2004, Pays de la Loire has had a higher GDP growth than the national level, displaying its economic dynamism despite a slowdown since 2008. The unemployment rate reflects the good economic performance of the region: in 2017, the region had an unemployment rate of 7.1% (lowest in France), 2.3 percentage point below the national average (9.4%). The service and the industrial sectors are the most important in terms of added value (respectively 49.6% and 17.8%). The region is the third-ranked industrial region in France (13.9% in metropolitan France), with industrial activities producing 17.8% of regional added value. In terms of infrastructures, 77% of regional households have access to broadband, compared to 79% at the national level (Eurostat, 2018). **Auvergne – Rhône-Alpes region** Auvergne-Rhône-Alpes is the second richest region, with an annual GDP exceeding 250 billion euros, that accounts for 11.6% of the national total and makes it the 4th European region. In 2017, the unemployment rate is 7.5%. It is the first French region in terms of volume of industrial jobs (490,000 jobs). The diverse business portfolio has numerous strengths in cutting-edge activities such as machines and other solutions for the 4.0 Industry, digital, electronic components, energy, pharmacy and medical technologies, bar turning, plastics technology, eco-technologies, etc. It is the 2nd French region in terms of R&D expenditure in 2016 (7.0 billion euros) and of number of patent applications in 2018 (2,689). Three industrial sectors are the main focus of the research and development: manufacture of components, electronic boards and computers, manufacture of plastic and rubber products, and manufacture of electrical equipment. 22.1% of the total French number of European patent applications come from Auvergne-Rhône-Alpes, mainly in the field of chemicals and materials, electronics and electricity and instrumentation. In Auvergne-Rhône-Alpes, regional authorities and stakeholders have identified "connected and automated mobility" as a grand challenge for the region. Auvergne-Rhône-Alpes is a leading region as the scientific base is very strong. In 2017, transport accounted for 11% of regional patent applications. The region hosts public research centres that are internationally recognized as well as industrial players like Michelin, Renault Trucks, Alstom, Iveco, Forcity and Navya. In total, 800 companies are part of this sector in Auvergne-Rhône-Alpes, corresponding to 130,000 jobs.

	
Adopted 4.0 technologies in the sector in the region	**Types of 4.0 technologies involved in the case study sector** **Pays de la Loire region** • According to the interviewees, the technologies introduced in the Pays de la Loire region are essentially those developed in the Techno Campus, namely: virtual reality, acoustics, electronics and the Internet of connected objects, immersive reality, composite reality / production / biotech / energy, and robotics. • The Pays de la Loire region is certainly not leader in robotics, electronics or even virtual reality, but it is one of the only regions in France that has all the bricks of solution providers in its territory. This is what distinguishes it from other French regions. **In Auvergne** – Rhône-Alpes region, the following technologies have been adopted: • Surface engineering, advanced manufacturing processes, intelligent systems, robotics and engineering driven by uses and services • Advanced manufacturing processes and autonomous production cells • Mechatronic (B to B sub-assemblies, B to C products and industrial robotics) • Virtual reality, additive manufacturing, cobotics, artificial intelligence, big data and connected objects **Types of potential socio-economic transformation due to the adoption of 4.0 technologies in the sector** • **In Pays de la Loire** region, the digital transformation of the economy as well as new usages (mobile, e-commerce, media, etc.) generate many software, application or website development projects. More and different skills are needed at all levels of positions. There is an especially high demand for research engineers. • **In Auvergne** – Rhône-Alpes region, according to interviewees, it is clear that 'connected and automated mobility' domain does not fully overlap with the transport sector. In other words, it is not expected that companies from this sector will be fully and only oriented towards connected and automated mobility. Rather, what

	is expected and targeted is that leading companies will go into that direction and will compete at international level while a large share of actors will carry on developing 'traditional' products or services while adopting 'generic' 4.0 technologies in order to strengthen their competitiveness **4.0 technologies that have been adopted in the sector and in the region** • **Pays de la Loire**: through the applications for financing or support submitted to the Regional Council, it is possible to see on which technologies companies are positioning themselves. Overall, there are two main themes that stand out. On the one hand, automation (it involves upgrading processes and reserving human intervention on the most complex subjects – this includes in particular connected objects, intelligent machines, etc.), and on the other hand, chain control in their processes, with, for example, Enterprise Resource Planning (ERP) or step-by-step cost controls. • **Auvergne – Rhône-Alpes** region: the robotization and digitalisation of the processes are the newest technologies introduced by industrial companies in their daily practices. Some companies are considering using SaaS to machine tool. Many companies consider integrating IoT and additive manufacturing. **Were 4.0 technologies produced by adopting firms or bought from producing firms? If directly produced, for what reasons?** **Pays de la Loire**: to answer this question, it should be recalled the two aspects of regional intervention to promote technological transformation and technology transfer: • The first regional intervention is about the development of the "solution providers" sector. They are a significant number in the Pays de la Loire region. They are an engine of growth and make it possible to have technical solutions on site close to regional companies, while anchoring these companies in the territory, and also by fixing and developing their skills according to needs. In concrete terms, it is about highlighting and enhancing existing regional know-how and skills. This component takes the form of actions to support and finance regional companies, as well as the networking of regional Techno campuses. These Techno campuses are shared research and technological innovation platforms bringing together large companies, SMEs, research centres, academic actors, competitiveness clusters, technical centres, clusters... They are dedicated to a key theme with an ambition of regional and national, or even international, influence. In order to better disseminate innovation and new technologies in all companies, and to strengthen technological excellence in manufacturing, the Pays de la Loire Region has decided to network its Techno Campuses. Indeed, this networking should enable regional companies to acquire a technological edge by combining the expertise of the various Techno Campuses. This networking therefore implies the enhancement of the technological themes promoted by the Techno Campuses, the identification of the Techno Campuses during sector-related events, the dissemination to SMEs, as well as the development and enhancement of the regional manufacturing service offer, for all the Techno Campuses and themes represented. • The second component of regional intervention to promote technological transformation and technology transfer, is the appropriation by traditional segments of the economy of these technological transformation segments to enable them to develop and grow. Indeed, the Pays de la Loire Region is aware that traditional companies must not miss these transformation stages to survive. And the sooner they do so, the sooner they have a positive impact on the territory. The traditional sectors identified by the region are industry and trade, and also, services. To this end, the Region has set up an individual support programme which

	is organised in several stages. It is a financial incentive, as well as a human support. It is supported by the delegated operators in the territories that are concretely located in the Techno Campuses, real regional platforms of expertise. It should be noted that the key areas of intervention of the Region in this field are as follows: digital, robotics, advanced production technologies. • So, everything is done to ensure that 4.0 technologies are developed by regional solution providers and then adopted by other companies. **Auvergne – Rhône-Alpes region**: Most likely, 4.0 technologies were not and are not produced by adopting firms. Adaptors are rather integrators of produced technologies. **Were 4.0 technology suppliers local/national/international?** **Pays de la Loire region**: Everything is done to ensure that 4.0 technologies are developed by regional solution providers and then adopted by other companies. **Auvergne – Rhône-Alpes region**: One objective / challenge is to produce (some of) these technologies regionally before they are adopted by regional actors
Preconditions for transformation	
Regional preconditions	**Pays de la Loire region** • First, interviews highlighted the strong cultural heritage of industrial collaboration in the Pays de la Loire region. This precondition is not specific for this sector, but it is for this region. • The density of structures, such as Technology Resource Centres, Technical Platforms or Techno Campuses on the territory, which provide thematic and local support to companies, was also mentioned: - The 10 inter-regional competitiveness clusters and particularly Images et Reseaux (Digital) - Research laboratories from national public research organisations - The community of universities and higher education institutions "Bretagne-Loire" (COMmunauté d'Universités et d'Etablissements - ComUE). In the ComUe, three universities are in Pays de la Loire: University of Nantes, University of Angers, and the University of Maine. The University of Nantes is an important research hub, with different doctoral schools in different fields and notably on of sciences and technologies and social sciences - The University of Nantes also has an innovation department in charge of research valorisation, which ensures technological transfers and collaborates with seven of the regional competitiveness clusters. It also collaborates with the Technology Acceleration Transfer Company Ouest Valorisation (Société d'Accélération du Transfert de Technologie, SATT) a public institution in charge of valorising public research and promoting technology transfers. - The region also hosts the "Jules Verne", an Institute of Technology that is specialised in advanced materials. • 'Furthermore, the Pays de la Loire institutions have set up various formal policy coordination tools that gather a large array of actors who are used in the definition of regional strategies impacting the industrial sector: regional conference on economy and sustainable employment (CREED), Regional consultative committee for RTD (CCRDT), and so on'. • 'Enterprises are also engaged in the policy planning and implementation in various ways, either through the participation of industry representatives in the above-mentioned commissions, or in co-financing major regional projects (for example, Techno Campuses). Finally, coordination is organised through multi-annual contracts (state-region contract plans), between the state and the

	local authorities or between public authorities and the industrial stakeholder in a given sector.' • The complementarity of the financing offers proposed by the Regional Council and Bpifrance (French Public Investment Bank), as part of the support for these digital transformations, is also one of the keys to success that were put forward by the stakeholders interviewed. • The region is a favourable territory for the creation of start-ups on these themes, especially since many training courses in electronics, computer and information technology professions are offered in the region. **Auvergne – Rhône-Alpes region**: • The region owns all preconditions necessary for 4.0 technologies adoption that is to say an industrial fabric, institutional actors supporting the sector, human skills and a good level of cooperation among actors. • The Auvergne-Rh√¥ne-Alpes region hosts a lab dedicated to urban mobility: Transpolis. The 80-hectare field enables to experiment numerous scenario essential for the development of connected, automated or even autonomous vehicles that require an adapted and modular "playground" in a single place. The region also hosts a platform dedicated to smart vehicles: Pavin. It is defined as an experimental site for the development and testing of fully automatic vehicles. If the development of autonomous vehicles come to fruition, it will have important socio-economic consequences on the urban development and the automobile industry, amongst others. • Auvergne-Rh√¥ne-Alpes is an acting member of the "interregional partnership on batteries", a project supported by the European Commission since the end of 2018. It aims at accelerating the volume manufacture and deployment of advanced materials and battery cells using sustainable and competitive technologies, for mobile and stationary batteries across Europe between now and 2025. The implementation of the research will have economic consequences on sectors relying on advanced materials and battery cells.
Sectoral preconditions	**Pays de la Loire region** • The development of the "solution providers" sector. They are an engine of growth and make it possible to have technical solutions on site close to regional companies, while anchoring these companies in the territory, and also by fixing and developing their skills according to needs • The networking of regional Techno campuses. These Techno campuses are shared research and technological innovation platforms bringing together large companies, SMEs, research centres, academic actors, competitiveness clusters, technical centres, clusters... They are dedicated to a key theme with an ambition of regional and national, or even international, influence. In order to better disseminate innovation and new technologies in all companies, and to strengthen technological excellence in manufacturing, the Pays de la Loire Region has decided to network its Techno Campuses. Indeed, this networking should enable regional companies to acquire a technological edge by combining the expertise of the various Techno Campuses. This networking therefore implies the enhancement of the technological themes promoted by the Techno Campuses, the identification of the Techno Campuses during sector-related events, the dissemination to SMEs, as well as the development and enhancement of the regional manufacturing service offer, for all the Techno Campuses and themes represented. • The main thematic of the Techno Campuses in Pays de la Loire region are: virtual reality, acoustics, electronics and the Internet of connected objects, immersive reality, composite reality /

	production / biotech / energy, and robotics. • The supportive policies implemented for digital sector: the region co-finances, with the Departmental councils, the construction of telecommunication infrastructures that, among other things, strengthens the competitiveness of digital players and the regional attractiveness. • The support of the regional digital industry ecosystem by recognized laboratories, namely the RFI AtlanSTIC 2020, the Jules Vernes Technological Research Institution and Regional Innovation Platforms, positioned on themes with high development potential such as software engineering, decision-making, big data, as well as virtual, augmented and mixed realities. • The structuring and coordination of the sector at the regional level in order to strengthen exchanges with the actors of the so-called traditional economy. • Overall, the following observation is made: "the more market pressure there is, the more the adoption of technologies is a question of survival and therefore a priority for the companies concerned". **Auvergne – Rhône-Alpes region**: • The main issue is related to the IT culture / literacy which is rather low in French SMEs in particular among SMEs managers who are often reluctant to digitalisation • Besides, the existence of Transpolis, the lab dedicated to urban mobility, and of Pavin, a platform dedicated to smart vehicles, is a strong enabler for the 4.0 technologies adoption in the automobile industry.
Social preconditions	**Pays de la Loire region:** Anticipating the skills required to deploy technological transformations is an essential factor. It is either the development of the necessary training on the territory, or the ability to recruit the required skills within companies. The Pays de la Loire region is experiencing a skills shortage in some sectors, which has the effect of limiting companies in their development projects. **Auvergne – Rhône-Alpes region:** According the interviewees, the sector has become increasingly important in the region, and has generated as many jobs as the four main regional industrial sectors combined (Chemicals-Rubber-plastic / Metallurgy-Metalworking / Manufacture of machinery and equipment / Agro-food) between 2016 and 2017 (3,000 new jobs). Besides, Auvergne-Rhône-Alpes hosts plenty of technology platforms that bring together resources (premises, services and human capital) made available to users, in particular companies, for R&D and innovation projects.
Policy preconditions	• **Pays de la Loire region:** • A major reform of the territorial organization (Act No. 2015-991 of 7 August 2015 on the new territorial organization of the French Republic (known as loi NOTRe)) has made the Region the leader in economic development. • One of the main policies supporting industry is the Regional Scheme for Economic Development, Innovation and Internationalization (SRDEII) (2016): The region's ambition is to develop local employment so that new opportunities can benefit all companies and territories. It has four main priorities: to bring out the SMEs of the future, to make major changes a driving force for production, to make training the guarantee of tomorrow's jobs, to make territories real levers for growth. • The 2014 – 2020 SRESRI (Regional Scheme for Higher Education, Research and Innovation) is also addressing innovation through public research. It tackles innovation through two of its four objectives: Allow research to contribute to economic development by supporting research and reinforcing synergies with the private sector; Valorise research to ease its transfer to the private sector.

	• The Smart Specialization Strategy (RIS3) has identified six areas of smart specialization: advanced production technologies for industrial transformation, maritime industries, food and bio-resources, information technology and electronics, design and cultural and creative industries, and health. • The network of French Chamber of Commerce and the national association Industry of the Future Alliance (Alliance Industrie du Futur) have created the "directory of solution providers for Industry 4.0" • The Industry of the Future, a national program of industrial excellence: On July 20, 2015, the Industry of the Future Alliance was officially created. Its role is to support French companies, and in particular SMIs, in the modernization of their industrial tools and the transformation of their economic model by new technologies, while placing the human being at the heart of the process. • The Pays de la Loire Region has allocated more than EUR 125 million (570 business projects financed) under this Industry of the Future Plan, including EUR 73.8 million for the training of operators of the future, EUR 31.4 million to strengthen regional technological excellence, EUR 13.7 million to modernise companies' production facilities, etc. This financial commitment facilitates all stages of a company's progress towards greater competitiveness: automation of production facilities (robotics/cobotics), industrial organization, digitization and digitalization, operator of the future. • The Pays de la Loire region was the first French region to be awarded the "French Fab" label in the summer of 2017. This label promotes industrial activities among young people, develops and promotes the excellence of regional industry, and encourages industrialists to develop commercially collectively, both nationally and internationally • At the same time, the "French Fab Tour" has been developed as a travelling tour to promote the industry, encourage vocations among young people, propose job offers and co-construct the industry of tomorrow. It started in January 2019 from the Pays de la Loire (in Laval), then went to the main cities of the region, before being duplicated on a national scale. • **Auvergne – Rhône-Alpes region:** • A major reform of the territorial organisation (Act N2015-991 of 7 August 2015 on the new territorial organisation of the French Republic - known as loi NOTRe) has made the Region the leader in territorial economic development. The 2017-2021 Regional Scheme for Economic Development, Innovation and Internationalisation (Schéma Régional pour le Développement Economique, l'Innovation et l'Internationalisation, SRDEII), published in 2016, aims at making the region a digital and an industrial leader in France and in Europe. To support that goal, one horizontal objective is to support innovation and the digital revolution in the region. The Auvergne-Rhône-Alpes region aspires to play a leading role in the partnership between local authorities and economic actors, to encourage the grouping of structures to create more added value and increase the leverage effect of regional financing, and to put companies at the heart of the public action and propose a responsive, flexible regional authority that guarantees territorial balance. • In 2014, the French Government launched the New Industrial France plan (Nouvelle France Industrielle) aiming at modernising the industry by transforming its business model through digital technology. There are 9 industrial solutions to major economic and societal challenges: data economy, smart objects, digital confidence, intelligent food, new resources, sustainable cities, ecological mobility, medicine of the future, and future transport. On 34 schemes included in that plan, the Auvergne-Rh√¥ne-Alpes region chose them all and launched its own Factory of the Future

	plan (Usine du Futur) in 2014. That 3.2-million-euro plan aims at supporting 200 SMEs in 3 years in modernising their production and information systems and their work organisation. Within that scope, the Auvergne-Rh√¥ne-Alpes has implemented two programmes to support companies' automatization and robotization projects, Performance SME (Performance PME). • In 2015, the national association Industry of the Future Alliance (Alliance Industrie du Futur) was officially created. Its role is to support French companies, and in particular SMIs, in the modernisation of their industrial tools and the transformation of their economic model by new technologies while placing the human being at the heart of the process. The Working Group on the Development of the Future Technology Offer then identified the seven key technologies for the development of the Future Industry in France in the form of technical sheets. These are: value chain digitization, automation / transitics / process robotics, additive manufacturing, monitoring and control, composites and new materials / assemblies, the place of man in the factory, energy efficiency and the environmental footprint of companies / integration into the ecosystem. After three years, the Industry of the Future Alliance and its 35 members updated its guide in March 2018 to include aspects that also involve the environment related to value chains and the transformation of companies' business models through the contribution of digital technology. • The network of French Chamber of Commerce and Industry and Industry of the Future Alliance launched the "directory of solution providers for Industry 4.0". Indeed, very small businesses, SMEs and companies of intermediate industrial sizes are faced with the challenge of modernising the national productive apparatus, i.e. moving up the range, creating more added value, increasing the adaptability of means of production, and transforming business models. This modernisation often requires them to combine several technological breakthroughs and integrate the best level of robotics, augmented reality, 3D printing, digital simulation, industrial internet, etc. The directory thus lists companies established in France and marketing products, services and solutions that appear in the Industry of the Future technology bricks of repository for industrial companies. In Auvergne-Rhône-Alpes, 183 solution providers are listed, making it second behind the Grand Est region. • During the second Digital Summit in Lyon in 2018, the Auvergne-Rhône-Alpes Region and Bpifrance announced that the French Fab was to be implemented regionally. It is bound to be a complete support system for industrial companies, MSMEs and mid-caps, in terms of innovation and digitalisation, ranging from diagnosis to dedicated financing and support. It supports the digital transformation of the industrial fabric, such as the Regional Digital Factory (Usine Num√©rique R√©gionale, UNR) to test new industrial control software. This alliance is materialised by a loan that includes a regional investment of EUR 15 million and that will generate a volume of EUR 75 million of interest-free and without any specific guarantee for the working capital needs of companies linked to their growth or their intangible investments . • In 2007, an open national Research Group in Robotics was established by the CNRS. One of the working groups is focused on autonomous vehicles. This paved the way to the "France Robot Initiatives" Plan announced in 2013 that, among others, has the objective to "robotise the automotive sector to restore the competitiveness of the sector" . In Auvergne-Rhône-Alpes, the regional authorities support a regional cluster, COBOTEAM, since 2015. The cluster has the duty to network the 500+ actors involved in robot projects that is to say related to cobotics (collaborative robotics), robotic subsystems, mobile platforms, navigation, motion and trajectory planning systems, artificial intelligence and complex data processing, sensors, energy management and autonomous motion, drones, robotic

	architectures and technology integration, personal, play and leisure robotics. Market applications include transport. • All in all, the national and regional support system towards technological transformation in the industrial fabric in Auvergne-Rhône-Alpes is strong, which illustrates the importance of this issue.
Actual transformations in the region	
Economic transformation	**Pays de la Loire region:** • According to the stakeholders interviewed, companies that have adopted 4.0 technologies have had to anticipate the recruitment or training of new skills needed for this development. To this end, many of them have also participated in the definition of regional training plans by sector, in order to express their need for the necessary skills. • According to the interviewees and the Economic Development Department of the Pays de la Loire Region, companies supported in their development, adoption or transfer of technologies through the various public measures involved, experience an increase in their turnover in the following years. This development is also often accompanied by job creation. • Auvergne – Rhône-Alpes region: • With the progressive 4.0 technologies adoption, companies required skills such as additive manufacturing and robotics that are still scare in the region. • According to a 2019 European report on SMEs and digitalisation, 'Although a majority of French SMEs, especially digitalised ones, are aware that digital transformation is necessary to remain competitive and expect a positive impact of digitalisation on their future business activity, most business owners or senior managers do not make digitalisation a top priority' . This statement most likely applies to 4.0 technologies. • Which market relationships were affected by the adoption of 4.0 technologies and how these changes took place? e.g. enlargement of the own market, changes in the relationships with suppliers and customers • Pays de la Loire region: • Companies that have adopted 4.0 technologies have often forged links within the regional ecosystem (whether between solution providers and companies seeking transformation, or also between companies to benefit from feedback). These contacts are usually made either through events or in dedicated locations that promote cross-fertilization and collaboration between traditional sectors and technology providers, and research laboratories (such as Techno campuses). **Auvergne – Rhône-Alpes region**: Information unavailable
Social transformation	**Pays de la Loire region:** • The need to develop attraction and training of young people, on skills that are highly sought after by companies. To this end, training plans have been defined. • The actors interviewed stressed the need to stop the industry bashing and to speak positively about the industry, and to show that industrial companies recruit, create and innovate. To this end, actions to promote these professions (including 4.0 industry jobs) are implemented throughout the Pays de le Loire region via the "French fab" business clubs and the involvement of business leaders. • The development of new uses (mobile, e-commerce, media, etc.) among the population. **Auvergne – Rhône-Alpes region:** • The CETIM provides a specific training on additive manufacturing

	to those who are already skilled in sintering; and local companies work with schools to develop new curriculums on additive manufacturing related to sintering, chemicals, powder metalworking, but skilled people will need several more years to graduate and enter the job market. • To face the lack of additive manufacturing and robotics skills, companies recruit foreigners
Actual and potential impacts	
In the sector in the region	**Pays de la Loire region:** • Companies supported in their development, adoption or transfer of technologies through the various public measures involved, experience an increase in their turnover in the following years. This development is also often accompanied by job creation. • To date, there is no evaluation of the regional mechanisms/schemes put in place, which makes it more difficult to analyse this impact. • The digital transformation of the economy as well as new uses (mobile, e-commerce, media, etc.) generate many software, application or website development projects that lead to a high demand for research engineers. According to" Pôle Emploi" , this profession is subject to strong recruitment tensions in the region, particularly for profiles with a baccalaureate + 5 years of higher education sought by companies. **Auvergne – Rhône-Alpes region:** • Employment is increasing in niches, such as leather work and metal products for the construction industry. On the contrary, the decline is stronger in the manufacture of transport equipment. • Most of the sectors surveyed benefited from an improving business flow and improved operating margins. • All in all, however it is impossible to measure the impact of adoption of 4.0 technologies on employment and turnover. Most likely, it remains very limited. • Clearly, adoption of new technologies can imply decrease in unqualified employment. For that reason, the regional institutional actors put a strong emphasis on developing curricula and training programmes to increase expertise and qualifications of the regional population. • It is not possible to precisely identify whether and what skills were destroyed. The additive manufacturing and robotics skills have been required by the sector in the region but more traditional skills (such as boiler making) are still very much required. • Industrial investments are on hold after the economic catching-up period in 2017: rubber-plastic, textile and metalworking segments have been impacted by the contraction in domestic and foreign orders. This delays the adoption of 4.0 technologies and, thus, their potential impact
In other sectors in the region	**Pays de la Loire region:** • Expected impact of introducing new technologies into companies are: competitiveness and attractiveness. • According to the interviewees and the Economic Development Department of the Pays de la Loire Region, companies supported in their development, adoption or transfer of technologies through the various public measures involved, experience an increase in their turnover in the following years. This development is also often accompanied by job creation. It should be noted that the Region understands this support approach is very often possible for companies that are already doing well. This type of impact should therefore be delayed for them. • It should also be recalled that the Pays de la Loire region has the lowest unemployment rate in France (7.1%), and that the share of industrial employment in its regional economy is high with 16.4% of jobs (against 12.2% nationally). These two data have been very resilient for decades, which means that the public policies

	deployed in this region and the dynamism of the ecosystem are consistent with the needs of companies. • But to date, there is no evaluation of the regional mechanisms/schemes put in place, which makes it more difficult to analyse this impact. **Auvergne – Rhône-Alpes region:** • It is possible to distinguish the big players that were forging ahead for the adoption of 4.0 technologies and the SMEs composing the supply chain which are lagging behind to that regards. This applies to all sectors, of which the automotive and industrial vehicle sectors. The regional economy has enough industrial producers of new technologies and has plenty of measures to support SMEs in the process of adoption of those technologies. Thus, the missing link does not come from the public and institutional support but from the willingness of SMEs to enter into such a process of change. • While the large companies compete at the international level and are often at the research frontier irrespectively of the industrial sector, SMEs are more "traditional" and less keen-on adopting new technologies or innovating in general. The idea that innovation means increase in costs, decrease in profitability and, eventually, the death of the company is still largely spread in France within SMEs. • This said, it is impossible to precisely identified the impact on 4.0 technologies on employment, turn-over, labour force, unemployment risk, skills created and destroyed. To our knowledge, there are no precise objectives in that regard (and as a matter of consequence the expected results of individual actions/schemes have not been identified either)
In the region	**Pays de la Loire region:** To date, there is no evaluation of the regional mechanisms/schemes put in place, which makes it more difficult to analyse this impact. **Auvergne – Rhône-Alpes region:** Industrial investments are on hold after the economic catching-up period in 2017: rubber-plastic, textile and metalworking segments have been impacted by the contraction in domestic and foreign orders. This delays the adoption of 4.0 technologies and, thus, their potential impact
Future outlook on 4.0 technologies	As regards technological transformation, national and regional policies have two legs. One is dedicated to the support of companies to adopt new technologies. This includes several types of actions: investment support, provision of technology in technical centres for SMEs, training programmes. The aim is to enable enterprises, and in particular SMEs, to strengthen their competitiveness. To a certain extent, this is a defensive policy to maintain or increase employment in industry. The targets are SMEs in traditional industrial sectors. The second leg of the policies is oriented towards the support of high-tech sectors. The aim is to support an entire sector in order to create national and global leaders capable of developing and adopting the most advanced technologies. **Pays de la Loire region:** as regards SMEs, the more market pressure there is, the more the adoption of technologies is a question of survival and therefore a priority for the companies concerned. Pays de la Loire region: as regards SMEs, the more market pressure there is, the more the adoption of technologies is a question of survival and therefore a priority for the companies concerned. The strategy to support the production of technologies and importance of the regional the industrial fabric are two conditions **Auvergne – Rhône-Alpes region**: The strategy in Auvergne-Rhône Alpes is to strengthen competitive advantages in several industrial sectors considered important for the region's industrial future. The choice of the

	transport, mobility and logistics sector should ultimately enable regional players to be champions in Europe and to sell the technologies (and associated services) in other regions. Inter-sectoral flows are also possible but probably less important than intra-sectoral but extra-regional flows.
Best practices	**Pays de la Loire region:** • The development of the "solution providers" sector: They are a significant number in the Pays de la Loire region. They are an engine of growth and make it possible to have technical solutions on site close to regional companies, while anchoring these companies in the territory, and also by fixing and developing their skills according to needs. In concrete terms, it is about highlighting and enhancing existing regional know-how and skills. • The appropriation by traditional segments of the economy of these technological transformation segments to enable them to develop and grow. • So everything is done to ensure that 4.0 technologies are developed by regional solution providers and then adopted by other companies. **Auvergne – Rhône-Alpes region:** • The Region's strategy is very relevant in that it is twofold with regard to the transport, mobility and logistics sector. On the one hand, it aims to support the technological development of the most RDI-intensive players at the frontier of technology. This enables the emergence of future champions in the sector. At the same time, it is a question of helping traditional companies in the sector to adopt new technologies, particularly SMEs, which are often the furthest behind in terms of these technologies. The objective is then to help these companies to strengthen their competitiveness and ultimately to survive in international competition. The cluster organization allows to have all the actors of the sector and to develop support actions according to these two types of sectoral actors. ….. • Preconditions of transferability of these best practices • In the case of Pays-de-Loire, preconditions are the existence of a strong traditional industrial fabric which provides earlier adopters of regionally developed technologies. In the case of Auvergne Rhône-Alpes, preconditions are the actors already installed in the regional economy. Without these actors, the strategy would necessary to create these actors from scratch which seems impossible to do.
Operational policy recommendations	**For private actors (i.e. firms involved in the transformation)** Support companies to set-up action plans in favour of adoption of new technologies. Emphasis should be put on the need to change the view of new technologies. They should be understood by companies as investments and not costs. Develop policy measures to attract and train of young people, on skills that are highly sought after by companies To stop the industry bashing and to speak positively about the industry, and to show that industrial companies recruit, create and innovate **For the society (i.e. citizens)** Anticipating the skills required to deploy technological transformations is an essential social factor for 4.0 technologies. It is either the development of the necessary training on the territory, or the ability to recruit the required skills within companies. Support the development of new uses (mobile, e-commerce, media, etc.) among the population. **For the public sector (i.e. local and regional goverments)** Reinforce awareness raising work on digital change and related impacts Put in place policies to support companies in integrating these changes.

3 Summative table for Poland

	Warsaw capital city region	**Podkarpackie region**
Setting the scene		
Regional baseline	**Warsaw capital city region** The region has become the leader of Polish transformation, a position which remained unchallenged both after the EU accession and in the wake of the last financial crisis, resulting in GDP per capita at 218.2% of the national average. This was due to development of service economy (also as a result of the influx of foreign capital) esp. pronounced in advanced business services (including information and communication) that are provided not only for Polish enterprises but also for foreign clients which share has been constantly growing. The positive balance of migration (about 15,000 per year) makes Warsaw Poland's leader in terms of population increase, which has a positive impact on its demographic structure (a relatively low share of the population in post-working age). Other than high salaries, Warsaw's attractiveness for migration stems from the quality of life it offers. This is the reason why employers prefer to locate in Warsaw the key elements of their operations that generate highest added value, a decision which enables them to compete for employees.	The region is one of the least developed Polish voivodships in terms of GDP per capita (70.4% of national average value), and one with a significant and still growing internal inequality. The industrial sector role dates back to pre-war industrialization of this traditionally agricultural area and constitutes an important element of its economic base. The share of industry in gross value added of the voivodship amounts to 27.8%, equal the national average. Particularly well developed are aviation, automotive, electromechanical, biotechnology, IT and chemical industries. In the region there are islands of 4.0 technologies adoption, occurring with various intensity and mixed effects. The processes are largely determined by specific characteristics of particular sectors and mechanisms typical for them. Podkarpackie on the one hand it is medium-tech, already with some signs of high-tech, and on the other hand we have a lot of traditional industries. Large heterogeneity of Podkarpackie region in terms of intensity of business activity, industrial locations and attractiveness for investors has significant impact on unequal adoption of the newest technology trends. Strong concentration of entrepreneurial activity is typical for the capital of the region characterised by high level of urbanisation, best accessibility by different modes of transport, presence of academic institutions and business support organisations, as well as a relatively higher level of income. The investment attractiveness of the region is the highest among the Polish regions located in the eastern part of the country.
	The Warsaw metropolis is a highly developed service region, increasingly oriented at foreign customers in the business services sector. On the other hand, the Podkarpackie Voivodship is a poorly developed industrial-agricultural region, but with some strong hi-tech industrial branches with a significant export potential. In both regions, considerable dependence on exogenous development factors can be observed, especially those connected with the inflow of foreign capital. Another important factor in the case of Warsaw is the city's attractiveness to attract talent, associated among others with a high quality of life. In contrast, in the case of Podkarpackie, the key factors include the region's industrial traditions and the greatest investment potential in the whole Eastern Poland macroregion.	

	Warsaw capital city region	Podkarpackie region
Adopted 4.0 technologies in the sector in the region	The technologies being developed in Warsaw are mainly associated with software development, information technologies and Internet services. Nonetheless, only a small number of companies in the emerging technologies sector use the solutions based on artificial intelligence. A significant and increasing internationalisation of technological enterprises. Globalisation is regarded as a development opportunity, since many enterprises on the domestic market as yet fail to appreciate the benefits of implementing modern IT solutions. Another barrier to their development on the home market is in many cases the lack of sufficient data that could be used to optimise business processes. There is a visible and increasing expansion and adoption of new technologies - including artificial intelligence - mainly in those branches which do not require significant investment outlays, i.e. analytics and big data (43%), customer service and chat bots (22%), marketing and advertising (37%), as well as retail and commerce (23%), as evidenced by the findings from the analysis of the Crunchbase database. Another significant branch is fintech (28%), whereas the Internet of things as well as industrial applications and robotics are less significant, but still remain within the scope of interest of ca one-fourth of enterprises.	Technological start-ups' sector in Podkarpackie includes mostly manufacturing, ICT and e-commerce firms, however companies active in biotechnology, robotics or artificial intelligence are also present. Moreover, 6.9% of enterprises used robots in industrial applications and services; 3.1% of enterprises used 3D-printing and 5.8% declared conducting big data analyses. More than 17% of industrial firms are in the high-tech sector (Podkarpackie is ranked 4th in Poland), they generate 30% of the regional GVA. The structure of the Podkarpackie industry generates higher than the country's average (43% compared to 34%) share of net revenues from sale of high- and medium-tech manufacturing. Podkarpackie is strongly focused on aviation, automotive, electromechanical, biotechnology, IT and chemical industries. The level of adoption of industry 4.0 solutions differs depending on industry. The aviation industry, representing almost 90% of the aggregate Polish production in aviation sector, is considered the leader in adoption of industry 4.0. The aviation industry largely structured around one company – a branch of global Pratt & Whitney company, which implemented digital production plan, 3D-printing, inventory management with very advanced tools, or using augmented reality. Another strong sector located in Podkarpackie is the automotive industry, which to a large extent subject to similar trends as the aviation industry. Both industries are highly internationalised and integrated within the global value chains. Processes of industry 4.0 solutions adoptions have been ongoing also in the IT sector. The sector's structure is based on SMEs; and for this reason developing own 4.0 technology solutions is more common than mere adoption of external technologies.
	The application of new technologies in the analysed regions is determined by wide structural differences between them. In Warsaw, the technology sector is well developed - especially considering the conditions of a semi-peripheral country - including the development and application of IT solutions based on big data and cloud computing, and - albeit to a lesser extent - artificial intelligence, including image identification and processing, data analysis, recommendation systems and NLP, cybersecurity and machine learning. In contrast, in the Podkarpackie Voivodship new technologies are implemented (and to a lesser degree developed) first and	

	Warsaw capital city region	Podkarpackie region
	foremost in the industrial sector mainly in aviation and automotive industries, where digital production plans, 3D-printing, inventory management or augmented reality are used. Nevertheless, the IT sector which acts as an integrator of the region's industry, is relatively well developed.	
Preconditions for transformation		
Regional preconditions	The Mazovieckie Voivodship, and the Warsaw capital region in particular, has been the primary location for research and development activity (38% of total outlays) in Poland. The volume of such outlays rapidly increased, mainly due to the activity of the private sector; its share in R&D expenditure reached 70%, which in 2016 represented 1.13% of the region's GDP (compared to a mere 0.35% in 2010). In parallel, the cooperation of the public academic sector and business was not as developed and, despite many efforts being made, it still encounters considerable obstacles. The most-digitised public sector in the country is a major client for the IT sector, which not only drives the growth of large enterprises, but also offers development opportunities for smaller businesses in the sector. A similar situation can be observed in the sector of households, which increasingly takes advantage of opportunities offered by new technologies, particularly with regard to online shopping. The advanced business services sector represents the lion's share of region's economic base, which helps to focus innovation activity on services.	The Podkarpackie Voivodship, considering its modest economic potential which is largely due to the inefficient, fragmented individual farming sector, enjoys a relatively high position in terms of R&D expenditure compared to the country at large (1.05% GDP). This is due to the country's highest share of private outlays in the R&D financing structure (85%). At the same time, collaboration between academia and business has not been well developed in the region and, despite many efforts, still encounters barriers. Neither the public sector nor the household sector is among Poland's leaders in terms of digital technologies penetration; this support intenrationalisation of local IT companies. The region has a strong industrial sector, also including such modern branches as aviation and automotive industries, supported by efficient and effective cluster initiatives. As a result, manufacturing makes up the economic base of the region, with traditions dating back to the pre-War industrialisation effort associated with the creation of the Central Industrial District (COP).
	The Warsaw region concentrates a major part of the R&D sector in Poland, particularly in services. The Podkarpackie region does not lag behind the national average in terms of R&D expenditure despite its low development level; at the same time, for many years now it has been distinguished by the highest share of private R&D funding in Poland. One characteristic feature of both regions is the dominant and still growing role of the private sector in outlays on R&D. In effect, although the two regions are far from fulfilling the criterion of a 3% share of such expenditure in the GDP enshrined in the Europe 2020 strategy, the role of private funds in the sectors that define the economic strength of the two regions, that is advanced business services (including IT/ICT) and modern industrial processing (aviation, automotive industry), is significant. In both regions – just as in Poland at large – the links between academia and business are not well developed, a consequence, among others, of many barriers associated with the dissimilar operational logic of these sectors (bureaucratic vs. entrepreneurial models). In the case of Warsaw, this is offset by the burgeoning startup ecosystem that encourages establishment of technological firms, and in the case of Podkarpackie – by efficient cluster initiatives such as those associated with unmanned aviation systems. The role of the public sector (similarly to that of the household sector) expressed by the degree of digitisation determining the demand for technological services varies: while the Warsaw region is among the leaders that do not fall behind the best-developed European countries in	

	Warsaw capital city region	Podkarpackie region
	that respect, Podkarpackie is at a level of countries occupying the bottom positions in those rankings. In consequence, while in Warsaw such a situation fosters the growth of local providers supplying relevant solutions, in Podkarpackie it prompts enterprises to seek expansion to domestic and foreign markets (e.g. Asseco).	
Sectoral preconditions	Warsaw is the country's leader in terms of innovations made in the service sector (70% of aggregate national expenditure); however, patent activity, just as that of Poland's compared to other European countries, is very weak. The relatively strongest presence in the region of large corporations that have sufficient data to implement advanced IT solutions such as SaaS and AI encourages the development of local providers of such services. The highest salary level nationally, especially in the IT sector, is an incentive for adopting new technologies that optimise business processes. The risk of employment reduction associated with this applies in particular to the most digitized branches of the financial sector. This is fostered by the pro-innovative attitude of the boards of large companies.	The innovative activity of enterprises in the Podkarpackie region is concentrated in the industrial sector. The volume of R&D expenditure is growing (40%), at the expense of reduced outlays on tangible assets (machinery, equipment, including hardware). Expenditure on the purchase of software is minimal. Conducting innovative activity is closely related to the size of the enterprise; such operation was declared by about 65% of the biggest companies, about 35% of medium-sized companies and only 10% among those employing between 10 and 50 people. Innovation also depended on ownership of the entity – most willing to introduce innovation were foreign entities (almost 50% of them); these companies were typically larger than Polish-owned entities. The pay pressure in Podkarpackie is not as strong as in Poland at large due to a higher unemployment rate, hidden unemployment in agriculture and, less so, to the inflow of workers from Ukraine.
	Innovative activity of enterprises, albeit more common in the case of Mazovieckie, is at a similar level in both regions in terms of the share of companies engaged in such activity. Its orientation, however, differs in the two regions. While Warsaw is an unquestionable leader in terms of innovation expenditure in services (70%), in Podkarpackie such a role is played by industrial processing (90%). In parallel, in both these regions there has been a shift in such outlays, from tangible assets (machinery, equipment, including hardware) to research and development activity, the share of which reached about 40% as compared to only 10-20% in 2010. The only difference could be observed in expenditure on the purchase of software; its share, although relatively insignificant, was several times higher in enterprises in the Mazovieckie region. In both regions, the propensity to innovate was closely correlated with the size of the enterprise, with large businesses as the leaders declaring adopting innovations twice as frequently as businesses from the SME sector. In turn, the latter did so three times as often as micro-enterprises. In both these regions, there were many large enterprises operating in key sectors for the local economic base, which facilitated dissemination of state-of-the-art solutions among providers and suppliers. The presence of large players is also a factor encouraging implementation of solutions based on big data analyses due to the fact that smaller entities in many cases lack sufficient databases. A similar situation could be observed in the case of entities with foreign shareholdings, which tend to adopt innovations more frequently due to their participation in global value chains. One factor that clearly fostered the implementation of innovative solutions in Warsaw has been increased remuneration level of IT specialists and other professionals in the service sector . In Podkarpackie, despite the presence of certain reserves limiting salary pressure associated with higher	

	Warsaw capital city region	Podkarpackie region
	unemployment such as hidden unemployment in agriculture and inflow of workers from Ukraine, labour shortages were also a factor inducing innovation in industry.	
Social preconditions	Warsaw has many public universities and colleges, usually occupying top places in the national rankings and present in the international rankings, which educate new professionals (155 thousand students), some of whom with high competencies in the field of emerging technologies (31 thousand students). The non-public higher education sector is also strong (89 thousand students); and offers education in the field of IT/ICT. According to some respondents, it is more flexible and therefore can better cater to the needs of the business sector associated with the 4.0 technological revolution than public universities. Extensive and competent human capital resources make Warsaw a city with a great and rapidly increasing number of startups, a manifestation of the residents' entrepreneurial spirit. A relatively well developed ecosystem (business environment institutions, venture capital funds, coworking spaces) is an additional incentive to engage in startup initiatives.	The higher and vocational education system in Podkarpackie is well developed, Rzeszów being the region's major academic centre. Altogether, 4% of all students in Poland study at public higher education institutions in Podkarpackie (36.4 thousand), and 1.5 thousand do courses related to ICT (4.2% share, increase by 0.4 percentage points). Within non-public education with its 11 thousand students (3.4% of the total number of students outside the unpaid public education) certain importance in terms of educating personnel necessary for the fourth technological revolution had the University of Information Technology and Management in Rzeszów. The number of businesses in Podkarpackie is on the rise, with the fastest increase observable in the IT/ICT sector and support service activities, in which the number of business entities has doubled. A considerable (20%) increase could also be observed in manufacturing activity, which is two times higher than the country's average. The industrial clusters operating in the region stimulate enterprise development in that NACE section.
	Despite a clear supremacy of Warsaw over the Podkarpackie Voivodship in terms of the pool of high-quality human resources, also thanks to the country's best-developed higher education system, owing to its long-established traditions in high-tech industries and a strong higher education sector (including technical education), Podkarpackie still successfully avoids brain drain, primarily with regard to employees working in the manufacturing sector. On the other hand, entrepreneurship is much better developed in Warsaw, and the emerging startup ecosystem encourages the creation of new technology enterprises. Nevertheless, the growth dynamics of businesses in the IT/ITC sector is also very high in Podkarpackie, with the increase of new manufacturing entities being among the fastest in Poland.	
Policy preconditions	A policy that responds to the challenges of the 4.0 technological revolution in Poland is a matter of the recent years, with a major role being played by regulations at the national level. Industry 4.0 is one of the priority areas of the Strategy for Responsible Development Until 2020. The key strategic document in Poland on technological revolution and applications of Technology 4.0 is The Policy for Development of Artificial Intelligence in Poland for the Years 2019-2027, prepared to accomplish the requirement of the European Commission related to the AI development in Europe. It defines the key activities for attaining this objective related to organisational, topical and financial infrastructure. These include, among others, the establishment of the Future Industry Platform, Polish Computation Centre, Observatory of International Policies on Artificial Intelligence and Digital Transformation; and Virtual Chair for Ethics and Law. Accordingly to respondents the activities relating to the 4.0 technological transformation in Poland need more coordination and	

	Warsaw capital city region	Podkarpackie region
	acceleration. On the regional level, the policy is created by the Regional Smart Specialisation Strategies. In both regions the smart specialisations do not directly mention the notion of Industry 4.0, but many of its elements refer to the constituent parts of the definition of the 4.0 technological revolution in the horizontal dimension. In particular in Mazowieckie, many measures providing support to ICTs in enterprises, promoting implementation of intelligent management systems and so-called e-services, popularising the Internet and its applications, improving digital competences of the public at large and ensuring cybersecurity are planned. The smart specialisations catalogue for the regions clearly reflects the 4.0 technological transformation. Both region has chosen smart specialisations related to application of IT solutions, in Mazovieckie – Intelligent Management Systems, in Podkarpackie – high-tech sectors: aviation, space and automotive. Some hopes are related to the newly established Polish Cluster of Industry 4.0 with seat office in Podkarpackie. It aims at supporting enterprises in the process of implementing Industry 4.0 solutions in terms of information, competencies and technologies, and at promoting business-to-business and business-to-science networking. So far, however, the activities stimulated by the Cluster has been very limited.	
Actual transformations in the region		
Economic transformation	In Warsaw, the recent years saw a robust growth of the advanced business services sector, which considerably boosted employment and increased the number of businesses registered in those NACE sections. This was due to the still increasing globalisation of the sector, a phenomenon that is manifested, on the one hand, by the influx of foreign corporations in those sectors, some of which also open their R&D centres here (e.g. Samsung, with its largest such centre located overseas). On the other hand, this also results from the process whereby the local enterprises are becoming more and more internationalised. While many respondents believe that the development of new technologies, mainly those based on artificial intelligence, may lead to a market oligopoly in the B2C segment and in some sectors of professional services, particularly the most heavily digitised ones, in the B2C sector, at least at the present stage, it can be anticipated that competition will grow on such a rapidly expanding market. This is due, firstly, to the development of the startup ecosystem drawing on the US experiences and, secondly, to the increasing volume of procurement from the public sector which requires new technology applications.	In the Podkarpackie Voivodship, service economy is observably developing, which can be due to the favourable situation of industrial processing manifested by an increasing demand for labour. One inherent feature of the region's economy is its internationalisation, not only with regard to the manufacturing activity in the aviation and automotive sectors, but also in the activity of SMEs in the IT sector due to various applications in some niche sectors. The linkages between big international corporations and the local SME sector play a significant role. The development of the latter is fostered by the existing cluster initiatives, in which the special role is played by main agents of change. In the region, the role of initiatives to support the development of technological startups is also increasing. In effect, new types of activities are being undertaken and new professions are emerging, e.g. in the unmanned aerial systems sectors. The challenge faced by institutions and programmes supporting startup expansion is how to skilfully inspire cooperation with larger companies so as to minimise the risk of oligopolisation in the process of small business reskilling.
	In both regions, the labour market situation is favourable for the workforce, as demonstrated by a considerable fall in the unemployment rate and a significant increase in the number of new jobs. In Mazovieckie, the advanced business services sector is developing rapidly, a process	

	Warsaw capital city region	Podkarpackie region
	which is largely attributable to shared services centres of foreign corporations, including those engaged in research and development. Development of service economy is also visible in Podkarpackie, potentially driven by the favourable situation in the industrial processing sector, manifested by an increased demand for labour. In both these regions, a considerable degree of internationalisation of business activity can be observed, predominantly in sectors that represent the economic base of these regions. Indisputably, that phenomenon is underpinned by the technological revolution. In consequence, there are some examples of Warsaw-based businesses from the new technologies sector opening their branches abroad, particularly in the United States. Similarly, the role of the well-developed startup ecosystem should not be neglected, nor the significance of public sector procurement. In contrast, in the Podkarpackie Voivodship, linkages between large transnational corporations and the local SME sector play a significant role, and are fostered by the existing cluster initiatives, in which the special role is played by main agents of change. The role of initiatives supporting the growth of technological startups is also increasing in that region.	
Social transformation	In Warsaw, the human capital is on the rise, both as a result of educating students at local universities and colleges and through attracting qualified professionals from other regions and from abroad. However, at a later stage upskilling takes place mostly in enterprises, particularly SMEs, for which gaining new competences is crucial to improve their market position. It is also emphasised that efficient HR departments play a key role in ensuring suitable dynamics for businesses operating in technological sectors. Willingness to learn is visible particularly among specialists and professionals, while managers often seem to be less prepared to the 4.0 technological revolution. Activities of the public authorities aimed to adjust to the new conditions are regarded as unsatisfactory; however, their lack can partly be explained by a booming labour market. Such activities are undertaken by the higher education sector, especially non-public establishments that open new programmes of study. At the same time, the academic and science sector is increasingly threatened by the brain drain of qualified staff. Labour market shortages, also of qualified specialists, are more and more resolved by foreign immigration, primarily from Ukraine.	In Podkarpackie region's industry the demand for employees with low and medium level of qualifications will fall, as that type of jobs will be automated, consequently causing demand for employees with higher qualifications. Quite common is the perception on incoming industrial revolution in logistics and transportation sector in connected with increasing automation of those processes. It was pointed out that there exists potential for new jobs being created in services, in administration and in broadly understood security as the 4.0 revolution advances. Some occupations, e.g. information technology, are undergoing far-reaching changes due to the advanced nature of specialisation processes. The region's science potential is not sufficient to develop 4.0 technologies on its basis. There are promising cases of inclusion of enterprises in shaping educational offer of universities and vocational schools oriented towards development of 4.0 technology. The influx of foreign residents and staff is relatively less significant in Podkarpackie than in other Polish regions, especially in Warsaw where the number of foreigners is the highest. Some higher education institutions, particularly non-public ones, enjoy a high share of internationalisation, with foreign students originating mainly from Ukraine. The respondents associate the development of 4.0 technologies in Podkarpackie also with the creativity of students or graduates coming from outside the region. In the region, some sharing economy solutions are now being implemented. The processes of

	Warsaw capital city region	Podkarpackie region
		digitisation of traditional services drawing on platform-based solutions are not as advanced in the region as in strongly metropolised areas, and their applications are mostly confined to the region's capital.
	Technological revolution boosts demand for qualified personnel, and this phenomenon is very well visible in both regions. On the other hand, expectations and, less frequently, symptoms concerning the need for reskilling some of the present workforce can also be observed. This process is mainly driven by private sector initiatives, whereas activities of the public sector in that regard are less favourably viewed, partly due to the still flourishing labour market. Such a situation can also be observed in the education sector which, according to the respondents, has become more responsive to new trends, primarily in the case of non-public HEIs. Simultaneously, the role of foreign immigration is growing in both regions, also with regard to qualified workers and students, especially those from Ukraine. As regards changes in consumer patterns, sharing economy is rapidly growing in both regions. In that regard, however, Warsaw has significantly outpaced Rzeszów. On the other hand, diffusion of innovation has visibly accelerated, both in adopting foreign solutions by Warsaw and their later dissemination across the national settlement system.	
Actual and potential impacts		
In the sector in the region	In the recent years, no significant improvement in labour productivity could be observed in Warsaw, which indicates that the number of the people in work is the key factor driving the region's development. This phenomenon is particularly well visible in the IT/ICT and professional services sectors and could suggest that the region's growth is based on the traditional technologies, whereas the development and applications of state-of-the-art solutions based on artificial intelligence still remains at a nascent stage. The observable increase in the number of employed in high-tech sectors of the economy is consistent with the forecasts according to which the declining employment in sectors which will be recipients of new solutions will be accompanied by a dynamic, and possibly even faster, rise of employment in technological sectors. This applies in particular to the IT, a sector that does not currently perceive any risks associated with the programmers' jobs being potentially soon replaced by algorithms such as deep machine learning.	The 4.0 technological revolution is mostly driven by big companies – branches of the international players in aviation and automotive industries. New technological solutions are predominantly regarded as support to business operations and are intended to increase productivity and reduce the costs of business operations, which is in line with the general trend. New 4.0 technology solutions allow enterprises to meet the demand and expand their operations. The main mechanism of a broader adoption 4.0 technologies in the production sector in the region relies on adjusting to the requirements of the company with the highest technological level in the cooperation network. Insufficient adaptation may eventually lead to the loss of the global subcontractor position. The 4.0 revolution in the production sector in Podkarpackie is to a great extend forced by external cooperation links in the global value chain. Different challenges for regional industrial enterprises stem from the inferior role of regional companies in the global value chain and strong exposure to political situation in global markets. The common problem to be faced by the Podkarpackie industrial sector is shortage of staff that results from strong competition and processes forced by the reform of Polish higher education. The requirements

	Warsaw capital city region	Podkarpackie region
		of the industrial sector needs in terms of the future employment force are expected to be not met to a full degree.
	Growth in both regions is largely based on traditional technologies. The impact of state-of-the-art, AI-based solutions is still in a nascent phase. New technological solutions are predominantly viewed as support to business operations and are intended to increase productivity and reduce the costs of business operations. The impact of linkages within global value chains on adopting novel solutions in Podkarpackie's industrial sector is greater than that in the IT sector in Warsaw. In addition to the lack of well-educated human resources, this factor potentially represents the major development challenge for the sector concerned. In both regions, there is a visible and growing demand for workers in the analysed sectors. For this reason, new technological solutions are expected to create opportunities for increasing labour productivity and resolving problems associated with shortage of labour.	
In other sectors in the region	Adopting novel solutions in other sectors of the Polish economy (other than IT/ICT) has been rather slow so far, which is partly due to some managers' lack of belief in benefits arising from their implementation. Such a view is reinforced by the booming economy, which affects propensity to try out new solutions. In such a situation, therefore, the shortage of labour is the main factor driving changes in that regard; this, according to some, opens up opportunities for new technology applications. At the same time, delays in carrying through the 4.0 revolution may at the end of the day cripple the competitiveness of Polish enterprises and lead to their being pushed out of the global value chains. In the case of Warsaw, this applies to the advanced business services sector which, if the degree of digitisation rises, may potentially be even more exposed to changes accompanying implementation of AI-based solutions than traditional branches of industry, given their modest role in the metropolitan economy. Many branches of the region's economy have a strong internationalisation potential, similar to the one in the IT/ICT sector. The impact of technology may also lead to a greater customisation of the available offer and accelerating the process of introducing new products, for example in e-commerce. On the other hand, in the case of the transport sector some more sceptical opinions were voiced, which suggested that the application of new technologies may have a greater impact on rail, and not car transport.	The IT industry starts to play the role of a hub for Podkarpackie industry for the purposes of technology 4.0 revolution. IT SMEs seem to have the tendency to create own 4.0 solutions, which contribute to their stronger presence on foreign markets. There are however entry barriers to a market controlled by global IT giants. Another challenge is the lack of well-qualified IT employees. According to experts, sectors which are likely to benefit the most from the introduction of AI-based solutions will primarily be traditional branches: trade, industry, transport and logistics, and energy. The relatively weak progress of the 4.0 technological revolution in Poland is usually explained by the fact that many Polish businesses, especially those in the SME sector, do not see any need for implementing innovations. On the other hand there are voices from some sectors that appearance of companies successfully adopting such technologies may be transforming for future local business environment, including e.g. logistics or manufacturing processes. Technological revolution is regarded as a horizontal opportunity, a phenomenon which should change not only the development of the leading medium-tech and high-tech industries, but also change the traditional sectors. While tourism my effortlessly benefit from the adoption of IT tools, becoming a front-runner in the domain of AI adoption in the agriculture is hardly possible due to the characteristics of the sector in Poland and the financial resources needed.

	Warsaw capital city region	Podkarpackie region
	The observable and expected effects of the 4.0 technological revolution vary across sectors. While in technological branches the range of applications of emerging technologies is relatively broad, their adoption in other sectors encounters barriers caused by poor motivation for change among some managers, which is due, among other things, to the excellent situation of the economy. The main factor driving seeking out solutions aimed to improve productivity are the increasing shortages of labour. At the same time, failing to adapt to the new economic circumstances poses a risk for Polish enterprises that they will be pushed out of the global value chains in the future. The expectations concerning the future impact of new technological solutions on specific sectors are rather varied. In Warsaw, they point to a potential reduction in the number of jobs in some advanced business services, especially the most digitised ones, whereas in Podkarpackie they suggest a transformation that could affect such traditional business activities as trade, industry, transport and logistics. At the same time, no significant impact on the region's agriculture is anticipated due to the local characteristics of the sector associated with a large number of small-scale farms.	
In the region	In the region, similarly to highly-developed countries, it is anticipated that labour market polarisation will increase due to the forecasted fall in the demand for workers performing elementary, easily automated tasks. It should be borne in mind that the current labour market situation in this particular segment is very good. Moreover, all respondents emphasise the strong and growing demand for highly qualified employees with competences matching the needs of digital economy and the resultant need to adjust the education sector and its individual stages. However, opinions on the labour market prospects vary and depend on the forecasting period. In the short term, all respondents see more benefits arising from the implementation of emerging technologies, but in the long term they raise the issue of the stability of the present development model of the Warsaw region, largely relying on low costs of labour in comparison to well-developed countries, also in the advanced services sector.	The dominant view is that the technological revolution will deal with the problem of workforce shortages in industry. The positive effect of becoming part of the 4.0 revolution is that new technologies will eliminate professions relying on painstaking, repetitive or burdensome operations, as well as that new professions will appear as a result of the demand of brand new sectors, like unmanned aerial vehicle sector. A challenge for the Podkarpackie industrial sector is its dependence on international corporation, low ability to create and commercialize technologically advanced regional final product. As a result the big hopes are put in the IT sector which produces new solutions, operates in market niches and have the potential to integrate industrial sector of the region. Impact of 4.0 revolution in a peripheral region relates to more general difficulties resulting from development of innovations in such regions. Regions with low economic potential the threat that enterprises may become dependent on easily available external funding for innovative projects is more plausible. The uneven adoption of technological trends by different sectors of the regional economy may question successful adoption and refrain positive impact of 4.0 revolution in the region. In particular the business sector (at least partially) has joined the technological revolution, while public sector is considering such changes for the future. This is evidenced by lack of regional studies in that respect and different

	Warsaw capital city region	Podkarpackie region
		definitions being applied to technological changes by entrepreneurs and authorities. Such differences in approaching the new developmental paradigm are exacerbated by low IT competences in general population, lack of knowledge on factors, mechanisms and effects of technological revolution and by the fact that legislative changes lag behind technological changes, which carries ethical and safety risks.
	In both regions, reduced demand for workers performing elementary, easily automated tasks is anticipated, so as strong and increasing demand for highly qualified staff with competences matching the needs of digital economy. The emergence of new occupations is also forecasted in newly-created sectors in parallel with changes in the already existing occupations. This means that the education sector should accordingly adjust its individual stages. In Podkarpackie, the hiatus between the adoption of 4.0 solutions in the enterprise sector and the public sector has been more strongly stressed than in Warsaw, as well as the insufficient skills of the public at large which may delay or impede the positive effects of the technological transformation. In Podkarpackie, the respondents pointed to challenges typically characterising peripheral regions, associated with a low level of innovation and a higher likelihood of innovation-based development being dependent on external funding. On the other hand, the respondents in Warsaw raised the issue of the stability of the present development model of the Warsaw region, largely relying on low costs of labour in comparison to well-developed countries, also in the advanced services sector.	
Future outlook on 4.0 technologies	Varied opinions have been expressed on the impact of 4.0 technological revolution on the labour market, which could be summarised, on the one hand, that most respondents expect the number of employees to increase and automation to help address problems with staff shortages in the short term, and on the other – that respondents differ in their opinions as regards the long term perspective: some make analogies with the previous technological revolutions while others highlight the singular nature of the 4.0 revolution and therefore anticipate a more negative impact on the labour market. In addition to that, the interviewees expressed some interesting views on the level of salaries: they pointed to certain symmetry associated with globalisation processes, manifested e.g. by a rapid increase in the number of freelancers. This, in the case of countries at medium level of development such as Poland, means that, on the one hand, residents of analysed regions may work for foreign clients and charge higher than local rates, but on the other hand competition may appear e.g. from Asian countries which can offer much lower rates for a range of services such as e.g. translation.	
Best practices	There are few significant effects of activities undertaken by the public sector regarding the 4.0 technological revolution at the national, regional and local levels. To some extent, it can be explained by the still nascent nature of the technological change taking place in Poland. However, the first programmes and instruments aimed to support this revolution have been launched in the recent months. Interestingly, these activities to a greater extent rely on solutions that were earlier implemented elsewhere rather than propose original solutions. Such new initiatives include: Formulating an AI development policy identifying 9 factors crucial for a successful creation of an AI ecosystem in Poland, which will be addressed in the form of public interventions in such areas as: organisation and management of the ecosystem; knowledge and competences; data; financing of social programmes, science, research, technology implementation and transfer; infrastructure; technical and organisational standards; the ethical dimension; the legal dimension; transborder	

	Warsaw capital city region	Podkarpackie region
	cooperation and the international dimension; Establishing an industry-of-the-future platform, which at the present stage is focused on: a) training programmes for the management, that is the leaders of change implementing digital strategies in enterprises; b) modular training programmes in specific technologies and their benefits; and c) advisory services for specific businesses in the SME sector; Launching, as part of the activity of the National Centre for Research and Development (NCBiR): a) InfoStrateg, a new strategic programme (with the first call for proposals to be announced in Q1 2020) involving machine learning with AI applications; b) increasing the allocation to, and reorientation of, the CyberSecIdent programme on online data security, and c) planning the launch of a new instrument, AI excellence centres; Launching a foundation course in AI addressed to the general public by the National Information Processing Institute (OPI PIB) in collaboration with the Foundation 'Digital Poland', as part of an initiative entitled #AIChallenge, whose mission is to familiarise the Polish general public with basic information about artificial intelligence. Every citizen may take the course on basic AI, freely available and modelled on relevant Finnish solutions. Public sector initiatives that were positively assessed by the respondents included, among others, the following: Industrial Doctoral Programme in the field of artificial intelligence – the Ministry of Science and Higher Education offers support to PhD theses prepared by doctoral students who conduct research on the application of artificial intelligence in technological or social processes, also those concerned with cybersecurity, the results of which may find applications in the activity of bodies employing doctoral students. Competence Centres, that is consortiums supporting collaboration between research institutions, academia and business; Dual university programmes (studies), that is a modern model of training drawing on German experiences and combining traditional university courses with professional work; while at university, students can gain vocational qualifications and experience, and upon graduation are ready to enter the labour market. It should also be emphasised that the major drivers of change regarding the technological revolution in Poland are mainly transnational corporations, but also private Polish firms, large enterprises and SMEs alike. In the regions concerned, in the context of the technological revolution, the following should be emphasised: Spontaneous emergence of a startup ecosystem in Warsaw, also as a result of the operation of foreign corporations (e.g. Google Campus, Cambridge Innovation Center) and venture capital funds; Inclusion of enterprises in shaping the educational offer of Podkarpackie: regional clusters initiatives in the area of innovative vocational education (Aviation Valley – 12 Regional Centres for Innovation and Technology Transfer, East Automotive Alliance – Podkarpackie Automotive Academy); dual studies on non-public University in Rzeszów and Rzeszów Technical University; Erasmus+ SKY 4.0 project increasing soft skills in aviation with the participation of the Aviation Valley Association. The role of NGOs such as e.g. the Foundation 'Digital Poland' whose mission is to disseminate knowledge about digital economy and new technologies in the society at large, can also be viewed as positive.	
Operational policy recommendations	The following operational recommendations for national/regional policy based on the result of research could be formulated: **Establishing an institution/platform offering open data access** Shortage of data is named one of the major barriers to implementing new business and technological solutions. Moreover, ensuring adequate access to the data collected by institutions and corporations is problematic. Equally important is a suitable storage of data so to ensure personal data protection, and making decisions on which data should be kept in the public domain. Therefore, it would be expedient to launch an institution/platform that would ensure open data access, guarantee that	

	Warsaw capital city region	Podkarpackie region
	data are properly stored and regulate rules of access. This should be a national-scale initiative, although regional-level initiatives would also be desirable, focused on providing support to specific applications/specialisations that are locally significant. Establishing an AI Council to represent interests of various actors Support to promoting the 4.0 technology and a shared understanding of the accompanying processes across sectors can be provided by an independent expert body furnished with legal powers to impact policy decisions. The AI Council in the UK - an independent committee of experts from industry, public sector and academia - is an example of a body that provides advice to Government and high-level leadership of the Artificial Intelligence (AI) ecosystem. The AI Council is responsible for providing an open dialogue and exchange of ideas between industry, academia and government; sharing research and development expertise, horizon-scanning for new AI technologies, applications and their impact as well as for advising the government on its priorities, opportunities and challenges for the responsible adoption of AI for the betterment of society. One important goal of such an AI Council would be to prepare the public in many aspects for the current and forthcoming changes brought about by the adoption of new technologies in all spheres of life based on an in-depth understanding of the social and societal consequences of the 4th technological revolution (4TR). The societal actors should become involved in the processes of the 4.0 revolution in ways that are changing technological evolution trajectories. The establishment of such a body would address both the weaknesses of AI policy as identified by the respondents and delays in the inclusion of the public into these processes in comparison to Western European countries. **Establishing a research institute specialising in AI development** It is necessary to unite and provide support to the scientific potential for the development of the 4.0 revolution in Poland. It would be desirable to establish a research institute dealing with research on artificial intelligence. The goal of such an institute would be to integrate the research already being conducted by individual academic centres in Poland and to make a stronger presence in the mainstream of global research. It would be necessary to ensure required financing not only for the pursued research but also for research trips. The establishment of a specialised research institute and integrating it with the international environment will help formulate novel research problems that go beyond the needs of the day. **Role of the public sector in procurement requiring/allowing new technology applications** More active involvement of the public sector in the development of new technologies should be considered; e.g. through public procurement aimed to apply such technologies in public sector operations and this, according to some respondents, is already taking place. More detailed recommendations regarding that topic can be found, among others, in the report for NICVA (2018), e.g. concerning market research and negotiations with bidders to adjust the procured items to the current technological capabilities, collaboration between institutions and departments to achieve the effects of scale and reduce the risk of duplicating activities; putting solutions in place that allow calculating and accepting the risks involved in implementing innovative solutions. Such initiatives may be pursued both at national and regional levels. **Supporting NGO initiatives disseminating knowledge about the digital economy** One of such initiatives aimed to disseminate knowledge about the digital economy is the Digital Week event, first organised in Poland in 2019. One of its goals is to educate the public on issues related to digitisation and high technologies. This initiative came to life as a product of collaboration between the Polish Chamber of Commerce for Electronics and Telecommunications (KIGEiT), Polish Chamber of Electronic Communications (PIKE), Polish National Chamber of Ethernet Comminication (KIKE), Polish Chamber of Information Technology and Telecommunications (PIIT), Digital Poland Foundation and the Polish Promotional Logo Foundation "Teraz Polska". In the future, the formula	

	Warsaw capital city region	Podkarpackie region
	could be expanded through the support of the public authorities, both nationally and regionally.	

4 Summative table for Slovakia

	Key messages by country
Setting the scene	
Regional baseline	Slovakia is one of the less developed countries in the EU with a GDP per capita of 22,600 PPS per capita, compared to 29,500 of the whole EU. According to the European Innovation Scoreboard, he is a moderate innovator with a Summary Innovation Index of 63.5% (EC, 2019b). The innovative ecosystem of the economy is fragmented and underfunded with low efficiency. Given the high volume of investments, especially in industrial production and high tech services, the economy is achieving relatively high rates of economic growth, driven by exports of medium and high tech products. Slovakia is characterized by large regional disparities, which are the result of inherited structural problems before 1989, the different responses of regional economies to the transformation process in the 1990s, and differences in the attractiveness of regions for foreign investors. Slovakia is considered to be a highly industrialised state where the share of industrial production in gross value added formation exceeds one fifth of the economy. According to the Statistical Office of the SR, in 2015 the share of gross value added of automotive in GDP at current prices was 22.79% and at constant prices by chaining to 2010 25.15%. There are currently only two EU Member States with higher proportion of industry in gross value added, namely the Czech Republic and Germany (Luptáčik, 2016). **Bratislava region** is metropolitan centre of the Slovak Republic. This region belongs among the most developed regions of the EU, with GDP per capita in PPS EUR 54,000. This represents 185% of EU average. Contrary to this performance, there is very low innovation activity compare to regions with similar economic performance and very low high tech patents. **The Eastern Slovakia** region is the second largest region in Slovakia in terms of size and population and it is predominantly rural, with an urbanization rate of 56.1%. The region is the most underdeveloped region in Slovakia reaching approximately 53% of the EU28 GDP per capita average (PPS). The region suffers from a relatively high unemployment rate, and intraregional economic and social disparities.
Adopted 4.0 technologies in the sector in the region	Out of 4.0 technologies, almost all types of 4.0 technologies were used in the automotive sector in **Bratislava region** - artificial intelligence, internet of things, on-line production monitoring, big data, augmented or virtual reality. Out of 4.0 technologies, almost all types of 4.0 technologies were used in the sector - artificial intelligence, internet of things, on-line production monitoring, big data, augmented or virtual reality. Technologies are from core technology field (software, hardware, connectivity), from enabling technology fields (analytics, user interface, 3D systems, artificial intelligence, security) and also from field in application domains (smart factories, autonomous driving or offices, intelligent robotics). Two main domains of usage - most of them connected to robotics and automation processes in the production, but extensively also used in developing new models (or its parts in case of Bratislava region) . Vast majority of technologies are purchased from technology providers that are primarily large multinational corporations. Adoption rate of 4.0 technologies in the region in the transportation and logistics is rather low compared to more developed regions of Slovakia. The technology leaders mostly use ready to use technologies developed in other regions outside the country. These mainly in the area of digitalisation for example international internet based loading platforms, real-time traffic management technologies, IoT technologies for identification of transported and stored goods, warehouse management systems and in some cases automated warehouses. In the public transport domain, new technologies are used for tracking vehicles, providing information about transportation connections and on line payments
Preconditions for transformation	
Regional preconditions	The different regional context of our case study regions creates different preconditions for adoption and dissemination of 4.0 technologies. Case study regions are significantly different in terms of level of economic

development and industrial structure. The region of Bratislava is the most economically developed region with a high degree of urbanization, well educated workforce, innovation capacities and a high share of employment in high-tech sectors. Eastern Slovakia, on the other hand, is the least developed region of the country with a low level of urbanization. The region is slowly transforming from a traditional old industrial region with a low technological level, a lower educational level and limited innovation capacities. Transformation is associated with high unemployment rates, increasing intra-regional disparities and brain drain. In the following table below we present the main differences between regions. From them especially industrial structure plays important role in 4.0 technology adoption.

The Bratislava region is a metropolitan region with a concentration of branches of large international companies that export their goods and services to other countries of the world. By contrast, the Eastern Slovakia region is peripheral region in which the number of internationally owned companies is significantly smaller. This means that in the Bratislava region the impulses for technological transformation are more closely linked to the activities of central firms and the changing demand of extra-regional consumers.

In international comparison both regions have a relatively inexpensive and affordable workforce that reduces the pressure to accelerate the deployment of new technologies to domestic firms where there is no direct pressure from the headquarters as it is in multinational corporations. More intense 4.0. technology deployment is also hampered by virtually no production of these technologies in both regions. This is also due to the very low concentration of public research on applied research (with a few exceptions in the Bratislava region).

	Bratislava rgion	**Eastern Slovakia**
Location and transport connections	Proximity to dynamic markets. Excellent international and interregional transportation links	Peripheral location and limited transport connections both within the region and internationally
Settlement structure	High urbanization enables better dissemination of new technologies and achieving economies of scale from digital infrastructure investments	Low urbanization and fragmented population
Economy	Above-average level of economic development, High growth rates of the regional economy	Low level of economic development. Significant intra-regional differences.
Industrial structure and entrepreneurship	Higher specialization in medium and high technology sectors Higher penetration rate of 4.0 technologies in dominant regional industries, especially in companies with foreign owners.	Main specialisation in low-tech industries
Innovation system	Dominance of basic public research and low efficiency in research. Nevertheless, extensive research capacities mean higher absorption capacity for new technologies.	Limited research capacities. Several regional initiatives on institutionalizing research in new technologies
4.0 technologies production	None	None

Sectoral preconditions	The adoption rate of new 4.0 technologies is influenced by several factors. First of all, case study regions differ in industrial structure. Large multinational companies dominate the Bratislava region, however the

penetration of foreign owned firms in the region of Eastern Slovakia is much lower and Slovak firms dominate the case study sector. Deployment of 4.0 technologies is therefore rather different. For multinational companies, as shown by the automotive industry, the deployment of 4.0 technologies is currently very intensive and often pushed by the headquarters of these companies. The choice of specific plants for pilot deployment of these technologies is decisive for their ability to successfully implement these technologies, and from the regional point of view main aspects related to this are the quality of the workforce, the presence of suppliers of 4.0 solutions or research capacities in the area. The study of the automotive industry, however, confirmed the deployment of these technologies also is basically at the same rate realized also in factories from underdeveloped regions; these are more sectoral than regional conditions for the introduction of these technologies. Companies in the Eastern Slovakia are more reactive in introducing new technologies. They mainly response to the changing customer needs or regulation in the industry (e.g. safety regulation). Another important factor is the value chain structure in the region and the sophistication of regional customers. Finally, there are also differences in qualifications and sufficiency of workforce. The introduction of 4.0 technologies is also partly initiated by shortage or cost of workforce. Relatively large labour pool in Eastern Slovakia explains to some extent lower adoption rates. Technology adoption is financed mainly from firm internal financial resources. Bratislava region is dominated by MNEs with larger pools of financial resources on the other hand forms in Eastern Slovakia are mainly locally owned, so their access to capital is more limited. A more detailed comparison of regions is provided in the table below.

	Bratislava (automotive)	**Eastern Slovakia (logistics and transportation)**
Industrial structure	There are 4 final producers located in the region or in neighbouring regions and a network of suppliers from Tier 1 to Tier 4. All important global suppliers in the automotive industry are located in the region. Companies have mostly foreign owners.	arge transport and logistics companies located in the region are mainly locally owned. In the region, branches of companies from the western part of Slovakia are operating as well. Regional companies provide mainly second party logistics (2PL). Companies that provide services at a higher technological level (third party logistics - 3PL) are located mainly in the western part of Slovakia.
Firm strategies	Active deployment 4.0 technology resulting from corporate strategies. The deployment of technologies is not necessarily the result of better regional conditions, although they support their deployment. Main driver are MNC and their 4.0 strategies.	The implementation of new technologies is not usually the result of strategic intentions, but is largely a response to customer needs and regulation.
Customers/ Suppliers	The deployment of 4.0 technologies at the top of the value chain results in downstream pressure (regional suppliers).	Less pressure of customers to use 4.0 technologies. Lack of sophisticated customers in the region.
Labour force	Relatively expensive and scarce labour force compared to national average. The qualification structure is on the edge	The relatively cheap and affordable workforce does not put pressure on replacing workers with new automated technologies. Ageing of

	of need. The additional growth in the use of 4.0 technologies requires an additional inflow of skilled labour.	employees hampers the adoption of technologies.
Capital	Provided by MNC, not consider as a problem in deployment of 4.0 technologies	In general, locally owned companies dominate the region. Access to capital is limited.

Social preconditions

Social preconditions are more favourable in Bratislava region compared to Eastern Slovakia. Bratislava region has more human capital, more educated workforce, higher digital skills and better research capacities. On the other hand, there is not enough IT specialists for future or larger expansion of 4.0 technologies compare to other similar EU regions.

A common feature of both regions is the problem of secondary vocational education to produce graduates in the number and quality required by the industries. Digital skills are higher in Bratislava, but do not have important impact on 4.0 transformation.

The attractiveness of regions in terms of labour migration is also different. The Eastern Slovakia region faces problem of brain drain of qualified workforce. On the contrary, the Bratislava region is attractive destination for labour migration. This partly reduces the wage pressure and at the same time improves the supply of skilled labour.

	Bratislava	**Eastern Slovakia**
Human capital	The high level of human capital creates suitable conditions for the high absorption capacity of new technologies. Lack of IT specialist. Region gains human capital from internal labour migration.	The difficulty of adapting to new technologies in the region results partly from lower educational levels of the population and lower technological levels of companies in the region. Region faces brain drain of qualified workforce.
Education	Sufficient learning capacities/ universities also in areas close to technology 4.0. Lack of students in these areas could limit future deployment.	Secondary education currently does not produce enough graduates with necessary skills.
Digital skills	Relative high digital literacy (compare to rest of Slovakia) and increase use of digital technologies by population.	Slightly lower level of use of digital technologies and internet infrastructure

Policy preconditions

The policy of promoting technological transformation has been implemented mainly at national level. Part of this support was implemented through EU funds, so it was limited primarily to regions outside the Bratislava region. However, the first supportive activities began to be implemented only in 2018, so we cannot adequately assess their results. Regional and local authorities in Slovakia do not have sufficient competences and financial resources to influence the transformation processes in the economy. In terms of their support for the introduction of 4.0 technologies, they are primarily involved adapting the secondary education to 4.0 technologies needs. Contrary to Bratislava region Eastern Slovakia has access to ESIF. However, these resources are not yet widely used for 4.0 transformations. Bratislava region benefited significantly from the state incentives for FDI. Even though the incentives were not directed to deployment of 4.0 technologies, these companies are significantly ahead in their implementation. Thus, the FDI policies indirectly contributed to the technology transformation process.

	Bratislava region (automotive)	**Eastern Slovakia (logistics and**

			transpotation)
	National 4.0.policies	Missing policies to support the adoption of 4.0 technologies as well as the impact of 4.0 technology deployment of the society, first measures taken in 2018. No region specific interventions.	Missing policies to support the adoption of 4.0 technologies as well as the impact of 4.0 technology deployment of the society, first measures taken in 2018. No region specific interventions.
	Regional policies	Limited possibility to finance policies from EU cohesion policy No own regional policy to support 4.0 technological transformation.	Individual activities at regional level are focused on secondary education, and in research and innovation. Lack of policy coordination. Regional authorities are lacking own financial resources for implementation of innovation strategies.
	Specific sectoral policies	None	None
	Other relevant policies	Strong FDI incentives were able to bring substantial number of MNC, which plays very important role in 4.0 transformation.	Region has access to ESIF which may contribute to the technology transformation.

Actual transformations in the region

Economic transformation

The economic transformation of 4.0 technologies seems to be strongly influenced by the structure of the sector. The automotive industry in the Bratislava region is a sector with very high share of MNC plants that does not have an end customers in the region. The transformation then focuses on production aspects (more flexible production, smooth and more accurate production, more skilled workforce to be able to move the plant in value chain, higher IT skills) with the aim of maintaining competitiveness with other plants within the multinational company. The key factor is the quality of the workforce and especially its IT skills, which can differentiate the plant from the competition. Companies are thus investing heavily in IT education and in-house training to improve the skills of their employees. Conversely, in Eastern Slovakia the transformation opens up new market opportunities. By purchasing new technologies, the company gained the opportunity to serve customers outside Slovakia and at a higher level of value chain. Here, however, we can see similar tendencies in the education of the workforce as in the Bratislava region. In both cases, the greater extent of transformation is hampered by lack of IT specialists.

	Bratislava region (automotive)	**Eastern Slovakia (logistics and transportation)**
Changes in skills	Higher IT skills developed, but still more IT skills needed. There is strong pressure from companies, but changes occur very slowly.	The use of new technologies required the acquisition of new (mainly digital) skills. Companies conducted internal trainings provided by technology vendors.
Key changes in organization	More flexible production – 4.0 technologies allow much faster introduction of new models/products	No significant impact on the organizational structure.
Changes in value chain and networks	More tight integration of IT systems within value chains, suppliers must follow final producer.	By purchasing new technologies, the company gained the opportunity to serve customers outside the

		Lead to pressure from final producer on suppliers to use all 4.0 technologies already adapted in their production Only strong MNC in IT sector are usually able more complicated and integrated IT systems - partial shift from local to global IT suppliers	SR and at a higher GVC level.
	Changes in market opportunities	Not for region, basically opportunities were open more for other competing regions	The main change associated with the use of new technologies is related to the penetration of companies into international markets. The new consumer behavior of local consumers also enabled niche markets in the area of shared services.

Social transformation

Re-organization of the local society is rather limited. This transformation is far behind the actual transformation of individual companies or dominant industries. The differences between the two regions are thus also smaller in this respect. The labour market and education systems are adapting only very slowly, and support policy has also begun to address the changes in the business environment to 4.0 technologies only in the last two years.

Economic growth in recent years does not force either the education system or the policy makers to work more intensively on improving 4.0 technologies as a tool for future competitive advantage.

	Bratislava region (automotive)	**Eastern Slovakia (logistics and transportation)**
Changes in skills	More IT skills developed, but still insufficient for future transformation	More IT skills are demanded for further deployment of new technologies but the process in hampered by lower educational level in the region in general
Changes in education	More capacities establish, but difficult to increase interest in IT positions	The formal educational system is slowly transforming but at this moment the demand for new study programs is very limited and schools have problems to find students.
Changes in consumer behaviour	There are no final consumers in automotive sector in the region.	Growing digital skills of local population open niche markets for more sophisticated solutions especially in sharing economy (including electromobility)
Changes in policies	Policy react later, only last year first activities implemented. Activities only on national level – focus on education, digital skills and public digitalization.	Main policies are developed on the national level, regional policies are facing problems with access to financial resources and are lacking coordination

Actual and potential impacts

In the sector in the region	All interviewed companies in automotive sector as well as logistics confirmed the fact that 4.0 technologies are essential for further growth in the industry's productivity. Improvements that can only be achieved by deploying faster and less energy-intensive technologies are already at the edge of their economic benefits and therefore 4.0 technologies are a key area for additional efficiency and savings. Both regions declare positive impact on turnovers, difference was observed in employment changes. In

<table>
<tr><td></td><td>automotive, the effect on employment was slightly negative, while in transportation and logistics it was neutral. The main reason is probably that while the automotive industry in the region is strongly production oriented, in logistics companies carry out all activities (such a marketing, customer service and etc.). Better efficiency thanks to new technologies has opened up new markets, which resulted in the higher demand for new workers. In transportation and logistics, this has happened directly in the region, while in automotive, where there is only manufacturing in the region, this has not happened to the same extent. In both regions, the need for IT specialists has increased as well as the need for higher IT skills at all levels of corporate business.
A particular impact is the threat of reshoring, which is particularly strong in sectors with a high share of FDI, in this case the automotive industry. Its fulfillment could have a significantly negative impact on employment than the 4.0 transformation of production itself.

<table>
<tr><th></th><th>Bratislava region (automotive)</th><th>Eastern Slovakia (logistics and transpotation)</th></tr>
<tr><td>Total Employment changes</td><td>Slightly negative due to transformation, but total employment increase due good general economic conditions</td><td>No significant changes in employment</td></tr>
<tr><td>Turnover and value added changes</td><td>Positive impact (only based on interview estimation)</td><td>Positive impact on turnovers</td></tr>
<tr><td>Composition of employment</td><td>Reduction of jobs for low qualified workers, more IT specialist. More IT skills at all level (from management to manual workers)</td><td>Minor reduction of manual workers in warehousing and higher demand for IT specialists</td></tr>
<tr><td>Other Key impact</td><td>Reshoring risk</td><td></td></tr>
</table>
</td></tr>
<tr><td>In other sectors in the region</td><td>The different impact of the sectors in both regions results mainly from the fact that while automotive is the carrier sector, logistics is an induced sector. Thus, the expected impact on other sectors in logistics is minimal and no evidence has been collected during the case study. The automotive industry has a significant impact on its supply sectors in particular. These are mainly companies in the textile, electrical, engineering and rubber industries. There is a similar process as in car factories, the gradual introduction of digitization and automation leads to slightly negative effects on employment and slightly positive turnover.
The second very important aspect is the creation of very strong links between companies and their suppliers, usually through integrated IT systems. This applies both to vertical suppliers in global value chains and to suppliers of ancillary services such as transport. While previously it was easier to replace a transport company, because it was not directly integrated in the information systems and company just need to find someone cheaper or more reliable, now the information systems of transport companies are inter connected with online exchange of information and commands. This leads to the creation of an internally closed production complex that is practically independent of location or local conditions. This again strengthens the position of multinationals in all supply activities and creates the strong danger of "domino" effects or reshoring.

<table>
<tr><th></th><th>Bratislava region (automotive)</th><th>Eastern Slovakia (logistics and transpotation)</th></tr>
<tr><td>Total Employment changes</td><td>Slightly negative due to transformation, but total employment increase due good</td><td>Introduction of new technologies in transportation and logistics is related with growth of</td></tr>
</table>
</td></tr>
</table>

		general economic conditions	efficiency of the client companies. As important part of the clients are located outside the region, regional effects are supposed to be only marginal.
	Turnover and value added changes	Positive impact (only based on interview estimation)	No evidence of such impact was identified during the case study As important part of the clients are located outside the region, regional effects are supposed to be only marginal.
	Composition of employment	Reduction of jobs for low qualified workers. More IT specialist needed.	No evidence of such impact was collected during the case study. As important part of the clients of regional firms are located outside the region, regional effects are supposed to be only marginal
	Types of skills changes	More IT skills at all levels (from management to manual workers)	
	Other key impacts	More integrated IT systems.	No special impact.
In the region	The case study method is not suitable for identifying macroeconomic consequences of technology changes. According to interviews, we expected the similar effects as was mentioned in two previous parts – positive on productivity, neutral or slightly negative on employment and substantial growth of the demand for digital skills. The biggest identified threat for Bratislava region was reshoring (not only in automotive industry, but also in other sectors with high presence of FDI as e.g. shared services centres). Technological transformation is associated with a growth of employment in high tech sectors in the Eastern Slovakia region. However, we are not able to identify direct causality of such relation.		
Future outlook on 4.0 technologies	The technological development is rather gradual process so we do not expect dramatic changes in current trajectories. Companies will continue to implement existing 4.0 technologies. One of the larger technological challenge is a growth of electromobility and introduction of autonomous vehicles. In case of autonomous vehicles, firms in Eastern Slovakia are rather sceptical because of the need for specialised transportation infrastructure in Slovakia. Firms expect further growth on the demand for digital skills such as in maintenance of new technologies or in the integration of information systems. This will result in a demand for new on the job trainings and changes in formal educational system.		
Best practices	We have identified several best practices, which document technological transformation in case study regions: • Good knowledge of the 4.0 technology capabilities by management significantly supported the success of the introduction of these technologies. The greatest advances in the use of 4.0 technologies and the greatest benefit appears in companies where the management itself had excellent knowledge of the possibilities of these technologies and at the same time qualified IT workforce to implement and exploit them. • The adoption of new technologies has allowed regional transport companies to penetrate the supply chains of multinationals and international transport markets. The adoption itself relates mainly with the purchase of ready to use technologies from foreign suppliers, change of information systems and subsequent training of employees. New technologies have been associated with cost reductions, better efficiency and faster response to delivery		

<table>
<tr><td></td><td>problems.
Local know-how in information and communication technologies in the field of mobility has led to the creation of a number of services for citizens on the principle of a shared economy, which is currently developing mainly in the field of electromobility. The provision of these services is conditional on a higher degree of population digitization and the existence of a critical mass that is higher in large cities. The main benefit may be related to the increase in the use of environmentally friendly public transport.</td></tr>
<tr><td>Operational policy recommendations</td><td>Table summarizes policy recommendations that could be important for future positive adoption of 4.0 technologies or future positive impact from this adoption. Some policy recommendations are more suitable for one region than another, but generally, the many of them are also sector specific, so most of the measure seems to be needed to some extent for both regions.

<table>
<tr><th>Key elements/developments</th><th>Policies to react on these developments</th></tr>
<tr><td>Reshore of companies (Bratislava region)</td><td>Increase of quality of labour force as main regional factor
Improve applied RD capacities in the sector to support cooperation with MNC
Support local plants in intercompany competition</td></tr>
<tr><td>Reduction of jobs for lower qualified workforce
(both regions)</td><td>Requalification support for other industries/services or higher value added jobs in automotive</td></tr>
<tr><td>Strong pressure on subsuppliers (Bratislava region)</td><td>Programs for networking, involvement of SMEs in global value chains</td></tr>
<tr><td>Integration of IT systems
(both regions)</td><td>Support local IT providers to enter global value chains
Build adequate IT infrastructure also on public sector side</td></tr>
<tr><td>Lack of IT specialists
(both regions)</td><td>Improve general IT skills (longlife education programs, more IT in secondary and primary schools)
Support tertiary education in IT profession</td></tr>
<tr><td>Improve skills for changes
(both regions)</td><td>Change management trainings in companies
Support of participation on trade fairs or other tools to provide good overview of technology changes for management of companies (specially in regions without presence of 4.0 technology providers)</td></tr>
<tr><td>Improve quality of workforce (both regions)</td><td>Specially in the field of IT
Need for more IT in secondary education, better dual education</td></tr>
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5 Summative table for Spain

	Key messages by country
Setting the scene	
Regional baseline	Catalonia (ES51) covers an area of 32,108 km2, with 7,543,825 inhabitants (2018). The Canary Islands (ES70) covers an area of 7,493 km2 and has a population of 2,127,685 (2018). As an Outermost Region, the Canarias economy has to overcome its remoteness from the continent, the small market size, the limited size of infrastructure, or the scarcity of qualified workers. It has limited shares of the industry in the economy, and a strong orientation towards services. Services sector makes up 76% of GDP and represent 77.5% of employment (ISTAC, 2018). The GDP per capita is 20,425€. The Catalan economy, whereas, has an important industrial tradition. The industrial network is composed of a broad network of small and medium-sized family firms in mature sectors, combined by a relevant number of large multinational firms. The industry represents 21% of Catalan economy, while comparatively the service sector accounts for 73%. The GDP per capita was 31,200€ (2018). Catalonia has become one of main tourist destination in Europe, with more than 19M tourists. The tourism sector accounts for 14% of employment and around 12% of GDP (2018). In Canary Islands, tourism is the large industry, being de main source of income and job creation. The tourist activity generated 35% of the GDP of the islands and the 40% of employment. In terms of digitalization, the ICT sector reached 2,363 companies and 16.000 workers (2018) in Canaries, most of these companies are mainly small and micro-sized, specialised on tourism sector. In Catalonia, there are 15,760 companies and 106,400 employees (2018), of which 2,766 are concentrated in the city of Barcelona (CTecno, 2018). Among them, 97% are service-oriented.
Adopted 4.0 technologies in the sector in the region	In both regions, the sector has adopted technological solutions like online booking, e-marketing, pricing, online reputation, data tracking and exploitation, market monitoring, Internet of Things, Artificial Intelligence… Canary Islands have strongly focused on e-marketing solutions for promotion tasks. In relation to the use of Big Data, actions of digital marketing have been carried out by segmenting the promotion messages. In Catalonia, Catalan Tourist Board is using Big Data for the prediction of consumer behaviour, and the personalization of the services offered. In both regions, public and public-private institutions have developed different projects and initiatives to improve the management of tourism business and costumer satisfaction by using Big Data.
Preconditions for transformation	
Regional preconditions	Based on interviews, in both regions there is strong institutional support for developing solutions. Catalonia and Canary Islands, have several policies, strategies and initiatives to support and promote digitalization, innovation and technology transfer among companies of the sector. Catalonia has developed initiatives to promote digitalisation among civil society. In both regions, there are also different instruments such as technological bonds and grants to promote the creation and expansion of technology-based companies focus on tourism activities. Nevertheless, Catalonia would have a higher degree of digitisation in existing businesses, having a strong ICT sector. It could facilitates faster technological transformation. Catalonia also counts with a technological hub as Barcelona, where take place international congress and events related to new technologies (e.g. the Mobile World Congress). Canaries has to promote individual development strategies by each islands due to the particularities of each one, and the difficulties to develop a homogenised 4.0 technology strategy.
Sectoral preconditions	Both regions have established public support programmes and initiatives that help the implementation of 4.0 technologies in the sector. The interviewees considered relevant the public-private collaborations for higher implementation of the 4.0 technologies in the sector. In Catalonia, it

	has been created the Tourism & ICT cluster or in Canaries there is ICT Demonstration Centre for Tourism Innovation, both based on public and private sector collaboration. But it has been especially important the private sector investment for technological transformation in Canaries. Generally, in both regions there is a positive receptivity of tourism to implement innovative actions.
Social preconditions	Catalonia traditionally has been a region characterised by its high rates of entrepreneurship, leading by Barcelona. In the case of Canaries, some stakeholders pointed out a lack of innovation culture among a part of Canaries society, although it is increasing recently. The interviews show that the workforce of the sector, in general, has not have a high level of technological readiness/digital literacy for facility this transformation. In both regions, the education programmes related to tourism are under transformation for introducing ICT skills. It is also get importance the sustainability awareness and environmental carrying capacity. In Catalonia, different tourism related institutions are working to analyse and evaluate the carrying capacity of the sector in the region, or to increase the good image of the sector among local residents.
Policy preconditions	Both regions have approved different strategies, plans and initiatives that establish the strategic framework for medium and long-term work to face the challenges of tourism activity in the region. The interviewees point out that in Catalonia and Canaries need properly political framework to achieve the objectives of more sustainable activity and socially more active tourism. In both region, tourism strategic plans and programmes highlight the importance of the digitalization of the sector for achieving these principles. In the case of Canary Islands, the bigger islands have available individualised strategies for their own territory, meanwhile the smaller ones do not have own strategies, and are run by regional programmes. In both regions, the strategies and programmes have contributed to develop different initiatives related to innovation and digitalization of tourism, mainly concentrated at local level in Barcelona or Tenerife.
Actual transformations in the region	
Economic transformation	According to interviewees, in both regions tourism is a strategic sector for their economies. In both regions, technology is generating more economic activity and new job opportunities, transforming sector labour market. This transformation has required the incorporation of new professionals' profiles with high technological skills into the labour market. So far, both regions have experienced changes in employee skills with growth in digital competences of workforce. In Catalonia, new training programmes are created for increasing the rates of digital competences of employees from the sector. The irruption of search and book online platforms (e.g. Booking or Expedia) has changed the relationships between the sector and tourists. Both regions share CRM programmes for segmentation of tourist profiles and personalisation of tourism promotion. Canaries bet strongly for digital marketing. CRM programmes, digital marketing or social networks management are creating new job opportunities related to analyses and monitoring tourism data (e.g. hotels are creating new departments to control online opinions). The customization of tourism products, cause with the technology has changed the way of how is understand a trip. Now, tourists search "experiences". Changes in consumption patterns has translated in new business models emerging that are intrinsically connected to 4.0 technology usage. In the case of Catalonia, new actors have entered to the sector. New business models based on P2P economy are consolidated. The sector is under generational changes, especially in Canary Islands. In this case, besides from some very large companies, most hotel entrepreneurs are still owners of small hotels, where digitalisation is a challenge. New generations are now starting to invest in their hotels introducing improvements based on 4.0 technologies.
Social transformation	In both regions, currently tourism model requires new ICT skills adoption by the workforce from the sector. Employees are increasingly trained in the use of new technologies (data management programmes or mobile applications). However, there is still a percentage of workforce without ICT capabilities. Educative programmes related to tourism are under

	transformation. In Catalonia, new training offers are created around innovation, digital transformation and digital marketing applied to tourism. Faculty of Tourism and Hotel Management – Sant Ignasi is committed to combine ICT skills with human abilities to generate greater added value of the sector. In Canaries, The Valley Canarias, an innovation hub specialised in digital training, is also betting for the digitalization of training programmes related to tourism combining inputs from private and public sector. In the case of Catalonia, and in the cities as Barcelona, new technologies are being using for enhancing better the tourist activity into the city management. Barcelona has the challenge to manage the tourism in those areas that has overcrowded.
Actual and potential impacts	
In the sector in the region	In both regions, the sector is experiencing an increased value added of the activity, positive impact on turnover and better productivity and competitiveness. Experts, for instance, estimated that the adoption of 4.0 technologies by the accommodation sector would increase the competitiveness of the sector around 20%. In both regions, also, the advances of 4.0 technologies applied to tourism new jobs are created, and some could disappear (e.g. traditional travel agencies or local guides). New profiles demanded by the sector will have high technological skills. There will be reduced manual and lower skills workers, and those jobs that currently develop repetitive tasks may disappear or be automated (e.g. receptionists could be replaced by automatic check-in and check-out machines, or even robots). Neither in Canaries nor in Catalonia automation processes of the sector have occurred. In both regions, there will be increased the number of professionals with higher ICT skills. According to experts, it will become increasingly important "the hybridisation of competences, and therefore tourism professionals, institutions and companies". The digitalisation of the sector has contributed to spread P2P economy, especially in Catalonia, where the number of accommodation, mobility or leisure services would be higher than in Canaries. Catalonia also is betting for collecting, analysing and exploiting big data to increase the knowledge of travellers' flows or behaviour in the region. For example, Barcelona has analysed the international tourist consumption patterns through their credit card payments for knowing their expenses across the city. The use of Big Data in the case of Canaries are mainly used fit better tourism promotion, personalised recommendations and fitted tourism experiences in the islands.
In other sectors in the region	The implementation of new technologies also has meant changes in other sectors of the Catalan and Canaries economy, although the impacts will be different depending on the region. In relation to the labour market, one of the main features will be the higher presence of machines (e.g. robots, new operating systems and algorithms) in the production processes. As new technologies become part of the productive process, some tasks can be done with fewer workers or even some jobs may disappear. It is expected to have higher impact in Catalonia than in the Canaries, given that the industrial sector (as in the case of the automotive industry) shares high rates in Catalan economy (industrial sector represents 20% of GDP). However, experts believed that possible automation processes would not reduce labour force of the region. The main skills required by the labour market will also change. In other sectors, it is expected that the jobs that require, for example, social skills, such as knowing how to communicate, leadership, or teamwork, skills that technology still has no capacity to develop, are becoming increasingly important, and having equally impact on both regions. With regard to the business dimension, the technology leads to a dual structure. In both regions, the digital advances will increase the production and the access to more markets. But at the same time there will be more opportunities for small specialized businesses, thanks to technological advances which allow companies to produce goods at a much lower cost.
Future outlook on 4.0 technologies	In terms of occupation, the sector will tend to generate more occupation in both regions. The sector is expected to continue generating employment and new professionals' profiles will be demanded. New jobs are being created, disappearing or replaced those focused on repetitive tasks. So,

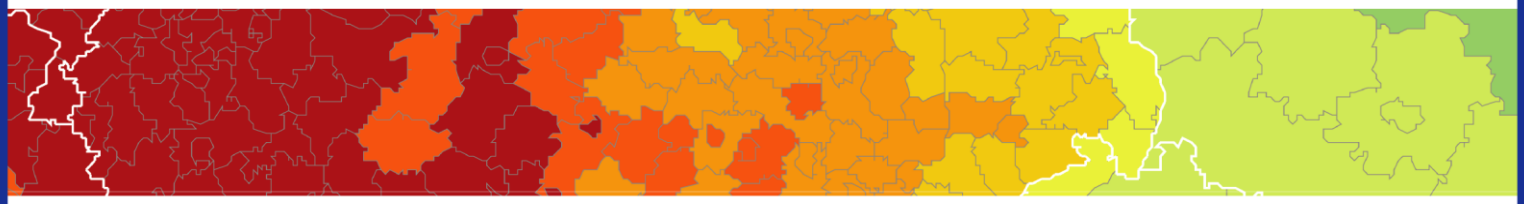
	some current occupations may be replaced by technology. In the sector, for instance, receptionists could be replaced by automatic check-in and check-out machines. Future jobs will be related to monitor, analyse or exploit data. In the case of Catalonia, those profiles are already demanded due to the higher share of ICT sector in the regional economy. The productivity and competitiveness will grow in both regions, and it will also have a positive impact in the sector following the general trends of the sector at a global level. Experts estimate that the incorporation into smart tourism will allow 20% growth in competitiveness. Even so, it will be necessary to take into account the current situation of main competitors of both regions. It will be important the role of good tourism image and a consolidated brand as already have Barcelona in Catalonia or Canary Islands. The sector tends towards the mixed concentration of SMEs and large operators. Both in the Canary Islands and in Catalonia, the presence of small and medium-sized companies and large operators in the sector will be combined (now already occurs). New actors have accessed to the market thanks to spread of P2P economy, especially in Catalonia. In relation to training, technology 4.0 becomes more important. In Catalonia, universities and research centres are working to promote digitalization, prioritising 4.0 technologies implementation in the sector. Collaborations between the sector and universities will be more relevant in the forthcoming years. Tourism governance models will tend towards public-private partnerships. Taking into account the weight of the occupation of the sector in the regional economy, training in technology and tourism is an important issue to take into account in the Canary Islands, which will require a great effort by educational institutions to adapt their training programmes to new professional aptitudes. With technological advances, the decentralization of activities could be increased, also tourism activity. New technology offers great opportunities for secondary destination areas. Some experts point out that due to environmental and sustainability issues, tourist concentration should be encouraged, through intelligent tourism management. Even so, many of the experts have pointed out that technology could contribute to the mitigation of negative externalities, but it must be taken into account that it is not the solution.
Best practices	The ICT initiatives are concentrated at local level, mainly in Barcelona city, where numerous initiatives have been identified. Clusters, applications and projects for the development of new activities are working on disciplines such as mobility, energy, health or food, among others, with participation of research and support centres (such as the Barcelona Supercomputing Centre), business incubators and other initiatives to introduce the use of new technologies among citizenship (such as the Fab Labs). Related to tourism, it has been created Tourism ICT cluster, composed by private companies that combine technology and tourism, universities and research centres, with the objective of collaborate for improving innovation and technological competitiveness of Catalan tourism. In the case of Canaries, some identified initiatives are related to innovation and digitalization support of tourism. Here, larger islands have developed their strategies and initiatives to a higher extent compared to smaller islands. There is the Cluster the "Canary Islands Technological Excellence" or Canary Islands Future Lab, a space for promoting the digital solutions. Related to tourism, in Gran Canaria there is the ICT Demonstration Centre for Tourism Innovation, a platform where public sector and private companies share their knowledge for implementing 4.0 technologies in the sector.
Operational policy recommendations	Tourism policies were mainly focused on the promotion and attraction larger number of visitors during the 90s and early 2000s overcrowding is beginning to be experienced by Canaries and Catalonia, tourism policies go to implement measures for a more integrated and transversal management of the sector. Policies have to coordinate, regulate and manage tourism activities, taking into account their environmental and social effects, and the potentialities to integrate the local economic development; and technology should contribute to achieve it. - Monitoring the tourist activity allows to know and understand the tourist flows across the region, and its segmentation to improve the management. However, those operators that have the data does not manage tourism

	activity, and often does not intend to share it either. - Technology allows bettering understanding the microscopic scale of tourism in places of high affluence or during mass events. The digitalization of the tourist sector implies the need to combine technological innovations, such as Artificial Intelligence (AI) or Internet of Things (IoT), with human abilities. New training programmes related to tourism are under development. - A good tourist image contributes to the global positioning, ant to increase the attractiveness of the region. It means developing a wider promotion of the destinations. - The Smart City model, where new technologies are designed to improve the daily life of its inhabitants, contributes equally to the improvement of the tourist destinations. - Public policies have to be strongly aimed at supporting SMEs business for incorporating the new tourism strategies based on new technologies due to the high number of SMEs business that there are in both regions.

6 Investment stimuli in Slovak republic (Bratislava region)

	Automotive in Eur	Others in Eur	Share of automotive %
2003	166,018,388	12,746,465	92/87
2004	261,899,356	51,502,986	83.57
2006	184,304,776	174,010,032	51.44
2007	77,778,505	93,534,587	45.4
2008	2,522,524	17,405,149	59.21
2009	15,070,000	60,200,583	20.02
2010	917,473	38,149,551	2.35
2011	27,935,611	36,994,584	43.02
2012	60,528,270	60,663,228	49.94
2013	5,670,000	55,183,168	9.32
2014	2,432,609	97,454,872	2.44
2015	155,035,581	24,425,541	86.39
2016	0	59,162,000	0
2017	19,428,736	64,516,784	23.14
2018	31,873,000	64,280,018	33.15

Source: own calculation based on data from the Ministry of Finance



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ESPON 2020 – More information

ESPON EGTC
4 rue Erasme, L-1468 Luxembourg - Grand Duchy of Luxembourg
Phone: +352 20 600 280
Email: **info@espon.eu**
www.espon.eu, **Twitter**, **LinkedIn**, **YouTube**

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