

T⁴ – Territorial Trends in Technological Transformations

Applied Research

Final Report – Case Study Annex A

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T⁴ – 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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Abbreviations

AAIS	Assumptions for AI Strategy
AI	Artificial Intelligence
AMTC	Association of Tourist Municipalities of the Canary Islands
AT + R	Cluster Automation and Robotics
BERD	Business Expenditure on Research and Development
CCRDT	Regional consultative committee for RTD
CE	Central and Eastern Europe
CNRS	National Centre for Scientific Research
COP	Central Industrial District
CREED	Regional conference on economy and sustainable employment
CRM	Customer relationship management
DESI	Digital Economy and Society Index
DPF	Digital Poland Foundation
EC	European Commission
ERDF	European Regional Development Fund
ERP	Enterprise Resource Planning
ESPON	European Territorial Observatory Network
ESPON EGTC	ESPON European Grouping of Territorial Cooperation
EU	European Union
EU	European Union
FDI	Foreign direct investment
FTE	Full time equivalents
GDP	Gross Domestic Product
GERD	Gross Expenditure on Research and Development
GVA	Gross value added
HEI	Higher Education Institution

I2DF	Index Industry of the Future
ICT	Information and communications technology
IDESCAT	Institu Català de Estadística
IFREMER	French Institute for Marine Research
ILO	International Labour Organisation
IMD	International Institute for Management Development
INE	Instituto Nacional de Estadística
INSERM	National Institute for Health and Medical Research
ISTAC	Instituto Canario de Estadística
IT	Information technologies
LFS	Labour Force Survey
LPI	Logistics Performance Index
NCBR	National Centre for Research and Development
NUTS	Nomenclature of Territorial Units for Statistics
NUTS	Nomenclature of Territorial Units for Statistics
OECD	Organisation for Economic Cooperation and Development
OP	Operational programme
OTAs	Online Travel Agencies
P2P	Peer to peer
PCT	Patent Cooperation Treaty
PDAI	Policy for Development of Artificial Intelligence
PLN	Polish Zloty
PPS	Purchasing Power Standards
PwC	PricewaterhouseCoopers
R&D	Research and development
RD <i>i</i>	Research & Development & innovation

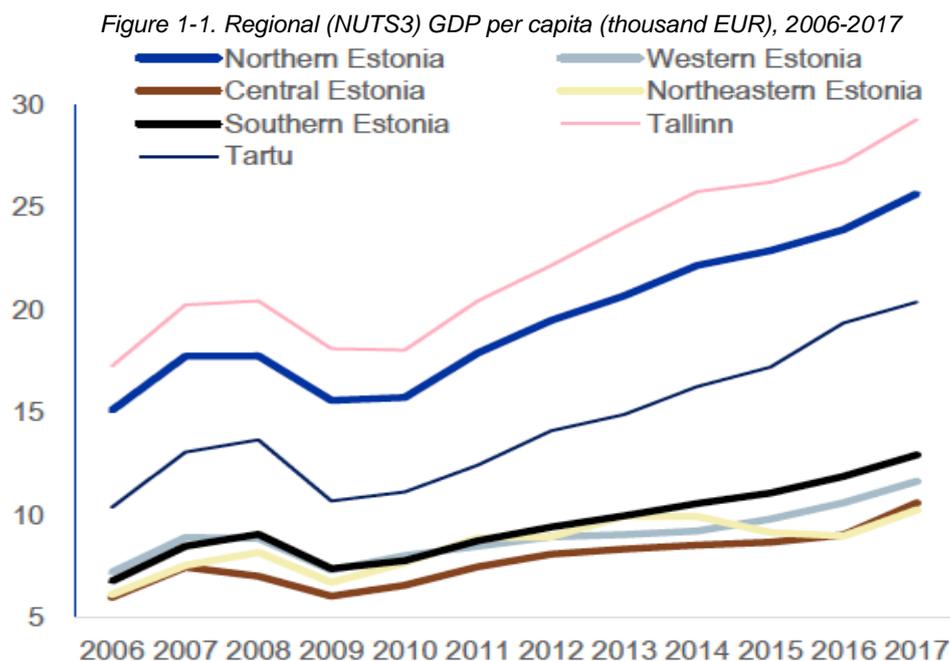
RES	Renewable energy sources
RIS3	Regional Innovation Strategy
RISMV	Regional Innovation Strategy for the Mazowieckie Voivodship
RMB	Barcelona Metropolitan Region
SME	Small and medium enterprise
SRD	Strategy for Responsible Development
VW	Volkswagen
WWII	World War 2

1 Estonia

1.1 Northern region

1.1.1 Regional baseline

Despite its small size, Estonia has high regional disparities with regional GDP per capita gap steadily growing during last decade. The Northern region is the most vibrant and dynamic region in the country due to its geographical location (seaport) and proximity to the capital city, Tallinn. Northern Estonia has been steadily maintaining the highest regional GDP per capita (Figure 1-1).



Source: Foresight Centre 2019 based on Statistics Estonia

The Northern region (which contains the capital city Tallinn) ranks in 20% of top regions in OECD in terms of jobs, access to services (broadband) and education. Inter-regional disparities are related to jobs, access to services (broadband) and civic engagement (voter turnout) as well as health (mortality rates and life expectancy) (OECD 2016¹). This is largely due to rapid growth of the North region, around capital city Tallinn (in 2016 GDP per capita in the North region was 2.6 times higher than in Northeast region) but overall regional economic disparities in Estonia are still above OECD median (OECD 2018).

Around half of industrial output is produced by the Northern region. This is due to the economic and logistical importance of the capital city (Tallinn) located in the region. The Northern boasts centres of academic and scientific excellence with one of the major public universities in Tallinn and solid presence of ICT and electronics firms.

¹ OECD. (2016). *OECD Regional Outlook 2016: Productive Regions for Inclusive Societies*. Available at: <https://www.oecd.org/gov/oecd-regional-outlook-2016-9789264260245-en.htm>, last accessed 26/7/2019.

The metal-processing industry in the Northern region is export-oriented where the metal-processing companies are mainly sub-contractors to larger, often foreign-owned firms. The majority of businesses in the sector are SMEs that are characterised by lower value-added.

1.1.2 Adopted 4.0 technologies in the sector in the region

All digital technologies used by industrial firms in metal-processing come from foreign sellers and no evidence exist of wide adoption of locally produced 4.0 technologies. This is despite the fact that Estonia features a well developed ICT sector with local companies producing 4.0 solutions. However, Estonian IT companies also primarily focus on the international markets and there is little demand locally for 4.0 technologies.

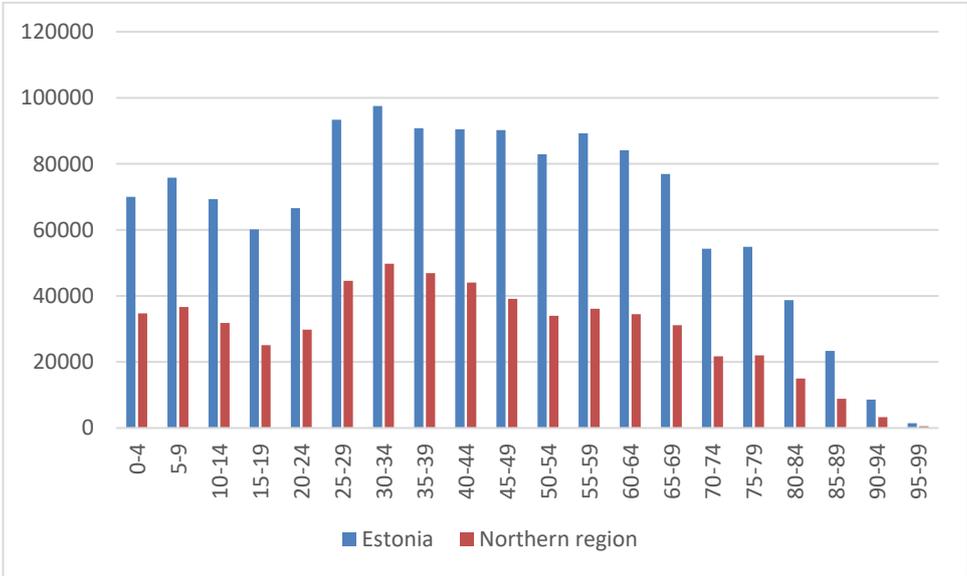
The metal-processing sector has adopted ERP systems, digital supply chain systems, digitised machinery and production lines and to some extent robots. However, the metal-processing sector has been less successful in the wider adoption of such practices and technologies.

1.1.3 Preconditions for transformation

Regional preconditions

Following the administrative reform (2017), the Northern region consists of Harju county, which surrounds the capital city of Tallinn. There are 589 610 people living in the region (2018), which is 44.7% of total population of Estonia. Figure 1-2 depicts the distribution among different age groups. Region’s population is relatively young: the number of younger people (between 20 and 39 years old) is significantly higher than the number of older groups (40 years and older).

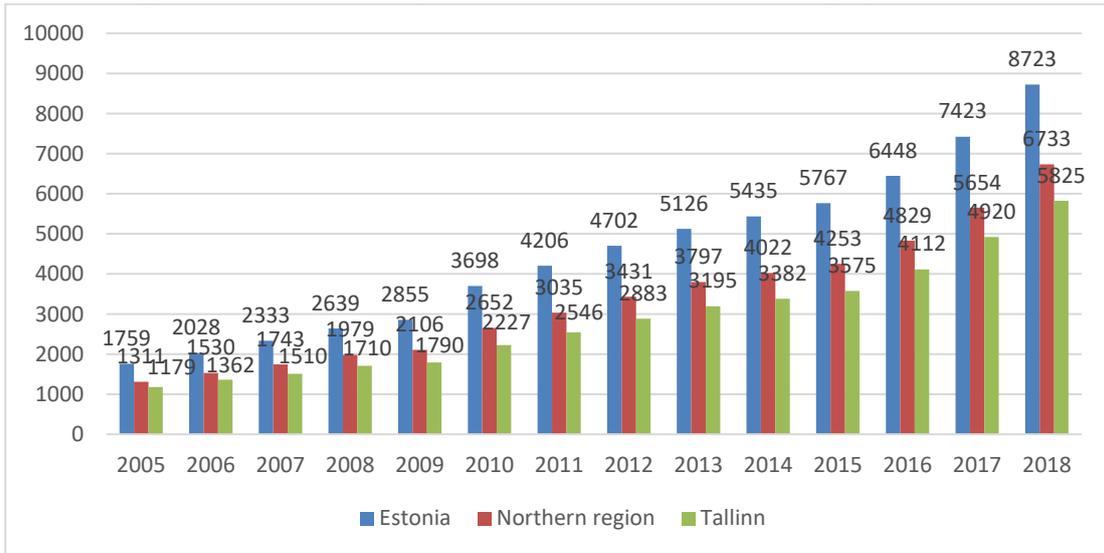
Figure 1-2. Population distribution among age groups in Estonia and the Northern region, 2018



Source: Statistics Estonia

The amount of enterprises in Information and Telecommunication (ICT) sector has been growing while the majority of firms are located in Tallinn. The growth of the number of ICT firms has been steady and, interestingly, remained unaffected by the significant economic downturn during 2009-2011.

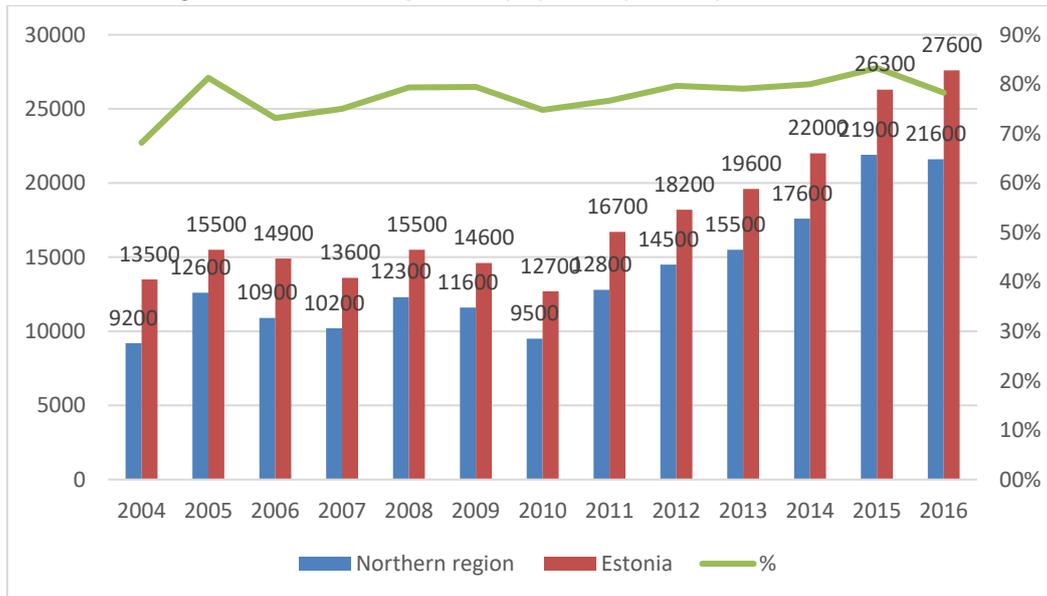
Figure 1-3. Number of enterprises in ICT sector in the Northern region, 2005-2018



Source: Statistics Estonia

Figure 1-4 depicts the number of employed persons in ICT sector in the Northern region, which has been rising and currently makes some 80% of all country's employment in ICT sector.

Figure 1-4. Northern region's employment by industry: ICT, 2004-2016

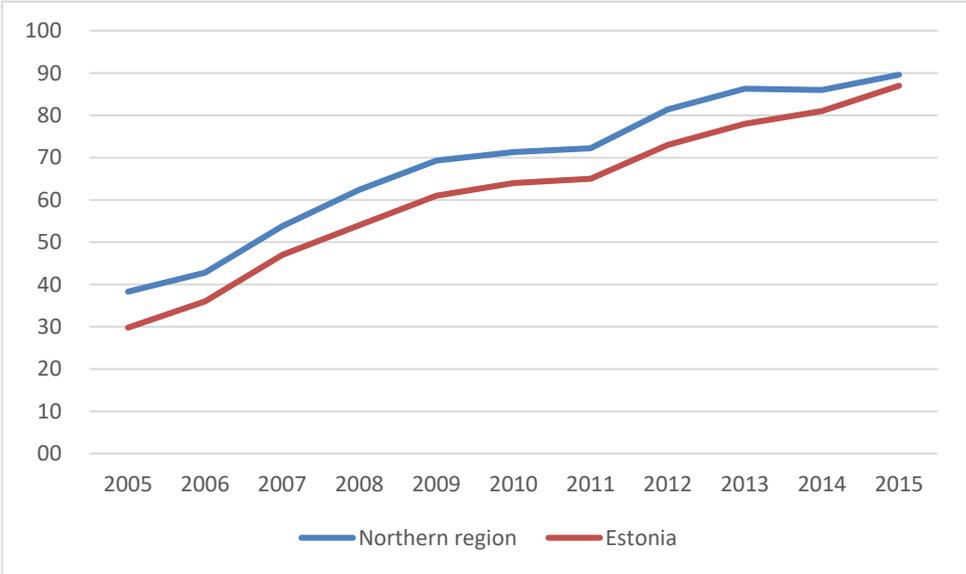


Source: Compiled by the author based on data from OECD

Estonia has been increasing its broadband coverage and access: the fixed broadband coverage increased from 87% (2015) to 89% (2017) but remains lower than the EU average (97% in 2017). This

is largely due to lower coverage rates in rural areas, which remain at 75% during 2015-2017.² At the same time, ultrafast and 4G coverage are higher than then EU average: 71% (2017) as compared to 58% of EU average (2017) and 96% (2017) as compared to 91% of EU average (2017) respectively. Given such context, Northern region has been steadily scoring higher in the internet broadband access than the national average indicators. (Figure 1-5)

Figure 1-5. Internet broadband access in the Northern region, 2005-2015

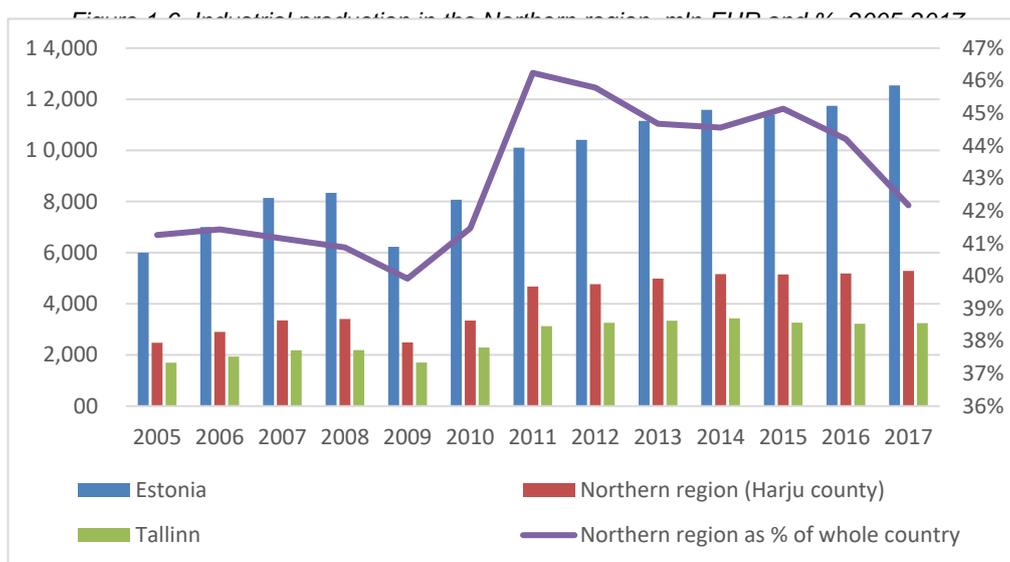


Source: OECD

Sectoral preconditions

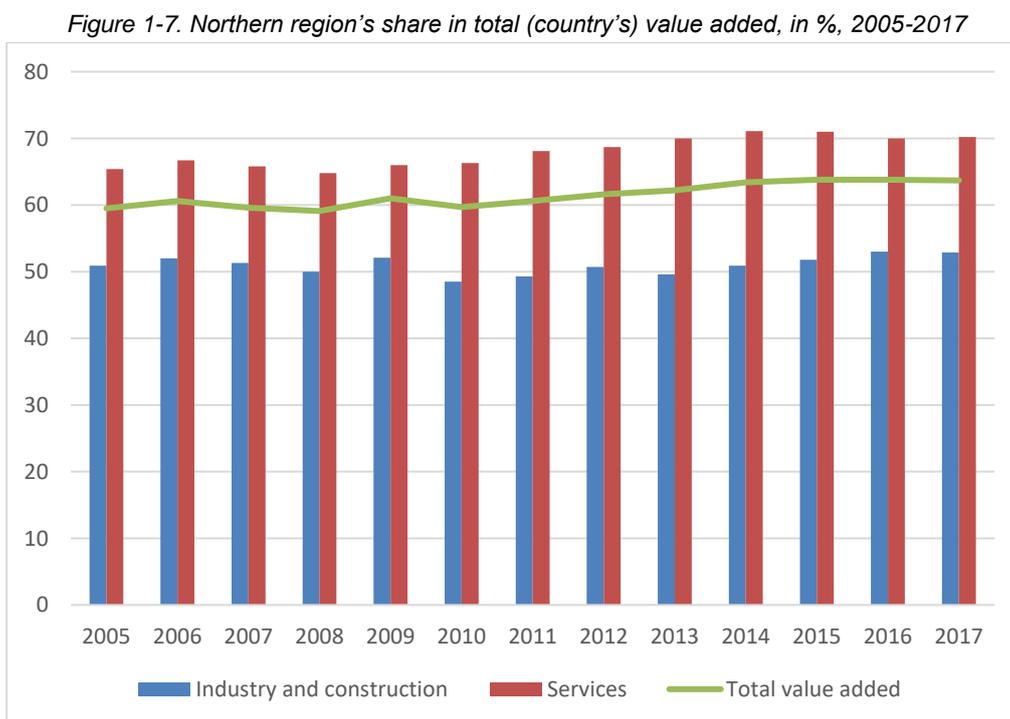
The Northern region can be characterised by concentration of industrial firms, including machinery, electronics and ICT; faster access to finance; logistical advantages and close proximity of industry-related centres of excellence (especially Tallinn University of Technology, the only technical HEI in Estonia). It accounts for more than 40% of total industrial production: larger manufacturing units are mostly concentrated in the Northern region, except for chemical and shale oil production sites which are located in the Northeast region. Figure 1-6 presents regional industrial output in absolute numbers and as a share of country’s total industrial production.

² DESI. 2017. EU Digital Progress Report. Telecoms Chapter: Estonia. Available at: <https://ec.europa.eu/digital-single-market/en/news/desi-report-2018-telecoms-chapters>, last accessed 2/9/2019.



Source: Compiled by the author based on data from Statistics Estonia

Northern region accounts for some 65% of total value added produced in Estonia. Figure 1-7 demonstrates that the Northern region's share in value added generated in services is 70%, which is significantly larger than the share of country's value added generated in industry (50%).

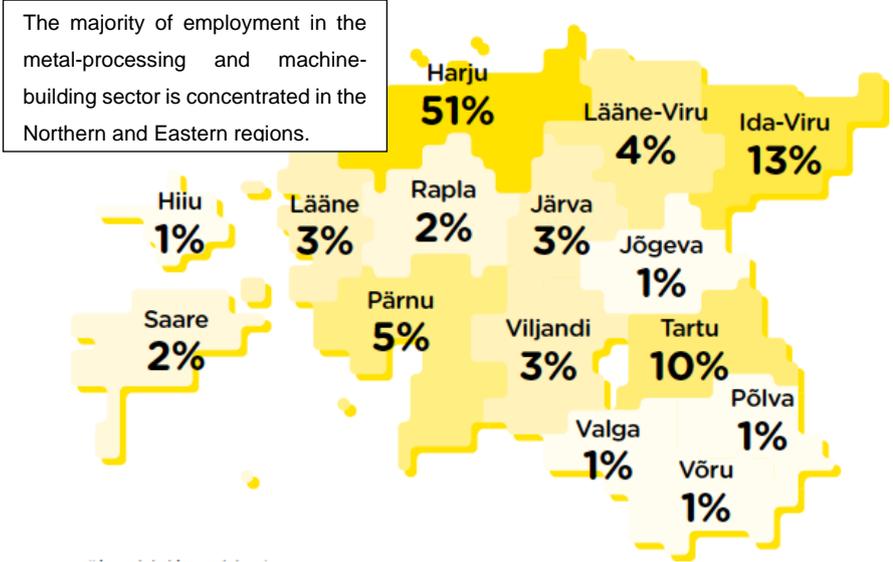


Source: Compiled by the author based on data from Statistics Estonia

Despite the highest level of ICT development in the Northern region, its application in more traditional industries can be very limited. This is the case of metal-processing industry. More than half of companies

working in metal-processing and machinery sector are located in the Northern region (Harjumaa), as depicted on Figure 1-8.

Figure 1-8. Geography of metal-processing and machine-building industry in terms of sectoral employment, 2012-2014



Source: OSKA 2016b

According to the latest sector-specific study³, the sector is generally characterised by substantial exports. The sector (in statistical terms, metal-processing is combined with machinery) is dominated by small firms, which predominantly act as subcontractors to larger companies located abroad. The sector has been continuously lacking labour force and has been importing workers from Ukraine and Belarus. The sector is also characterised by many firms where the general level of ICT skills is low, especially among more senior workers. Metal-processing industry in Estonia is characterised by relatively low value added, is dominated by small companies, which act as subcontractors to large foreign owned enterprises. According to the national data from 2012-2014, 76% of companies in metal-processing were micro-enterprises (with less than 10 employees). Metal-processing is dominated by manufacturing of metal products (95% of all sector) and makes some 50% of exports in the entire machinery and metal sector. It has been characterised by a lower growth in value-added but the highest productivity per a worker as compared with the manufacturing sector.⁴ In this regard, the developments in metal-processing industry in the Northern region reflects the overall problems of the sector in Estonia.

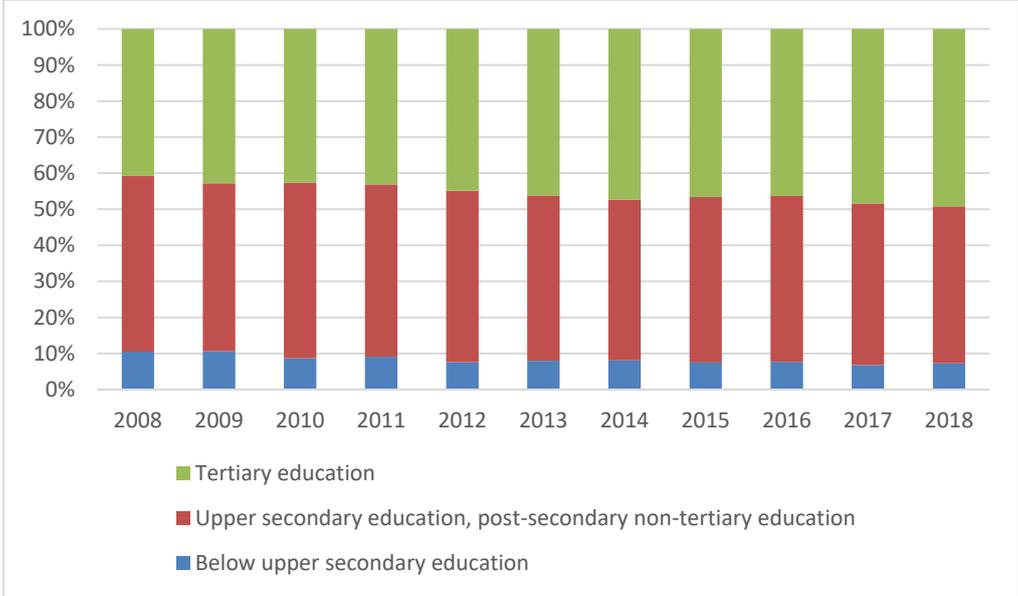
The increasing use of digital machines and robots produces the demands for skilled maintenance specialists. Subcontracting orders are typically small and therefore production lines need to be adjusted very often and fast. This creates the need for a lot of adjustment jobs performed and therefore the decreasing amount of machine operators can be counter-matched with the increasing need for adjustment and calibrating specialists. Engineers and production line operators need to understand the

entire production process and a lot of machinery-related technical specifications, which involves sector-specific digital knowledge.³

Social preconditions

In terms of human capital, the Northern region is characterised by a high share of tertiary education in region’s labour force, which has been steadily increasing during the past decade (Figure 1-9).

Figure 1-9. Share of educational level in labour force in the Northern region, 2008-2018



Source: Statistics Estonia

Despite the overall high level of higher education among employed persons, all interviewed representatives of enterprises and industry associations lamented on the critical scarcity of qualified people in the manufacturing industries overall. This is related to decreasing share of younger people choosing to work in manufacturing, the absence of qualified educators in institutions of applied education and the absence of modern curriculums that would incorporate digitisation of manufacturing and sophisticated automation.

There have been some attempts in surveying and upgrading teaching curriculum and materials in the Northern region. This is largely due to the fact that Tallinn University of Technology, the only technical HEI in Estonia, is located in Tallinn. The ‘Specialised Programme in Industry 4.0 and 5.0’ has been recently developed at Tallinn University of Technology at the Master level. Admission to the programme started in September 2019 and the programme specifically targets managers of various levels working in the industry as well as consultancy experts in the field of digital manufacturing. The program aims to

³ Ibid

introduce the growth and production models that are implemented in production plants by also aligning to the principles of the Internet of Things (IoT), Artificial Intelligence (AI), 3D printing, etc.⁴

The survey of 26 companies conducted in 2018⁵ concluded that the lack of skills to develop company-based digital solutions or to apply and operate sophisticated automated systems is the critical bottleneck in Estonian industry. The new generation of middle-level managers and machine operators are needed in this regard. The association of metal-processing and machinery building was actively involved in assessing the education needs and reforming the curriculum for institutions in applied education. The project-based initiative (2017-2019⁶) involved partners from Latvia, Lithuania and Germany. The main outputs of the project were the comparative analysis of standards and qualifications in metal-processing curriculum and newly developed teaching materials for students. The project revealed significant differences in national systems of qualifications that, in turn, affect the content of the study curriculum. This makes the transfer of best education practices from one country to another less viable. In Estonian context the major challenge remains the lack of staff and instructors in institutions of applied education that would be able to teach such curriculum.

Overall, the metal-processing is dominated by smaller companies, but they are mainly subcontractors for larger client firms located abroad. Subcontracting as such does not imply a lower- productivity trap but the metal-processing industry in Estonia has been stagnating at a lower value- added end. The industry is rather capital-intensive, similarly to wood-processing, and is characterised by the need for high precision machinery (cutting, optics, robotics). Yet, its structural characteristics (subcontracting) reinforces short-term orientation of operational strategies, greater need for skilled workers and a larger proliferation of legacy systems (old machinery, lack of basic digital skills).

Policy preconditions

The importance of digital skills of population is recognised at the policy level in Estonia: The Digital Agenda 2020 (updated in 2018) includes specific targets in terms of development of ICT skills that should be reached by 2020. There are four groups of targets, as listed below.

⁴ <https://www.ttu.ee/en/?id=192164>

⁵ Ministry of Economic Affairs and Communication. (2018). 'Analysis of Digital Transformation of Industry.' DIGINNO project report.

⁶ Industry 4.0 CHALLENGE: Empowering metalworkers for smart factories of the future (4CHANGE)

Box 1-1. Estonia: The Digital Agenda 2020 targets of development of ICT skills

Source: Digital Agenda 2020 for Estonia

1. Percentage of internet non-users ²⁶ among Estonian inhabitants aged 16-74
a. Starting level: 18% (2013) → Interim level: 11% (2018) → Target level: 5% (2020)
2. Percentage of those aged 16-74 among Estonian inhabitants who have used e-commerce
a. Starting level: 49% (2014; EU average 45%) → Interim level: 61,3% (2018; EU average 62%) 2017 → Target level: EU average 2020 (2020)
3. Percentage of ICT specialists in the employed population
a. Starting level: 4.9% (2013) → Interim level: 6.8% (2017) → Target level: 8% (2020)
4. Percentage of top-level specialists in the employed population
a. Starting level: 9.3% (2014) → Interim level: 10.8% (2017) → Target level: 12% (2020)

More importantly, the level of ICT skills among the labour force has been also supported by policy measures. There are three major initiatives that aim to directly contribute to nurturing digital skills: Programme “Choose IT!” (2017), Digital Literacy Training for Industry Employees (2017), and Foreign recruitment grants (2018)..

Table 1-1. Major existing initiatives that aim at developing digital skills (as of July 2019)

Year	2017	2017	2018
Programme	Programme ‘Choose IT!’	Digital literacy training for industry employees	‘Bringing 2000 ICT foreign specialists to Estonia’ project – foreign recruitment grant
Type	Adult retraining programme	Basic ICT skills for employees	Support for hiring from abroad
Objective	To increase the supply of ICT specialists in Estonia to alleviate the shortage of ICT specialists. The major goal of the project is to create a continuing education model based on practical learning that meets the needs of software development ICT companies, and to pilot an advanced training model for training ICT	By providing ICT-based training, to create prerequisites for the development of the Estonian industrial sector and the increase of added value, particularly to support industrial digitalisation. Another aim is to increase the awareness amongst managers of industrial	To encourage foreign recruitment to positions in the field of ICT.

	professionals that will allow the developed model to be extended to further training of other ICT professionals.	enterprises about the value of digitalisation.	
Short description	This is an adult retraining programme, aimed at piloting new form of training and giving the participants initial basics of the software developer. Training lasts for 3.5 months.	The goal of the training is to enable participants to acquire digital literacy to work effectively with the technology. This pertains to 3,000 employees in industry enterprises. Another part of the initiative is to raise awareness of industry enterprises' managers about the role of skills and knowledge of innovative solutions to create value added.	The foreign recruitment grant is aimed at supporting recruitment of foreign ICT specialists to help alleviate shortage of ICT specialists. The grant can partially compensate for expenses related to foreign recruitment, if they indicate that an ICT specialist from abroad (from the European Union or third countries) has stayed in Estonia to work here. Activities may include: sharing job advertisements and introducing the employer in foreign portals; financing language courses; adaptation, accommodation and migration expenses (airline tickets, rent, etc.); visit to get acquainted with the country; additional work by an HR manager or a colleague to support adaptation, etc. The amount of the grant per one recruited ICT specialist is EUR 2,000.
Granting organisation	Ministry of Economic Affairs and Communications	Ministry of Economic Affairs and Communications	Enterprise Estonia (EAS)
Participating organisations	Services provided by private companies BCS Koolitus and IT Koolitus. Developed in cooperation	Services provided by the private company IT Koolituskeskuse OÜ in cooperation with the	n/a

	with the Estonian Association of Information Technology and Telecommunications and IT companies.	Estonian Employers' Confederation.	
Sectors targeted	All economic fields	All industry fields (trainings will be delivered to 3,000 industry employees, of which at least 60% work in the forestry and wood industries or in the machinery and metal industries)	All economic fields
Funding	1,419,522.48 EUR (85% European Social Fund, 15% co-financing by Estonian Government), 2017–2020	450,000 EUR (85% European Social Fund, 15% co-financing by Estonian Government), 2017–2020	4 million EUR (100% national government), 2018–2020
Current status of the initiative (2018)	145 employees from 37 companies in total have benefitted from the initiative by the end of 2018.	296 employees from 27 companies in total have benefitted from the initiative by the end of 2018.	67 grants (19 companies) in 2018 ⁱ and four grants (three companies) in 2019 ⁱⁱ as of 21.01.2019

Source: VVA 2019

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.'⁷ 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. Table 1-1 lists all relevant strategic documents and initiatives currently in place in Estonia.

Table 1-2. Overview of policy initiatives and documents relevant to digitalisation of industry and ICT

Initiative	Year	Sectors targeted	Budget	Source
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⁷ Ministry of Economic Affairs and Communication. (2014). 'Made in Estonia 3.0.' *The Estonian foreign investments and export action plan for the years 2014-2017 for increasing the export capacity of Estonian companies and involving foreign investments*. Available at https://www.mkm.ee/sites/default/files/mie_3.0_english_version.pdf, last accessed 25/7/2019.

Digitisation grant, including green ICT	2019	Manufacturing industries	€3m (national government funds 100%) + Norway Grants Green ICT Programme (€23m)	(eng) https://www.eas.ee/teenus/digitalisation-grant/?lang=en https://www.eas.ee/teenus/norwaygrants/?lang=en
AI strategy „Kratt Report“	2019	All sectors but main focus is on public sector	n/a	(est) https://www.riigikantselei.ee/sites/default/files/riigikantselei/strateegiaburoo/estesti_tehisintellekti_kasutuselevotu_eksperdiruhma_aruanne.pdf
Industry loan	2018	Manufacturing industries	*€6m (national government funds 100% + equity of KredEx)	(eng) https://kredex.ee/en/services/teenused-ettevotte-finantseerimiseks/industry-loan
Digital diagnostics	2018	Manufacturing industries	€4.2m (national government funds 100%)	(eng) https://www.eas.ee/teenus/digital_diagnostics/?lang=en
Industrial Policy Green Paper	2017	All industries	No	(est) https://www.mkm.ee/sites/default/files/toostuspoliitika_roheline_raamat_.pdf
*Foreign recruitment grant (part of 'Bringing 2000 foreign ICT specialists to Estonia' project)	2018	All sectors	€4m (national government funds 100%)	n/a
ICT Development Programme 2018-2020	2017 (updated 2018)	ICT	€27.99m including €5.35m for digitisation of industry (mixed sourced)	(eng) https://www.mkm.ee/sites/default/files/ikt_arenguprogrammi_uuendamine_29.11.2018.pdf
*Programme „Choose IT!“	2017	All sectors	€1.42m (85% European Social Fund + 15% national government funds)	n/a

*Digital literacy training for industry employees	2017	All sectors (trainings delivered to 3000 employees, of which at least 60% work in the forestry and wood-processing industries and / or machinery and metal-processing industries)	€450000 (85% European Social Fund + 15% national government funds)	n/a
Enterprise Development Programme	2016	Manufacturing industries (firms older than 3 years, experience in exporting); smart specialisation fields	€73m (European Regional Development Fund 100%)	(eng) https://www.eas.ee/teenus/enterprise-development-programme-2-2/?lang=en
Innovation voucher 2014-2020	2015 (est. 2009)	All sectors	€4m (European Regional Development Fund 100%)	(eng) https://www.eas.ee/teenus/innovation-voucher/?lang=en
Development voucher 2014-2020	2015	All sectors	€6m (European Regional Development Fund 100%)	(eng) https://www.eas.ee/teenus/development-voucher/?lang=en
StartUp Estonia 2014-2015	2015 (est. 2011)	All sectors	€7m (European Regional Development Fund 100%)	(eng) https://euagenda.eu/upload/publications/untitled-191856-ea.pdf
Digital Agenda for Estonia 2020	2014	No targeted sectors, horizontal approach (except for e-Health)	€223m (mixed sources)	(eng) https://www.mkm.ee/sites/default/files/digital_agenda_2020_estonia_engf.pdf (est, full version) https://www.mkm.ee/sites/default/files/eesti_infouhiskonna_arengukava.pdf

Source: Compiled by the author

Notes: *based on VVA 2019⁸

According to initiatives and policy documents listed above, 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

⁸ VVA and Wik Consult. (2019). *Monitoring Progress in National Initiatives on Digitising Industry. Country report: Estonia.*

potential of ICT sector to spur productivity increase in other sectors and industries, including public sector. In doing so, the 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. Digitisation of industry and Industry 4.0 are explicitly stated in the two most recently designed policy documents: Industrial Policy Green Paper (2017) and ICT Development Programme (2017). In other words, there is no separate strategy on digitisation of industry. Neither there are any sectoral and/or performance targets in the Industrial Policy Green Paper. The most detailed strategic document that constrains the description of measures and related budget allocations is the ICT Development Programme (2017).

Support to facilitate digitisation of industry consists of digital diagnostics (including raising awareness thereof among enterprises) and carrying out digitisation projects. Projected targets include: raising value added in manufacturing by €13m due to implementation of ICT technologies; carry out digital diagnostics in 400 companies; and implement 10 pilot projects in digitisation of industry, all by 2020.

The most recent 'Kratt report' published in May 2019 is a report on application of AI in various sectors in Estonia. The report outlines various applications of AI and measures to support its deployment in various sectors, including public and private sectors. The potential of Big Data and AI to foster competitiveness of Estonia's business sector is explicitly recognised and various support measures are listed, including in education and R&D. At the same time, most of the emphasis is put on deploying AI in the public sector rather than setting equally ambitious targets for facilitating technological transformation in the private sector.

1.1.4 Actual transformations in the region

Economic transformation

The composition of regional industrial base is highly favourable for the Northern region where 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 which suggests a stronger urban/rural divide when looking at the economic transformation.⁹

The Northern region is also the most dynamic region of Estonia and its economic structures are the most diversified. The share of services in the regional economy in the Northern region is the highest (over 75%) and has been growing.

⁹ Martyanova, I. (2019) Analysis of regional economic network structures based on Estonian VAT transaction data. Master's thesis. University of Tartu. Available at: https://www.riigikogu.ee/wpcms/wp-content/uploads/2019/02/Analysis-of-regional-economic-structures-based-on-Estonian-VAT-transaction-data_2019.pdf, last accessed 14/1/2020.

The Northern region demonstrates higher internationalisation of business firms and therefore highest share of total exports. The growth of regional GDP per capita during 2012-2017 was 34.3% for the Northern 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. However, it is evident that the growth of entrepreneurship activity has been confined to the two urban centres – Tallinn in the north and Tartu in the south – and reflect urban/rural divide with no active rebalancing effects stemming from regional development.¹⁰

Social transformation

Northern region and Tallinn have been experiencing population growth which reached an increase of 6.2% during 2007-2013 while all other regions in Estonia have been experiencing decrease in population.¹¹ 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.¹² The share of industrial employment in the Northern region has been slightly decreasing during 2007-2013.

1.1.5 Actual and potential impacts

In the sector in the region

The adoption of the ICT and Industry 4.0 technologies have been very uneven and very slow in some traditional sectors, such as metal-processing. Metal-processing sector in Estonia is characterised by lower value-added, which is related to the fact that most of companies are very small and act as subcontractors to large foreign-owned client-firms. In terms of operation strategy, this often means shorter cycles and therefore manufacturing facilities should be able to switch between the orders quickly. Besides the overall question of timing and quality, large foreign client-companies are concerned with the overall manufacturing capacity (in terms of quantities). Such demand-based factors define operational strategies of local firms in Estonia, which tend to be more short-term and highly risk-averse.

This creates the conditions not too favourable for the adoption of Industry 4.0 technologies and indeed, machinery and metal-processing sector is characterised by lower levels of automation and robotisation.¹³ The sector lacks qualified professional while small- and micro-scale companies have

¹⁰ Rahandusministeerium. (2019) Eesti regionaalarengu strateegia 2014-2020 elluviimise 2018. aasta seirearuanne. Available at: <https://www.rahandusministeerium.ee/et/regionaalareng-ja-poliitika>, last accessed 14/1/2020.

¹¹ Poliitikauuringute Keskus Praxis ja Rakendusuringute Keskus CentAR. (2015) Perioodi 2007–2013 struktuuri- vahendite mõju regionaalarengule. Available at: <http://www.praxis.ee/tood/struktuurivahendite-moju-regionaalarengule/>, last accessed 15/1/2020.

¹² <http://archimedes.ee/en/blog/>

¹³ Sepp, V. (2019) Eesti regioonide majandusarengut mõjutavate uuenduste ja trendide analüüs. Atenguseire keskus. Available at: https://www.riigikogu.ee/wpcms/wp-content/uploads/2019/02/ASK_Regionaalset-arengut-suunavad-trendid_Veiko-Sepp-1.pdf, last accessed 14/1/2020.

limited opportunities to hire digital experts on a full-time basis. At the same time, such experts are needed due to large amount of information generated by interconnected production systems, including along the supply chain. Digitisation offers complex systems of monitoring and control over the production process, which requires analytical and digital competences. Engineers are expected to be creative in areas of mechatronics and design while sales managers are expected to have a stronger understanding of technological potential and specific characteristics.

Greater digitisation of the metal-processing sector involves the question of climbing up the value chain towards greater value-added. This will require sales managers, customer relations and marketing skills, which are not yet developed due to predominantly sub-contracting relations with client-companies. On the production level, operators of digital machinery are increasingly expected to have the skills of computer-aided design (CAD) and CNC-operating skills. More traditional machinery will still be used for smaller quantities of customised products.

In other sectors in the region

Due to a more diversified industrial base and a high share of services in the Northern region, digitisation and automation have achieved top levels in some sectors, particularly electronics, ICT, logistics, eHealth services. Subsidiaries of foreign-owned companies, such as ABB and Ericsson, are the drivers of this transformation. At the same time, these companies typically have very few linkages with the local economy except for employment and tax revenues. Due to typically high share of imported components, it is unlikely that there will be significant positive spill over effects from top-notch automation systems operating at such foreign-owned subsidiaries. When they start using local suppliers, then integration into digital supply chain and potentially higher quality demands can facilitate the digital upgrade of local small sub-contractors. This is the case of metal-processing sector and can be equally applied to other industries, including machine-building.

The ICT sector, which has the strongest presence in the Northern region, is likely to further internationalise along with further developments in Industry 4.0 technologies and services. Leading Estonian ICT companies that specialise in such products are already active in servicing clients in more technologically advanced European countries (Germany) and this trend is more likely to continue.

In the region

The impact of Industry 4.0 technologies has been uneven, including in the Northern region. Sectors with higher share of exports demonstrate higher productivity and can sometimes have easier access to the foreign talent, such as the case of ICT industry. The decision to attract foreign talent to Estonia ICT sector has been made at the policy level and is reflected in the highest level of internationalisation, including in terms of foreign employees.

Digitisation and automation will most probably further amplify the differences between the Northern region and the rest of the Estonian economy. Higher concentration of knowledge intensive services, such as finance, mobility services, R&D in the Northern region creates excellent opportunities for increasing productivity, reducing costs, and value-added of existing services and for creating new jobs

in knowledge intensive sectors through further digitisation. Companies located in the Northern region have a faster access to information resources, support services, finance, – this is likely to make them ready to digitise faster once they decide to do so. Meanwhile, threats of losing competitiveness exist for firms with lower levels of automation.¹⁴ Because of the lower share of traditional sectors in the region, the negative effects of technology-induced unemployment are unlikely. However, the digital divide and demographics can also contribute to technology-induced unemployment.

1.1.6 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.
- 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.

1.2 Southern region

1.2.1 Regional baseline

Southern Region similarly lags behind the Northern parts of Estonia while various factors make two regions more comparable and the comparison more sensible: both regions have centres of academic and scientific excellence (two major public universities in Tallinn and two – in Tartu); both regions have solid presence of ICT and electronics firms; both regions have regional strategies and strong local government offices. This common base enables comparative case study design to be more robust and realistic.

¹⁴ Sepp, V. (2019) Eesti regioonide majandusarengut mõjutavate uuenduste ja trendide analüüs. Atenguseire keskus. Available at: https://www.riigikogu.ee/wpcms/wp-content/uploads/2019/02/ASK_Regionaalset-arengut-suunavad-trendid_Veiko-Sepp-1.pdf, last accessed 14/1/2020.

The wood-processing industry in the Southern region is notable as export-oriented and demonstrates high value-added. The sector is dominated by SMEs but in the case of wood-processing, almost entire value chain is located in Estonia.

1.2.2 Adopted 4.0 technologies in the sector in the region

The wood-processing sector primarily uses foreign-made 4.0 technologies. While the ICT sector features local producers of 4.0 solutions, the Estonian market lacks sufficient demand for them. Thus, local IT companies are primarily supplying international markets which, ironically, leaves the local wood-processing sector reliant on international supply for the technologies.

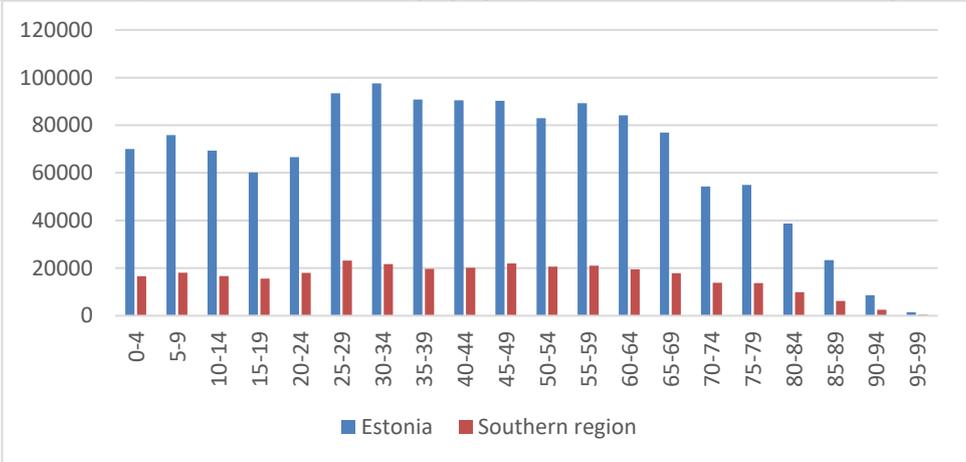
Looking at specific 4.0 technologies the sector has adopted ERP systems, digital supply chain systems, digitised machinery and production lines and some robots. Wood-processing industry has a larger share of more digitally advanced firms. This is because the wood-processing has formed a well-performing cluster with firms exporting finished goods with higher value-added. The entrance into international markets is driving adoption of new technologies to meet the standards and demands of international clients. Wood-processing also has a positive spill over effects onto related sectors, such as furniture, wood-based biofuel, etc.

1.2.3 Preconditions for transformation

Regional preconditions

Following administrative reform (2017), the Southern region consists of the following counties: Jõgeva, Põlva, Tartu, Valga, Viljandi and Võru. The largest town is Tartu, which is the second largest city in Estonia and where the oldest and largest university is located (University of Tartu). It is landlocked but is well connected with the capital city of Tallinn and shares borders with Latvia and Russia. There are 317,115 people living in the region, as of 2018, which is 24% of Estonia’s total population. Age groups are depicted on Figure 1-10. In relative terms, the amount of younger people (between 20 and 39 years old) is only slightly higher than the number of older groups (40 years and older).

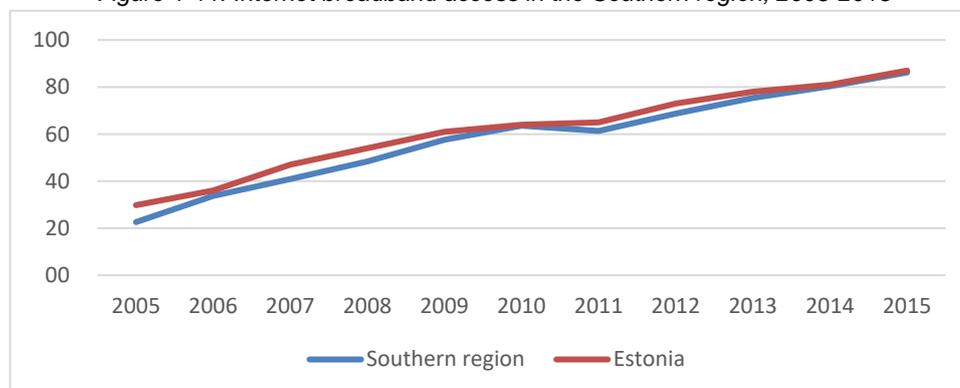
Figure 1-10. Population distribution among age groups in Estonia and the Southern region, 2018



Source: Statistics Estonia

Southern region demonstrates slightly lower rates of internet broadband access as compared to Estonia's national average. (Figure 1-11) At the same time, there are no significant regional variations in internet connectivity: regional differences diminished towards 2013-2015.¹⁵

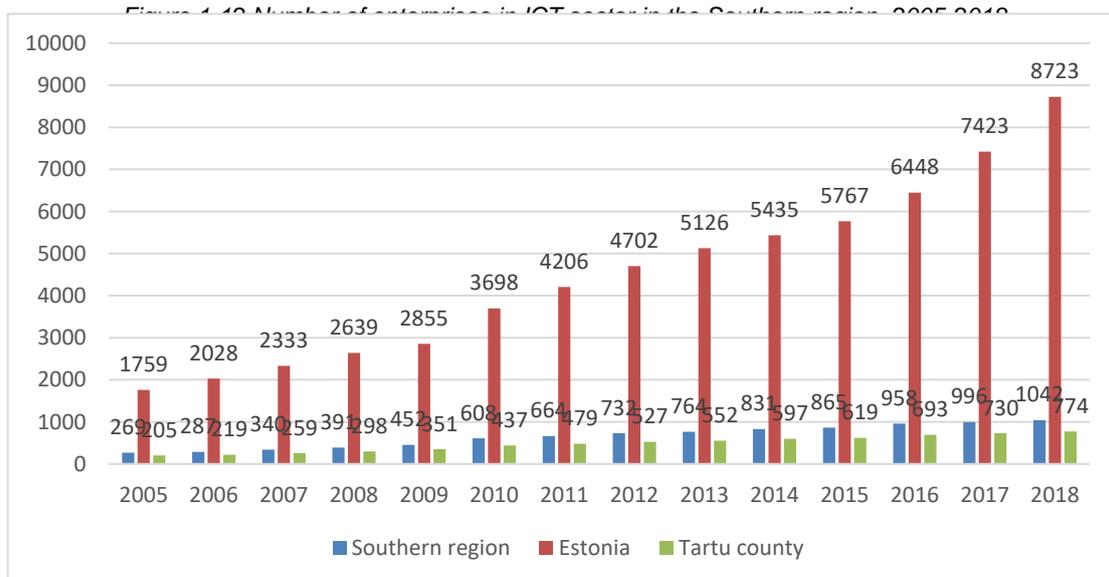
Figure 1-11. Internet broadband access in the Southern region, 2005-2015



Source: OECD

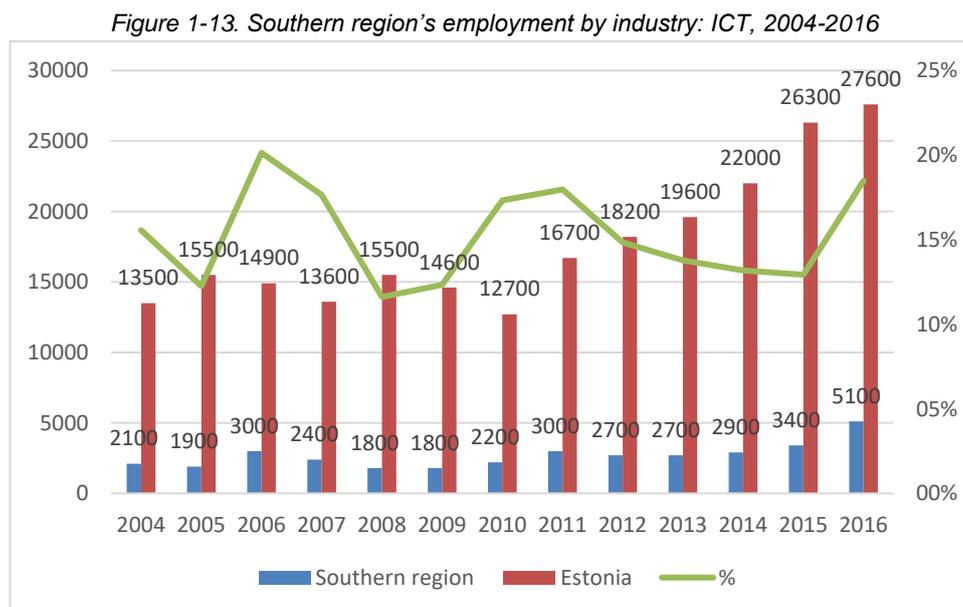
The amount of ICT firms in the region has been steadily growing during the last decade and Tartu county accounts for the lion share of ICT enterprises in the region. (Figure 1-12)

¹⁵ Poliitikauuringute Keskus Praxis ja Rakendusauuringute Keskus CentAR. (2015) Perioodi 2007–2013 struktuuri- vahendite mõju regionaalarengule, p. 55. Available at: <http://www.praxis.ee/wp-content/uploads/2015/03/sv-m6ju-regionaalarengule.pdf>, last accessed 14/1/2020.



Source: Compiled by the author based on data from Statistics Estonia

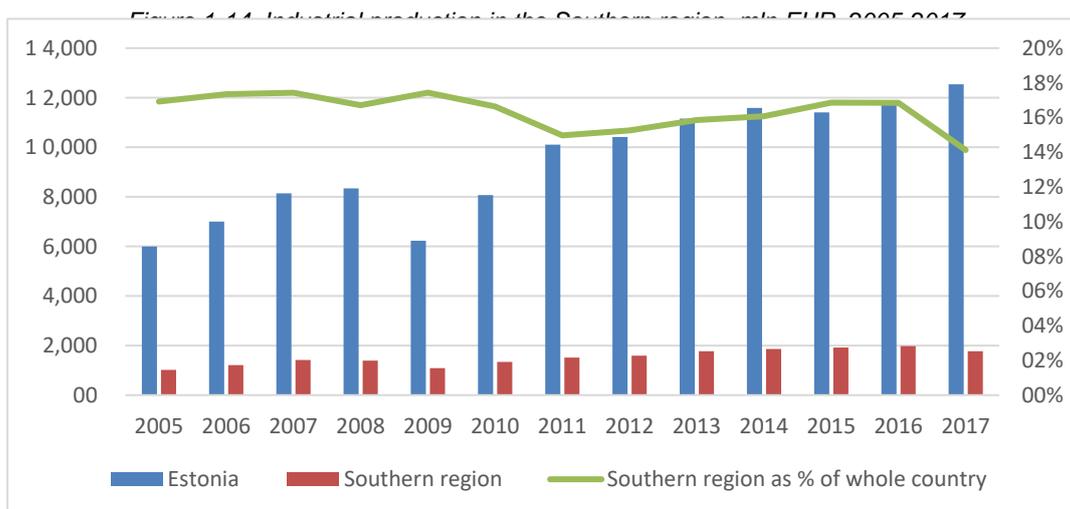
Furthermore, the Southern region accounts for some 15-20% of total employment in ICT sector in Estonia.



Source: Compiled by the author based on data from OECD

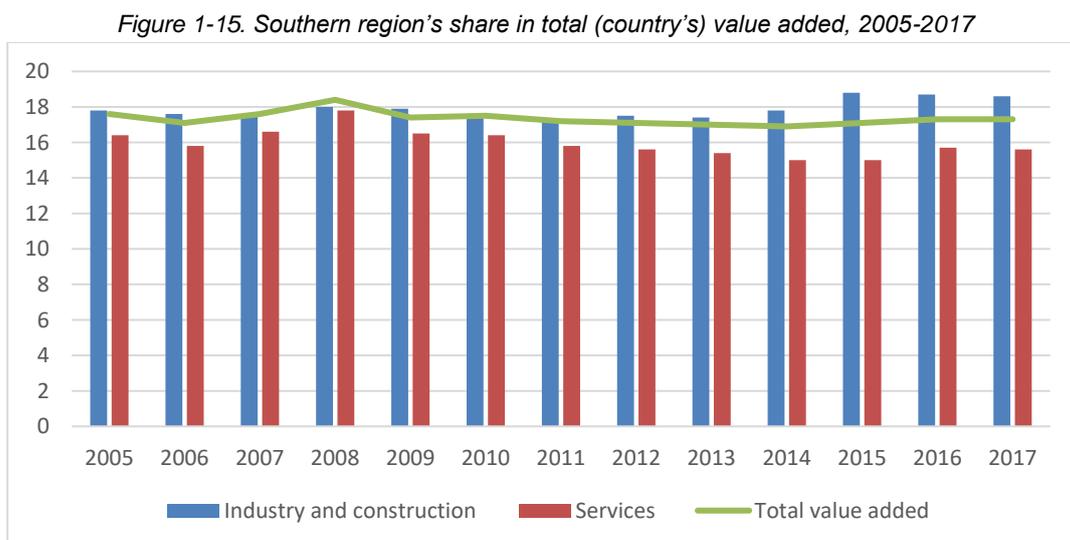
Sectoral preconditions

The region is characterised by a smaller presence of manufacturing sector (Figure 1-10). At the same time, due to a small size of Estonia (the distance between Tallinn and Tartu is less than 200 km), the region cannot be considered too remote in terms of finance (pool of potential investors), networks (associations, expos, trade events) and access to qualified labour force.



Source: Compiled by the author based on data from Statistics Estonia

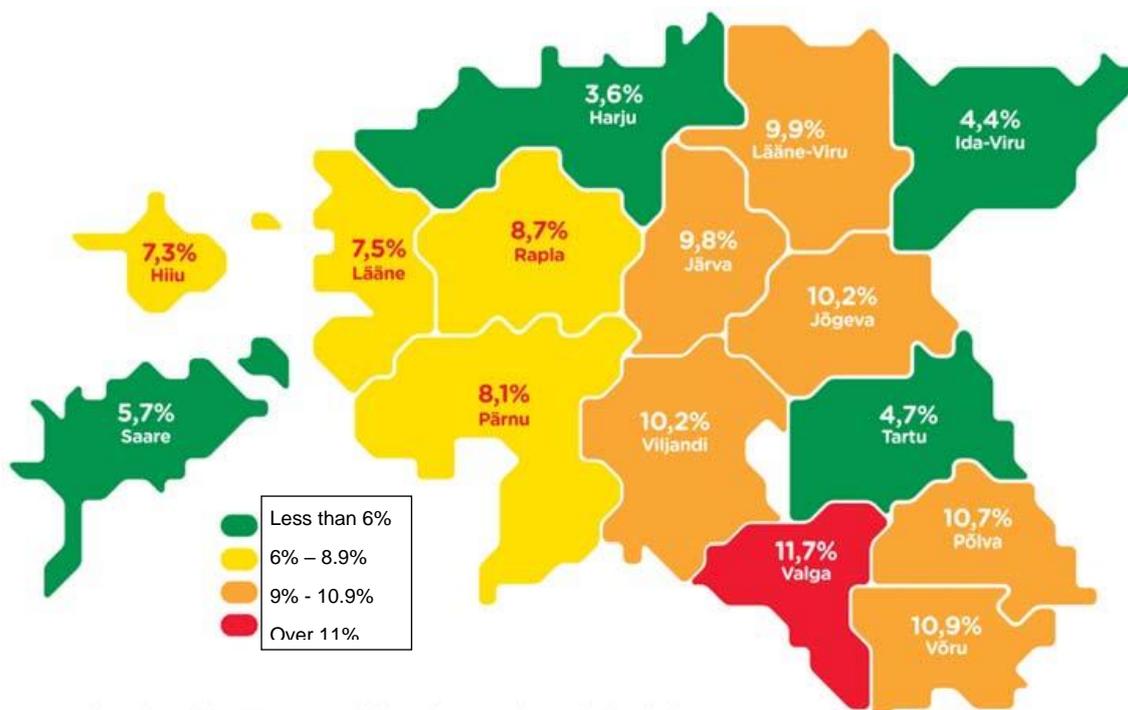
Southern region accounts for some 17% of total value added produced in Estonia. Figure 1-15 demonstrates that Southern region's share in value added generated in services is 15%, which is lower than in industry (18,5%). Moreover, the share of services has been decreasing for the last 10 years while the share of value added in industry demonstrated an upward trend during the same period.



Source: Compiled by the author based on data from Statistics Estonia

The Southern region is known for a well-developed cluster of wood-processing companies. Indeed, forestry and wood-processing sector is predominantly located in the Southern region (Tartu, Viljandi, Valga, Võru, Põlva, Jõgeva), as depicted on Figure 1-16. Because of generally lower share of industry in the Southern region, forestry and wood-processing is a large employer and therefore has an important role in rural development in Estonia.

Figure 1-16. Geography of forestry and wood-processing industries: share of the sector in region's employment, 2011-2013



Source: OSKA 2016a

Forestry and wood-processing sector has contributed to regional development by creating employment outside of major urban areas and usual employment centres. The sector accounts for 30.3% and 22.2% of regional value-added in Central and Southern Estonia respectively. Similarly, the sector employs 19.7% of the total regional labour force in the Central region and 15.4% of the total regional labour force in the Southern region. Overall, it consists of some 3,500 companies, which employ 6.3% of all employed population in Estonia. When direct and indirect effects are taken into account, the sector accounted for 11.2% of national gross value added, and 9.75% of all national employment in 2017. Within the sector, mechanical wood-processing is the largest industry in terms of revenues, employment and value-added. 38% of firms working with mechanical wood-processing are located in the Southern region. They account for 17.6% of value-added produced in mechanical wood-processing industry in Estonia.

Exports-wise, the sector is predominantly export-oriented with over 65% of total production sold to foreign markets.¹⁶ Wood-based products represent one of the major export sectors while wood-processing industry demonstrates similar structural characteristics as compared to other industries: disproportionately large share of micro-enterprises (less than 10 employees), which roughly account for ¼ of all firms¹⁷, and many firms that act as subcontractors to foreign companies. At the same time, there is a strong recognition among industry association (Eesti Metsa- ja Puidutööstuse Liit) and its members about the need to increase productivity and domestic value-added. Some interviewees have referred to positive developments and an increasing number of locally owned companies started working on own

¹⁶ <https://www.metsamajandusuudised.ee/uudised/2020/01/03/puidusektor-vottis-sugisel-suuna-alla>

¹⁷ Ernst and Young. (2019) Metsa- ja puidusektori sotsiaalmajandusliku mõju analüüs.

product design – this is the case of prefabricated log houses, for example. In other words, there have been positive developments in generating local demand for digital industrial and product development solutions, albeit at a slow pace. There are also a few truly innovative groups of companies, which operate along the entire supply chain: from forest management to wood-processing and to the production of biofuel, bioenergy and biomaterials. Graanul Invest Group¹⁸ is such an example, with own R&D unit operating in Estonia and multiple production sites abroad.

In terms of application, ICT technologies have been used in logistics of timber and forest management: logistics, digital maps and geoinformation systems, drones for gathering forestry data, mobile apps for measuring dimensions of timber logs. In wood-processing, digital technologies have been predominantly used in optimisation of production processes through ERP systems and digital integration of the supply chain. In other words, the potential for using sector-specific ICT technologies is heavily underexplored. According to the detailed study of sector-based labour market needs and skills conducted in 2016¹⁹, forestry and wood-processing sector lacks qualified specialists in both, production line operations and production management. There is a growing need to educate specialists with more applied digital and sector-specific knowledge, at all levels, including production and management. Due to increasing digital component and changing organisation of production, the set of traditionally narrow skills related to a set of stationary machinery used in wood-processing are increasingly complemented by digital skills. The increasing digital component requires the ability to use computer-aided design and CNC-operated (Computer Numerical Control) machines; abilities to work with product design in 3D in line with client's specification and to programme the production lines and adjust it accordingly; the ability to supply products with extensive product and production documentation. In other words, digitisation of production increases the discretion of individual machine operators and demands more sophisticated, quite specialised ICT skills from production managers and line operators. Due to interconnectedness, the production processes become more integrated with less clear knowledge boundaries between product development, design, production lines and quality control.

According to interviewees, especially wood-processing industry suffers a dramatic lack of scientific knowledge and basic R&D that would help develop new materials and related production methods. Forestry, as a sector, benefits from university-based research to a larger extent. Most likely, this is due to the higher importance and policy relevance of environmental topics, to which forestry clearly belongs. At the same time, the research performed in the area of wood materials and techniques at Estonian universities has very little relevance for the industry's needs.

Overall, wood-processing sector is characterised by lower share of foreign ownership and in many cases the entire supply chain (from forest management to biotech) is largely located in Estonia. The sector

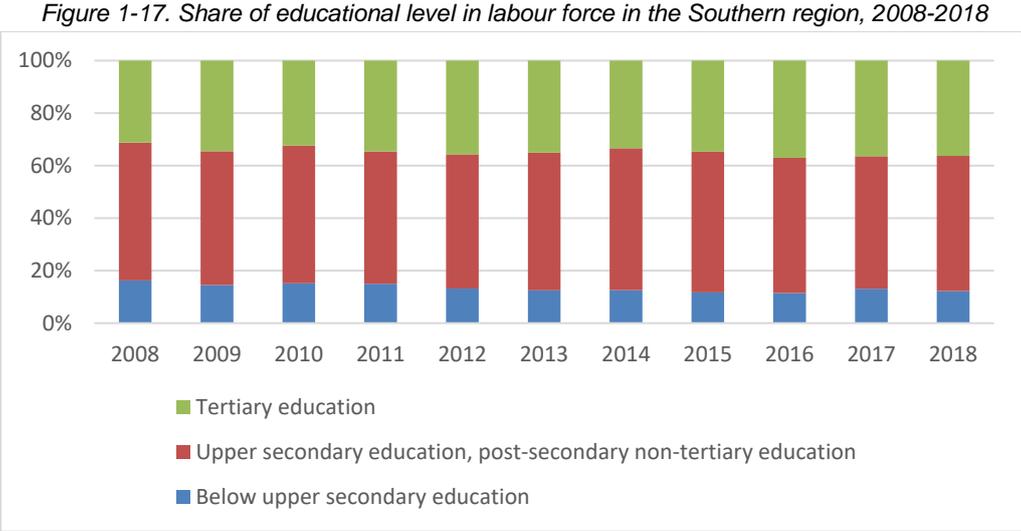
¹⁸ <https://www.graanulinvest.com/eng/group/group>

¹⁹ OSKA. (2016a). Metsanduse ja puidutööstuse valdkonna uuring. Available at: <https://oska.kutsekoda.ee/wp-content/uploads/2016/04/METSPUIT-Raport-OK.pdf>, last accessed 26/7/2019.

evolved towards a strong exporter with the main trading partners coming from Scandinavia and other EU countries. Despite lower R&D capacities and the lack of industry-academic research links, the sector is one of the fastest adopters of ICT technologies, especially when companies are established with 'greenfield investments' (no need to deal with legacy systems, old machinery and old production processes).

Social preconditions

In terms of human capital, the Southern region has some 35% of labour force with tertiary education, which only slightly grew during last ten years. (Figure 1-17)



Source: Statistics Estonia

In terms of education and training infrastructure, there is no lack of resources. Out of the all 60 applied education curricula in Estonia, 26 programmes open for admissions are located in the Southern region (43%) (based on data for 2015/2016) and 9 out of 23 tertiary education programmes are located in Tartu, including 1 PhD programme at the University of Life Sciences.²⁰ Yet, a substantial reform of the curricula is needed in order to better match both, technical and digital skills of graduates towards the needs of industry.

University of Tartu offers a Master-level programme in Industrial IT²¹ at the Institute of Computer Science (STACC). The programme has an industry-related component: 17 months of internship in a partner company. There is no explicit emphasis on Industry 4.0 as such but the overall direction points to training ICT specialists closer to the business sector field. The Institute of Computer Science is one of the national centres of excellence in ICT in Estonia. The design of the programme is different from the approach of Tallinn University of Technology where the new curricula was developed and will be taught

²⁰ OSKA. (2016a). Metsanduse ja puidutööstuse valdkonna uuring. Available at: <https://oska.kutsekoda.ee/wp-content/uploads/2016/04/METSPUIT-Raport-OK.pdf>, last accessed 26/7/2019.

²¹ <https://www.cs.ut.ee/en/studying/industrial-masters-programme-it>

by the engineering faculties rather than IT. The problem, nevertheless, remains: the region lacks qualified work force that would be able to work with digital manufacturing technologies.

In addition to nation-wide policy measures supporting digitisation of industry, Tartu City government launched Innovation Vouchers Programme in March 2019. It is too early to judge upon the effectiveness of this policy tool but there was a dozen of SMEs supported in the Tartu county, which invested in digitization of warehouse management systems, quality control systems and such.

Policy preconditions

The importance of digital skills of population is recognised at the policy level in Estonia: The Digital Agenda 2020 (updated in 2018) includes specific targets in terms of development of ICT skills that should be reached by 2020. There are four groups of targets, as listed below.

Box 1-2. Estonia: The Digital Agenda 2020 targets of development of ICT skills

1. Percentage of internet non-users ²⁶ among Estonian inhabitants aged 16-74
a. Starting level: 18% (2013) → Interim level: 11% (2018) → Target level: 5% (2020)
2. Percentage of those aged 16-74 among Estonian inhabitants who have used e-commerce
a. Starting level: 49% (2014; EU average 45%) → Interim level: 61,3% (2018; EU average 62%) 2017 → Target level: EU average 2020 (2020)
3. Percentage of ICT specialists in the employed population
a. Starting level: 4.9% (2013) → Interim level: 6,8% (2017) → Target level: 8% (2020)
4. Percentage of top-level specialists in the employed population
a. Starting level: 9.3% (2014) → Interim level: 10.8% (2017) → Target level: 12% (2020)

Source: Digital Agenda 2020 for Estonia

More importantly, the level of ICT skills among the labour force has been also supported by policy measures. There are three major initiatives that aim to directly contribute to nurturing digital skills: Programme “Choose IT!” (2017), Digital Literacy Training for Industry Employees (2017), and Foreign recruitment grants (2018). Table 1-3 lists some further details.

Table 1-3. Major existing initiatives that aim at developing digital skills (as of July 2019)

Year	2017	2017	2018
Programme	Programme ‘Choose IT!’	Digital literacy training for industry employees	‘Bringing 2000 ICT foreign specialists to Estonia’ project – foreign recruitment grant
Type	Adult retraining programme	Basic ICT skills for employees	Support for hiring from abroad

Objective	To increase the supply of ICT specialists in Estonia to alleviate the shortage of ICT specialists. The major goal of the project is to create a continuing education model based on practical learning that meets the needs of software development ICT companies, and to pilot an advanced training model for training ICT professionals that will allow the developed model to be extended to further training of other ICT professionals.	By providing ICT-based training, to create prerequisites for the development of the Estonian industrial sector and the increase of added value, particularly to support industrial digitalisation. Another aim is to increase the awareness amongst managers of industrial enterprises about the value of digitalisation.	To encourage foreign recruitment to positions in the field of ICT.
Short description	This is an adult retraining programme, aimed at piloting new form of training and giving the participants initial basics of the software developer. Training lasts for 3.5 months.	The goal of the training is to enable participants to acquire digital literacy to work effectively with the technology. This pertains to 3,000 employees in industry enterprises. Another part of the initiative is to raise awareness of industry enterprises' managers about the role of skills and knowledge of innovative solutions to create value added.	The foreign recruitment grant is aimed at supporting recruitment of foreign ICT specialists to help alleviate shortage of ICT specialists. The grant can partially compensate for expenses related to foreign recruitment, if they indicate that an ICT specialist from abroad (from the European Union or third countries) has stayed in Estonia to work here. Activities may include: sharing job advertisements and introducing the employer in foreign portals; financing language courses; adaptation, accommodation and migration expenses (airline tickets, rent, etc.); visit to get acquainted with the

			country; additional work by an HR manager or a colleague to support adaptation, etc. The amount of the grant per one recruited ICT specialist is EUR 2,000.
Granting organisation	Ministry of Economic Affairs and Communications	Ministry of Economic Affairs and Communications	Enterprise Estonia (EAS)
Participating organisations	Services provided by private companies BCS Koolitus and IT Koolitus. Developed in cooperation with the Estonian Association of Information Technology and Telecommunications and IT companies.	Services provided by the private company IT Koolituskeskuse OÜ in cooperation with the Estonian Employers' Confederation.	n/a
Sectors targeted	All economic fields	All industry fields (trainings will be delivered to 3,000 industry employees, of which at least 60% work in the forestry and wood industries or in the machinery and metal industries)	All economic fields
Funding	1,419,522.48 EUR (85% European Social Fund, 15% co-financing by Estonian Government), 2017–2020	450,000 EUR (85% European Social Fund, 15% co-financing by Estonian Government), 2017–2020	4 million EUR (100% national government), 2018–2020
Current status of the initiative (2018)	145 employees from 37 companies in total have benefitted from the initiative by the end of 2018.	296 employees from 27 companies in total have benefitted from the initiative by the end of 2018.	67 grants (19 companies) in 2018 ⁱⁱⁱ and four grants (three companies) in 2019 ^{iv} as of 21.01.2019

Source: VVA 2019

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.²² 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. Table 1-4 lists all relevant strategic documents and initiatives currently in place in Estonia.

Table 1-4. Overview of policy initiatives and documents relevant to digitalisation of industry and ICT

Initiative	Year	Sectors targeted	Budget	Source
Digitisation grant, including green ICT	2019	Manufacturing industries	€3m (national government funds 100%) + Norway Grants Green ICT Programme (€23m)	(eng) https://www.eas.ee/teenus/digitalisation-grant/?lang=en https://www.eas.ee/teenus/norwaygrants/?lang=en
AI strategy „Kratt Report“	2019	All sectors but main focus is on public sector	n/a	(est) https://www.riigikantselei.ee/sites/default/files/riigikantselei/strateegi_aburoo/eesti_tehisintellekti_kasutuselevotu_eksperdiruhma_aruanne.pdf
Industry loan	2018	Manufacturing industries	*€6m (national government funds 100% + equity of KredEx)	(eng) https://kredex.ee/en/services/teenused-ettevotte-finantseerimiseks/industry-loan
Digital diagnostics	2018	Manufacturing industries	€4.2m (national government funds 100%)	(eng) https://www.eas.ee/teenus/digital_diagnostics/?lang=en
Industrial Policy Green Paper	2017	All industries	No	(est) https://www.mkm.ee/sites/default/files/toostuspoliitika_roheline_araamat_.pdf
*Foreign recruitment grant (part of ‘Bringing 2000 foreign ICT specialists to Estonia’ project)	2018	All sectors	€4m (national government funds 100%)	n/a
ICT Development Programme 2018-2020	2017 (updated 2018)	ICT	€27.99m including €5.35m for digitisation of industry (mixed sourced)	(eng) https://www.mkm.ee/sites/default/files/ikt_arenguprogrammi_uuendamine_29.11.2018.pdf

²² Ministry of Economic Affairs and Communication. (2014). ‘Made in Estonia 3.0.’ *The Estonian foreign investments and export action plan for the years 2014-2017 for increasing the export capacity of Estonian companies and involving foreign investments.* Available at https://www.mkm.ee/sites/default/files/mie_3.0_english_version.pdf, last accessed 25/7/2019.

*Programme „Choose IT!“	2017	All sectors	€1.42m (85% European Social Fund + 15% national government funds)	n/a
*Digital literacy training for industry employees	2017	All sectors (trainings delivered to 3,000 employees, of which at least 60% work in the forestry and wood-processing industries and / or machinery and metal-processing industries)	€450,000 (85% European Social Fund + 15% national government funds)	n/a
Enterprise Development Programme	2016	Manufacturing industries (firms older than 3 years, experience in exporting); smart specialisation fields	€73m (European Regional Development Fund 100%)	(eng) https://www.eas.ee/teenus/enterprise-development-programme-2-2/?lang=en
Innovation voucher 2014-2020	2015 (est. 2009)	All sectors	€4m (European Regional Development Fund 100%)	(eng) https://www.eas.ee/teenus/innovation-voucher/?lang=en
Development voucher 2014-2020	2015	All sectors	€6m (European Regional Development Fund 100%)	(eng) https://www.eas.ee/teenus/development-voucher/?lang=en
StartUp Estonia 2014-2015	2015 (est. 2011)	All sectors	€7m (European Regional Development Fund 100%)	(eng) https://euagenda.eu/upload/publications/untitled-191856-ea.pdf
Digital Agenda for Estonia 2020	2014	No targeted sectors, horizontal approach (except for e-Health)	€223m (mixed sources)	(eng) https://www.mkm.ee/sites/default/files/digital_agenda_2020_estonia_engf.pdf (est, full version) https://www.mkm.ee/sites/default/files/eesti_infouhiskonna_arengukava.pdf

Source: Compiled by the author

Notes: *based on VVA 2019²³

²³ VVA and Wik Consult. (2019). *Monitoring Progress in National Initiatives on Digitising Industry. Country report: Estonia.*

According to initiatives and policy documents listed above, 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. Digitisation of industry and Industry 4.0 are explicitly stated in the two most recently designed policy documents: Industrial Policy Green Paper (2017) and ICT Development Programme (2017). In other words, there is no separate strategy on digitisation of industry. Neither there are any sectoral and/or performance targets in the Industrial Policy Green Paper. The most detailed strategic document that constrains the description of measures and related budget allocations is the ICT Development Programme (2017).

Support to facilitate digitisation of industry consists of digital diagnostics (including raising awareness thereof among enterprises) and carrying out digitisation projects. Projected targets include: raising value added in manufacturing by €13m due to implementation of ICT technologies; carry out digital diagnostics in 400 companies; and implement 10 pilot projects in digitisation of industry, all by 2020.

The most recent 'Kratt report' publishes in May 2019 is a report on application of AI in various sectors in Estonia. The report outlines various applications of AI and measures to support its deployment in various sectors, including public and private sectors. The potential of Big Data and AI to foster competitiveness of Estonia's business sector is explicitly recognised and various support measures are listed, including in education and R&D. At the same time, most of the emphasis is put on deploying AI in the public sector rather than setting equally ambitious targets for facilitating technological transformation in the private sector.

1.2.1 Actual transformations in the region

Economic transformation

In terms of productivity, Tartu-based firms have the highest regional productivity.²⁴ This speaks of stronger urban/rural rather than regional divide when looking at economic transformation and this message is similar for both Northern and Southern regions.

²⁴ Martyanova, I. (2019) Analysis of regional economic network structures based on Estonian VAT transaction data. Master's thesis. University of Tartu. Available at: https://www.riigikogu.ee/wpcms/wp-content/uploads/2019/02/Analysis-of-regional-economic-structures-based-on-Estonian-VAT-transaction-data_2019.pdf, last accessed 14/1/2020.

The strength of Tartu is also evident by a high share of services in the regional economy but not with the Southern region as a whole, where share of services has been lower in comparison to other Estonian regions.²⁵ The growth of regional GDP per capita during 2012-2017 was 33.6% for the Southern region.

Entrepreneurship has also been primarily evident in Tartu county, to the point where Tartu manages to raise the indicator slightly for the Southern. It is evident that the growth of entrepreneurship activity has been confined to the urban centres and further reflects urban/rural divide with no active rebalancing effects stemming from regional development.²⁶

Social transformation

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%).²⁷

1.2.1 Actual and potential impacts

In the sector in the region

Forestry and wood-processing sector has been one of the fastest adopters of automation and digitisation, including in the Southern sector where its share of regional employment is the highest. A few innovative companies that operate across the spectrum of wood-based products are located in the region. Further, companies that build prefabricated houses (one of important export categories in Estonia) are also located in the Southern region and have been slowly moving towards developing own product designs, which in turn, generates domestic demand for various 3D designer software solutions.

Successful adoption of digital technologies in forestry and wood-processing sector has resulted in higher wages and higher productivity thereby having clear rebalancing effects in terms of regional disparities. The sector remains one of the most attractive employers in the Southern region. There are, nevertheless, a lot of micro-enterprises in the sector that have very low levels of digitisation. Both groups of companies are experiencing shortage of skilled labour: companies with digitised productions and companies with lower levels of automation. Forestry and wood-processing represents one of traditional industries, which have been less and less attractive to the young people. Companies with lower level of automation heavily rely on foreign workers, mostly from Ukraine, although existing bureaucratic procedures make importing foreign labourers quite difficult and time-consuming. Companies with higher

²⁵ Poliitikauuringute Keskus Praxis ja Rakendusauuringute Keskus CentAR. (2015) Perioodi 2007–2013 struktuuri- vahendite mõju regionaalarengule. Available at: <http://www.praxis.ee/tood/struktuurivahendite-moju-regionaalarengule/>, last accessed 15/1/2020.

²⁶ Rahandusministeerium. (2019) Eesti regionaalarengu strateegia 2014-2020 elluviimise 2018. aasta seirearuanne. Available at: <https://www.rahandusministeerium.ee/et/regionaalareng-ja-poliitika>, last accessed 14/1/2020.

²⁷ Rahandusministeerium. (2019) Eesti regionaalarengu strateegia 2014-2020 elluviimise 2018. aasta seirearuanne. Available at: <https://www.rahandusministeerium.ee/et/regionaalareng-ja-poliitika>, last accessed 14/1/2020.

levels of digitisation experience a serious shortage of skilled operators and managers with sufficient sector-specific ICT expertise. Due to an increasing digital component and changing organisation of production, the set of traditionally narrow skills needed for operating stationary machinery in wood-processing are increasingly complemented by specific digital skills. These include the ability to use computer-aided design, to use CNC-operated (Computer Numerical Control) machines, abilities to develop product design in 3D in line with client's specification, to programme the production lines and adjust it according to design specifications, the ability to supply extensive product and production line documentation. In other words, digitisation of production increases the discretion in decision-making of the employees. Interconnectedness of the production stages, which increases due to the digital integration, creates the need for very specialised digital knowledge related to particular products or sub-sectors. There is a strong recognition that the teaching curricula in all types of education institutions need to be adjusted accordingly. Further, there is a need to develop the modern standards for wood-processing technologies/techniques and technical specifications for product development – both would benefit the industry as well as applied education and training curricula.

The developments in the wood-processing sector related to digitisation and automation echo the general pattern of business dynamics and productivity trends in Estonia and many other Eastern European countries: micro-enterprises, low productivity and low R&D intensity, shortage of skills even for less advanced/more manual jobs, and therefore lower value-added. In addition, exports are dominated by semi-finished goods. This is a typical structural problematics of Eastern European transition economies, which integrated into the Western European production chains mainly as subcontractors or host countries of foreign-owned assembly lines.²⁸ Within this context, the proximity of Estonia to the Scandinavian markets and the ability of Estonian wood-processing industry to upgrade the standards and develop own industrial capacities is a good success story. The digitisation represents a different challenge: the lack of active industrial policy and rather passive supply-side type of policy interventions, including in supporting digitisation, might result in very few companies which will be able to adopt the Industry 4.0 technologies. This, in turn, will further polarise the skills and job opportunities in the sector. Which, in turn, might contribute to existing disparities in regional development. On the map of robotisation Estonia represents the case where robotization happens in the 'niches' (see Map 4.3 Impact of robot adoption in 'induced' sectors on GDP p.c. growth rate by regional transformation patterns, 2013-2017 in the Final Report).

During the course of interviews, it became clear that most of stakeholders have a realistic understanding of existing conditions. New curricula is being designed and companies are vocal about the need to take a more strategic approach towards manufacturing sector and its competitiveness in the long run. Therefore, there is a substantial amount of recognition among industries that digitisation of domestic

²⁸ Myant, M., & Drahoukoupil, J. (Eds.). (2014). *Transition Economies after 2008: Responses to the crisis in Russia and Eastern Europe*. Routledge.

industry is the only available source of Estonia's future long-term competitive advantage. Further dynamics in this process are conditioned by (more active) industrial policy initiatives.

In other sectors in the region

Logistics is another sector in the Southern region, which has been fast in adopting digital solutions and services. Some of the warehouses are located in remote areas of the Southern region while being equipped with the latest technological solutions and warehouse management systems. ICT industry is well developed in the region, but it is unclear whether and what links does it have with regional industrial companies. The wider adoption of Industry 4.0 technologies in carrier and induced sectors in the Southern region might be limited by the modest share of industrial sectors overall. Forestry, wood-processing and logistics are among the most dynamic sectors in the region while other sectors (agriculture, spa and hospitality services) continue demonstrating lower levels of digitisation. Traditional industries also tend to contain a larger share of micro-enterprises with very low levels or close to no digitisation.

In the region

The impact of Industry 4.0 technologies has been uneven, including in the Southern region. Export-oriented sectors and industries with higher share of greenfield investment projects – such as logistics and wood-processing in the Southern industry – exhibit higher levels of digitisation. At the same time, increasing automation can negatively affect traditional industries where the number of micro-firms and manual labour remain high. In the Southern region this is mainly related to agriculture and furniture industry where the risk of technology-induced unemployment is the highest. Tourism and hospitality sectors are also well present in the Southern region and their competitiveness might be negatively affected if they will continue with traditional methods of business operations. At the same time, there is a big potential for increasing productivity, value-added and for raising region's competitiveness if to facilitate digitisation of production in smaller towns in the region. Overall, Industry 4.0 technologies in the Southern region represent opportunities, threats as well as negative effects. Opportunities are related to increasing productivity, complexity of skills and raising region's competitiveness through digitisation of smaller firms in counties. Threats of losing competitive advantage concern small firms relying on manual labour, especially in traditional sectors and some services (hospitality). Negative effects are related to the loss of jobs due to increasing automation in the region.

There has been a growing gender balance in the wood-processing sector with women clearly outnumbering men in design-related and product development jobs.²⁹ Digitisation can help further contribute to this development by creating more of high-skilled digital jobs in the sector.

²⁹ OSKA. (2016a). Metsanduse ja puidutööstuse valdkonna uuring [Forestry and wood-processing sector study]. Available at: <https://oska.kutsekoda.ee/wp-content/uploads/2016/04/METSPUIT-Raport-OK.pdf>, last accessed 26/7/2019.

1.2.2 Operational policy recommendations

Operational policy recommendations include the following:

- 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. Digitisation is a key component in Industry 4.0 and while Estonia demonstrates some of the best developments when it comes to public digital services, the same does not hold up for the private sector. Over the year Estonia has accumulated a considerable degree of experience when it comes to mass digitisation of services and these experiences can be translated towards increasing the digital literacy and digital uptake among businesses.
- 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). Industry 4.0 operationalisation is an essential component in developing strategies and other measures targeting Industry 4.0 as it establishes the sectors where digitisation should be prioritised, the available supply of relevant 4.0 technologies (either locally produced or coming from international suppliers). It should also answer whether Industry 4.0 in Estonia should result in national or international value-chain integration.
- Reforming teaching and training curricula in industrial professions (including retraining programmes) in order to incorporate automation and sector-specific digitisation knowledge. This calls for closer cooperation between industrial stakeholders and academia to achieve a balanced approach that is capable of meeting the short-term demand for suitable specialists (i.e. fast-track training programmes or modules to existing programmes) while recognising the necessity for structural changes that would facilitate a steady supply of skilled workers in the long-term (i.e. ICT literacy becomes imbedded as a core part of higher and professional education programmes preparing industrial professionals).
- Popularisation of jobs in traditional sectors (such as wood-processing) among the youth. Targeted communication campaigns that demonstrate the opportunities linked to wood-processing industry of Estonia would boost the general interest among young people who have showing a decreasing interest in job opportunities in this sector. Further incentives could take the form of industry-academia partnerships with placements in wood-processing businesses made available to students. In this manner student would get a better, hands-on, understanding about the sector, while establishing linkages between academia and business.
- 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.

- Re-assessment of industrial policies and developing a more strategic take on facilitating structural transformation, increase in productivity and value-added. 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. A number of different approaches are possible in order to facilitate Industry 4.0 entering the policy discourse.
 - Adding Industry 4.0 to wider strategies. Examples of such practices have commonly been identified in Smart Specialisation Strategies of regions (i.e. the Norte and Centro regions of Portugal have both included Industry 4.0 related developments as part of their Smart Specialisation).
 - Producing a national strategy which is then further adapted to specific regions. This is evident in the French Industrie du Futur programme which targets Industry 4.0 developments nation-wide. However, individual regions of France have adopted the programme to fit their specific regional context (i.e. the L'usine du Futur of Nouvelle-Aquitaine is clearly grounded in Industrie du Futur programme). This is arguably the best option for Estonia as the small size of the country means that a national programme targeting Industry 4.0 would better facilitate large scale developments which can then be transferred to regional approaches.
 - Adopting region-specific strategies targeting Industry 4.0 development. This approach offers the best approach in terms of specialised, targeted approach that is grounded in regional nuances. However, because Industry 4.0 represents interplay between stakeholders supplying high-skill workforce (i.e. HEIs), businesses supplying 4.0 technologies and businesses adopting Industry 4.0, a regional approach necessitates recognising the role of the different stakeholders and ensuring that each is accounted for. This either means that a) the strategy must prepare measures that allow for different stakeholders to develop in parallel; thus, resulting in a regional value-chain; or b) the strategy accounts for either the workforce and/or 4.0 technologies being supplied from outside the region; thus, resulting in embedding regional businesses in (inter)national value chains.

2 France

2.1 Pays de la Loire

2.1.1 Regional baseline

Located in the West of France, the Pays de la Loire region is the eighth most populated region in France with nearly 4 million inhabitants in 2016. The region is organized around one central urban axis (Nantes), and including both rural areas and the Nantes-Saint-Nazaire industrial port. The region stands out for its population growth and attractiveness, driven by its quality of life and economic opportunities.

The Pays de la Loire region has more than 1.5 million jobs in 2015, spread over nearly 320,320³⁰ 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 France³¹. Industry, which accounts for 16.4% of jobs, is also more represented in the region than at the national level (12.2%)³², 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 servitisation.

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% 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 value³³.

Among manufacturing industries, the agri-food industry is the most important sector, including several market leaders (Fleury Michon, Pasquier, Sodebo, Tipiak). Other prominent industrial sectors are

³⁰ INSEE (2017) « Connaissance locale de l'appareil productif », available at: <https://www.insee.fr/fr/statistiques/2517292>, last accessed on 28/08/2019

³¹ INSEE (2015) « Estimations d'emplois en 2015 », available at : <https://www.insee.fr/fr/statistiques/2491904>, last accessed on 28/08/2019

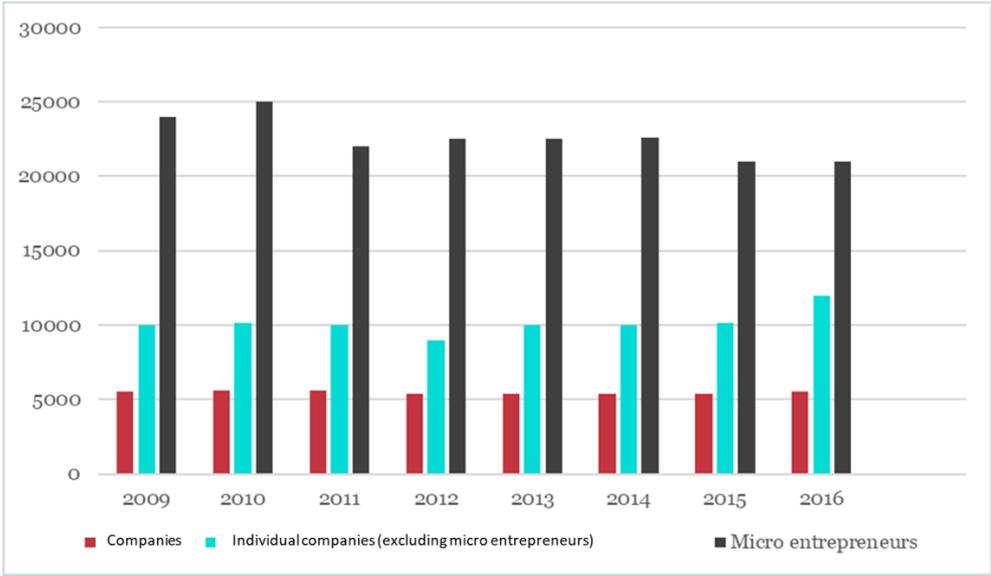
³² INSEE (2016) « Estimations d'emplois en 2015 », available at : <https://www.insee.fr/fr/statistiques/2491904>, last accessed on 28/08/2019

³³ Observatoire régional Economique et Social (2017) « Industrie – Construction », available at: <http://ores.paysdelaloire.fr/711-industrie-construction.htm>, last accessed on 28/08/2019

aerospace, military and civil maritime industry, mechanical and equipment material, metallurgy and electronic material. The civil maritime industry represents 4.1% of the wealth generated by regional companies while only representing 1.9% of its workforce. Bénéteau (leisure shipyard) and STX (cruise shipyard) are two world leaders located in Pays de la Loire. Concentration of manufacturing industries in a number of areas is a key characteristic of Pays de la Loire: 40% of the available workforce is located in La Ferté-Bernard, Sablé-sur-Sarthe, Les Herbiers and Segré.

The Pays de la Loire region has also experienced very strong variations in the evolution of the number of new business start-ups, with a stronger increase than at national level over the period 2002-2007, then a significant drop from the crisis in 2008 to 2015³⁴ (Figure 2-1). For example, in 2013, 60 companies were created per 10,000 inhabitants in Pays de la Loire compared to 74 nationally (source: APCE). However, since 2016, business start-ups have rebounded in the region (22,000 businesses created, or +1.9%)³⁵. The number of business failures is also down: 2,700 recorded in 2016 compared to 3,100 in 2015, or -14.7%. They had increased by 3.9% in 2015. Insolvencies decreased in all sectors except agriculture (+13.9%). The decline is particularly significant in industry (-18.5%) and construction (-21.2%).

Figure 2-1. Evolution of business creation in the Pays de la Loire



Source: Technopolis Group

In terms of infrastructures, 77% of regional households have access to broadband, compared to 79% at the national level (Eurostat, 2018).

³⁴ European Commission (n.d.) « Programme Opérationnel FEDER-FSE Pays de la Loire 2014-2020 », available at: https://ec.europa.eu/regional_policy/fr/atlas/programmes/2014-2020/france/2014fr16m2op008, last accessed on 28/08/2019

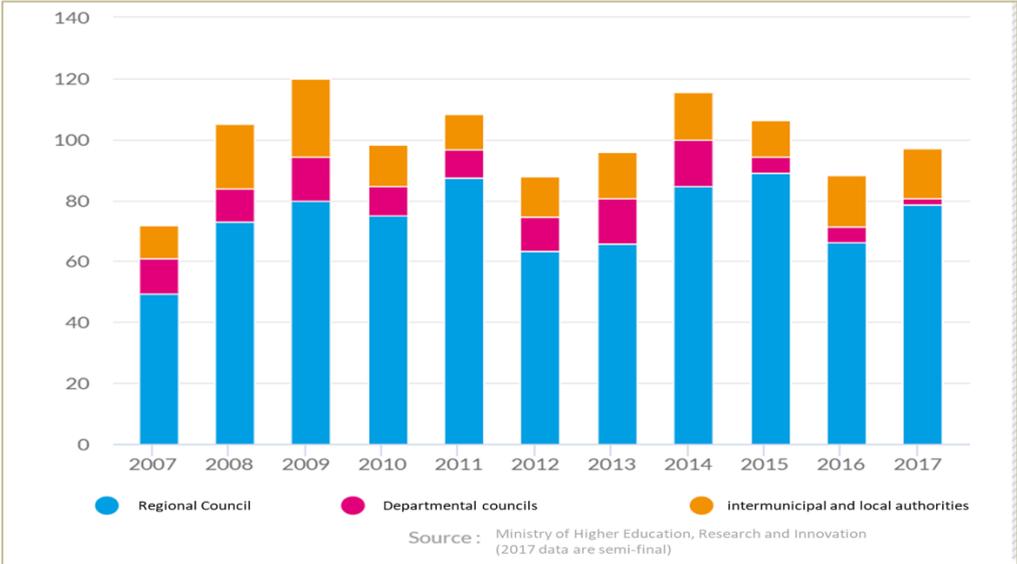
³⁵ INSEE (2017) « Bilan économique 2016 - Pays de la Loire », available at: <https://www.insee.fr/fr/statistiques/2863177?sommaire=2862012>, last accessed on 28/08/2019

Focus on the Research and Technology Transfer budget of the Pays de la Loire territory

In the Pays de la Loire region, over the past 5 years, the research and technology transfer budget of local authorities has increased by 10%³⁶. However, this increase conceals heterogeneous trends: The Region's expenditure increased by 24% and that of intermunicipal and local authorities by 23%. On the other hand, the Research and Technology Transfer expenditure of five Departmental councils has fallen sharply (-82%) in line with the implementation of the NOTRe Act in 2015, and the resulting redefinition of the competences of local authorities (the Region has become the leader in economic development competence). In 2017, 81% of the Pays de la Loire Research and Technology Transfer budget was provided by the Regional Council.

In 2017, funding for Research and Technology Transfer by local authorities is directed primarily towards technology transfers: 40% of the Regional Council's total Research and Technology Transfer budget is allocated to this purpose (Figure 2-2; Figure 2-3). These transfers, together with real estate transactions, aim to improve companies' access to the resources necessary for an innovative approach. Real estate operations account for 17.2% of the Research and Technology Transfer budget. Research projects are also significantly represented with 22.5% of the overall budget.

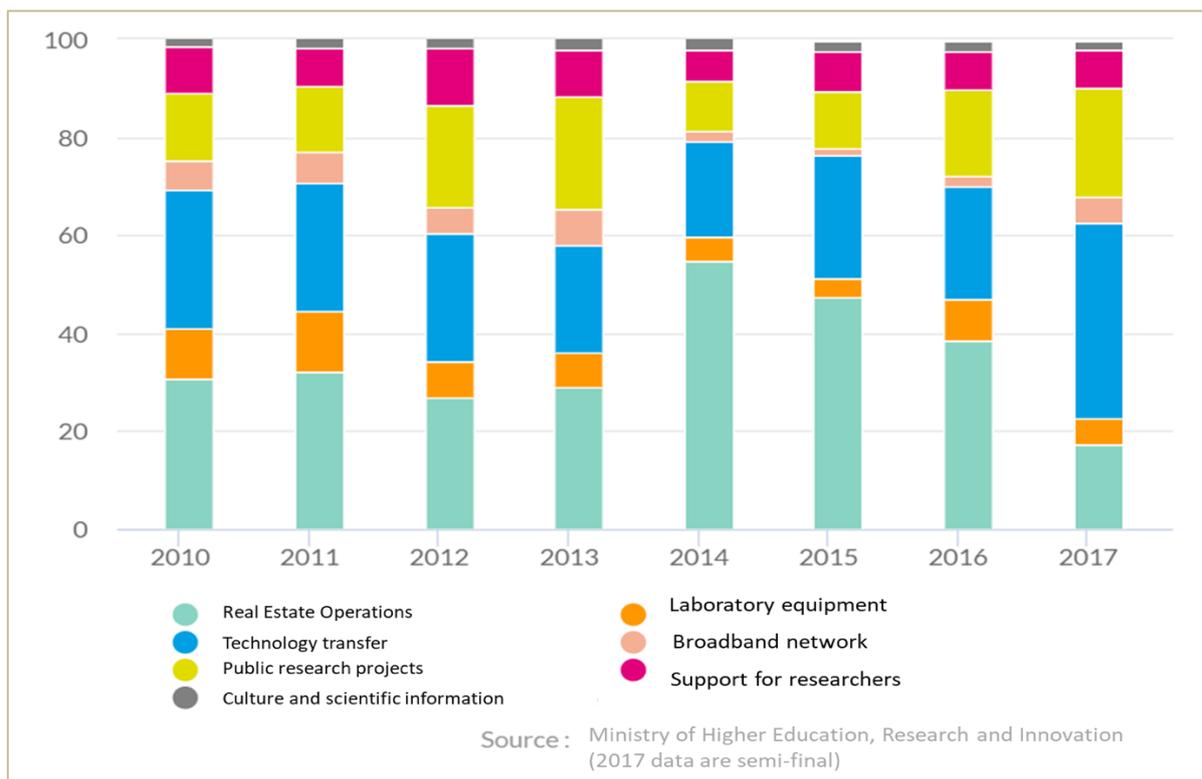
Figure 2-2. Research and Technology Transfer public budget of the Pays de la Loire territory - regional and local authorities (cumulative budget in millions of euros)



Source: Ministry of Higher Education, Research and Innovation

Figure 2-3. Research and Technology Transfer public budget of the Pays de la Loire territory - regional and local authorities - by type of operation (as a % of the Research and Technology Transfer budget)

³⁶ The Research and Technology Transfer budget of the Pays de la Loire region corresponds to all the expenses incurred by the Regional Council, the Departmental, inter-municipal and municipal councils within the regional territory. These expenses are intended to develop the Research and Development activities of universities and public bodies, to support innovation and research in companies, to promote technology transfer, to promote research results and to develop scientific and technological culture.



Source: Ministry of Higher Education, Research and Innovation

The budget devoted to Research and Technology Transfer by the Pays de la Loire Regional Council represents nearly 12% of its total budget in 2017. This proportion places the Pays de la Loire in second place among the others French regions, just behind the Ile-de-France. In France, only five Regional councils devote more than 10% of their budgets to Research and Technology Transfer expenses (Auvergne-Rhône-Alpes, Nouvelle Aquitaine, Occitanie, and Ile-de-France).

Focus on patent applications in the Pays de la Loire region

Regarding the publication of patent applications at the National Institute of Industrial Property (Institut National de la Propriété Industrielle, INPI) in 2018 in the French regions, the number of publications according to the inventor's address is the highest in Ile-de-France as the region accounts for 38.1% of French inventors' applications. The Pays de la Loire ranked 8th with 471 requests, representing a weight of 3.5% (3.9% in 2017, 7th in the ranking). On a per capita basis, the Pays de la Loire gained one place and ranked 7th with 1.24 published patent applications per 10,000 inhabitants in 2018.

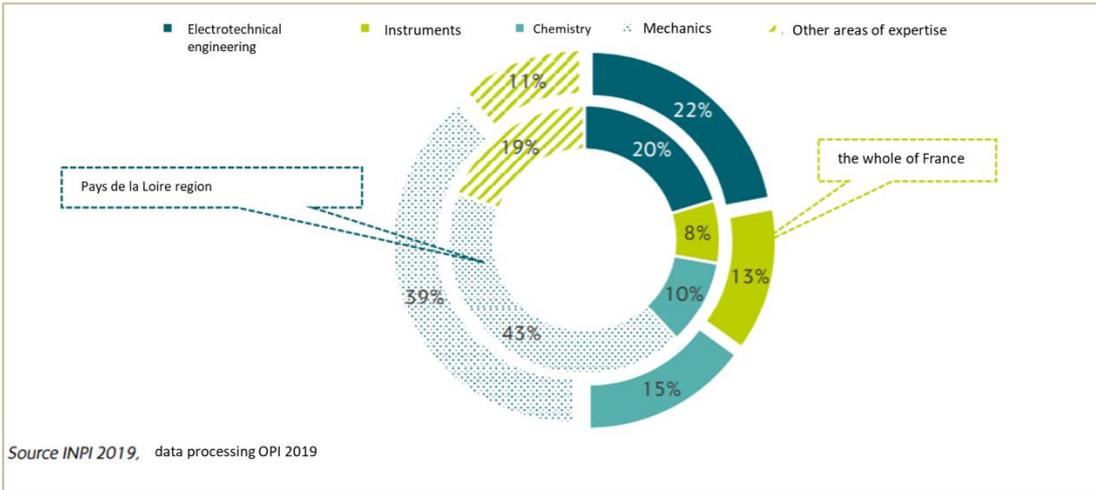
The INPI draws up a list of the main patent applicants at the INPI according to the number of published patent applications. In 2018, the Pays de la Loire accounted for 2.2% of applications published by applicants with an address in France. 78.7% of patent applications published at the INPI by applicants with an address in Pays de la Loire are applications from legal entities, i.e. 232 published applications. The top 5 applicants in the Pays de la Loire region include three higher education and research institutions: University of Angers, University of Nantes and the Jules Verne Institute of Technological Research. Two private companies are also present in the ranking: the Dorel France group, known for

its childcare brands, and the agricultural equipment manufacturer Kuhn. The latter is even positioned ahead of the University of Nantes and the Jules Verne IRT.

A classification of the invention contained in the patent is carried out by the INPI for any patent application (Figure 2-4). These requests are grouped into five technological fields: electro technical engineering, instruments, chemistry, mechanics and other fields. These correspond to 35 technology sub-areas (or sectors). These sectors correspond to the field of application of the invention and not to the economic sector of activity. In 2017, the Pays de la Loire region had a share of published patent applications that was 8 points higher than the national average in the "Other fields" domain (19% compared to 11% at the national level). The regional share in the "Mechanics" sector is 4 points higher (43% compared to 39%). Mechanics is the most important technological field in the region and in all French regions.

It should be noted that in the field of ICT³⁷, several technological fields (or sectors) are concerned in the electrotechnical technological fields. In these technological fields, 33 patent applications were filed in 2017, representing 31.42% of patent applications in the electrotechnical technological fields, and 6.35% of all patent applications in the same year.

Figure 2-4. Distribution of patent applications published by the INPI according to the 5 technological fields for the Pays de la Loire region in 2017



Source: INPI

2.1.2 Adopted 4.0 technologies in the sector in the region

According to the interviewees, the technologies introduced in the Pays de la Loire region are essentially those developed in the Techno Campus (see below), namely: virtual reality, acoustics, electronics and

³⁷ ICT is understood here as the "field of telematics, i.e. the computer, audiovisual, multimedia, Internet and telecommunications technologies that enable users to communicate, access information sources, store, manipulate, produce and transmit information in different forms: text, music, sound, image, video and interactive graphic interface". Legal and regulatory texts use the term "electronic communications".

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.

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.

The sectors and industries that benefit most from this development, adoption and transfer of technologies are, according to interviewees, aeronautics, mechanical industries, and the automotive industry, among others. 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.

In order to enable traditional sectors to be "irrigated" as best as possible by these developments, adoption and transfer of technologies, the actors interviewed specified that the detection of entrepreneurial projects is done by all the actors of the ecosystem deployed in the territories. In addition, the Chamber of Commerce is responsible for "prospecting" potential companies to be mobilized outside the usual circle (this is an action financed by the Regional Council). It should also be noted that an entrainment effect was observed via the events where these transformation subjects 4.0 are treated. The role of professional federations was also highlighted as essential. They promote on their own scale the challenges of introducing new technologies into companies.

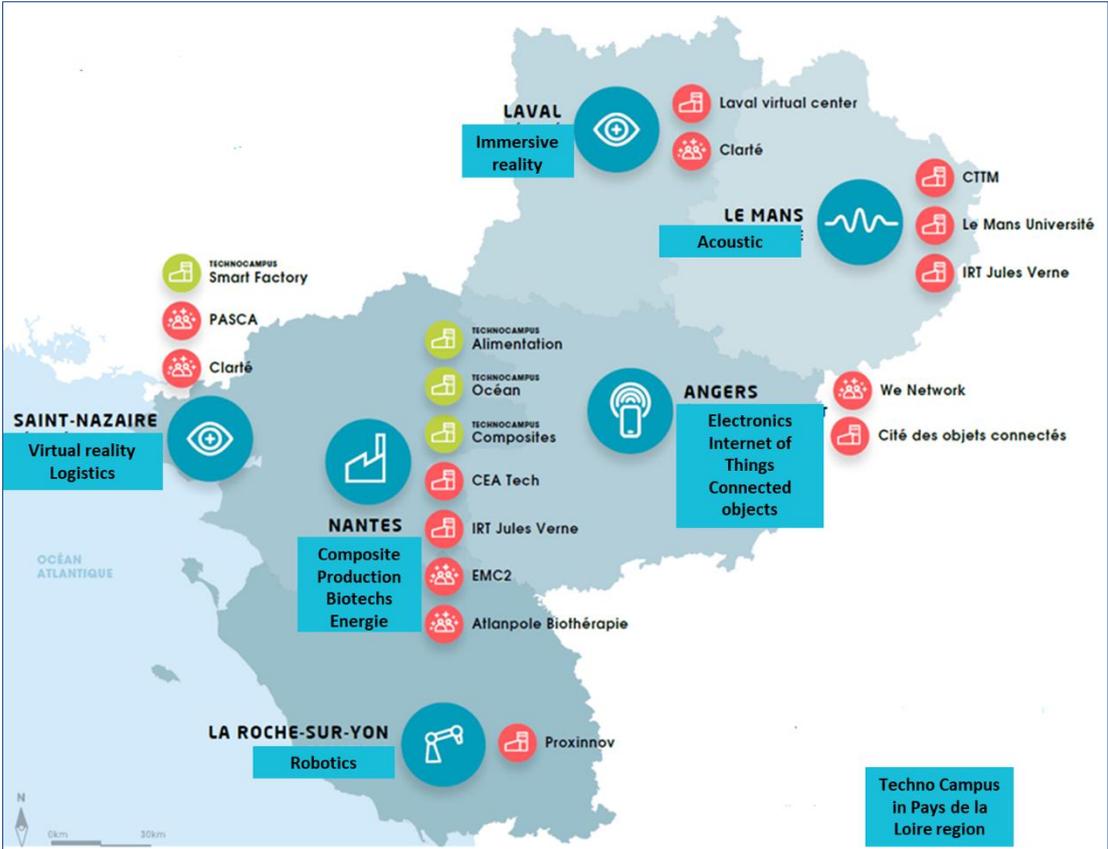
Two aspects of regional intervention have been put forward by the Pays de la Loire Region, during the interviews, to promote technological transformation and technology transfer.

The first part 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.³⁸ (Figure 2-5) Indeed, this networking should enable regional companies to acquire a technological edge by combining the expertise of the various Techno Campuses. For example, a collaboration between the Techno Campus Smart Factory and Robotics and Cobotics (Clarity and Proxinnov) has already been set up. It has enabled the creation of an industrial demonstrator for robotic assembly, integrating augmented reality and virtual reality technologies, for the food industry. Now, eight companies were involved in this project.

Figure 2-5. Mapping of the thematic of the Techno Campuses in Pays de la Loire region



Source: Pays de la Loire Region adapted by Technopolis Group

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.

³⁸ "Techno Campuses" are shared technological research platforms that bring together cutting-edge equipment and major industrial and academic players in strategic sectors. They are positioned in a key area for the industry of the future: advanced production technologies. The Techno Campus is based on a unique public/private model.

It should be noted that compared to other European regions (Discussed more in depth in the Final report) the degree of regional specialisation, between 2008 and 2016, in manufacturing carrier sector is rather high in the Pays de la Loire region. The same applies to the degree of regional specialisation in manufacturing induced sector. On the other hand, this is less the case in the manufacturing technology sector (see maps 4.1, to 4.3).

As regards services, over the same period at the comparative European level, the degree of regional specialisation in service technology, careers and also induced sectors is, for Pays de la Loire region, lower than in the manufacturing sector (see maps 4.4 to 4.6).

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 makes it possible to gradually support company managers. Three steps are proposed and linked together to encourage them to move on to the next step:

- Diagnosis / feasibility study; then
- Testing and integration of the technology into the company's process: this represents a lot of time for the company and is a hidden cost that banks do not finance. To overcome this difficulty, the Region proposes to make loans and grants; then
- Operational deployment / production start-up and services of new equipment enhanced by technologies developed or adopted by the company.

This system is therefore 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 (these are not the priority sectors of the region but the areas of intervention of the region on this subject).

Thus, everything is done to ensure that 4.0 technologies are developed by regional solution providers and then adopted by other companies.

2.1.3 Preconditions for transformation

Regional preconditions

According to interviewees, there are different regional preconditions necessary for 4.0 technologies adoption in the specific sector in Pays de la Loire region (Table 2-1).

Table 2-1. Key figures Pays de la Loire Region Innovation and Research

10 inter-regional competitiveness clusters, 4 of which have their headquarters in Pays de la Loire (2019)	France: 56 competitiveness clusters
14,780 employees in research and development 2016 (MESRI - SIES, semi-discrete data) - workforce measured in FTEs, researchers and research support staff in the private and public sectors	9th French region
1,413 million euros: R&D expenditure 2016 (MESRI - SIES, semi-discretionary data) - regional domestic expenditure by administrations and companies	9th French region
97 million euros: local authorities' budget devoted to research and technology transfer (R&T) 2017 (MESRI-SIES, semi-discrete data)	4th French region
471 patent applications of regional origin 2018 (INPI-OPI)	8th French region

Source: Compiled by the author

It should be noted beforehand that the weight of research and innovation in Pays de la Loire is less important than the economic and demographic weight of the region at the national level. Domestic expenditure on research and development represents only 1.3% of the regional GDP in 2016 while this indicator stands at 2.2% in metropolitan France. Yet, over the period 2013-2016, Pays de la Loire was the leading region for the increase in annual domestic R&D expenditure (+10%).

The staff assigned to R&D in Pays de la Loire represents 3.4% of the national R&D workforce, i.e. nearly 15,000 full-time equivalents (FTEs).

In Pays de la Loire, over the period 2015-2018, the number of patents filed each year fluctuates around 500, ranking the region at the 8th place³⁹.

Besides that, **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, have been mentioned as one of the regional preconditions necessary for 4.0 technologies adoption:**

- The region has ten inter-regional competitiveness clusters (and particularly Images & reseaux - TES about digital sector) and four that are headquartered in Pays de la Loire.

Table 2-2. Competitiveness clusters in Pays de la Loire Region

Competitiveness clusters	Main location	Other regions which are concerned	Activity sectors
Atlanpole Biothérapies	Pays de la Loire	Centre-Val de Loire, Bretagne	Biotechnology, Health
EMC2	Pays de la Loire	Bretagne	Materials, Microtechnology/Mechanics
iDforCAR	Pays de la Loire	Bretagne, Nouvelle Aquitaine	Specific Vehicles and Mobility

³⁹ Observatoire régional Economique et Social (n.d.) « Innovation et Recherche », available at: <http://ores.paysdelaloire.fr/712-innovation-et-recherche.htm>, last accessed on 28/08/2019

Pôle Mondial du Végétal (PMV)	Pays de la Loire	Centre-Val de Loire, Bretagne, Auvergne-Rhône-Alpes	Agriculture/Agro-Food, Chemicals
Images & reseaux - TES	Bretagne	Pays de la Loire, Normandie	Digital
Valorial	Bretagne	Pays de la Loire, Normandie	Agriculture/Agro-Food
Elastopôle	Centre-Val de Loire	Pays de la Loire, Auvergne-Rhône-Alpes, Ile-de-France, Nouvelle Aquitaine	Rubber, Materials
Pôle Mer Bretagne Atlantique	Bretagne	Pays de la Loire	Bioresources, Ecotechnologies/Environment, Energy, Transport
S2E2	Centre-Val de Loire	Pays de la Loire, Nouvelle Aquitaine	Ecotechnologies/Environment, Energy
Xylofutur	Nouvelle-Aquitaine	Pays de la Loire, Grand Est, Bourgogne-Franche-Comté, Auvergne-Rhône-Alpes	Bioresources, Wood industries, Materials

Source: Compiled by the author

- The region also hosts research laboratories from five national public research organisations:** the National Centre for Scientific Research (Centre National de Recherche Scientifique, CNRS), the National Institute for Agricultural Research (Institut National de Recherche Agronomique, INRA), the French Institute for Marine Research (Institut Français de Recherche pour l'exploitation de la mer, IFREMER), the National Institute for Health and Medical Research (Institut National de la Santé et de la Recherche Médicale, INSERM) and the French institute of science and technology for transport, spatial planning, development and networks (Institut Français des sciences et technologies des transports, de l'aménagement et des reseaux, IFSTTAR) that does research in transport, planning and networks (Pays de la Loire, 2017). They employ 33% of public researchers in Pays de la Loire, compared to around 50% in France.
- In terms of higher education, the main public universities of Pays de la Loire** are gathered in the community of universities and higher education institutions "Bretagne-Loire" (COMmunauté d'Universités et d'Établissements - 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 11 doctoral schools in the fields of biology and medical research, sciences and technologies and social sciences, and 246 PhD dissertation candidates in 2016 (University of Nantes, 2017). The region has nearly 124,000 students at the start of the 2014 academic year, representing 3.4% of the population (the same for France's regions). The region welcomes 56% of students, 13 in higher technical sections, 7% in engineering schools, 3% in preparatory classes for higher education, 5% in private university institutions and 17% in other higher education institutions (public and private). The

university population of Angers has about 21,000 students, that of Le Mans 10,000 and that of Nantes 35,000⁴⁰.

- **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. Created in 2012, as part of the Future Investments Programme, SATT Ouest Valorisation aims to link the world of public research and the private sector at the local level, in particular by promoting the results of public research programmes (filing patents, licences, creation of start-ups, etc.) and by meeting the needs of the industry. Even if its headquarters are in Bretagne, its scope of action also involves the Pays de la Loire region. Its four shareholders are the ComUE Université Bretagne Loire, the CNRS, the Institute of Research for Development (Institut de Recherche pour le Développement, IRD) and the Deposits and Consignments Fund (Caisse des Dépôts et Consignation, CDC). It has a budget of around EUR 70 million to invest in R&D projects. SATT Ouest Valorisation finances and supports technologies until they are adopted by the industry, taking the technological and financial risk inherent in projects. SATT also allows existing and new companies to access these innovations more quickly.
- **The region also hosts the “Jules Verne”, an Institute of Technology** that is specialised in advanced materials.

Others regional preconditions necessary for 4.0 technologies adoption have also been mentioned. Indeed “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”.

Furthermore, “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.

⁴⁰ Observatoire régional Economique et Social (n.d.) « Enseignement supérieur », available at: <http://ores.paysdelaloire.fr/708-enseignement-superieur.htm>, last accessed on 28/08/2019

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

The interviews also highlighted **the strong cultural heritage** of industrial collaboration in the Pays de la Loire region. This asset is not transferable as such since this collaborative approach is deeply rooted in the culture of the region. This precondition is not specific for this sector, but it is for this region.

Sectoral preconditions

Manufacturing industries are over-represented in the region Pays de la Loire. Four sectors are predominant (Agro-food; Manufacture of basic metals and fabricated metal products, and other non-metallic mineral products; Manufacture of rubber and plastics products, except machinery and equipment; Transport)⁴¹. Next to these traditional sectors, the region has strong assets in the following sectors: Electronics, Aeronautics; Robotics (combination of mechanical engineering, electronics and digital); Information Technologies, Agro-food; Medical therapeutics; Shipbuilding; Vegetal resources.

Focus on the electronics sector. The electronics sector is strongly represented in Pays de la Loire. The region ranks 5th nationally in terms of jobs and establishments in terms of total electronic activity with 255 establishments and 15,400 employees (Thales Communication & Security, Cofidur EMS (headquarter (HQ) in Île-de-France), Eolane, Tronico, SELHA, Lacroix Electronics, Evolis (HQ in Pays de la Loire), Souriau - Groupe Esterline (HQ in USA), Europlacer (HQ in Great Britain)). It is a region rich in leading assembly companies in France and Europe. The export rate of the sector is high (45%) and the subcontracting activity is strongly represented (53% of establishments in the regions). **The challenges of the regional sector lie in the competitiveness of companies in the growth markets of professional electronics such as automotive, industry and medical, aeronautics/defence and security, naval, connected objects for professional markets and the smart city.**

⁴¹ Observatoire régional Économique et Social (2016) « Chiffres clés » in *L'économie des Pays de la Loire*

Box 2-1. Key figures for the electronics sector in the Pays de la Loire region

- A region positioned in electronic assembly, with leading companies at national and European level (source: Décision Conseil, study 2010),
- 5th place among French regions in terms of establishments and jobs (source: Acoess 2015),
- The electronic board assembly manufacturing sector (22% of the workforce): the region's leading employer in electronics (list of NAF codes, source Acoess 2015),
- 255 establishments, 15,400 employees, 250 researchers (source: Acoess 2015),
- An export rate of 45% (source: Banque de France 2014),
- An average rate of value added of 37% for regional companies (source: Banque de France 2014); the average rate of value added in the Pays de la Loire industry as a whole is 27.5%.

Source: Compiled by the author

The poles and clusters that develop know-how in connection with the electronics sector, present in the region, are:

- Competitiveness clusters: S2E2 (Smart Electricity Cluster), specific to the electronics sector; iD4CAR (specific vehicles and sustainable mobility), of which two out of four technological axes are linked to the electronics sector (intelligence of embedded systems and ICT and sustainable mobility); Images & Networks (Images et Réseaux), for the link with digital technology; EMC2 on Advanced Production Technologies (TAP).
- The Wen cluster (West electronics & applications network) which coordinates the collective ambition of all the regional players in the professional electronics sector with the aim of having the region recognised as a territory of excellence in Europe.

Also noteworthy is the presence of **We Network, the technical centre of the French electronics industry**, which accelerates the digital transformation of Tech (to accelerate electronic dissemination in products) and Fab (to accelerate the industry of the future, especially in the electronics sector) companies from of the electronics and Internet of Things professions. It is an operator of the new Electronic Techno Campus.

Focus on the robotics sector. The activities of the robotics sector are mainly concentrated in three departments of the region: Loire-Atlantique, Maine-et-Loire and Vendée. It is also in these departments that the innovation, development, research and training structures related to the robotics sector are located.

In the regional value chain, the most represented links are integrators (42 companies) and design offices (26 companies). Many companies in the Loire have one main activity (automation or equipment manufacturer) and are diversifying into robotics. The industrial fabric is mainly composed of small companies (ECMA, Axiome, Europe Technologies, Huguet ingénierie, SITIA, Gobio, Robotique expertise, ARD72). However, the most important company, SEPRO Robotics (the only French manufacturer of industrial robotics), has more than 400 employees.

Robotics is an important sector for the development of regional policies to improve the competitiveness of companies through robotization. A link with the "Industry of the Future" plan is sought.

The regional innovation platform Proxinnov in Vendée acts as an interface between SMEs, integrators and robot manufacturers in order to raise awareness and support companies in robotization. The IRT Jules Verne, the Technocampus Smart Factory, the IRCCyN laboratory of the Ecole Centrale de Nantes (part of the Equipex Robotex, an excellent equipment financed since 2014 as part of future investments), which are more focused on R&D, the CEA Tech⁴² in Bouguenais and the Technical Centre of the Mechanical Industries (Centre Technique des Industries Mécaniques, CETIM), both involved in the ROBOT Start PME program, are also developing their robotics skills.

ROBOT Start PME is a support program for SMEs with first access to robotization. It is part of the France Robots Initiatives national robotics plan, launched on March 19, 2013 by the French Minister of Productive Recovery. ROBOT Start PME finances 10% of the SMEs' investment of the first robotics cell and provides them with expert support (diagnosis, project definition, choice of integrator, follow-up).

Box 2-2. Key figures for the robotics sector in the Pays de la Loire region

- One of the first regions in France in robotics (source Key Technologies 2020 – DGE-Direction Générale des Entreprises)
- 60 establishments, 1,500 employees, 150 researchers (source ADIT 2016)
- A regional robotics market estimated at 165 million euros in revenue (source: ADIT estimate)

Source: Compiled by the author

Robotics is oriented towards the production of technologies for the regional companies. From that perspective, the regional fabric is made of industrial sectors that can benefit the most from the Industry 4.0 and from related technologies developed and produced in the region.

In addition, the Pays de la Loire Region, whose robotics initiatives are led by Proxinnov, focuses its communication strategy on collaborative robotics, particularly for the Industry of the Future. Major companies such as SEPRO Robotics, BA Systems (now B2A Technology) are involved in the animation of the ecosystem and the IRT Jules Verne facilitates the Industry Research links.

Focus on the digital sector. In the Pays de la Loire region, the digital industry ecosystem is made up of many companies, particularly in software publishing, large information systems, cloud computing and virtual reality. With nearly 2,000 establishments with at least one employee, representing a total of more than 35,200 jobs, the Pays de la Loire is the 3rd largest region in France in the digital sector. The turnover of the digital sector in Pays de la Loire is about EUR 2 billion. The ICT manufacturing and

⁴² CEA Tech's mission is to produce and disseminate technologies for the benefit of industry, by providing a "bridge" between the scientific world and the economic world. CEA Tech also provides access to generic technologies developed for CEA's other operating divisions.

telecommunications sectors are mainly composed of establishments employing at least one employee. The Managed Services sector is largely made up of establishments with no employees.

Over the period 2011-2015, the total number of employees in the digital sector increased by nearly 12%. The number of employees increased sharply over this period with growth of 33% in the software/internet publishing sub-sector (about 2,800 employees in total), 30% in managed services (about 6,500 employees in all in the regions) and 19% in consulting, engineering and ICT training (a dominant sub-sector in the regions with more than 13,500 employees in total). On the other hand, the number of employees in the telecommunications sub-sector decreased by 13%, and the number of establishments by 23%.

Pays de la Loire region is home to important digital companies, particularly in software publishing, large information systems and cloud computing, such as Capgemini Technology Services, Bouygues Telecom, Orange, Vecteur Plus, Afone... and many start-ups set up in the region, since many training courses in electronics, computer and information technology professions are offered in the region. The turnover in the region is about EUR 2 billion. This dynamism can also be explained by the supportive policies implemented: 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 regional digital industry ecosystem is supported 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 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. It is also worth noting the presence of an interregional competitiveness cluster in Brittany Pays de la Loire: "Images et Réseaux".

The Nantes metropolis is the "locomotive" of digital technology in the region with, in 2016, more than 1,600 establishments (+66% between 2009 and 2014) and more than 20,000 jobs recorded (+32% between 2009 and 2014). Nantes was awarded the French Tech label in 2014 among nine French metropolitan areas, thanks to an attractive ecosystem (presence of talent, entrepreneurial culture, technological expertise, etc.) that meets the needs of French start-ups, investors and foreign talent. Angers was also awarded the French Tech label in 2015, particularly around the "Cité de l'Objet Connecté", which was inaugurated in 2015⁴³. Each year, three digital-related events garner attention and momentum in the region: "Laval Virtual", an international fair that focuses on virtual technologies,

⁴³ A private industrial accelerator dedicated to connected objects, it brings together all the skills required to design "intelligent" products in electronics, plastics, mechanics or design. Its objective is to enable any connected object project owner to quickly transform his idea into a project ready for serial production.

Web2Day, the second digital fair in France on innovation, and Digital Week that gathers the main digital players from the city of Nantes.

The Pays de la Loire region also includes five thematic networks labelled French Tech in 2016. These networks enable digital actors to have greater visibility at national and international level, networking and coordination with other national ecosystems, and easier access to funding for start-ups.

- HealthTech - NantesTech: this theme addresses issues of health, well-being, biotechnology and ageing.
- IoT and Manufacturing - NantesTech and AngersTech: the theme is the Internet of Things.
- CleanTech and mobility - NantesTech, Vendée FrenchTech and Le MansTech: the network is dedicated to green technologies, energy, transport and sustainable cities.
- Retail - NantesTech: commerce is largely affected by digital developments: e-commerce, digitalization of points of sale, logistics, collaborative consumption.
- EdTech and Entertainment - NantesTech and LavalTech: this theme includes all training and leisure activities: media, music, video games, social learning, virtual and augmented reality.

For this digital sector, the challenges are 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. Issues relative to training (in the face of recurrent tensions in certain professions, such as design and development), the financing of its companies (and in particular start-ups) and internationalization, were put forward by the Pays de la Loire region in its economic diagnosis in preparation for its Regional Economic Development, Innovation and Internationalization Plan (SRDEII). Finally, the relocation of the production of connected objects in the Pays de la Loire region is an important issue.

So according to interviewees, the main sectoral preconditions necessary for 4.0 technologies adoption in the specific sector are:

- 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 / biotechs / 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.
- The ability of the manager to spend time to take an interest in the issue and go beyond a simple diagnostic step is another precondition. It is on this point that public action is trying to intervene. In addition, the ability to adapt the support tools offered by institutions to the world, the pace and industrial needs has been put forward as an important condition for the success of the proposed support.
- Connections within the regional ecosystem (whether between solution providers and companies seeking transformation, or also between companies to benefit from feedback) were also suggested as necessary. These contacts are made either through events or in dedicated places that promote cross-fertilization and collaboration between traditional sectors and technology suppliers, and research laboratories (such as Techno Campuses). One example is the First Regional Meetings Tech and Fab which took place in Le Mans in June 2019. All the providers of new technologies and regional industrialists motivated by these subjects were present. Finally, the importance of 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.
- 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”.

Social preconditions

One of the first social preconditions is the development of new uses (mobile, e-commerce, media, etc.) among the population.

Anticipating the skills required to deploy technological transformations is also 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. 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.

The challenge is to attract and train young people. To this end, training plans for each sector have been defined. The stakeholders interviewed also consider that the Pays de la Loire Region has the capacity to generate this transformation of regional human resources.

However, this situation does not prevent the Pays de la Loire Region from being very attractive for certain sectors of activity and certain associated skills. Thus, the quality of life of the Nantes Metropolitan Area, its high-speed train service in Paris, its very competitive real estate prices and salaries make it very attractive. This makes it difficult, for example, to recruit IT developers in Ile-de-France who, once they graduate, prefer to settle in the Pays de la Loire region.

The actors interviewed also 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 la Loire region via the "French fab" business clubs and the involvement of business leaders.

Pays de la Loire region therefore has an active network at the service of the diffusion of innovation (10 competitiveness clusters, 4 technopoles, more than 40 regional innovation platforms...). But the region still has a deficit of young people engaging in long-term studies and companies that have made the bet on innovation. Thus, the historically low presence of national research organisations weigh (33% of public researchers in Pays de la Loire, compared to around 50% in France), for example, on the territory's ability to position itself on a national scale. If the organizations' commitment were in line with the national average, institutions would benefit from nearly 500 additional full-time equivalents of researchers. Faced with these challenges in the short, medium and long term, the Pays de la Loire Region has defined its Regional Scheme for Higher Education, Research and Innovation (SRESRI) in order to define a collective ambition and the implementation of shared tools as part of an operational strategy at the scale of the territory.

Policy preconditions

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.

This Scheme also presents different sectors:

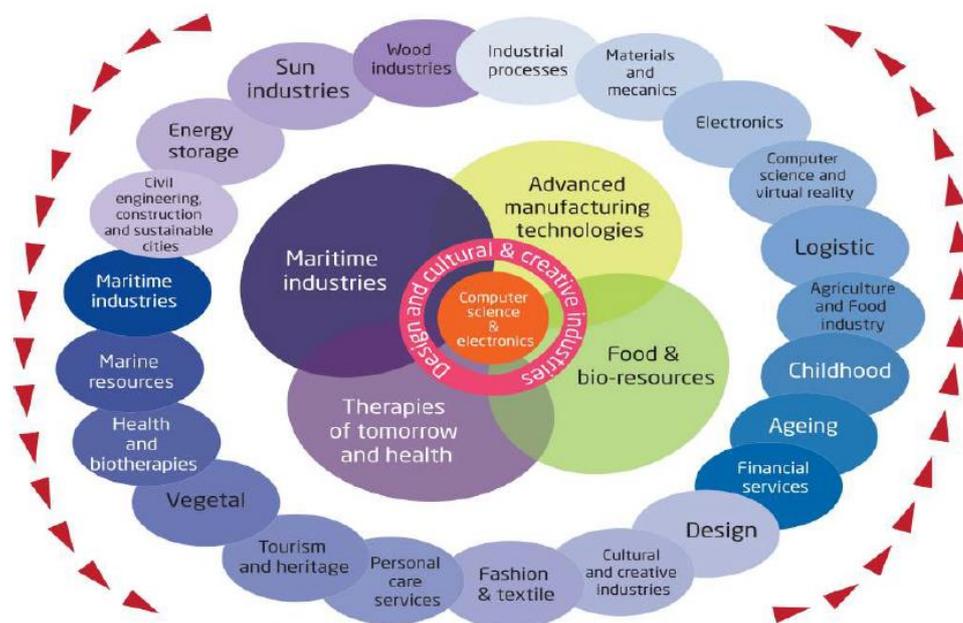
- **Industrial sectors with a strong knock-on effect** such as aeronautics, shipping, agri-food industries, which rely on the dynamics of markets of world leaders, major principals and networks of subcontractors present in the region. The upper tertiary sector is an essential support for the development of industry. Similarly, both the healthcare and electronics sectors in the Pays de la Loire region have recognised skills and know-how that should enable them to meet market growth prospects.
- **Economic sectors that are undergoing structural change and that need to be revitalised to regain sustainable competitiveness**, such as the construction and public works sector, or also agriculture. The tourism, the automotive and textile sectors are also experiencing profound changes (market challenges, attractiveness of business lines, modernization of production equipment).

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 (Figure 2-6. Articulation between the 22 regional industrial sectors and the six regional specialisations in Pays de la Loire region).

Figure 2-6. Articulation between the 22 regional industrial sectors and the six regional specialisations in Pays de la Loire region



Source: Regional Innovation Strategy for a Smart Specialisation (2014)

Source: *Regional Innovation Strategy for Smart Specialisation (2014)*

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”⁴⁴. Indeed, very small businesses, SMEs and companies of intermediate industrial sizes are faced with the challenge of modernizing 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. To achieve this, the French Chamber of Commerce and the Industry of the Future Alliance have prepared this directory of "solution providers" which is national and can be adapted by region. It lists companies established in France and marketing products, services and solutions that appear in the Industry of the Future technology bricks repository for industrial companies.

Focus on 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 Working Group on the Development of the Future Technology Offer then identified the seven key technologies

⁴⁴ Alliance Industrie du Futur (n.d.) « Offeurs », available at: http://www.industrie-dufutur.org/recherche?searchQuery=offreurs&filters%5BtypeDocument%5D=solutions_offers&orderBy=default, last accessed on 28/08/2019

for the development of the Industry of the Future 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. These sheets highlight the levers of competitiveness and should help leaders of companies to act quickly.

After three years, **the Industry of the Future Alliance** and its 35 members updated this 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.

In addition to the industry of the future, New Industrial France (Nouvelle France Industrielle) is based on nine industrial solutions that provide concrete solutions to major economic and societal challenges and position French companies in the markets of the future in a world where digital technology is breaking down the divide between industry and services. These nine industrial solutions are: Data Economy, Smart Objects, Digital Confidence, Intelligent Food, New Resources, Sustainable Cities, Ecological Mobility, Medicine of the Future, and Future Transport.

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. Thus, the region's industrialists took possession of this "French Fab" banner particularly quickly and the Region has set up a "French Fab" club in all its five departments of the territory. 568 companies are now involved. These project supports and accompaniments also mobilise the expertise of other partners such as Chambers of Commerce and Industry, technopoles, the Innovation Development Network, competitiveness clusters, etc.

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.

2.1.4 Actual transformations in the region

Economic transformation

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.

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).

Social transformation

A 2016 National Institute of Statistics and Economic Studies (Institut National de la Statistique et des Etudes Economiques, INSEE) report states that the economic recovery is underway in the Pays de la Loire. The territory must continue to capitalize on its rich and diversified economic apparatus to bring out new companies, and to allow companies to structure themselves, innovate and be competitive to maintain themselves in the economic environment. The digitalization of companies has led to a transformation of professions and user behaviour. The direct consequences for digital service companies, recruitment firms but also companies in traditional sectors are the difficulty in recruiting qualified profiles in the face of the emergence of new needs

According to another INSEE report, in 2015⁴⁵, 27,400 employees are working in the digital sector in the Pays de la Loire region. **The region is the leading French region (excluding Ile de France) in the development of digital professions over the past six years (+18% from 2009 to 2015, or +4,100 jobs). Several factors explain this trend.** First, the economy of the Loire is generally more dynamic than in France – excluding Ile-de-France (+2% growth in total employment compared to stability in the provinces). In addition, the attractiveness of the region and the metropolis of Nantes fuels this dynamic as large digital service companies are located in the region (Thales Communication, Capgemini, Sigma informatique, Orange, etc.). They are based on numerous local skills, a diversified economic fabric but also on easier access to the Parisian market combined with reduced operating costs (salaries, rents, etc.).

The INSEE also notes that the development of digital professions is more marked in the digital sectors than in the rest of the Pays de la Loire economy (+25% against +9%). In France – outside the Ile-de-France region, this trend is confirmed but with less importance (respectively +15% in the digital sectors, against +4% in the rest of the economy). To reduce costs or because they do not have

⁴⁵ INSEE (2018) « Forte croissance des métiers du numérique, tirée par les secteurs au cœur du monde digital », available at: <https://www.insee.fr/fr/statistiques/3604254>, last accessed on 28/08/2019

the in-house skills, companies can outsource certain activities by using a specialised service provider in the digital sectors.

As in other dynamic French regions in the digital sector, there are many needs for programming and consulting and other IT activities in the Pays de la Loire region. This sector contributes to almost all the development of digital professions (+2,900 jobs), representing a 35% growth between 2009 and 2015. In parallel, some digital sectors are losing digital jobs: -26% in ICT sales (-120 jobs) and -30% in computer repair (-120 jobs). In ICT manufacturing, the workforce in digital professions is stabilising in the Pays de la Loire region, where large companies in the sector are located.

The dynamics of digital professions are spreading to other sectors of the economy. To innovate and develop, they also rely on digital skills. However, growth is less strong than in the digital sectors: +9%, or 880 digital jobs created between 2009 and 2015, including 690 senior engineers. The Pays de la Loire ranks first among the most dynamic regions in the development of engineering jobs (+27%), with 2,500 jobs created between 2009 and 2015. This business contributes to 62% of the evolution of the digital workforce in the region. In the provinces, the growth of this business is less important (+20%). The digital transformation of the economy as well as new usages (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 Emploi⁴⁶, 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. It should be noted that the Pays de la Loire are also characterised by a development of the professions of employees and operating operators in IT (+ 120 employees).

The analysis at the European level (see main report) shows that during the period 2013-2018, the former region Pays de la Loire had a high displacement of high-skill jobs (Map A.9.1.). As regards low-skill jobs, Pays de la Loire had a low displacement (Map A.9.2.).

Focus on Research and Development workforce

Between 2011 and 2016, the region's R&D spending grew faster in the public sector than in the private sector. In companies, R&D spending is increasing faster in the Pays de la Loire than the average in France: +16% compared to +12%. This phenomenon is even more important in the public sector, with an increase in domestic research and development expenditure of 39% in Pays de la Loire and 6% on average in France.

In terms of headcount, in Pays de la Loire, the trends are identical in the private and public sectors: +10%. In France, over the same period, the number of employees grew less rapidly than in Pays de la Loire: +7% in both the public and private sectors.

⁴⁶ Public employment agency in France

Thus, with a 10% increase in the number of R&D staff in the private sector, the Pays de la Loire is one of the most dynamic regions in France (2nd place just behind the Provence Alpes Côte d'Azur region). In terms of public sector employees, the Pays de la Loire ranks 5th among the others French regions.

In terms of private research, in this region, the number of researchers is concentrated in companies with less than 250 employees: 44.7% of the total number of employees. This proportion is much higher than the average in France (32.2%). On the other hand, 31.6% of researchers work in companies with more than 1,000 employees, a much smaller share than the average in France: one researcher in two works in a company with more than 1,000 employees at the national level. This distribution of researchers in the Loire companies is explained by the structuring of the regional economic fabric, which consists of a high proportion of companies with less than 250 employees and large companies that are often focused on low-technology manufacturing activities, particularly agri-food.

In addition, the Pays de la Loire region has benefited less than other French regions from the historical location of companies and research institutions in sectors supported by public policies: nuclear, armaments, rail transport, etc.

2.1.5 Actual and /or expected impact

It should be noted that the Industry of the Future was launched in 2015, and the SRESI and the SRDEII were adopted in 2014 and 2016 respectively. We therefore have little distance from the impact of these public policies.

In the sector in the 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 of the adoption of 4.0 technologies on employment and turnover in the sector in the region.

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.

In Pays de la Loire region, there is no destruction and no creation as such of skills, but an intensification of the demands for skills such as research engineers.

In other sectors

Generally, the main reasons for introducing new technologies into companies are always the same: 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.

Moreover, to date, there is no evaluation of the regional mechanisms/schemes put in place, which makes it more difficult to analyse this impact.

In addition, 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.

In the region

To date, there is no evaluation of the regional mechanisms/schemes put in place, which makes it more difficult to analyse the direct and indirect impact of the adoption of 4.0 technologies on the local economy in general (e.g. GDP growth, productivity growth, employment growth, composition of the labour force).

2.1.6 Operational policy recommendations

The following operational recommendations for national/regional policy based on the result of research including opinions of interviewees could be formulated:

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.
 - This can be done both through awareness training, support and advice to help companies carry out a diagnosis and then a plan of action, or also through financial support.
- Develop policy measures to attract and train of young people, on skills that are highly sought after by companies
- To this end, training plans for each sector , based on skill needs, have to be defined. This involves, for example, promoting the quality of life in the host region, working to stop the "bashing industry" by promoting industrial jobs...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.
 - There too, to this end, training plans for each sector , based on skill needs, have to be defined. Actions to enhance the value of the professions and the region will also be envisaged. The two hypotheses (endogenous and exogenous) can also be developed in parallel.
- Support the development of new uses (mobile, e-commerce, media, etc.) among the population.
 - Such an approach must be based on an initial territorial diagnosis in order to define a vast action plan on subjects such as: autonomy and digital inclusion, administrative procedures, education and culture, economic development, etc.

For the public sector (i.e. local and regional governments)

- Reinforce awareness raising work on digital change and related impacts
 - Such an approach must be based on valuable feedback / success stories on targeted sectors, actions to raise awareness of the expected impacts via professional organizations, public institutions ...
- Put in place policies to support companies in integrating these changes.
 - These policies must be consistent with the expected sectoral changes and impacts They can also take the form of advisory support, networking, or financial support...

2.2 Auvergne-Rhône-Alpes

2.2.1 Regional baseline

Located in the East of France, the Auvergne-Rhône-Alpes is the second largest area in France. With more than 8 million inhabitants in 2018, it is the second most populated French region (12.8% of the Metropolitan population). The region is organized around two metropolitan areas, the district of Lyon and the district of Grenoble-Alpes, and has eight urban conglomerations of more than 100,000 inhabitants: the district of Saint-Étienne, the district of Clermont Auvergne, Valence-Romans Sud Rhône-Alpes, the Grand Annecy, Bassin de Bourg-en-Bresse, district of Chambéry, Porte de l'Isère, and the Roannais district. 80% of the region is located in mountainous areas, and the region gathers three Alpin mountain range, including the Mont Blanc, making it the first European mountainous region.⁴⁷

⁴⁷ Auvergne-Rhône-Alpes Region (n.d.) A geography (Une géographie), available at: <https://www.auvergnerhonealpes.fr/7-une-geographie.htm>, last accessed on 29/08/2019

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%.

Although services are the main sector of activity (64.5% of the GDP), Auvergne-Rhône-Alpes is best known for its industry: **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. This industrial expertise is mainly showcased at The Global Industry fair, which is held in Lyon every two years and has welcomed more than 45,800 people in 2019. Hence, the region is very oriented towards the export, that represents 12.5% of the national GDP, and mainly trades with Germany (15.7%), Italy (10.3%) and Spain (8.4%).

During the period 2008-2016, the former Region Rhône-Alpes displayed a stronger specialisation in 'technology' manufacturing sectors with regard to the European average and a lower specialisation in 'induced' manufacturing sectors. The former Region Auvergne presents opposite patterns: a lower specialisation in 'technology' and 'carrier' manufacturing sectors while a stronger specialisation in 'induced' manufacturing sectors. As regards to services, both Rhône-Alpes and Auvergne were under-specialised in 'technology' and in 'induced' sectors. Rhône-Alpes presented a stronger specialisation in 'carrier' service sectors (see Maps A.4.1. to A.4.6.).

Two national clusters located in the region and dedicated to the production and transfer of technologies for the manufacturing industries have decided to merge: Mont-Blanc Industries and ViaMéca become CIMES (Creating Integrated Mechanical Systems). ViaMéca was engaged in projects dealing with Surface Engineering, Advanced Manufacturing Processes, Intelligent Systems and Robotics and Engineering driven by Uses and Services. Mont-Blanc Industries supported projects in the fields of precision machining (advanced manufacturing processes and autonomous production cells) and mechatronics (B to B sub-assemblies, B to C products, and industrial robotics). CIMES is now bound to rise to the challenges represented by the digital, environmental and international evolutions faced by the mechanical sector⁴⁸.

In the Auvergne-Rhône-Alpes region, the robotization and the 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 others consider integrating IoT and additive manufacturing, especially for start-ups. Yet, additive manufacturing is a scarce skill in the region: the CETIM provides a specific training 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,

⁴⁸ Mont-Blanc Industries, ViaMéca (2019) Labelling of the new competitiveness cluster on mechanics: CIMES (Labellisation du nouveau pôle de compétitivité de la mécanique : CIMES) available at: <https://www.montblancindustries.com/wp-content/uploads/Communiqu%C3%A9-de-Presse-labellisation-pole-de-comp%C3%A9titiv%C3%A9-CIMES.pdf>, last accessed the 02/09/2019

powder metalworking, but skilled people will need several more years to graduate and enter the job market. The issue is the same with robotics, for which skills are lacking in the region – within the CETIM as well, which can be problematic when wanting to keep up with the latest innovations and provide relevant and accurate trainings. The UIMM have recently created trainings on advance production line pilots, but the issue remains the same as for the schools. Thus, companies currently recruit skilled foreigners to fill the positions.

Besides the lack of skills, the local companies face other difficulties when considering implementing technological upgrading in their practices such as:

- The technological gap: for the more traditional companies, completely reimagining their practices is a tough exercise that refrains them from adopting new technologies.
- The high cost of the technology: the gap between the pioneering companies who have adopted the technology and those who are waiting for the technology to be more mainstream and less expensive is widening. Some companies, in particular for additive manufacturing, EDM chemicals, and traditional machining systems, choose to invest together to reduce the risk but these initiatives remain scarce.

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. The final objective of an innovation platform is to ensure technology transfer between the research sector and the industrial sector and to promote collaborative projects.

Yet, despite all the institutions, clusters and platforms present in the region, and the regional and national policies implemented to support companies in their technological transformation, a regional barometer on digital maturity found in 2018 that, on 1,500 companies surveyed, only 44% had a project related to digital transformation. This result mostly concerns the SMEs, as 80% of mid-cap companies declared that they had a project but did not actually know how to implement it and needed support to this regard. Furthermore, despite the existence of many awareness-raising and support mechanisms present in the region regarding digital technologies, only 1,100 SMEs and mid-caps (i.e. around 0.2% of the total regional companies) made use of them in 2017⁴⁹.

With the support of the CETIM, the Industry of the Future Alliance launched the “Index Industry of the Future I2DF©” (Indice Industrie du Futur I2DF©) in July 2019. This index will measure the progress made by industrial mid-cap companies towards the Industry of the Future – at the national level, regional level and sectoral level. It will include 6 competitiveness boosters, 29 themes and 80 technological blocks (Table 2-3).

Table 2-3. 29 themes of the index organised according to the 6 identified competitiveness boosters

⁴⁹ Région Auvergne-Rhône-Alpes (2018) *Digital Summit – press kit* (Digital Summit – dossier de presse)

6 competitiveness boosters	29 themes
IoT and industrial internet	Connected products
	Machine-connecting technologies
	Data exchange infrastructure
Advanced manufacturing technologies	New materials and intelligent materials
	Innovative manufacturing processes
	Environmentally responsible processes
	Advanced robotics and intelligent machines
	Automation, machines and industrial robots
	Intelligent components
	Multi-physical monitoring and capture
	Control command
New approach to people at work, innovative organisation and management	Mobile and social applications
	Quality of Work Life (QWL)
	Physical assistance
	Cognitive assistance
	Change management
Connected, controlled and optimized plants and lines/islands	Virtualization for production system optimization
	Management of industrial operations
	Digital product and process engineering
	Product control
Integrated customer/supplier relationships	Digitalization of the value chain
	Innovation and collaborative production
	Product lifecycle management extended to services
New economic and societal models, Strategy and alliances	Integration into the community, common good
	New business model
	Extended and agile enterprise
	Strategic company
	Intangible capital

Source: *Industry of the Future Alliance*, processed by *Technopolis Group*

This index being a recent initiative, its results ought to be observed and analysed over time to observe technology adoption in the industry in Auvergne-Rhône-Alpes following the implementation of the New Industrial France plan in 2014.

2.2.2 Adopted 4.0 technologies in the sector in the region

In Auvergne-Rhône-Alpes, regional authorities and stakeholders have identified “connected and automated mobility”⁵⁰ 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

⁵⁰ Refers to autonomous / connected vehicles or self-driving cars (vehicles that can guide themselves without human intervention): European Commission (n.d.) Connected and automated mobility in Europe, available at: <https://ec.europa.eu/digital-single-market/en/connected-and-automated-mobility-europe>, last accessed on 02/09/2019

applications⁵¹. During the period 2010-2015, the former region Rhône-Alpes over-performed compared to the European regional average regarding the number of 4.0 application patents in smart technologies per 1,000 inhabitants (see main report, Map A.3.4.). 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 jobs⁵².

The national cluster CARA, headquartered in the region, is a major institutional actor as regards to mobility and is the cornerstone of the regional strategy and policy related to the industrial mutation of the automotive sector. Bringing together more than 200 actors in order to “support developments in urban mobility and in transport systems for passengers and freight, and create vehicles of the future”, it fulfils a two-fold mission.

The first mission is focused on innovation and technological development of connected and automated mobility. The strategy is then to support a small part of the regional actors to develop technological building blocks in relation with mobility. This might be related to digital technologies and in particular to cybersecurity or 5G. In that case, the regional actors can rely on the industrial actors on the digital sector as well as on the cluster MINALOGIC. For instance, at the time being, the region is missing specific technological building blocks related to the autonomous vehicle. In order to ensure the development and the production of these blocks, the Regional council started a mapping exercise together with the competitiveness clusters CARA, INDURA, MINALOGIC, Aerospace Cluster Auvergne-Rhône-Alpes and ViaMéca (now CIMES). Around 100 companies have been identified which can participate in the development of these blocks.

The second mission of the cluster CARA is to network the industrial actors of the automotive and industrial vehicle sectors. The aim is to support industrial actors in adapting to mutations of transportation. The main challenge is related to the modernisation of the processes and tools of tiers.

The Regional council set-up recently a steering committee to propose an action plan in relation to the necessary transformation of the industrial fabric due to the end of the thermic engine. The cluster CARA is coordinating the committee together with the national cluster Mont-Blanc Industries (now CIMES) located in the region. Involving trade associations like UIMM or SNDC (Screw Machining), the first activity is focused on the identification of companies which will eventually be contacted to support them in diversifying their markets and training their staff.

⁵¹ INPI (2019) National Patents - By Domains - Applications Published in 2017 (Brevets voie nationale - Par domaines - Demandes publiées en 2017)

⁵² Auvergne-Rhône-Alpes Entreprises (n.d.) Our excellence areas (Nos filières d'excellence), available at: <https://www.auvergnerhonealpes-entreprises.fr/nos-filieres-dexcellence>, last accessed on 02/09/2019

Auvergne-Rhône-Alpes is an acting member of the “interregional partnership on batteries” which is a project supported by the European Commission since the end of 2018⁵³. This partnership aims to “accelerate the volume manufacture and deployment of advanced materials and battery cells using sustainable and competitive technologies, for mobility and stationary batteries across Europe between now and 2025. To do so, it will generate a pipeline of business investment projects by building upon existing regional assets to leverage complementary assets available across the partnership. It will identify and address key missing elements in the regional ecosystem and the industrial value chain to reach out to the end user. The partnership has the ambition to represent the regional dimension of the European Battery Alliance stakeholders”.

2.2.3 Preconditions for transformation

Regional preconditions

Auvergne-Rhône-Alpes is the second most dynamic region in France regarding research and development: 7 billion euros were spent in 2016, accounting for 14.2% of the national expenditure or 2.7% of the regional GDP. The private sector is particularly active as it contributes up to 69.5% of that amount. 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.

13.6% of the national R&D workforce is located in Auvergne-Rhône-Alpes, i.e. nearly 40,000 full-time equivalents (FTEs). They are mostly located in three departments: Isère, Rhône and Puy-de-Dôme. Between 2007 and 2014, the number of researchers within private companies increased by 33%, while the support staff workforce stagnated. The researchers in the public sector increased by 13%, while the support staff workforce increased by 5%.

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. This public and private dynamism makes it the 4th European region and the 2nd French region⁵⁴ (

Table 2-4).

⁵³ European Commission (2019) Annex to the Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee, the Committee of the Regions, and the European Investment Bank – Building a Strategy Battery Value Chain in Europe

⁵⁴ Chamber of Commerce and Industry Auvergne-Rhône-Alpes (2019) *Key figures (Chiffres clés) Auvergne-Rhône-Alpes*

INSEE Auvergne-Rhône-Alpes (2017) Research and Development – Auvergne-Rhône-Alpes invests for growth (Recherche et Développement – Auvergne-Rhône-Alpes investit pour la croissance)

MESRI – SIES (2018) Research and technology transfer (R&T) budget of local and regional authorities (Budget de recherche et de transfert de technologie (R&T) des collectivités territoriales), available at: https://www.data.gouv.fr/fr/datasets/budget-de-recherche-et-de-transfert-de-technologie-r-t-des-collectivites-territoriales-1/#_, last accessed on 29/08/2019

Table 2-4. Key figures of Auvergne-Rhône-Alpes Innovation and Research

Regional characteristics	National ranking
14 regional and inter-regional competitiveness clusters	France: 56 competitiveness clusters 1st French region
38,652 employees in research and development 2016 (MESRI – SIES, semi-discrete data) – workforce measured in FTEs, researchers and research support staff in the private and public sectors	2nd French region
6,979 million euros: R&D expenditure 2016 (MESRI – SIES, semi-discretionary data) – regional domestic expenditure by administrations and companies	2nd French region
98.3 million euros: local authorities’ budget devoted to research and technology transfer in 2015	2nd French region
2,689 patent applications of regional origin in 2018	2nd French region

Source: Regional Scheme for Higher Education, Research and Innovation

In France, there are 56 national competitiveness clusters (Table 2-5). These clusters bring the public and private sectors together to implement projects that aim at strengthening the local and national economy and at creating jobs, favouring the emergence of the 4.0 Industry. 13 of the competitiveness clusters are located (totally or partially) in Auvergne-Rhône-Alpes and are related to the region’s areas of excellence: the 4.0 Industry, the construction industry, digital, health, agriculture, agri-food and forestry, energy, mobility and smart transport system, and sports, mountain and tourism.

Table 2-5. Competitiveness clusters in Auvergne-Rhône-Alpes region

Competitiveness clusters	Main location	Other regions which are concerned	Activity sectors
Alimentation Bien-être Naturalité (ABEN)	Provence-Alpes-Côte-d’Azur	Auvergne-Rhône-Alpes	Agriculture / Agro-food
Axelera	Auvergne-Rhône-Alpes		Chemistry Environment
CIMES (formerly ViaMeca and Mont-Blanc Industries)	Auvergne-Rhône-Alpes	Centre-Val de Loire	Precision machining Mechatronics Mechanics
Elastopôle	Centre-Val de Loire	Auvergne-Rhône-Alpes, Ile-de-France, Nouvelle Aquitaine, Pays de la Loire	Rubber Materials
Lyonbiopôle	Auvergne-Rhône-Alpes		Health
Minalogic	Auvergne-Rhône-Alpes		Micro and nano electronics
Plastipolis	Auvergne-Rhône-Alpes	Bourgogne-Franche-Comté	Plastics processes
Pôle CARA	Auvergne-Rhône-Alpes		Transportation
SAFE Cluster	Provence-Alpes-Côte-d’Azur	Auvergne-Rhône-Alpes	Aeronautics Space Engineering

Techtera	Auvergne-Rhône-Alpes		Textile
Tenerdis	Auvergne-Rhône-Alpes		Energy transition
Vegepolys Valley	Pays de la Loire	Auvergne-Rhône-Alpes, Centre-Val de Loire, Bretagne	Agriculture / Agro-food Chemicals
Xylofutur	Nouvelle Aquitaine	Auvergne-Rhône-Alpes, Bourgogne-Franche-Comté, Grand Est, Pays de la Loire	Forestry Materials Bioresources

Source: *Regional Scheme for Higher Education, Research and Innovation*

There are five of the eight national public scientific and technological institutions (établissements publics à caractère scientifique et technologique) located in the region: the National Centre for Scientific Research (Centre National de Recherche Scientifique, CNRS), the French Institute of Science and Technology for Transport, Development and Networks (Institut français des sciences et technologies des transports, de l'aménagement et des réseaux, IFSTTAR), the National Institute for Agricultural Research (Institut National de Recherche Agronomique, INRA), the French Institute for Research in Computer Science and Automation (Institut national de recherche en informatique et en automatique, INRIA), the National Institute of Health and Medical Research (Institut national de la santé et de la recherche médicale, INSERM), and the National Research Institute of Science and Technology for Environment and Agriculture (Institut national de recherche en sciences et technologies pour l'environnement et l'agriculture, IRSTEA)⁵⁵.

In terms of higher education, there are 8 universities and 50 Grandes écoles⁵⁶. Three associations or communities of universities and institutions (University of Lyon, Grenoble-Alpes and University Clermont Auvergne) structure these academic institutions. The universities of Lyon and Grenoble are certified "Excellence Initiative" (IDEX) by the State, which highlights their scientific and educational excellence and supports their international reach. The institutions that have been certified are bound to attract the best assets from all around the world, to accelerate technology transfer and to strengthen the partnerships between universities, Grandes écoles and research institutions.

The region is also home to two Technology Research Institutes: NanoElec in Grenoble that is specialised in nanoelectronics, and Bioaster, in Lyon and Paris, dedicated to microbiology and infectiology. These research institutions bring together higher education and research institutions, major companies and SMEs around a joint technological research programme.

Besides, Auvergne-Rhône-Alpes has many institutions that directly support industrial sectors, beginning with the regional Technical Centre of the Mechanical Industries (Centre Technique des Industries

⁵⁵ INSEE Auvergne-Rhône-Alpes (2017) *Research and Development – Auvergne-Rhône-Alpes invests for growth (Recherche et Développement – Auvergne-Rhône-Alpes investit pour la croissance)*

⁵⁶ The Grandes écoles in France are extremely selective higher education establishments which admit students on the basis of competitive exams.

Mécaniques, CETIM). Its competences cover technological innovations such as virtual reality, additive manufacturing, cobotics, artificial intelligence, big data and connected objects. The CETIM acts as a mediator between the Chambers of Commerce and Industry (Chambre de Commerce et d'Industrie, CCI), the competitiveness clusters, and the Union of Metallurgies Industries (Union des Industries et Métiers de la Métallurgie, UIMM) that all work collaboratively to support the regional industrial fabric. The CETIM also disseminates information on new technologies: it supports companies in training employees to new skills and in testing new technologies.

The UIMM is a trade association that gathers regional industrial company heads to represent them in institutions, advise them, inform them on regional affairs but also legal, environmental and security-related news, support them in their recruitment and skill upgrading processes, and financially support them in their projects. The Auvergne-Rhône-Alpes UIMM specifically focuses on the digital revolution of the industry, and targets numerous sectors: aeronautics, aerospace, automobile, electrics, electronics, digital, mechanics, materials, tools, metalworking, rail, robotics, health, and cutlery.

Sectoral preconditions

Auvergne-Rhône-Alpes is a major industrial region with a diversified portfolio of activities, largely oriented towards exports. The regional industry has many strong points in its high-tech activities: machines and other solutions for the industry of the future, digital, electronic components, energy, pharmaceuticals and medical technologies, bar turning, plastics, eco-technologies...

In terms of industries and relation to Industry 4.0, the region is noteworthy for its **manufacturing industries which generate 18% of the regional added value** (national average is 14%) and the region weights 15.8% of the national employment in the manufacturing industries. Manufacture of basic metals and fabricated metal products, except machinery and equipment encompasses 16.4% of the regional employment, followed by manufacture of food products, beverages and tobacco products (12.2%) and manufacture of rubber and plastics products, and other non-metallic mineral products (11.3%). Those three sectors that represent 40% of the employment all belong to medium-low-technology industries or low-technology industries. On the other hand, high-tech sectors like manufacture of computer, electronic and optical products and manufacture of pharmaceuticals, medicinal chemical and botanical products represent respectively 5.0% and 3.6% of regional employment⁵⁷.

In the former Region Auvergne, several initiatives were launched to support not only technological innovation but also innovation by usage, i.e. innovation services or innovation in business models. Some specifically focus on the smart transport system and mobility sectors. For instance, at the level of research, the University of Clermont-Ferrand was awarded dedicated national funding for conducting high-level research on mobility within the research centre called "LabEx IMobS3". The ambition is to create "an international reference centre for the mobility of people, goods and machines through the

⁵⁷ Chamber of Commerce and Industry Auvergne-Rhône-Alpes (2019) *Key figures (Chiffres clés) Auvergne-Rhône-Alpes*

development of efficient and environmentally aware technological bricks and treating technological, organizational, environmental and societal mobility aspects”⁵⁸.

The Auvergne-Rhône-Alpes region hosts a lab dedicated to urban mobility: Transpolis. It is defined as “a hub to design, test and showcase new technologies through systemic innovation and international partnerships at the crossroads of strategic activities: vehicles, energy, infrastructure and building, communication (IT, networks, IoT), e-commerce & delivery services”. 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 place⁵⁹.

Social preconditions

In Auvergne-Rhône-Alpes, there are 343,000 students in 2018, which represents 12,8% of the national student population, and 10,200 PhD candidates⁶⁰. The university of Lyon has about 140,000 students and 5,400 PhD candidates, that of Grenoble 46,000 students, that of Saint-Etienne 20,000 students and 360 PhD candidates, that of Clermont-Ferrand 34,000 students and 858 PhD candidates, and that of Savoie-Mont-Blanc 14,510 students and 303 PhD candidates⁶¹. Around 83% of the student population receive a public education: 60% of the total student population go to the university, 9% to higher technical sections, 2% to Grandes écoles, 4% to engineering schools, 3% to preparatory classes for higher education and 2% in private university institutions. The remaining go to specialised institutions (business, administration, art and culture, paramedical care, etc.)⁶².

In association with the university of Lyon, the Auvergne-Rhône-Alpes region, the district of Lyon, the district of Saint-Étienne and IDEXLYON, the Student Pole for Innovation, Transfer and Entrepreneurship BEELYS (Boosting the Entrepreneurial Spirit Lyon Saint-Etienne) assists the students and researchers

⁵⁸ IMOBS³ (n.d.) IMOBS3 LABEX PRESENTATION, available at: <http://www.imobs3.uca.fr/index.php/en/labex/presentation>, last accessed on 02/09/2019

⁵⁹ Transpolis (n.d.) Urban mobility laboratory (Laboratoire de mobilité urbaine), available at: <http://www.transpolis.fr/n/prestations/Ville-Laboratoire/r81.html>, last accessed on 02/09/2019

⁶⁰ MESRI – SIES (2019) *Enrolment in higher education (Effectifs dans l'enseignement supérieur) 2018-2019*

⁶¹ Lyon University (n.d.) Key figures of the Lyon University (L'université de Lyon en quelques chiffres), available at: <https://www.universite-lyon.fr/l-universite-de-lyon/>, last accessed on 29/08/2019

Grenoble Alpes University (n.d.) Key figures (Chiffres clés), available at: <https://www.univ-grenoble-alpes.fr/l-universite/decouvrir-l-uga/chiffres-cles/>, last accessed on 29/08/2019

Saint-Etienne University (n.d.) The Jean Monnet University (L'université Jean Monnet), available at: <https://www.univ-st-etienne.fr/fr/universite/presentation-et-chiffres-cles.html>, last accessed on 29/08/2019

Clermont Auvergne University (n.d.) Our strengths, key figures (Nos atouts, chiffres clés), available at: <https://www.uca.fr/universite/nous-connaître/nos-atouts-chiffres-cles/>, last accessed on 29/08/2019

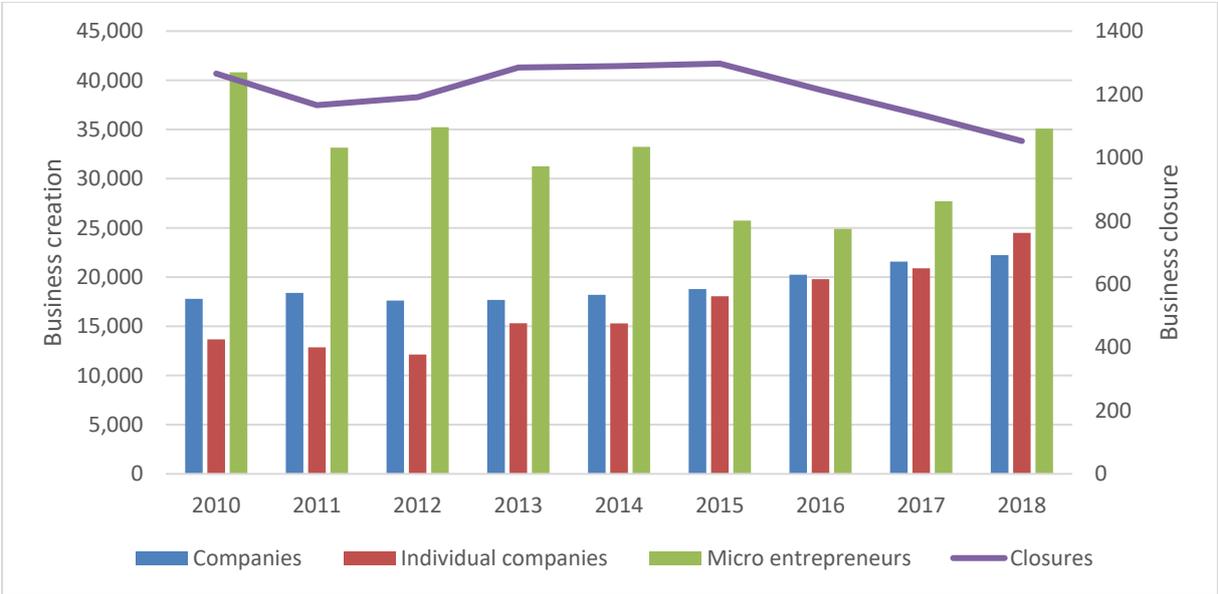
Savoie-Mont-Blanc University (n.d.) History and context (Histoire et contexte), available at: <https://www.univ-smb.fr/universite/decouvrir-lusmb/son-histoire/>, last accessed on 29/08/2019

⁶² MESRI (n.d.) Number of students enrolled by subject - 2015-2016 (Effectif d'étudiants inscrits par filière - 2015-2016), available at: https://publication.enseignementsup-recherche.gouv.fr/atlas/atlas-REGION-R84-total-total-2015-les_etudiants_inscrit_dans_l_enseignement_superieur_region_auvergne_rhone_alpes_en_2015_2016.php, last accessed on 30/08/2019

who are interested by innovation and entrepreneurship. The university of Lyon also supports its researchers in valorising their research and in transferring the results to the socio-economical world by associating itself to the technology transfer acceleration company Pulsalys (Société d'Accélération de Transfert de Technologie, SATT), a public institution in charge of valorising public research and promoting technology transfer that benefits from 57 million euros for 10 years. The National Centre for Scientific Research and the Deposits and Consignments Fund (Caisse des Dépôts et Consignations, CDC) also take part to this initiative.

The Auvergne-Rhône-Alpes region is quite dynamic regarding business creation: in 2018, more than 81,800 new businesses were registered – a number never reached since 2000 and representing a 17-percent increase compared to 2017. 43% of them are micro entrepreneurs, 30% are individual companies and 27% companies (Figure 2-7).

Figure 2-7. Evolution of business creation in Auvergne-Rhône-Alpes



Source: INSEE, processing by Technopolis Group

Industry accounts for only 4% of all applications for registration. After a decline in 2017, registrations are on the rise again, rising by 15% in 2018.

In terms of business failures, nearly 6,200 were recorded in Auvergne-Rhône-Alpes in 2018, 5.3% less than in 2017. All in all, the number of company closures in the region has been declining for five years. With the exception of business services (18% of regional failures), which are stable, all other sectors are facing less closures. The industry is characterized by a sharp 11-percent decrease. Failures in the

trade, transportation, accommodation and food services sector, which accounts for nearly 40% of all business terminations, fell by -6.3%⁶³.

A regional barometer on digital maturity produced by the regional Chamber of Commerce and Industry found in 2018 that more than 95% of the 1,500 surveyed companies are connected to internet – it is mostly an ADSL or low speed internet, as only 15% of the companies are connected to high speed internet; with strong differences according to the territories and the sectors. Besides, 25% of the companies connected to internet consider switching to the fibre connection within a year⁶⁴.

With nearly 65,000 jobs, digital technology is a central to the regional economy. With 8,150 jobs created between 2013 and 2017 by companies in the digital industry, Auvergne-Rhône-Alpes is consolidating its leading position, behind Ile-de-France. This sector has become increasingly important in the region, as it 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). Moreover, this job creation occurred in all the regional metropolitan areas and urban conglomerations, although more important in the Valence Romans district and district of Lyon.

In a study published by EY and Digital League in 2018, the 173 digital businesses surveyed indicated that the main obstacle to their development was the difficulty to recruit. This is a growing concern, as the number of respondents choosing this obstacle increased between 2016 and 2017. Companies look for almost all digital jobs (web development, sales, telecoms, project management, etc.) but mostly for object programming and developing profiles. Two other obstacles mentioned are the national and regional competition and the weight of the taxes.

Between 2013 and 2017, foreign direct investments in Auvergne-Rhône-Alpes mainly focused on industrial machinery, chemicals and plastic, and digital technology. The region has ranked as the 20th most attractive European region for foreign direct investments in digital technology between 2013 and 2017. As such, Auvergne-Rhône-Alpes is the only French region, with Ile-de-France, to be in the top 25. To boost the regional economic competitiveness, Auvergne-Rhône-Alpes can rely on the initiatives developed within the “Four Drivers for Europe” agreement set up 28 years ago with the regions of Lombardy, Catalonia and Baden-Württemberg to strengthen their economic, scientific and technological competitiveness. In September 2017, this coalition organised an economic mission to Denmark and

⁶³ INSEE (2019) Economic review 2018 - Auvergne-Rhône-Alpes (Bilan économique 2018 - Auvergne-Rhône-Alpes), available at: <https://www.insee.fr/fr/statistiques/4134402?sommaire=4137843#graphique-figure5>, last accessed on 30/08/2019

⁶⁴ Région Auvergne-Rhône-Alpes (2018) *Digital Summit – press kit* (Digital Summit – dossier de presse)

Sweden around life sciences and Clean Tech. This sharing of know-how and best practices has enabled the region to reflect on new economic and technological projects around the digital industry⁶⁵.

Policy preconditions

A major reform of the territorial organisation (Act N° 2015-991 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 Économique, 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.

The region is in the top 10 European regions for research and innovation. Now, the region's ambition is to establish itself at the international level. To do so, it drafted a new **Regional Scheme for Higher Education, Research and Innovation 2017-2021** (Schéma Régional Enseignement Supérieur, Recherche Innovation SRESRI) with seven priorities:

- Proximity and spatial planning: strengthen the 15 regional university campuses;
- Economy and employment: bring research and business closer together;
- Training and skills: support industries that recruit, double the number of traineeships;
- Students: improve student life;
- Excellence: enhance the regional academic excellence;
- International: encourage students to go abroad;
- Research and innovation: become the researchers' 1st partner.

In 2017, the region published its **Strategic roadmap on the digital sector 2017-2021** (Feuille de route stratégique Numérique) to become the European Silicon Valley and push forward digital transformation. This project has three specific ambitions:

- A fully connected region;
- A region that creates jobs;

⁶⁵ EY France, Digital League (2018) *Accelerate, always – Digital industry observatory in Auvergne-Rhône-Alpes – 3rd edition, November 2018* (Accélérer, encore – Observatoire de l'industrie Numérique en Auvergne-Rhône-Alpes – 3^{ème} édition, Novembre 2018)

- A region that creates services.

To reach these objectives, the region has allocated a total budget of EUR 650 million around four actionable levers:

- Deploying fixed and mobile infrastructures;
- Supporting the digital transition of companies in all sectors through awareness raising and financing, the acceleration of research and innovation, the implementation of an ambitious Industry of the Future plan, and the internationalisation of the region;
- Developing digital citizenship and trust;
- Federating all the actors in the region: the support ecosystem (competitiveness clusters, agencies, etc.), the Department councils, the EU, companies, citizens and local governments.

In 2013, the **Smart Specialisation Strategy** (RIS3) identified eight strategic areas, including two that have a link with the Industry 4.0 (in italics):

- Personalised healthcare for infectious and chronic diseases. This involves diagnosis, therapy, vaccine, medical technologies, health, nutrition and some target diseases (infectious diseases, cancers, other chronic diseases and ageing).
- Smart and energy-efficient buildings . This covers the active management of buildings, innovative materials and integrated photovoltaic solar energy.
- *Industrial processes and eco-efficient factory*. This covers the sectors of chemicals and the environment: low-carbon and eco-efficient processes, metrology and environmental instrumentation, recycling and waste management and bio-based chemistry.
- Smart mobility systems. This covers smart transport systems, the vehicle of the future, modelling and uses.
- *Digital technologies and user-friendly systems*. This involves advanced production and industrial robotics, service robotics and ambient intelligence, the treatment of complex data and cybersecurity, and digital culture and education.
- Sports, tourism and mountain infrastructure. This encompasses sport articles and equipment, accessibility and infrastructure, security and management of natural risks, and an integrated offer of services linked to experiential tourism.
- Networks and energy storage. This involves multi-scale smart networks (micro grids, smart grids and super grids) and multi-energy storage.

During the drafting of the S3, the regional authorities put a strong emphasis on the Key Enabling Technologies and identified those with outstanding regional assets:

- White and red biotechnologies for which the regional actors weight 2.1% of European patenting. The main players are bioMérieux, CNRS, CEA, UCLB, UJF, IFP EN.
- Microelectronics & photonics with CEA, STMicroelectronics, Soitec, CNRS, Alcatel, E2V, Teem Photonics, Atmel.
- Advanced processes with Somfy, CEA, SNR Roulements, STMicroelectronics, Thales, CNRS.
- Advanced materials with Rhodia, CEA, Bluestar silicones. CNRS, Coatex, Saint Gobain.

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-Rhône-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-Rhône-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 SMLs, 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 Numérique Régionale, 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 investments⁶⁶.

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 2013⁶⁷ that, among others, has the objective to "robotise the automotive sector to restore the competitiveness of the sector"⁶⁸. 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.

2.2.4 Actual transformation in the region

Economic transformation

Two national clusters located in the region and dedicated to the production and transfer of technologies for the manufacturing industries have decided to merge: Mont-Blanc Industries and ViaMéca become CIMES (Creating Integrated Mechanical Systems). ViaMéca was engaged in projects dealing with Surface Engineering, Advanced Manufacturing Processes, Intelligent Systems and Robotics and Engineering driven by Uses and Services. Mont-Blanc Industries supported projects in the fields of precision machining (advanced manufacturing processes and autonomous production cells) and

⁶⁶ Le Progrès (2018) Bpifrance and the Auvergne Rhône-Alpes Region create the 1st regional French Fab (Bpifrance et la Région Auvergne Rhône-Alpes crée la 1ere French Fab régionale), available at: <https://www.leprogres.fr/economie/2018/03/20/bpifrance-et-la-region-auvergne-rhone-alpes-cree-la-1ere-french-fab-regionale>, last accessed on 03/09/2019

⁶⁷ Opinions Libres (2019) 2019 Startup guide (Guide des Startups 2019), available at: <https://www.oezratty.net/wordpress/2019/guide-des-startups-2019/>, last accessed on 30/08/2019

⁶⁸ MESRI – Ministry of Productive Recovery (2013) *France Robot Initiatives*

mechatronics (B to B sub-assemblies, B to C products, and industrial robotics). CIMES is now bound to rise to the challenges represented by the digital, environmental and international evolutions faced by the mechanical sector⁶⁹.

In the Auvergne-Rhône-Alpes region, the robotization and the 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 others consider integrating IoT and additive manufacturing, especially for start-ups. Yet, additive manufacturing is a scarce skill in the region: the CETIM provides a specific training 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. The issue is the same with robotics, for which skills are lacking in the region – within the CETIM as well, which can be problematic when wanting to keep up with the latest innovations and provide relevant and accurate trainings. The UIMM have recently created trainings on advance production line pilots, but the issue remains the same as for the schools. Thus, companies currently recruit skilled foreigners to fill the positions.

Besides the lack of skills, the local companies face other difficulties when considering implementing technological upgrading in their practices such as:

- The technological gap: for the more traditional companies, completely reimagining their practices is a tough exercise that refrains them from adopting new technologies.
- The high cost of the technology: the gap between the pioneering companies who have adopted the technology and those who are waiting for the technology to be more mainstream and less expensive is widening. Some companies, in particular for additive manufacturing, EDM chemicals, and traditional machining systems, choose to invest together to reduce the risk but these initiatives remain scarce.

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. The final objective of an innovation platform is to ensure technology transfer between the research sector and the industrial sector and to promote collaborative projects.

Yet, despite all the institutions, clusters and platforms present in the region, and the regional and national policies implemented to support companies in their technological transformation, a regional barometer on digital maturity found in 2018 that, on 1,500 companies surveyed, only 44% had a project related to digital transformation. This result mostly concerns the SMEs, as 80% of mid-cap companies declared

⁶⁹ Mont-Blanc Industries, ViaMéca (2019) Labelling of the new competitiveness cluster on mechanics: CIMES (Labellisation du nouveau pôle de compétitivité de la mécanique : CIMES) available at: <https://www.montblancindustries.com/wp-content/uploads/Communiqu%C3%A9-de-Presse-labellisation-pole-de-comp%C3%A9titiv%C3%A9-CIMES.pdf>, last accessed the 02/09/2019

that they had a project but did not actually know how to implement it and needed support to this regard. Furthermore, despite the existence of many awareness-raising and support mechanisms present in the region regarding digital technologies, only 1,100 SMEs and mid-caps (i.e. around 0.2% of the total regional companies) made use of them in 2017⁷⁰.

In Auvergne-Rhône-Alpes, regional authorities and stakeholders have identified “connected and automated mobility”⁷¹ 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 applications⁷². 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 jobs⁷³.

The national cluster CARA, headquartered in the region, is a major institutional actor as regards to mobility and is the cornerstone of the regional strategy and policy related to the industrial mutation of the automotive sector. Bringing together more than 200 actors in order to “support developments in urban mobility and in transport systems for passengers and freight, and create vehicles of the future”, it fulfils a two-fold mission.

The first mission is focused on innovation and technological development of connected and automated mobility. The strategy is then to support a small part of the regional actors to develop technological building blocks in relation with mobility. This might be related to digital technologies and in particular to cybersecurity or 5G. In that case, the regional actors can rely on the industrial actors on the digital sector as well as on the cluster MINALOGIC. For instance, at the time being, the region is missing specific technological building blocks related to the autonomous vehicle. In order to ensure the development and the production of these blocks, the Regional council started a mapping exercise together with the competitiveness clusters CARA, INDURA, MINALOGIC, Aerospace Cluster Auvergne-Rhône-Alpes and ViaMéca (now CIMES). Around 100 companies have been identified which can participate in the development of these blocks.

The second mission of the cluster CARA is to network the industrial actors of the automotive and industrial vehicle sectors. The aim is to support industrial actors in adapting to mutations of transportation. The main challenge is related to the modernisation of the processes and tools of tiers.

⁷⁰ Région Auvergne-Rhône-Alpes (2018) *Digital Summit – press kit* (Digital Summit – dossier de presse)

⁷¹ Refers to autonomous / connected vehicles or self-driving cars (vehicles that can guide themselves without human intervention): European Commission (n.d.) Connected and automated mobility in Europe, available at: <https://ec.europa.eu/digital-single-market/en/connected-and-automated-mobility-europe>, last accessed on 02/09/2019

⁷² INPI (2019) National Patents - By Domains - Applications Published in 2017 (Brevets voie nationale - Par domaines - Demandes publiées en 2017)

⁷³ Auvergne-Rhône-Alpes Entreprises (n.d.) Our excellence areas (Nos filières d'excellence), available at: <https://www.auvergnerhonealpes-entreprises.fr/nos-filieres-dexcellence>, last accessed on 02/09/2019

The Regional council set-up recently a steering committee to propose an action plan in relation to the necessary transformation of the industrial fabric due to the end of the thermic engine. The cluster CARA is coordinating the committee together with the national cluster Mont-Blanc Industries (now CIMES) located in the region. Involving trade associations like UIMM or SNDC (Screw Machining), the first activity is focused on the identification of companies which will eventually be contacted to support them in diversifying their markets and training their staff.

Auvergne-Rhône-Alpes is an acting member of the “interregional partnership on batteries” which is a project supported by the European Commission since the end of 2018⁷⁴. This partnership aims to “accelerate the volume manufacture and deployment of advanced materials and battery cells using sustainable and competitive technologies, for mobility and stationary batteries across Europe between now and 2025. To do so, it will generate a pipeline of business investment projects by building upon existing regional assets to leverage complementary assets available across the partnership. It will identify and address key missing elements in the regional ecosystem and the industrial value chain to reach out to the end user. The partnership has the ambition to represent the regional dimension of the European Battery Alliance stakeholders”.

With the support of the CETIM, the Industry of the Future Alliance launched the “Index Industry of the Future I2DF©” (Indice Industrie du Futur I2DF©) in July 2019. This index will measure the progress made by industrial mid-cap companies towards the Industry of the Future – at the national level, regional level and sectoral level. It will include 6 competitiveness boosters, 29 themes and 80 technological blocks (Table 2-6).

Table 2-6. 29 themes of the index organised according to the 6 identified competitiveness boosters

6 competitiveness boosters	29 themes
IoT and industrial internet	Connected products
	Machine-connecting technologies
	Data exchange infrastructure
Advanced manufacturing technologies	New materials and intelligent materials
	Innovative manufacturing processes
	Environmentally responsible processes
	Advanced robotics and intelligent machines
	Automation, machines and industrial robots
	Intelligent components
	Multi-physical monitoring and capture
	Control command
New approach to people at work, innovative organisation and management	Mobile and social applications
	Quality of Work Life (QWL)
	Physical assistance

⁷⁴ European Commission (2019) Annex to the Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee, the Committee of the Regions, and the European Investment Bank – Building a Strategy Battery Value Chain in Europe

	Cognitive assistance
	Change management
Connected, controlled and optimized plants and lines/islands	Virtualization for production system optimization
	Management of industrial operations
	Digital product and process engineering
	Product control
Integrated customer/supplier relationships	Digitalization of the value chain
	Innovation and collaborative production
	Product lifecycle management extended to services
New economic and societal models, Strategy and alliances	Integration into the community, common good
	New business model
	Extended and agile enterprise
	Strategic company
	Intangible capital

Source: *Industry of the Future Alliance*, processed by *Technopolis Group*

This index being a recent initiative, its results ought to be observed and analysed over time to observe technology adoption in the industry in Auvergne-Rhône-Alpes following the implementation of the New Industrial France plan in 2014.

Social transformation

Lack of competence is the key issue and has been put forward by all interviewees. The industrial fabric in Auvergne-Rhône-Alpes, and more generally in France, is made of large companies (historically supported by the State by one way or another), plenty of small SMEs and very few intermediate-sized enterprises. While the formers 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.

As a matter of fact, adoption of technologies 4.0 can only but rely on two elements. The first is to change mentalities within the population of executive directors of small companies. The second is to train people (either initial training or life-long learning). Auvergne-Rhône-Alpes witnesses several initiatives in that respect. To name but one, the Region launched in 2017 the Campus Region of Digital (Campus Région du Numérique) in order to train people of jobs related to digital. However, the number of students who will benefit from the training is too low to expect any positive impact on the regional economy after two years of creation. On training too, the regional actors share a common diagnosis on what needs to be done and on initiatives to launch but policy actions are still limited.

More globally on the region itself, Lyon has ranked itself as the first big French metropolitan area (except for the Great Paris) according to its attractiveness and dynamism, before Toulouse and Bordeaux, in a 2018

study. Grenoble was also in the top 3, at the third place, and Valence was ranked first as a city⁷⁵. Lyon has also been qualified as the smartest city in France by a study published in 2015, and the 10th at the European level by the European Parliament in 2015, which opens up the prospects for companies of the sectors related, may they be industrial, digital or tertiary.

This shows that the region is very attractive, for companies as well as for people looking to live in Auvergne-Rhône-Alpes: with the mountains and the Mediterranean Sea close by, the Rhône and the Loire crossing the region, the region offers a very high quality of life.

The analysis at the European level (see the Final report) shows that during the period 2013-2018, the former region Rhône-Alpes had a high displacement of high-skill jobs when Auvergne had a moderate displacement (Map A.9.1.). As regards low-skill jobs, Rhône-Alpes had a low displacement and Auvergne a moderate displacement (Map A.9.2.).

2.2.5 Actual and/or expected impact

The Industry of the Future, the national programme of industrial excellence was launched in 2015, and the Regional Scheme for Higher Education, Research and Innovation and the Regional Scheme for Economic Development, Innovation and Internationalisation (SRDEII) were adopted in 2014 and 2016 respectively. We therefore have little distance from the impact of these public policies.

In the sector of the region

Considering the willingness to accompany the top-level industrial actors of the automotive and industrial vehicle sectors, it is possible to expect important impacts in the future. One already mentioned is the interregional partnership on batteries that involves the Region. The regional actors are more precisely involved on the following technologies: Improved lithium-ion batteries and innovative cell manufacturing for generation 4. This initiative illustrates the know-how and the local competences and skills of the regional actors. In this regard, the Regional council is targeting an increase of its support.

However, it is not intended that all industrial actors become leaders on the autonomous and clean vehicle. The Region will carry on supporting the traditional actors and the supply chain to adopt new technologies to resist and adapt to competition, may it be local, national or international. The scheduled end of the thermic engine is both a threat and an opportunity for the actors. With a strong research base and forward-looking Regional authorities, Auvergne-Rhône-Alpes is on the right way towards an evolution of the local industry through technological transformation.

⁷⁵ Arthur Loyd (2018) Arthur Loyd publishes the 2nd edition of the barometer of the attractiveness and dynamism of French metropolitan areas (Arthur Loyd publie la 2^{ème} édition du baromètre d'attractivité et de dynamisme des métropoles françaises), available at: <https://www.arthur-loyd.com/media/livreblanc/1-100/43/baromegravetre-2018-arthur-loyd.pdf>, last accessed on 04/09/2019

In other sectors in the region

Between 2010 and 2016, salaried employment in Auvergne-Rhône-Alpes in the manufacturing, mining and other industries sectors has remained stable, except in 2017 where it dropped by 25%. It increased again in 2018 by 34% to finally reach 486,920 salaried employees in the first quarter of 2019.

In each first quarter since 2010 to 2019, a constant decrease can be observed despite the strong regional ecosystem to support the industry in Auvergne-Rhône-Alpes. Several elements account for this decline:

- The increase in productivity: the automation in the manufacturing industry has led to a yearly 3% increase of productivity in the industry since 1999, three times the productivity gains made by the market services;
- The decrease of production volume: the volume of industrial production has fallen by 10% since 2009, after having been almost stable between 1999 and 2009. This decrease is partly due to the international competition and its impact on regional competitiveness. As a consequence, some companies relocated to more competitive localisations. Another consequence of the international competition is the specialisation of the companies on niche sectors, their restructuring, their concentration or even their closure. Thus, the impact of the international competition is difficult to quantify, in France and in the Auvergne-Rhône-Alpes region;
- The increase of import: although Auvergne-Rhône-Alpes was and remains a very dynamic region regarding export, and export in France has increased by 25% between 1999 and 2008, this growth has slowed down between 2008 and 2013, while import has increased by 45% between 1999 and 2008, and a further 15% between 2008 and 2013;
- The outsourcing of some activities: in the region, between 2008 and 2013, there has been a strong increase in employment in tertiary sectors such as engineering and technical studies, technical analyses, tests and inspections, biotechnology research and development, specialized design activities, legal or accounting activities, office services such as human resources management, bill collection agency activities, warehousing and storage, and packaging activities. There were 15,500 jobs created over this period in these sectors, some of which are industrial outsourcing.

In most sectors, employment is declining at a slightly lower rate than the national average. This is particularly the case for the agri-food, chemical, pharmaceutical, electrical and electronic industries, which are well represented in Auvergne-Rhône-Alpes. This is less the case for metalworking and the clothing and textile industry. 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 equipment⁷⁶.

As shown on Figure 2-8, the number of salaried employees in the region improves from 2018 onward. All industrial sectors are concerned by this improvement – manufacturing of transport equipment, the agri-food industry and the energy and waste management industry⁷⁷. In 2019, the industry employs nearly 20% of the total salaried employees in Auvergne-Rhône-Alpes⁷⁸. (Figure 2-8)

Figure 2-8. Salaried employment in Auvergne-Rhône-Alpes - Manufacturing, mining and other industries



Source: INSEE – semi-discretionary data

According to a study led by the regional representation of the Bank of France (Banque de France) in December 2018, the growth recorded in 2018 by 4,500 companies surveyed in Auvergne-Rhône-Alpes is satisfactory. Most of the sectors surveyed benefited from an improving business flow and improved operating margins, and employment has increased despite recurrent tensions due to a lack of available labour. Industrial investments are on hold after the catching-up period in 2017. While some sectors such as food processing, pharmaceuticals and chemicals are doing well in the beginning of 2019, the rubber-

⁷⁶ INSEE, S. Perrin, A. Gilbert (2017) Industry: changes in jobs and territories (Industrie : mutation des emplois et des territoires), available at: <https://www.insee.fr/fr/statistiques/2656175>, last accessed on 04/09/2019

⁷⁷ Pôle Emploi (2019), Industry in Auvergne-Rhône-Alpes (L'industrie en Auvergne-Rhône-Alpes), available at: <https://www.pole-emploi.fr/region/auvergne-rhone-alpes/informations/l-industrie-en-auvergne-rhone-alpes-@/region/auvergne-rhone-alpes/article.jspz?id=658390>, last accessed on 04/09/2019

INSEE, A. Robert, S. Brouillet (2018) Slight slowdown in the regional economy early 2018 (Léger ralentissement de l'économie régionale début 2018), available at: <https://www.insee.fr/fr/statistiques/3589069>, last accessed on 04/09/2019

⁷⁸ Banque de France (2019), The economic situation in Auvergne-Rhône-Alpes (La conjoncture en Auvergne-Rhône-Alpes)

plastic, textile and metalworking segments have been impacted by the contraction in domestic and foreign orders.

Regarding the manufacturing of transport equipment sector, the production has slightly increased in July 2019 but not enough to compensate the decline observed in the previous months⁷⁹.

In this context, the 4.0 technologies seem to still have a long way to go before significantly impacting the industrial performance in Auvergne-Rhône-Alpes, that is still struggling to compete globally.

In the region

It is difficult to assess impact on the regional economy, but 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 diagnosis of the Regional authorities and the interviewees seem to confirm that the process of adoption is still beginning for the SMEs. 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.

Expenses regarding research and development keep increasing. Between 2007 and 2014, the total expense increased by 26%, especially in the public sector that has raise the number of researchers by 24%. In 2014, EUR 6.6 billion were dedicated to research and development, representing 2,7% of the regional GDP – which gets Auvergne-Rhône-Alpes closer to the 3% target set by the European Union for 2020. Two thirds of that expense are made by private companies, that invest to improve the efficiency of their production, its quality or to create new goods and services. In 2014, companies in Auvergne-Rhône-Alpes spent EUR 4.5 billion on research and development, amounting to 14.5% of the national expenses. The main sectors that carry on these activities are manufacture of components, electronic boards and computers, manufacture of plastic and rubber products and manufacture of electrical equipment, but also pharmaceuticals⁸⁰.

Regarding research and development specifically targeting technological transformation, Michelin has grouped together technologies dedicated to innovation in a research and development centre north of

⁷⁹ Auvergne-Rhône-Alpes Entreprises (2019) Economic situation note – Allier Department (Note de conjoncture économique – Département de l'Allier)

Banque de France (2019) The economic situation in Auvergne-Rhône-Alpes (La conjoncture en Auvergne-Rhône-Alpes)

⁸⁰ INSEE, T. Geay, S. Depil (2017) Research and development: expenditure close to the 3% of GDP target (Recherche et développement : une dépense proche de l'objectif de 3 % du PIB), available at: <https://www.insee.fr/fr/statistiques/3125365>, last accessed on 04/09/2019

Clermont-Ferrand in 2016. Michelin is actually the 5th most important investor in research and development in France, making it an important regional player when it comes to innovation.

2.2.6 Operational policy recommendations

The following operational recommendations for national/regional policy based on the result of research including opinions of interviewees could be formulated:

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.
 - Several actors are in close relation with companies to support them in adopting new technologies. To fight against the low willingness of companies to do so, accompanying measures are needed to communicate towards companies and incite them to enter into a change process. There are already several actors which carry out this work already, but a stronger effort is needed to meet companies, follow them up and convince them to develop a strategy in favour of the adoption of new technologies. This would require additional human resources to become effective.
- To stop the industry bashing and to speak positively about the industry, and to show that industrial companies recruit, create and innovate
 - A communication strategy is needed at different level: national, regional and local in order to deliver a positive image of what industry is and what jobs it requires.

For the society (i.e. citizens)

- Anticipating the skills required to deploy technological transformations is an essential social factor for 4.0 technologies. It corresponds either to the development of the necessary training on the territory or to the ability to recruit the required skills within companies.
 - With relation to digital, initial learning insufficiently matches companies' needs. Several initiatives have been designed to reduce the gap, but these are focused on specific geographical areas as well as on specific needs. A dedicated exercise to identify the competences needed now and in the future at the level of the region. Once this done, actors involved in vocational education and training might be able to define training sessions/programmes that would fit companies' needs.
- Support the development of new uses (mobile, e-commerce, media, etc.) among the population.
 - Specific measures implemented at regional or local level could be useful to incite very specific types of population to develop new uses. For instance, measures could be supported by the ERDF targeting the development at regional level of e-health services. Few projects were designed in the past but were insufficiently designed as

experimentation with a view to operationalise them at a larger scale once the proof-of-concept demonstrated.

For the public sector (i.e. local and regional governments)

- Reinforce awareness raising work on digital change and related impacts
- Put in place policies to support companies in integrating these changes.
 - Policies implemented at national and regional level too often put the emphasis on the “usual suspects”, i.e. companies that are already forging ahead when the most important needs come from companies falling behind. A stronger focus should be put on these actors which are most often tiers of OEMs from different sectors.

3 Poland

3.1 Warsaw capital city region

3.1.1 Regional baseline

The relative position of the region in the national economy

The Warsaw capital city region (statistical NUTS2 region) occupies an area of 6,100 km² and has a population of ca. 3.0 million inhabitants, of whom 1.7 million live in the city of Warsaw (56%). 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 in 2016. Metropolitan functions play a key role in the city's economy and thus in the whole region, which is associated, among others, with the headquarters of the largest companies and advanced producer services being located in the city. This is largely due to the influx of foreign capital, as evidenced e.g. by the presence of 30 companies from the Fortune Global 500 ranking, which operate shared services centres here, and of services centres of 9 out of 50 world's largest banks (**ABSL 2019**). In effect, this led to a rapid growth of modern office space, which made Warsaw a city with the largest concentration of office space in Central and Eastern Europe (over 5 million sq m), excluding Moscow. The relatively low costs of labour, coupled with highly skilled workforce, make Warsaw competitive in relation to Western European metropolises, which is in turn translated into the city's prominent places in the rankings of business-friendly metropolitan centres in Europe.

The capital city region constitutes a part of the Mazowieckie Voivodship, an administrative unit having a dual, self-governing and governmental nature, which occupies an area of 35,500 km² and has a population of 5.4 million. The remaining part of the voivodship is considerably less developed than the Warsaw metropolis: the GDP per capita of the region's other part accounts for merely 85.3% of the national average. This is a consequence of wide structural disparities between the metropolis and the region, manifested in the labour market structure, technological advancement of industry, demographic structure and migration (**Smętkowski et al. 2011**). It should be noted that a considerable portion of the data presented in the report shows the situation in the whole of the voivodship since there are no statistics for the capital city region itself – it was not separated for the purposes statistical classification at NUTS2 level until 2017.

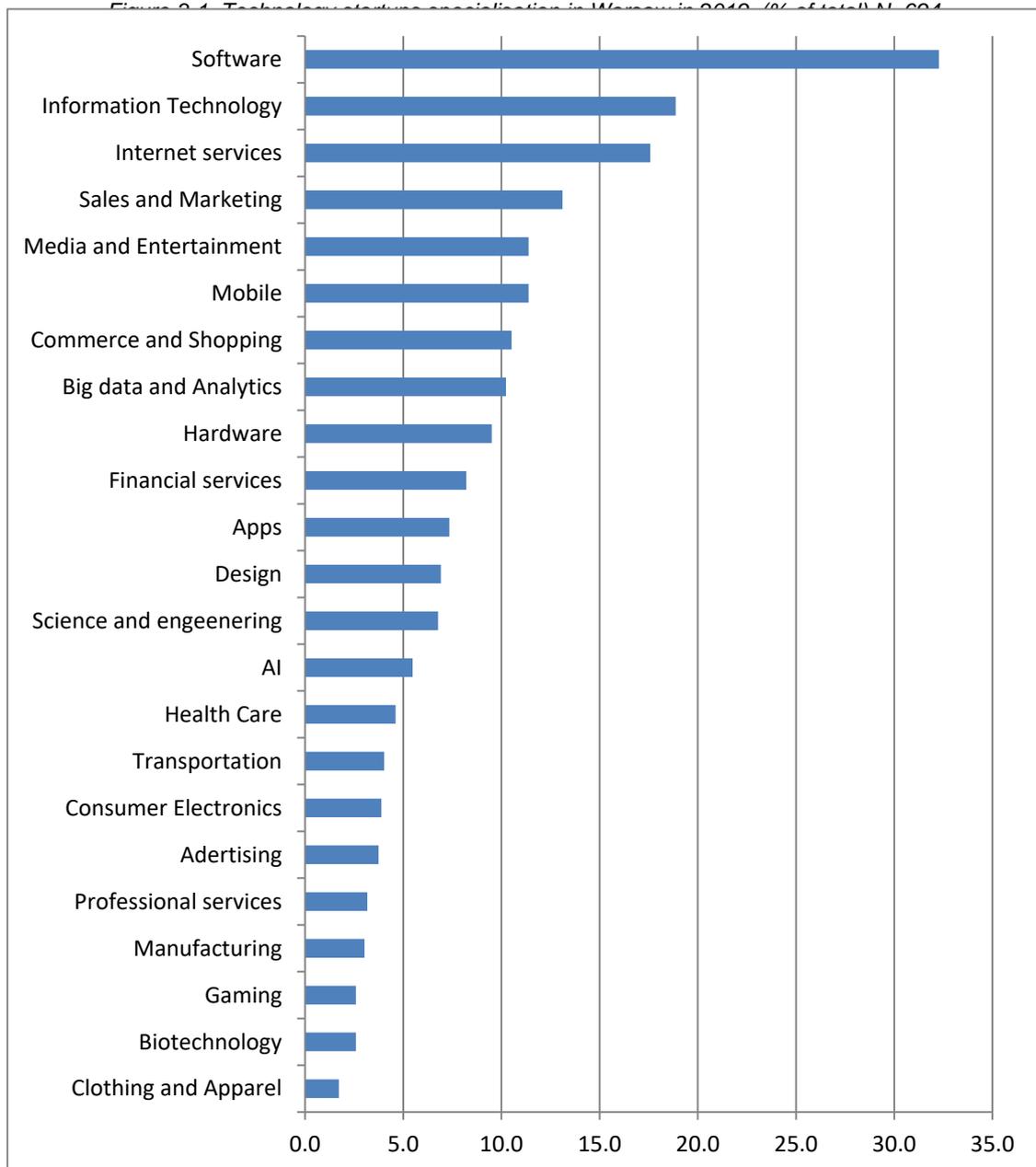
The economy of the Warsaw capital city region is primarily based on services and current technological transformation leads to further servitisation that combines digitalisation in service and a high entrepreneurial capacity (**see** Map. 4.1 in the Main Report). The share of manufacturing in the added value of Warsaw's metropolitan area is 8.8%. In Warsaw, industry processing accounts only for 5.1% of its GDP, but it reaches 22% in its vicinity, which is at the level of the national average. Warsaw's position on the map of Poland is also due to its well-developed higher education sector, which fosters migration of individuals not only for work but also for university studies. 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)

(Gołata, Kuroпка 2016). 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; *"it pays better to run an R&D centre in Warsaw despite high costs of labour because competing for well-qualified staff is so fierce that maintaining such staff, say, in the Podkarpackie Voivodship, would be tremendously difficult given the fact that today every employer offers a social package and individual development opportunities in addition to salary"* **(W1, WAW)**

3.1.2 Adopted 4.0 technologies in the sector in the region

Development and profiles of technological startups

Even though Warsaw and the Mazowieckie Voivodship – just as Poland – is not a leader as regards the number of innovative startups in comparison to such leading players as the United States, China or most Western European countries, it can be observed that this sector of the economy has been rapidly developing in the recent years. According to the Crunchbase database **(2019)** that was originally built to track startups and has information on innovative companies on a global scale, there were 694 such enterprises in the Mazowieckie Voivodship (Figure 3-1).



Source: Compiled by the author based on Crunchbase.

The dominant ones included startups associated with software development (32%), information technologies (19%) and Internet services (18%). Some of them operated in the mobile devices sector (11.4%) and developed applications specifically for such devices (7.3%), while others specialised in sales or marketing (13.1%), trade (10.5%) and advertising (3.7%). The mass-media and entertainment sector also played a significant role (11.4%), including games production (2.6%). Big data analytics was also relatively well developed (10.2%), although only 5.5% enterprises registered in Crunchbase declared using artificial intelligence. In addition, financial and professional services were also well developed (8.2% and 3.2%, respectively). On the other hand, there were fewer enterprises operating in the sector having a more material nature: they dealt with IT equipment (9.5%), science and engineering

(6.8%), consumer electronics (3.9%), industrial processing (3.0%) and biotechnology (2.6%). Other sectors of some significance also included health care (4.6%), transport (4.0) and energy sector (1.6%).

Specialisation in information solutions rather than in material ones is corroborated by the data on the use of specific technologies in enterprises in the Mazowieckie Voivodship (**GUS 2018**). According to such data, 5.8% enterprises in the Mazowieckie Voivodship used industrial or service robots, i.e. fewer than the country's average (6.3%), and only 2.5% enterprises used 3D printing, which was at the average national level. In contrast, enterprises in the Mazowieckie Voivodship more frequently declared Big Data analyses: 11.1% as compared to 7.9% in Poland.

Adaptation of AI-based solutions

Implementation of high technologies in the sector of advanced business services for enterprises may be examined from the perspective of producers and providers of such solutions. Particularly notable is the sector associated with implementing AI-based solutions, which, also thanks to a report by the Digital Poland Foundation (**DPF, 2019**), was diagnosed relatively well. Its results can be directly related to the situation of the Warsaw region since 43% of the surveyed enterprises were located in the Warsaw metropolis, and altogether 85% of firms in that sector were located in Poland's 6 largest metropolitan areas. This is a new and dynamic phenomenon, as proved by the fact that half of these enterprises began to introduce these solutions in the past 2 years (2017-2018). The main applications of artificial intelligence included image identification and processing, data analysis, recommendation systems and NLP, cybersecurity and machine learning. Similarly to startups, the sources financing the development of new technologies were mainly own funds (2/3 of enterprises), while about 1/4 of enterprises were financed from venture capital funds. Public funds did also play a role, especially those provided under the programmes run by the NCBR (National Centre for Research and Development). Foreign capital was engaged in 1/3 of enterprises, which is a similar level to the overall degree of penetration of the Polish economy by investors from other countries. The financing raised from local VC funds as a rule does not exceed PLN 3 million (EUR 750,000).

Among clients of businesses offering such solutions large enterprises prevail, with about 30% of such solutions being implemented. Since that sector is relatively weak in Poland, the offer of technological companies is predominantly addressed to foreign clients, and about 1/3 of enterprises dealing with AI operate branches abroad. Only 1/4 of companies operate solely on the Polish market. According to some respondents, this is due to the fact that Polish enterprises underestimate opportunities offered by artificial intelligence, which poses the main barrier hindering the sale of these products on the home market. Applicability is also limited by the accessibility of adequate data that could be used to optimise business processes. Therefore, it is pointed out that there is a need to undertake relevant promotional activities in that respect, also by public authorities.

The key sectors in Poland which provide applications based on artificial intelligence include (**DPF 2019**): analytics and big data (43%) and customer service and chat bots (22%). Marketing and advertising (37%), as well as retail and commerce (23%) are also notable sectors, as evidenced by the findings

from the analysis of the Crunchbase database. Another significant branch is fintech (28%). Internet of things as well as industrial applications and robotics are less significant, but still remain within the scope of interest of ca 1/4 of enterprises comprised by the survey. Furthermore, these applications are more and more popular among the clients of companies that offer AI-based solutions. The business models employed by such companies include mostly SaaS, software houses, and, to a lesser degree, hiring personnel or outsourcing consultants to the client. On the other hand, proceeds from advertising represent an important business model for only 4% enterprises (**DPF 2019**).

It should be noted that Poland still lacks public R&D centres specialising mainly in AI. In parallel, there is a growing demand for data science services, which is particularly well visible in Warsaw.

3.1.3 Preconditions for transformation

Regional preconditions

The R&D sector

The Mazowieckie Voivodship, and the Warsaw capital region in particular, has been the primary location for research and development activity in Poland. In 2017, the R&D expenditure per capita was 2.8 times higher than the national average, but this gap has decreased in comparison to 2000, when such expenditure was 3.3. times higher. Nonetheless, of all R&D expenditure in Poland, as much as 38% is still spent in the Mazowieckie Voivodship. Moreover, such expenditure is much higher per 1 person employed in the sector (EUR 38,000) as compared to the national average (140% of the average). It should be pointed out, however, that when compared to the regional GDP, even the Mazowieckie Voivodship still has a long way to go to achieve the objectives set in the Europe 2020 strategy. In 2016, the R&D allocation in relation to the regional GDP was about 1.7%, while in Poland such expenditures account for 0.9% GDP. Still, a positive trend could be observed, manifested by a visible increase of this value in the recent years (in Mazowieckie, it was 1.2% even in 2012). This can mainly be attributed to the enterprise sector, which saw a spike in R&D expenditure in relation to the regional GDP from 0.35% in 2010 to 1.13% in 2016. In effect, the share of the enterprise sector in the Mazowieckie Voivodship in R&D expenditure, which was only 25% in 2010, went up to 70% in 2016. A mere 10% of R&D expenditures was spent by enterprises from the manufacturing sector, which only demonstrates a relatively insignificant role of that kind of activity in the economy of the Mazowieckie Voivodship, particularly Warsaw.

Cooperation between academia and business

In Poland, cooperation between academia and business is not particularly well developed. As **Invenity's report (2018)** suggests, the main barriers hampering such collaboration include the time-consuming and complicated formalities on the part of academic institutions (protracted decision making processes, multitude of university bodies engaged, difficulties with agreeing the terms of such cooperation), which is further compounded by legal barriers as well as complicated and lengthy application processes for external funding and accounting of how such funding was expended. More often than not, such cooperation is initiated by businesses, and one of the major obstacles is finding suitable scientists-

specialists willing to perform the implementation work, because businesspeople prefer contacts with concrete, specific scientists. Nevertheless, according to some respondents, signs of improvement can be seen „*It looks that it's better and better because of industrial doctoral programmes, initiatives such as Competence Centres, that is consortiums between research institutions or universities and business. Businesses are also making efforts to open their own programmes in universities, and strive, may sometimes too soon, to drain universities of their students or graduates. These relations are developing because business provides the money for this, people want to earn money, and the number of students in graduate programmes is dwindling, and growing in extramural programmes.*” (W3, PL/WAW).

Use of ICTs in public administration and households

In Mazowieckie, 67.4% (2017) of public administration bodies had access to broadband Internet, but it should be assumed that the shortages in this regard did not occur in the Warsaw capital region but rather in more peripheral parts of the region. The Mazowieckie Voivodship was also the leader as regards provision of administration employees with mobile devices having Internet access (27%), compared to merely 17% in the country at large. Furthermore, 45% public administration bodies declared use of Intranet (38% in Poland), and about 3/4 of them used electronic workflow of documents. On the other hand, policy of open data access was not widespread, being pursued by merely 7.5% public administration bodies, similarly to offering access to applications that can be downloaded to mobile devices. On the other hand, official websites of public bodies were better suited for use on mobile devices (70%).

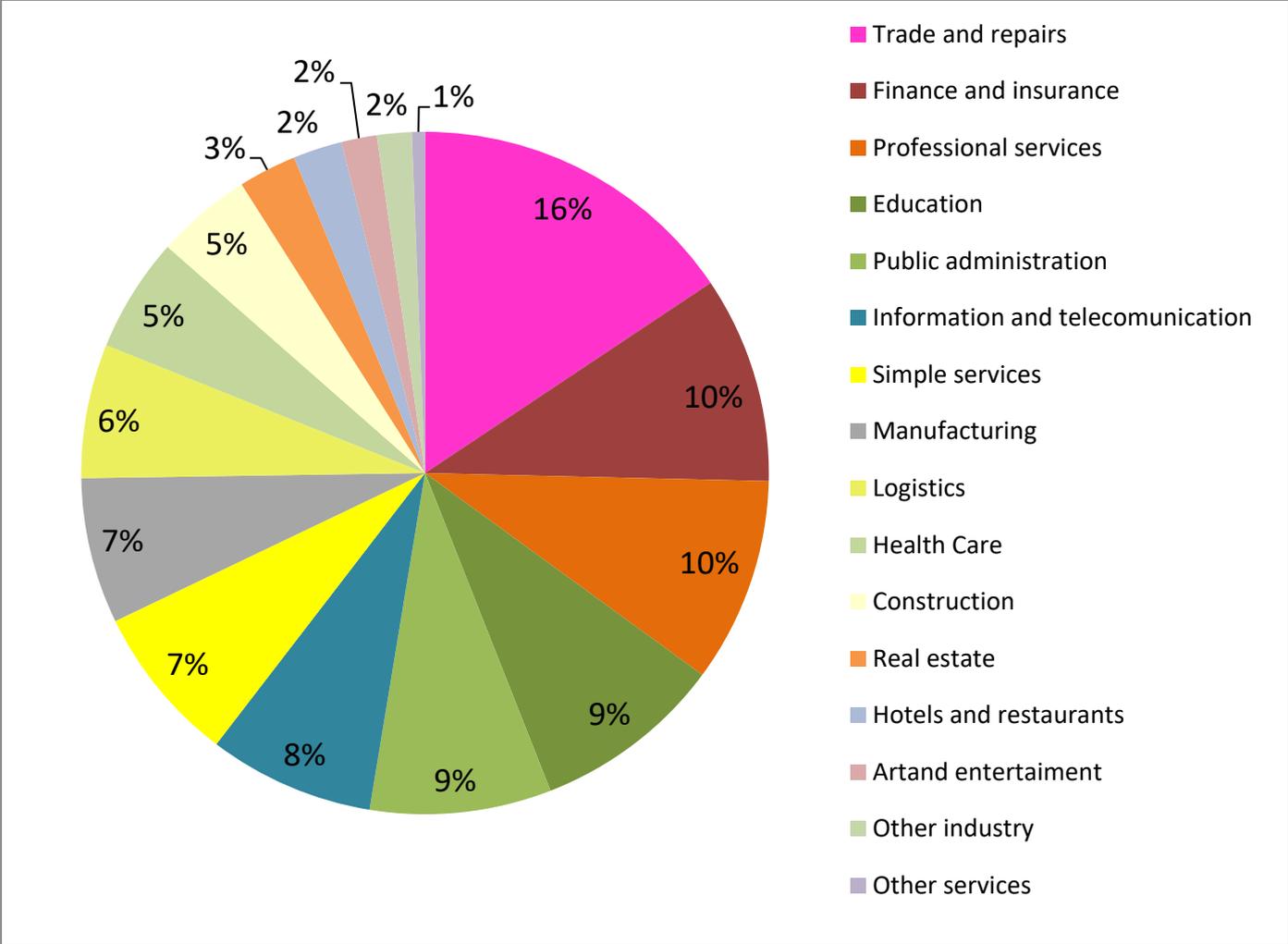
About 60% of employees in Mazowieckie's enterprises used computers in their work, while 53% had access to the Internet, which corresponded to the average EU level and was 13 p.p. higher than the country's average. The level of computerisation was higher in the case of households. Over 82% households owned computers, and 70% of Poland's residents used them on a regular basis. Smartphones made Internet access even more widespread – 84% households declared having access to the Internet, which was only slightly below the EU average (87%), and 80% of them had broadband access (87.4% in the Mazowieckie Voivodship). It should also be assumed that this percentage is considerably higher in the Warsaw capital region, on a par with countries that are the most advanced in this respect, such as the Netherlands or Germany. Thanks to their provision with adequate equipment, the share of consumers who order goods and services on the Internet is steadily increasing, reaching 52% in 2018.

Labour market structure and development

The key branches for Warsaw's economic base were those classified in the advanced producer services sector, i.e. information and communication (NACE J), finance and insurance (NACE K), professional services (NACE M), including especially legal and accounting services, head offices and management consultancy. The sector offers employment to a total of 244,000 people (businesses employing more than 9 staff), and this makes up approximately 27.2% of the total Warsaw's workforce (Figure 3-2). It should also be borne in mind that the relatively greatest employment was recorded in trade and repairs

(NACE G); this was because the enterprises based in Warsaw handled the bulk of Poland’s foreign trade (Gorzelał, Smętkowski 2012).

Figure 3-2. Structure of the labour market in Warsaw in 2016, in p.p.



Source: Compiled by the author based on CSO data.

Since 2013, employment in the non-agricultural sector has dynamically increased in Poland, which was especially well visible in comparison to the period following the 2008 financial crisis. In 2013-2017, the number of people in work in the Mazowieckie Voivodship increased by 11.1% compared to 8.8% in Poland at large. The fastest growing section in Poland was NACE Section N – “Administrative and support service activities” (a 30% workforce increase, up to approximately 480,000 in 2017). In this section, in addition to businesses providing cleaning or security services which do not require highly qualified personnel to operate, also startups supporting economic transformation processes towards 4.0 technologies are also registered. In the Mazowieckie Voivodship, the number of jobs in that section increased by 46%, and this growth was particularly well visible in Warsaw. The second fastest growing section in terms of employment was information and communication (NACE J), which recorded a growth of 24%, up to a level of 258,000 employed across the country. This growth was slower in the Mazowieckie

Voivodship, reaching a level of 17.5% in the period 2013-2017; it should be noted, however, that the region employed nearly half (49.1%) of the sector's employees nationally. The section in question provided employment mostly to software developers, programmes and IT specialists, who also played a key role in transforming the economy towards 4.0 technologies. The number of jobs also increased in industry (NACE C+D+E+F), a sector in which, following many years of decline, employment in Poland began to dynamically increase: by 8.4%, up to 2,849,000; in Mazowieckie, that growth was even faster than average, at a level of 10.2%. At the same time – as some respondents observed – jobs in this sector did not have to be a function of an increase in the number of people employed in processing, but could be a result of the development of non-productive divisions (including IT) in industrial enterprises: *“The IT layer is found in all industrial plants because these are car factories and electric tools factories and robots and software and systemic software for all enterprises, including vertical integration equipment in industrial plants” (W6, PL/WAW)*

In 2014-2018, the net number of new jobs was on average 80,000 per year, to reach a record 95,000 in 2018. Thus, the rate of growth of new jobs in the Mazowieckie Voivodship since 2014 has reached a level comparable to the pre-crisis 2008, which saw the creation of 82,000 new jobs. By comparison, in 2009-2013 only 23,000 new jobs were on average created annually (with a record low of 5,000 in 2009, the crisis year). This triggered a fall in the number of registered unemployed, which decreased from 178,000 to 136,000 (in Warsaw, after a temporarily deteriorated situation associated with the global crisis, the number of registered unemployed rebound to the 2008 level, i.e. some 20,000). This means a very low unemployment rate, at a level of 1.5% (compared to 4.9% in the Mazowieckie Voivodship). In parallel, what could be viewed as proof of a mismatch between the offered higher education programmes and the labour market expectations was the share of university graduates in the number of the unemployed in Warsaw, which grew from 21% in 2008 to 33% in 2018, compared to about 16% in the whole voivodship.

Sectoral preconditions

Innovation in enterprises

On average, about 20% of enterprises in Mazowieckie declared implementing innovations in the past 3 years. Notably, the Mazowieckie Voivodship accounted for ca 70% of expenditure on innovation in the services sector in Poland, compared to ca 20% in the case of industry. Moreover, the total value of outlays on innovation in services was about 1.5 times higher than that in industry, whereas in other regions of Poland the services sector spent on innovation half the amount spent by the industrial sector. In case of service enterprises, increase in the share of R&D activity in innovation outlays could be visible particularly well – it increased from 10% in 2011 up to 40% in 2017. In parallel, the share of funds allocated to purchase of machinery and technical equipment fell from about 50% to 15%. This could indicate saturation with computer hardware and ICT infrastructure, as well as emergence of innovative services such as e.g. SaaS. On the other hand, the share of outlays on purchase of software remained at a relatively stable level, between 10% and 20%. At the same time, the share of expenditure on the marketing of new or significantly improved products increased only slightly, up to a level of ca 10%. It

should be emphasised that, in the vast majority of cases, implementation of innovations was associated with investing own funds (90%).

Pursuing innovative activity was rather closely connected with the size of the enterprise: among the largest enterprises, about 60% declared such activity, 30% among the medium-sized ones, and only 10% in the group of enterprises employing 10 to 50 staff. The extent of innovation depended on the ownership status of the enterprises: foreign and public entities (over 30%) were more prone to introduce innovations, which however could be due to the fact that, as a rule, these were larger entities. At the same time, the share of new or significantly improved products in the value of sales fell from ca 30% in 2005-2007 to ca 8% in 2017. This could be caused by the popularisation of certain solutions, meaning that they were no longer innovative, and by the accelerated process of generating innovations.

However, the practically complete computerisation of the enterprise sector in the Mazowieckie Voivodship (97%) was not accompanied by a full use of Internet-related opportunities, since only 72% enterprises had a company website. Furthermore, a modest 17% enterprises accepted orders via computer networks, and 37% placed orders in such a way.

Cooperation with academia was rather poorly developed, and only about 10% of SMEs were engaged in cooperation based on cluster initiatives. Patent activity was also done on a very limited scale. In 2018, 756 patent applications were filed, of which 70% were positively evaluated. This meant that there were about 10 patents per year per 100,000 population. Over the past 10 years, the situation in that regard has only slightly improved (see Map 3.3.in the Main Report).

Salaries

Low salaries in Poland in comparison to Europe (ca EUR 1200 monthly per employee in 2018) have been, and still are, a key constituent of the competitiveness of Polish enterprises and a major factor attracting inward capital. However, over the past 2 years this situation has changed considerably due to a rapid salary increase (by 16% in 2016-2018) and pay differentiation across both occupations and regions. First, salaries of professionals are typically more than 120% of the average salary, while salaries of workers employed in industrial processing are about 20% lower than the average. Second, the section in which a given economic activity is categorised even to a greater extent determines pay differences. For instance, while the salaries in the Information and Telecommunication section represented 175% of the average, in industrial processing (including professionals and managers) they were at the national average level. In effect, this leads to a spike in salaries in Warsaw's IT and professional services sector, which encourages companies to seek solutions that reduce the pressure on salaries: *"In Warsaw, the pay pressure is exceptionally strong, and rates even at assistant positions are higher and higher. So, businesses are mostly interested in investing in IT, primarily in CRM systems. For example, we will now implement an application to speed up contacts with clients, and we want to reduce the amount of the human factor to a minimum"* (W9, WAW).

Social preconditions

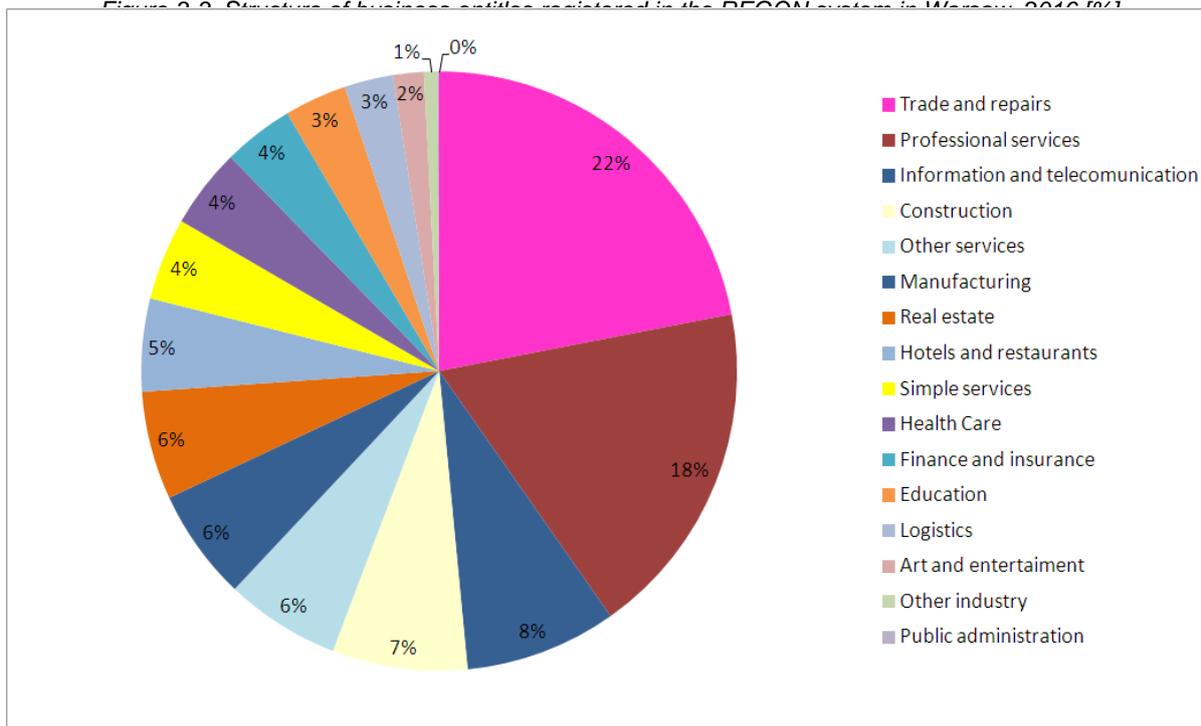
Education

In 2018, a total of 155,000 students were studying at public universities and colleges (17.2% of all students in Poland) in the Mazowieckie Voivodship, among others in the following fields: a) engineering and technology: 19,500 (a 12.6% share, and a drop by 1.2 p.p. compared to 2014), b) ICT technologies – 7,300 (a 4.7% share, and a rise by 0.8 p.p.), c) physics, mathematics and statistics – 4,200 (a 2.7% share, and a drop by 0.5 p.p.). Non-public tertiary education sector, with 89,000 students (27.2% of all students in non-public sector in Poland) played a distinct role only in ICT education, offering training to 7,300 students (about 8% of all students). According to some respondents, the latter establishments may play an even greater role in the future: *“non-public higher education institutions are definitely more flexible, mainly in employing people that are currently sought after in the market. They can also anticipate certain changes and can introduce new courses more easily”* (W3, PL/WAW). In conclusion, the inflow of graduates educated in Warsaw with skills that are potentially useful in technological transformation can be estimated at 8,000, which represents ca 1% of total employment in entities employing over 9 staff. However, in the respondents’ opinion the real inflow of graduates may be smaller *“Relatively few, around 3,000 employees, start work on the Warsaw labour market per year, and they are graduates from courses that might be regarded as technological programmes”* (W1, WAW). On the other hand, surveys indicate that about 6% enterprises in Poland were looking for ICT specialists. The greatest demand was recorded in the NACE section representing advanced business services: information and communication, and in finance and insurance, where such skills were required of 2/3 employees, compared to 1/4 in professional services, which however showed the fastest dynamics of growth of all the sectors (GUS 2018).

Entrepreneurship

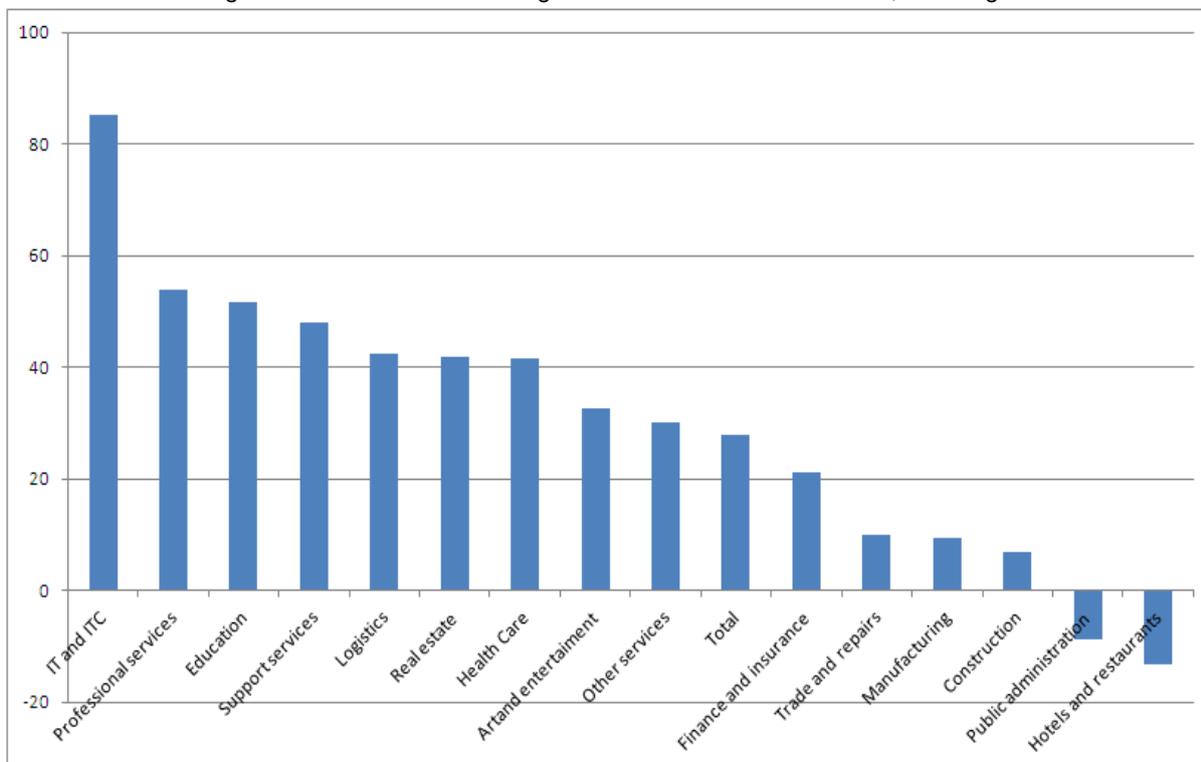
About 400,000 enterprises were registered in Warsaw, of which 95% had fewer than 10 staff. In 2008-2016, their number increased by approximately 30%. The fastest growing section was information and communication (an 80% increase), which in consequence grew to be the third most numerous section in terms of the number of microenterprises in Warsaw (Figure 3-3; Figure 3-4). The remaining rapidly developing branches included professional services, which are starting to close the gap to the previously dominant trade sector, as well as business support services, in which some of the startups are registered.

Figure 3-3. Structure of business entities registered in the REGON system in Warsaw, 2016 (n=1)



Source: Compiled by the author based on CSO data.

Figure 3-4. Business entities registered in REGON in 2008-2016, % change



Source: Compiled by the author based on CSO data.

The dynamic growth in the number of enterprises in Warsaw is mainly financed by own funds, although raising financing through crowdfunding is increasingly popular. Capital support is offered by a number

of public entities such as e.g. Bank Gospodarstwa Krajowego (bank), Mazowiecki Fundusz Poręczeń Kredytowych (guarantee fund), Mazowiecki Regionalny Fundusz Pożyczkowy (loan fund). In parallel, various venture capital and business angels funds operate, such as e.g. Hedgehog Fund or Protos VC. There are also many acceleration programmes in place; in 2017, such programmes provided assistance to about 1,000 projects, some of which involved application of new technologies (**UM 2017**). The rapid growth in the number of startups led to the creation of many coworking spaces; in 2018, there were about 125 such places in Warsaw which offered altogether approximately 100,000 square metres of office space (2% of total office space). The largest one, currently under construction, and planned as an innovation centre offering 15,000 square metres of office space, is currently being developed in the Varso office complex, which will also feature the tallest building in the European Union. *“The building will be open 24 hours a day and will offer a number of support functions, e.g. a social initiatives centre, a space hub, a med-tech hub, a smart city hub, a culture-tech hub, free space for innovation leaders; all in all, this is a game-changer in the approach to how office buildings should be built” (W4, WAW).*

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 (**SRD, 2017**) – a document that defines the future directions of Poland’s development until 2030. The Strategy recognises activities related to the development of Industry 4.0 as crucial for improving the competitive standing of Poland’s economy. The first area of intervention, that is Reindustrialisation, stipulates development of technical infrastructure and competences for Industry 4.0. The Strategy heralds the creation of the Polish Industry 4.0 Platform that will support industrial transformation towards digitisation of technological and management processes in enterprises. This process will notably include reconstruction and integration of infrastructure based on the forecasts concerning development of the market for the Internet of things, RES (renewable energy sources), fossil fuels, energy warehouses and electric cars post 2020. Activities related to Industry 4.0 envisaged in the Strategy are horizontal in character. The diagnostic part of the Strategy identifies changes on the labour market that include, among others, replacing human labour by high technologies and increased demand for workers with new qualifications and skills. Therefore, it anticipates a number of measures to support vocational education and training for the needs of Industry 4.0, as a precondition for making a leap into the future by the Polish economy. The Strategy proclaims implementation of a project entitled *“Modern human resources for Polish industry”*, which combines education and vocational placements at the employers’ establishments; active involvement of industry in preparing school curricula; development of practical training centres and vocational qualifying courses. The Strategy broadly discusses the determinants that may have an impact on whether the set objectives will be attained; among such factors, it lists digitisation in addition to human and social capital, transport, energy, environment and national security.

The key strategic document in Poland that in its entirety discusses issues of the technological revolution and applications of 4.0 technologies is The Policy for Development of Artificial Intelligence in Poland for

the Years 2019-2027 (**PDAI, 2019**). The document that provided the foundation for formulating the strategy was an action plan prepared in late 2018 by the Ministry for Digital Affairs, entitled Assumptions for AI Strategy in Poland (**AAIS, 2019**). The plan to promote a “data-based” economy in Poland was laid out in 3 perspectives: short-term (up to 2 years); mid-term (up to 6 years) and long-term (until 2030). In the short-term, it is recommended to undertake educational activities on the “learning by doing” basis; in the mid-term perspective, the document recommends first and foremost commencing activities that would enable the Polish economy to escape the equivalent of the “middle-income growth trap” in a data-based economy, and, in the long-term, public policy should focus on building a lasting, global domination of Polish enterprises in selected specialisations.

The aforementioned strategy entitled The Policy for Development of Artificial Intelligence in Poland for the Years 2019-2027 is an unofficial document, currently in the process of social consultations. Similarly to the national AI strategies of the EU Member States, this document was prepared in line with the recommendations laid down in the 2018 Communication from the European Commission, entitled Artificial Intelligence for Europe, whereas the deadlines for the formulation of these documents were provided in the European Commission’s Coordinated Plan on Artificial Intelligence. That material was prepared by an interdepartmental analytical and editing team, set up pursuant to the memorandum adopted on 26 February 2019 by the Minister for Digital Affairs, Minister of Entrepreneurship and Technology, Minister of Science and Higher Education and Minister of Investment and Economic Development. The key premise of the policy to develop Artificial Intelligence in Poland in 2019–2027 is to secure the best possible role for Poland in the global value chain, which is increasingly determined by technologies and applications of artificial intelligence. The Strategy identifies Poland’s potential for a dynamic shift from being a challenger to an AI leader, with the “+PL” brand that is recognised in international markets. Looking to the year 2025, the aim for Poland is to join a small group of 20-25% countries that develop AI. In practice, it means that the sector developing artificial intelligence must grow 25-fold. Such a strategy will help minimise the negative consequences for the labour market. As priority sectors where AI is expected to produce most benefits, the Strategy identifies industry, medicine, transport, logistics and energy sectors, and, secondly, state administration, commerce and marketing, construction and cybersecurity. The document defines the key activities for attaining this objective related to organisational, topical and financial infrastructure. These include, among others, the creation of the Future Industry Platform aimed to coordinate the cooperation of entities taking part in the process of digital transformation, such as the operation of digital innovation hubs, the learning factories and virtual research teams. The Strategy promises support to the Economy 4.0 processes: in institutional aspects, in the form of the Polish Computation Centre; in advisory aspects, in the form of the Observatory of International Policies on Artificial Intelligence and Digital Transformation; and in legislative aspects, in the form of the Virtual Chair for Ethics and Law at the ministry competent for IT matters.

At the regional level, the main document that underpins processes of the 4.0 technological revolution is the Regional Innovation Strategy for the Mazowieckie Voivodship Until 2020 (**RISMV, 2015**). In its

content, the Strategy does not directly refer to 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. Motifs associated with promoting the 4.0 technological revolution are most frequently encountered in the assumptions to Objective 5 of the Strategy: “Development of an information society inspired by the assumptions of the European Digital Agenda”. This objective is to be attained both by providing support to ICTs in enterprises, promoting implementation of intelligent management systems and so-called e-services (e-administration, e-health, e-logistics, e-finances, e-trade, e-work, e-education), popularising the Internet and its applications, improving digital competences of the public at large and ensuring cybersecurity.

The set of smart specialisations of the Mazowieckie Voivodship clearly emphasises its links with the 4.0 technological revolution, especially in the services sector. One of the region's smart specialisations are Intelligent Management Systems. That particular specialisation comprises infrastructural and process solutions increasing the level of automation, which facilitate an effective monitoring of economic processes, such as improved raw materials and energy efficiency and improved quality of life. The specialisation also refers to infrastructural solutions in the field of e.g. intelligent transmission networks, buildings and management systems, Internet of things, robotisation of control and diagnostic systems as well as cybersecurity solutions. In the Safe Food specialisation, elements of Industry 4.0 may be found in production processes (e.g. robotisation of production systems, systems for monitoring and controlling production processes), in distribution (e.g. supply cycle manufacturing, warehousing). The specialisation State-of-the-art Business Services includes solutions related to full customisation of solutions for business, big data analysing and processing, ensuring access to customised business and economic information and IT systems used in management (ERP- enterprise resource planning and CRM - customer relationship management), while the specialisation High Quality of Life denotes advanced technological and organisational solutions used in the provision of social services, particularly in the sphere of education, health, safety, work and leisure; activities aimed to foster social innovations, development of social capital and preventing negative consequences of the region's polarised growth.

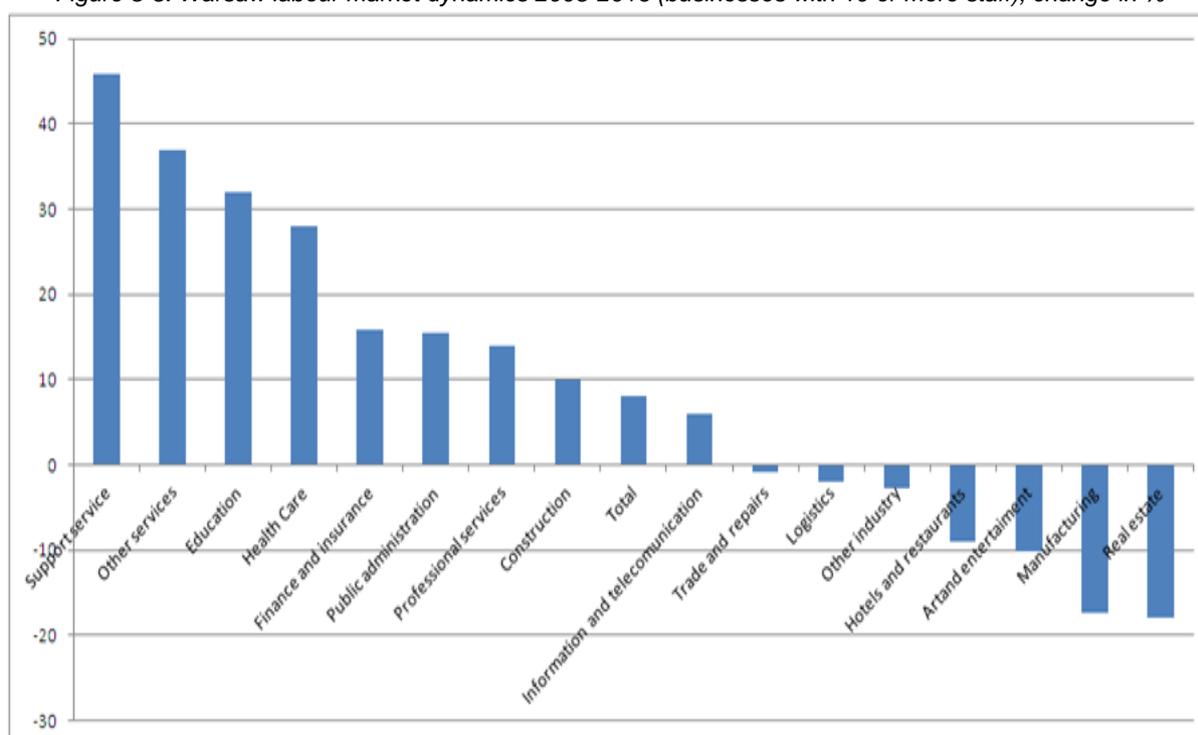
3.1.4 Actual transformations in the region

Economic transformation

Labour market transformation

In the years 2008-2016, Warsaw's labour market underwent a distinct transformation (Figure 3-5). In addition to administrative and support service activities (NACE N), and public domain services such as education (Section P) and health care (NACE Q) (in which growth was propelled mainly by private service providers), employment increased at the fastest rate in advanced business services: finance and insurance (NACE K) (16%), professional services (NACE M) (14%) and information and communication (NACE J) (6%). As regards manufacturing (NACE C), a distinct fall in employment could be observed (by 20%), although this decreasing tendency was halted in the past 2 years. Interestingly, the real growth in the number of employed in NACE J and M sections is even higher since these sections account for the largest number of startups which are not comprised by these statistics.

Figure 3-5. Warsaw labour market dynamics 2008-2016 (businesses with 10 or more staff), change in %



Source: Compiled by the author based on CSO data.

Labour market changes can partly be attributed to the development of foreign services centres (including those operating in IT and R&D sectors). According to the data of the Association of Business Service Leaders (ABSL), in 2016 there were 126 business services centres with foreign shareholdings operating in Warsaw, which in total employed 32,700 staff and had a rate of growth on a par with Poland's average. Nationwide, such entities employed in all 177,000 staff, a twofold increase compared to 2011. They can be divided into 3 categories: a) centres providing services to different clients (a 51% share in total employment); b) centres servicing various divisions of a single transnational corporation – so-called shared services centres, SCC (34%); and c) centres engaged in R&D activity irrespective of the type of client (15%). The main services offered by these centres include first and foremost finance and accounting, IT services, research and development (including software development) and client services (excluding IT). For instance, *“Samsung’s largest R&D centre worldwide located outside of South Korea is in Warsaw” (W10, PL/WAW)*. At the same time, these centres less frequently deal with human resources management, other financial services, advisory services and logistics.

Internationalisation of enterprises

The development of information economy considerably increased internationalisation of enterprises operating in the emerging technologies sector in Poland. Although there are no up-to-date statistics to illustrate the phenomenon, the respondents fully agreed in that respect, as epitomised by the following opinion expressed by an SME sector representative: *“Thanks to the technological revolution, we are doing projects in various locations, which in effect leads to our operations being done independently of*

our office location. We do most of our foreign projects remotely, which means that we go to a meeting to show we're real and learn what the client wants, and then we work remotely/off-site, using all available access data, online meeting techniques and so on. Technologies allows for very strong globalisation, especially in the sector of professional services (IT) in which we operate" (W12, WAW). Some technology firms also decide to set up their branches on the major markets, e.g. in the United States. In effect, two new offices of the Polish Investment and Trade Agency specialised in providing services to the IT/ICT sector were opened, in Houston and the Silicon Valley.

Changes in the markets for hi-tech products/services

The development of the IT/ICT market in Warsaw is visible mainly in the B2B sector, while in the case of the B2C sector a growing risk of oligopolisation can be observed, attributable to market mechanisms. *"The development of advanced technologies leads to the oligopolisation of advanced technology markets. This is due to a trend whereby production marginal costs fall when production is knowledge-based. If knowledge becomes the basic factor of production, then the cost of manufacturing consecutive product items becomes lower and lower"* (Wierzbicki 2015). In consequence, the distinct advantage of US corporations in the consumer sector is widely emphasised. *"Europe lost B2C, that is Facebook's, Google's, the consumer sector"* (W10, PL/WAW), and therefore opportunities are sought in developing solutions for the B2B sector. Both in Warsaw and Poland, those types of activities are pursued which do not require significant expenditure but rather suitable qualifications of staff. *"It's easiest to do what does not require much financing up front, that is marketing, targeted advertising, cloud computing, for example in the retail sector [...] software doesn't need considerable outlays, and Polish companies are largely subcontractors, also in R&D, which is also good at the beginning"* (W10, PL/WAW).

It is also pointed out that, as regards the development of own AI-based solutions, there may be a serious barrier to market entry flowing from the need to set up large teams dealing with such issues *"most businesses will only be users of such solutions, because in order to build your own tools you need really powerful programming resources, and these are expensive"* (W4, WAW).

In parallel, in other sectors of professional services, it is anticipated that enterprises which will be pioneers in the emerging technologies will gain an advantage over others. For example, in accounting: *"We are already making preparations for this robot-accounting; for instance, one Polish firm offers systems processing 70% of accounting documents with 98% accuracy. Our sector, however, that is accounting firms, well I think 90% of them are not prepared for this and are not changing their business models. And what chance will a small accounting office that does everything by hand stand in the competition game against an IT company that does automated book-keeping?"* (W9, WAW).

Business environment for start-ups and IT sector

The dynamic growth of IT startups is largely due to the startup ecosystem in Warsaw that is increasingly taking shape (UM 2017). In addition to efforts by such private investors as e.g. Cambridge Innovation Center that plans to expand its operations in 2020 when its new office building is completed, *"we will get investors from the United States thanks to building industrial hubs focusing on several areas, i.e. space,*

medtech, smart city and culture-tech, demonstrated for example by what Netflix now does with 'The Witcher'", the public authorities are also undertaking many smaller-scale initiatives such as enterprise incubators, creativity centres, urban acceleration programmes, training programmes and workshops, in addition to export support provided to small and medium-sized enterprises from the Warsaw agglomeration.

In addition to the startup ecosystem, public sector procurement also plays a role in the development of startups and the IT sector in general as it can act as a driver for innovation in enterprises due to implementation of IT projects based on new technologies: *"The public sector in Poland pursues ambitious projects as it needs to adapt to various requirements associated e.g. with the tightening of the tax system; in effect, these are the biggest IT projects, in Poland at least, that use big data analyses and artificial intelligence, which makes it possible to seek correlations on a scale that is not known in average enterprises"* (W12, WAW). This is also corroborated by data showing that public procurement backed by EU funds accounts for about 25% of demand for IT/ICT services in Poland (PARP 2017).

Social transformation

Role of skills and human resources

Adequately skilled human resources undoubtedly play a key role in development and adaptation of new technologies in enterprises. The respondents agree that the rate of enrolment and qualifications of university graduates in Warsaw are high, and this, coupled with lower labour costs, improves Poland's attractiveness for investors, also in technological sectors *"Still, one of our huge advantages is the rate of enrolment and standard of education of our students and later of graduates. True, our universities do not top the global league tables, but this does not change the fact that foreign investors, when seeking where to invest, also in high tech, look at Poland as one of potential locations."* (W2, PL/WAW).

Technological development poses a challenge for firms to improve competences related to the qualifications of staff. This is a particularly strong development driver for smaller enterprises in technology sectors: *"A firm such as ours focuses on selling competences, which means that we strive to have competences ahead of our users, clients, that is to be able to do things that they already know they need but haven't learnt yet. Therefore, continuous progress is for me the foundation of the firm's growth, because if technology comes to a halt and everybody learns to do the same things, they will no longer buy it from me but will do it on their own instead. So, firms with narrow specialisations in certain technologies [...] need to have basic orientation as to what to invest in because we must do it faster than our clients. If the client decides he wants machine learning now, we must have the know-how involved and help him do it"* (W12, WAW). Respondents also emphasise the role of efficiently functioning HR divisions in technological startups *"some Polish startups that got a good HR specialist would double their workforce every year"*. (W6, PL/WAW)

It is also observed that while engineers are widely aware of the need to upskill, such an awareness is not at all common among managers: *"Engineers are well educated because they work for clients abroad and they know that if they complete a training programme this will show in the money they make. Also,*

some projects require knowledge of specific solutions. On the other hand, managers are poorly educated [...] they know little about new solutions because such knowledge does not directly translate into their salaries, because for example there are no relevant certificates, unless we speak of specific professions such as accountants” (W10, PL/WAW).

Reskilling and education/training

Among the major technology-related social changes is the need to improve staff competences, and this is also well visible on the Warsaw labour market. This could also require a complete change of qualifications in a situation where there is no longer demand for specific occupations. So far, in Poland activities that could facilitate retraining are mostly undertaken by the private sector (within individual enterprises), whereas the public sector plays only a minor part in these processes. This is reflected, among others, in one of the lowest values in Europe showing participation in lifelong learning programmes, and is confirmed by the respondents: *“The government doesn’t do anything about it, so-called reskilling, i.e. training people to learn new skills, for example someone who works on the till today, and the cash register gets automated; and on the other hand we lack male nurses or tram drivers – there should be dynamically operating reskilling centres; or, say, today you’re an engineer in one sector and tomorrow in another. Poland is as far as I know ranked one before last as regards participation in continuous learning” (W10, PL/WAW).* On the other hand, it should be borne in mind that the very good, and still improving, labour market situation does not encourage public authorities to step up its activities in that regard.

In parallel, the higher education sector is increasingly expanding its offer in an effort to address the demand of the business sector for staff qualified to implement new technologies. *“There are more graduate courses, also undergraduate and graduate programmes, focused on new technologies and artificial intelligence. For example, the non-public Kozminski University offers a course that combines AI and business” (W11, PL/WAW).* Due to the demand for staff there is an observable brain drain of scientists and researchers leaving academia for business: *“Scientists claim that they are enticed to start such cooperation. In other words, either they do their own startups or find employment as specialists which, in the longer term, may lead to many scientists quitting university jobs – which is a widely discussed topic” (W11, PL/WAW).*

Foreign immigration

The development of new technologies and the growing presence of Warsaw on the global map both for clients (e.g. Samsung’s R&D centre) and local manufacturers increases the internationalisation of the labour market through attracting talent from other countries, particularly Ukraine. At the end of 2018, 372 thousand foreign nationals had valid residence permits to stay in Poland, i.e. twice as many as in 2014. Most of them – 179 thousand, i.e. about 50% – were Ukrainians. The highest number of foreigners with residence permits were staying in the Mazowieckie Voivodship, that is mostly Warsaw – 114 thousand (30%). At 328 thousand, the number of work permits was similar to that of residence permits, with 72% such permits being issued to Ukrainian citizens. Research has found that about one fourth of

all Ukrainians in Poland work at specialist positions (**NBP, 2016**). This means that the total number of legally working specialists from Ukraine can be estimated at some 10 thousand. It can also be assumed that a large portion of them are employed in the IT/ICT sector, which currently offers about 70 thousand full-time positions in Warsaw-located firms employing over 9 staff. Additionally, over 30 thousand smaller firms, many of which are sole traders, operate in this particular section. The existing staff shortages are filled in by foreign workers mainly from Ukraine as demonstrated above, but also from such countries as India or Pakistan: *“Highly qualified individuals from Pakistan, India, who find work here, in service companies, not only in shared services centres but also in technological firms” (W1, WAW).*

Digitalisation of traditional services, platform economy and gig jobs

Warsaw is Poland's key diffusion centre of sharing economy solutions. Therefore, the digitisation process of platform-based traditional solutions is the most advanced there. For instance, merely 4 years after Uber's coming to Poland 30% of the capital's residents use its services, which means that, in Europe, Warsaw is surpassed only by London and Paris. This can also be said about other mobility services (e-scooters, e.g. Lime), which appeared in Warsaw some 6 months after they had debuted in San Francisco. The model also comprises e.g. catering services (such as UberEats). Similarly, new business solutions are becoming increasingly popular on the business space lease market, where, in addition to traditional co-working solutions based on sharing economy, big business actors have started offering network solutions (e.g. WeWork). As a result, the gig jobs market, involving periodic task-based work in line with the current market situation, is dynamically expanding.

3.1.5 Actual and/or expected impact

In the sector in the region

New technological solutions are predominantly regarded as support to business operations and are intended to increase productivity and reduce the costs of business operations. So far, no negative impact on the size of employment has been observed in Poland. This could flow from the fact that companies employing such solutions are gradually building their competitive advantage, and a growing economy boosts the development of the whole market. According to CSO statistics, labour productivity roughly calculated as gross added value per employee has been stable in the recent years in Warsaw but lower than the national dynamics, which could suggest that it is an increased number of people in work and not increased labour productivity that has been the main factor underpinning economic growth in the Warsaw capital city region in the recent years. This could arise from the still nascent phase of the development of the 4.0 technological revolution, and is for example demonstrated by the fact that companies offering AI-based solutions as a rule have a workforce of fewer than 5 staff, and only 15% enterprises employ more than 20 relevant specialists. Nevertheless, increased interest in the recruitment of new staff to work on such solutions can be observed, as declared by 85% firms (**DPF 2019**).

According to the authors of the report on the assumptions of the AI strategy in Poland (**Ministry of Digital Affairs 2018**) participation in processes of AI development and not only in the implementation of AI-based solutions is crucial for the situation on the labour market since, according to estimates, every

100 liquidated jobs (of technology consumers) will create about 130 new jobs for AI programmers. This is corroborated by the opinions voiced by some of the respondents: *“It’s not that artificial intelligence will come in the form of androids who will replace workers as they will be able to do everything. It seems to me that if we replace 3 workers with a machine, this machine will be operated by 3 specialists, and so on. If we replace 3 analysts with artificial intelligence, this artificial intelligence will be programmed by 3 software developers. In effect, people will have to migrate from one set of competences to another, and demand for work will grow, as is ever the case”* (W12, WAW). Furthermore, it can be expected that the GDP of countries that develop AI will on average increase by 1.5 p.p. faster than that of other countries (Accenture 2018). 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. It should be observed, however, that the sector of advanced business services may also gain a lot in that regard even though it is not regarded as a priority one in the assumptions to the AI strategy (Ministry of Digital Affairs 2018).

The respondents expressed a relatively optimistic view that the capital city region will cope well in the conditions of the 4.0 technological revolution as regards implementing the existing solutions, but also with regard to developing its own potential for innovation. *“Within a space of 2 years the innovators’ community in Poland will be about 30,000 and bound to increase, so in 5 years we expect to test the level of 100,000”*. (W4, WAW) In that respect, Warsaw will play a crucial role as a pivot location for integrating such efforts, also because of the anticipated development of mobile work. Some interviewees, however, predict that the transition will be more evolutionary, and as an example quote the development of cloud computing *“all the big players no longer build their own data centres, but everything is in the cloud, and this revolution did take place even though it did not happen, let’s say, overnight, but can we really say that it turns everything upside down?”* (W8, WAW).

Machine learning may also play a role in the **IT industry**, which will allow replacing expensive system integrations with an adaptive learning system that *“exports records from Excel, opens a new app, and imports these records, instead of explicitly programming the integration which later will have to be supported, automated and so on, or there’s an integration that can’t be done at all because there is no documentation for such systems”* (W8, WAW). This can raise the question whether AI is able to replace software developers *“I think that this is happening to some extent, in the sense of tools that we’re using – nowadays they suggest or prompt certain things, but the code written by developers is rarely ever written fully manually; simply, a lot is done all the time, with some prompts or with quality control of such code – we also do that, but the truth is that this quality control also suggests how the code should be developed, so, obviously, the share of such tools in development will also increase. But this, in my opinion, will shift the competences of humans towards designing or setting the requirements, and so on.* (W8, WAW)

In other sectors in the region

The relatively weak progress of the 4.0 technological revolution in Poland in other sectors than IT is usually explained by the fact that many Polish businesses, especially those in the SME sector, do not

see any need for implementing innovations “*What poses a serious challenge for enterprises is to recognise the need to innovate – because many enterprises, more than 40 per cent, do not even see such a need because in their opinion these innovations will not affect the quality of the product that these firms will offer*” (W2, PL/WAW). Such lack of interest is also explained by a growing economy “*now the economy is booming, so entrepreneurs are not thinking about what tomorrow will bring. They do not analyse what will happen if they drop out of the value chain.*” (W3, PL/WAW). On the other hand, opinions voiced in some advanced business services sectors suggest that the emergence of businesses which successfully implement such technologies may in effect transform the local economic landscape in the future, for example in accounting or auditor services. The role of agents of change is also emphasised, so as their significance for the implementation of new technologies to overcome the barrier posed by the lack enthusiasm for technological innovations “*Currently we’re launching bids for training programmes and courses for senior management. As they are in fact so-called promoters of change, they are the people who can make change happen in their firms. That is why, as I said, great emphasis is put on strategic change and how they can gain from it.*” (W3, PL/WAW)

According to a report by the **Ministry of Digital Affairs (2018)**, there is a serious threat that those Polish businesses either will not implement new technologies or will delay their implementation, as a result of which they will lose their competitive advantage. This can affect both the advanced business services sector as well as traditional sectors such as trade, industry or agriculture. This can be especially pertinent in the case of the Warsaw capital city region, since arguably the potential for AI implementation in the advanced business services sector in the short term is higher than that in traditional branches, as demonstrated by the experiences in implementation to date. In effect, delaying with introducing new technologies may bankrupt many small businesses, as is reported for example in the accounting segment, but may also affect the market for translations or other professional services. Some protection can be seen in the fact that these threats come from Polish businesses rather than foreign ones owing to local considerations associated with language as well as the legal and administrative context.

Some respondents in the Mazowieckie Voivodship see certain benefits in automation which may alleviate staff shortages, which are increasingly visible “*definitely a trend towards automation can be observed, which means that all these basic operations and activities done by the personnel, where we have shortages, [are automated], so it’s a positive trend for us*” (W6, WAW).

Clearly, the popularisation of new technologies may facilitate expansion of Polish businesses to foreign markets. It is also pointed out that while finding new clients abroad e.g. in the IT sector is not difficult, attempts at developing e-commerce initiatives on foreign markets are not always successful (e.g. Allegro in Germany). On the other hand, less attention is given to the potential threat posed by solutions being offered by huge corporations, which could affect the situation in many sectors. One possible protection against it is that some of them open their R&D centres in Warsaw, which enables Polish workers to take part in building their competitive position.

Depending on the sector, there is an observable variety of solutions associated with the fourth technological revolution, notably artificial intelligence.

In **e-commerce**, it is anticipated that the role of personalisation will increase, that is systems which recommend what clients should buy based on their profiles. Furthermore, there is a widespread view concerning the growing significance of bots used in interactions with clients; such bots will answer clients' questions and handle the orders for products or services. It is also pointed out that the acceleration of production and sale processes is very likely *“if you have several dozen brands in your portfolio, and each has hundreds of showrooms or retail outlets, and its own websites, social media, and so on. Analysis of such data by a human brain is practically impossible, at least at a speed that allows us to use feedback from such data for managing prices, promotions, and so on. This is an area where automation comes in, and it is also an area where you have very many algorithms” (W8, WAW).*

Another widespread opinion is the belief in the forthcoming revolution in the logistics and transport sector associated with the progressive automation of these processes. However, some opinions are more sceptic in relation to autonomous vehicles implementation underlining the possible obstacles related to climate *“That’s why I’m saying let’s forget about automatic cars, because it’s still science fiction, as these sensors cannot as yet cope with rain nor snow – not without reason they are tested in California, where it’s dry and you have nice weather. Therefore, I’d rather start with automation of the rail transport” (W11, WAW/PL).*

In the region

Labour market needs and qualifications

According to ILO forecasts, the global technological revolution and growth of artificial intelligence (**Ernst et al. 2018**) is expected to increase labour market polarisation, with some differences, however, dependent on the level of individual groups of countries. In highest-income countries there has been, and can still be observed, an increase in the number of highly qualified jobs, accompanied by a falling demand for medium-skilled workers and a stable number of workers with lowest qualifications. In parallel, in lowest-income countries, the greatest increase can be observed and is anticipated among low-skilled personnel, whereas in countries with low to medium level of income the number of jobs for highly qualified staff is expected to increase, but the number of jobs for medium and low-skilled workers is anticipated to fall rapidly. These predictions are confirmed by other forecasts for the USA and Western Europe (**MGI 2018**), which anticipate a considerable fall in demand for workers with physical and manual skills and basic cognitive skills by 2030, coupled by a lower increase in the category of workers with higher cognitive skills. Conversely, demand for workers with technological skills and those with social and emotional skills is anticipated to grow significantly. According to the authors, these changes are expected to balance out, not leading to any considerable increase or decrease in the demand for work expressed in hours. It is to be expected that this forecast may also be accurate for Poland.

The situation in the advanced services sector should not widely differ from this overall picture, which means that the demand for workers with low and medium skills is expected to fall since such activities

will be automated (e.g. accounting, banking), which could, in parallel, create demand for higher-qualified workers. At the same time, the enterprises that are leaders in implementing innovations will increase their market shares. Some doubts may be raised by the diversity in the enterprises sector, which should experience consolidation due to entities that do not keep up with technological change being pushed out of the market.

Staff shortages and matching education to labour market needs

Most respondents pointed to the growing, and potentially increasing, skills mismatch with regard to needs associated with introducing new technologies *“Mining the ‘Polish coal’ of the 21st century, that is engineers, programmers and software developers can’t keep up with the demand. Worse still, the lack of qualified workers is often experienced by most innovative startups, those which develop machine learning, neural networks, artificial intelligence and blockchain technologies”*. (Beauchamp et al. 2018). Improving the competences of current employees is also becoming a necessity *“These are not data analysts for whom pivot tables are the best they can do. These are data analysts who are able to use algorithms, who are able to use programs”*. (W3, PL/WAW) In effect, respondents point to the need to educate managers in the very understanding of the essence of the 4.0 technological revolution to enable introduction of relevant practices in that regard (DPF, 2019). On the other hand, there is an observable increased interest in training in new technologies even at the secondary school level *“the movement of people between individual sectors, and increased popularity in specialised training even at the secondary school level as far as technological sectors are concerned.”* (W1, WAW). Changes are also visible in tertiary education *“universities are increasingly aware that they need to partly collaborate with business and should get accustomed to it. What I would wish for is for all higher education institutions to have such a need, to send their students to some mandatory internships. So that they could see how you run a business, so that they know what will, in no time, happen to them.”* (W9, WAW)

Labour market future

Varied opinions have been expressed on the impact on the labour market, which could be summarised, on the one hand, that most respondents expect the number of employees in Warsaw 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 in Warsaw: 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 Warsaw 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. In general moderate polarisation of Warsaw labour market is expected (see Map. 5.7 in the Main Report).

Future threats related to new technologies

As regards threats, respondents, among others, pointed out the following aspects:

- Dropping out of the chain of production *“At the economic level, there is a threat that Polish enterprises will be pushed out of the value chains because if they fail to go digital, they might lose clients simply overnight. The change will be effected mainly through platform models.” (W3, PL/WAW),*
- Risk of oligopolisation *“at the end of the day, everything will operate through a small number of entities that specialise in developing various solutions in the AI environment.”* Also, a fall in the number of microenterprises in some sectors *“firms in our sector are not as yet changing their business models, and if we all don’t make a step into the future, there will be no business at all – what chances will a sole trader who does everything by hand have against an IT company that makes entries of records in an automated way? (W9/WAW)”*
- Automation that allows integration of services and development of CRM systems may significantly curb employment not only of low or medium-skilled staff but also of specialised and managerial staff *“Everything that is today regarded as valuable jobs, that is associated with combinatorics, logics and so forth, these are jobs that will not be done by humans. Even today, very many heads of huge companies are figureheads, politicians. Decisions are made by large software packages.’ (W6, PL/WAW).* One of the proposed solutions is to shorten the hours of work done by humans.
- Cybersecurity and deliberate disinformation *“in the social sphere, the level of cybersecurity poses a serious threat. Besides, we are sure to experience many more manipulations at the political and microsocial level.” (W6, PL/WAW)*

Another unquestionable challenge will certainly be the pace of change that can affect those types of activities that need long-term engagement, such as the teaching process *“For instance, a new area for innovation emerges, somebody starts a university programme for that innovation, commences the admission process and so on. These graduates will take at least 3 years to get a bachelor’s degree, so in these 3 years the innovation will develop so it does not need people to do the work, right? Or they will retrain some people to deal with it or, when these students graduate, the innovation will be gone. Because 5 years is really a long time today and everything can change in 5 years’ time”*

At the same time, there are opinions that the greater the knowledge about emerging technologies and their applications, the more optimistic the view of the future: *“Scientists agree that artificial intelligence will bring positive results, but those who actually do this artificial intelligence are the most optimistic, whereas those with lesser knowledge have more fears. Therefore, as the classic will have it, the smaller the knowledge, the greater the fear ” (W11, PL/WAW).*

3.1.6 Operational policy recommendations

The following operational recommendations for national/regional policy based on the result of research including opinions of interviewees could be formulated:

(1) 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. *“There is no access precisely to enterprises’ data, for example to do some application projects. [...] if there is no demand for these services, there is no awareness that data should be gathered in a specific manner” (W11, PL/WAW)*. 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 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.

(2) 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. *“And they are already thinking how to strengthen enterprises on the one hand, but also, on the other, how to strengthen the society so as to make it ready for these new technologies. Obviously, they invoke ethics a lot, but this is, well, seen everywhere in Europe, but as for us, in our strategy it’s only words so far, and I have a feeling that there are few actual activities being done on the ground. And they, they have a completely different approach, the issues they tackle are more advanced, and so are the questions they are trying to answer.”*

(3) 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. *“Such concrete solutions for the world of academia are lacking. Such a leading institute should be given support. The idea that circulates here is a bit Canada-like, to support several different bodies. Myself, I’m rather for an idea such as the NCBR [The National Centre for Research and Development], to have one strong institute in Warsaw, at the NCBR, at the NCN [The National Science Centre], at the University of Warsaw, several other higher education institutions, and together build once such centre where we can hire Poles today working with Open AI, give them really comparable salaries. If we have a virtual institute, which will become dissolved in the same, often petrified structures, in various locations, then this potential will be wasted. It should be a billion zlotys, a sizeable amount to attract an interesting professor from abroad, to grow” (W10, WAW/PL).*

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. *“And there (UK) they have a completely different way of thinking, the problems they formulate and the questions they try to answer are more advanced. An interesting example for me was how the Alan Turing Institute handled the question of data. They are no longer considering how to obtain data, structure them and so on. They are already considering how to store data, which data to store and who should make decisions on what data should be stored and what erased, because we have too many data” (W11, WAW/PL).*

(4) 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: *“The public sector, and in particular companies with a major stake of the state, should pursue such procurement and experiment” (W10, PL/WAW)*, 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.

(5) 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 Communication (KIKE), Polish Chamber of Information Technology and Telecommunications (PIIT), Digital Poland Foundation and the

Polish Promotional Logo Foundation “Teraz Polska”. In the future, the formulat could be expanded through the support of the public authorities, both nationally and regionally.

3.2 Podkarpackie region

3.2.1 Regional baseline

The relative position of the region in the national economy

Podkarpackie Voivodship is a unit of national and local administration, with the area of 17.8 thousand km² and population of 2.1 million. 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. While GDP per capita for the sub-region of Rzeszów, the “capital city” of the region, amounts to 87.6% of the national average, in border regions of Krosno and Przemyśl this ratio is only 57.7% and 52.8% (respectively). One of the reasons for this is very high share of agriculture in the labour market, which in conjunction with very low work efficiency in this sector indicates the size of its hidden unemployment.

The industrial sector, on the other hand, is very important in the regional economy; its role dates back to pre-war industrialization of this traditionally agricultural area and constitutes an important element of its economic base. Podkarpackie was part of the Central Industrial District (COP), the second largest Polish government development programme in the 1930s. The overriding objective was to strengthen the Polish economy, bring down unemployment and reduce the disparities between Polish regions resulting from the Partitions of Poland. The general idea of the COP was maintained even after WWII: most of the enterprises continued to operate after changing their profiles from military to civil purposes. The COP led to the establishment of several important enterprises, some of which operate until today in the Podkarpackie region. a steel mill and a power plant (Huta Stalowa Wola) in the brand new city of Stalowa Wola, a rubber factory in Dębica, an aircraft factory in Mielec, an aircraft engine and artillery factory and a machine tool plant in Rzeszów. At the same time, as a result of the COP scheme Podkarpackie and its surrounding areas obtained technical infrastructure which had been virtually absent: roads and railways, power plants and electric power grids, telecommunication infrastructure and gas pipelines. This policy of the Polish state created infrastructure and set up several branches of industry that are still present in the region.

Currently, the share of industry in gross value added of the voivodship amounts to 27.8% and in Tarnobrzeg subregion and Rzeszów subregion it amounts to 43.1% and 27.5% (respectively), as compared to the national average of 27.3%. Particularly well developed are aviation, automotive, electromechanical, biotechnology, IT and chemical industries. In view of the peripheral location of the region noticeable is the well-developed sector of higher education – Rzeszów, with its relatively low population (195 thousand people) is an important academic centre. This reduces the outmigration of students to other academic centres. The negative balance of migration after 2004 amounted to about 2.5 thousand a year, which corresponded to about 1 permille of the region’s population. Thanks to positive natural increase rate its negative impact on demographic structure of the voivodship is limited.

Consequently, the share of post-working age population, even though growing, is still relatively low when compared to the rest of the country (19.8 against 21.4%). Rzeszów itself, however, is one of the few Polish cities with growing population (net migration in recent years exceeded 1000 people a year) – importantly, however, this resulted to a certain extent from administrative expansion of the city. Significant outmigration, on the other hand, is suffered mostly by the peripheral gminas (communes) of the voivodship, generally those located in Krosno and Przemyśl subregions.

Islands of 4.0 revolution in the region

Podkarpackie is one of the regions where the spreading of new technological opportunities can be observed in the years 2010-15 in comparison to 2000-2009 (see Map 3.1 and Map 3.2 of the Main report). In the region there are islands of artificial intelligence solutions' adoption, occurring with various intensity and mixed effects. The processes are largely determined by specific characteristics of particular sectors and mechanisms typical for them (see Chapter 2.2). This can be said to happen in the form of islands of innovation, adopting 4.0 solutions faster than others and are already part of the technology revolution. The interviewees express that in the following words: as far as industry 4.0 revolution goes it is very difficult to talk about any broader regional structure. *We can discuss single cases of entities in the business universe. But those are not a common thing. We can hardly talk about any industry 4.0 revolution in agricultural or organic production or in the case of tourism (W7/PODK).* Large heterogeneity of Podkarpackie region in terms of intensity of business activity, industrial locations and attractiveness for investors has a significant impact on unequal adoption of the newest technology trends. This firstly results from the distribution of enterprises, which is uneven in the region. Strong concentration of entrepreneurial activity is typical for the capital of the region (Rzeszów), where almost one-fourth of the region's enterprises are located. This results from a higher 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. On the other hand, the Przemyśl and Lubaczów counties (poviats) located in the eastern part of the region are characterised by the lowest level of entrepreneurship. The same refers to the investment attractiveness of the region, which again is very low in comparison to the rest of Poland, but at the same time is the highest among the Polish regions located in the eastern part of the country (since 2010 Podkarpackie has been ranked 10th out of 16 regions in Poland). The Rzeszów subregion is regarded as a highly attractive investment location for high-tech industrial and service activity. Therefore Rzeszów and the north-western part of the region are undoubtedly change leaders. Enterprises in that region have been implementing industry 4.0 solutions for a couple of years. The eastern part of the region, however, whose internal potential is mostly based on tourism has not seen any technological revolution yet: Podkarpackie is an interesting region, since 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. *We can divide Podkarpackie into the South: Bieszczady mountains, tourism, eco-etno, and the North: Mielec, Rzeszów, i.e. companies reaching for top-notch technologies (W4/PODK).* Those differences in the level of technology adoption may deepen not only due to different

sectoral composition but also due to various levels of technological competences and readiness of the local communities to accept changes.

3.2.2 Adopted 4.0 technologies in the sector in the region

Development and profiles of technological startups

Even though Poland – unlike United States, China or most Western European countries – is not among the leaders in terms of the number of innovative start-ups, this sector of the economy has been rapidly growing in recent years. The growth, however, can mostly be seen in the largest cities, particularly in Warsaw. Based on **Crunchbase (2019)** database, created to track startups and containing information on innovative companies on a global scale, in Podkarpackie Voivodship there were only 38 such enterprises. For such a small number of enterprises it is difficult to determine their specific specialisation; the most important direction of development, however, include manufacturing (16%), ICT (13%) and e-commerce (13%). Among technology start-ups, there were, however, single instances of companies active in biotechnology, robotics or artificial intelligence

Importance of the industrial sector for regional economy is confirmed by the data on the application of particular technologies in Podkarpackie enterprises (**GUS 2018**). According to the data, 6.9% of enterprises used robots in industrial applications and services, mostly in traditional manufacturing (see map 3.11 in the Main report); the value was a bit higher than average for the country (6.3%), but still well below the most advanced regional economies of EU, as well as then Czech and Slovenia and Hungary (see Map 3.3-3.6 in the Main report) . 3D-printing was used by 3.1% of enterprises, which was the second result in the whole country, with Dolnośląskie Voivodship coming first. Podkarpackie enterprises significantly less frequently, however, declared conducting big data analyses: 5.8% against 7.9% for Poland.

Adaptation of AI-based solutions

Industrial enterprises are an important component in the economy of the Podkarpackie region. 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.

Podkarpackie fall into the category "4.0 producing regions" within the taxonomy of 4.0 inventing regions, as the exception among all eastern Poland regions and as one of 9 regions of this kind in Europe, (see map 3.2 if the Main Report), However, It means that Podakrpackie shows a patent intensity in 4.0 and in 3.0 technologies above the European average but is not specialised in 4.0 nor in 3.0 technologies. The level of adoption of industry 4.0 solutions differs depending on the industry. The aviation industry, representing almost 90% of the aggregate Polish production in the aviation sector, is considered the leader in the adoption of industry 4.0. There are several major companies located in the region which collaborate within the Aviation Valley Association, an aviation cluster that is unique in

Central and Eastern Europe. These include, e.g.: Pratt & Whitney-WSK Rzeszów, UTC Aerospace Systems, Heli-One, PZL Aircraft Mielec – Sikorsky and MTU Aero Engines. The aviation industry is largely structured around one company – a branch of global Pratt & Whitney company with headquarters in Rzeszów (former WSK Rzeszów). According to respondents, the company is the region's frontrunner in Industry 4.0 - the giant who started *"and that plays the leading role in all that"* (W1/PODK). The company has been adopting industry 4.0 solutions since mid-2017: Six months ago [June 2017] at Pratt & Whitney Rzeszów we started a systematic adoption of the fourth industrial revolution. In working teams we analyse and review: digital production plan, 3D-printing, inventory management with very advanced tools, or using augmented reality. *"These processes are extremely dynamic, which the respondents summarised as follows: technological development is taking place at a horrifying pace"* (W7/PODK). Another strong sector located in Podkarpackie is the automotive industry, with enterprises such as: Borg-Warner, Pilkington Automotive Poland, Lear, Federal Mogul, Kirchhoff, Goodyear and Uniwheels, just to mention a few. Both industries are highly industrialised and integrated within the global value chains. For instance, more than 40% of the total value of exports in the region is related to machinery and equipment, electrical and electronic engineering equipment, and almost one fifth of the value of Podkarpackie's exports comes from turbojets, turbopropellers and Other Gas Turbines.⁶ Automotive industry in the region is to a large extent subject to similar trends as the aviation industry "Borg-Warner is implementing these rules, which means among others that the machines while working are so well tuned together that when a tool is physically worn, so as to avoid shortages, the machine notifies the operator about the change that needs to be made, or necessary servicing that needs to be done, or changes in the bearings, settings, and so forth" (W7/PODK).

According to respondents' opinions, processes of industry 4.0 solutions adoptions have been ongoing for the last 2-3 years also in the IT sector: *We do that, most companies work precisely on mobile solutions or deep data analytics, on issues in big data and so on. And this is quite common* (W1/PODK).

3.2.3 Preconditions for transformation

Regional preconditions

The R&D sector

Podkarpackie Voivodship was characterized with relatively high expenditures on research and development activities as compared to its economic potential. In 2017 R&D expenditures per capita equalled 69% of the national average, even though not so long ago – in 2013 and 2014 – they were slightly higher than the average. Visible improvement, however, took place as compared to the period before 2008, when such expenditures were lower than 50% of the national average. In absolute terms, however, the voivodship's significance in the country is low, with only 3.8% of the total R&D expenditures. Annual R&D expenditures per 1 person employed in R&D amount to EUR 26 thousand, which matches the national average amount. At the same time expenditures amounting to 1.05% of the regional GDP put Podkarpackie Voivodship above the national average (109% of the average in 2016, reaching a record value of 148% in 2014). Those expenditures, however, remain far beyond the 3% provided in the Europe 2020 strategy. We can, however, see a positive trend of marked increase in the

value of this index (until 2009 the expenditures had not exceeded 0.4% of GDP). This mostly results from increased expenditures of the corporate sector, resulting in increase of their ratio to regional GDP from 0.50% in 2010 to 0.79% in 2016. Consequently the share of Podkarpackie region's corporate sector in R&D expenditures increased from 55% in 2010 to 85% in 2016, which was the highest value in the country. At the same time over half (52%) of R&D funds was spent by industrial enterprises, which shows significant role of this sector for expenditures as compared to others regions of the country (national average was 28%).

Cooperation between academia and business

Science-business cooperation in Poland is not particularly well developed. According to **Invenity (2018)** report the main obstacle are time-consuming and complicated formalities on the part of the academic institution (longer decision-making process, multiple university units responsible for action, difficulty in cooperation arrangements), followed by legal barriers and complicated and time-consuming processes of applying for external funding and their settlement (**Olechnicka, 2014**). Cooperation is most frequently initiated by companies, experiencing great difficulty in finding the scientist with the right specialization interested in undertaking implementation works – since entrepreneurs prefer to have direct contact with a specific scientist. The obstacles on the part of the university are well reflected in statement from one of our interviewees: *the science-business cooperation platitudes are far from reality. When someone needs to do a simple research at the university, the procedures are impossibly long. Not only procedures, but also availability of researchers in connection with holidays and the whole academic calendar (W3/PODK)*. The situation according to some interviewees has been improving, particularly in terms of the universities adjusting to market needs: *universities realised that some fictitious faculties that do not guarantee employability or certification will be something no-one will ever try again and that things will be going towards cooperation with business, real cooperation, allowing us to respond to labour market needs, but only in such close collaboration, which also applies to the future (W3/PODK)*.

It should be noted that Podkarpackie Voivodship, despite generally unimpressive R&D expenditure levels, is a leader in Poland in terms of share of the R&D expenditure financed from the business enterprise sector in the total R&D expenditure. For last 15 years Podkarpackie has been the leader in that respect. The interviewees express it as follows: *70%, or 60%, of the funds available to a technical university in Rzeszów are funds coming from the market. External business from companies result in the university doing commercial research, right? (W7/PODK)*.

Use of ICTs in public administration and households

In Podkarpackie Voivodship 61.5% (2017) of public administration units had broadband Internet access. However, the voivodship was one of the weakest regions in terms of availability of mobile devices with Internet access to employees of public administration (11%), while in the whole country this was on average 17%. Moreover 31% of public administration units declared using intranet (nationwide 38%), and over 70% of them used electronic document flow. Open data access policy, on the other hand, was not common – it was used by only 3% of public administration units, similarly as availability of

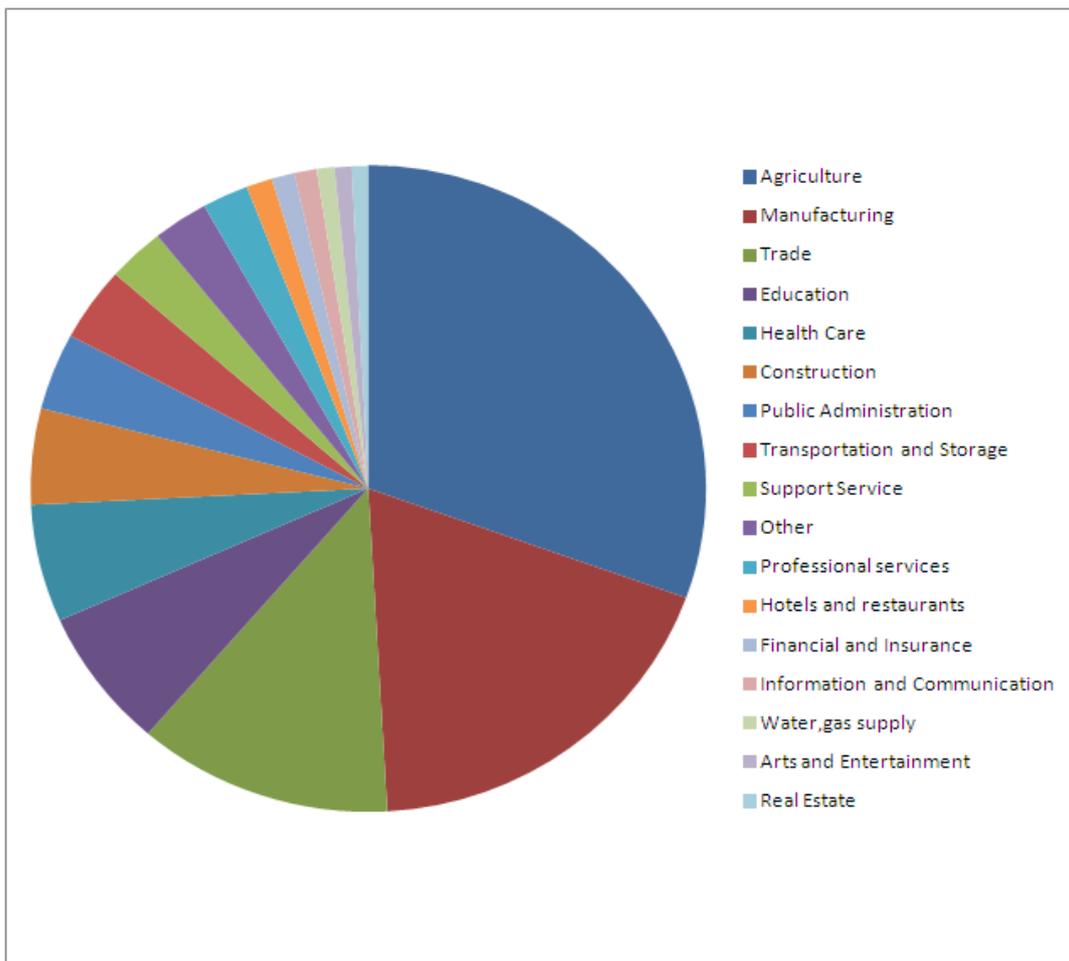
downloadable mobile applications. Better, on the other hand, was the adaptation of authorities' websites for mobile devices (63%).

About 36% of employees in Podkarpackie enterprises used computers and 31% of them had Internet access, which was a result significantly worse than the national average, which was 46% and 41% (respectively); consequently, the results was similar to that in Romania, which holds the penultimate place in the EU in that respect. Computerization was larger in households. Over 85% of them had computers, and about 70% of inhabitants of the region regularly used them. Internet access on smartphones was even more common - 86% of households declared having Internet access, which corresponded to the EU average (87%), and 80% among them had broadband access. Thanks to the new opportunities the share of people ordering goods and services online kept rising and in 2018 amounted to 40%.

Labour market structure and development

Manufacturing was undoubtedly the most important factor for the economic base of Podkarpackie region, coming second (after agriculture) in terms of employment (18%). Agriculture's share was 30%, but due to small size of farms and low efficiency of agriculture as compared to the number of its employees it should be treated as a potential source of labour force for other sectors, and not a sector contributing to the development of regional economy. 158.6 thousand people worked in manufacturing, constituting 26.7% of the total employment outside agriculture, as compared to the nationwide 21.3%. (Figure 3-6). Important in terms of the location quotient, apart from the industrial sector, were only the sectors traditionally treated as public services, such as: healthcare, education and public administration, also having very significant share in the regional labour market.

Figure 3-6. Labour market structure in Podkarpackie Voivodship in 2017 (in %)



Source: Compiled by the author based on CSO data.

Since 2013 employment in non-farming sector has been growing dynamically throughout Poland, which is particularly pronounced when compared to the period directly following the 2008 global crisis. In 2013-2017 the rate of employment in Podkarpackie Voivodship increased by 11.1% as compared with nationwide 12.6% increase. This resulted from the fact that in Podkarpackie Voivodship 12 thousand new jobs were created annually in 2013-2018, and in the record year 2017 – as much as 17 thousand of new jobs. Therefore the rate of increase in the number of new jobs since 2013 exceeded the pre-crisis 2008 level, when only 9 thousand new jobs were created. For comparison, on average only 1 thousand new jobs were created in 2009-2012 (including a decline by 9 thousand in 2009). This translated into a decline in the registered (official) number of unemployed persons, which shrunk from 154 thousand to 82 thousand, i.e. lower than in 2008, when it amounted to 115 thousand. This resulted in the lowest rate of regional unemployment since 1989, amounting to 8.8%, which was still 3 points higher than the country average. However a certain lack of match between the offered academic courses and the market needs is probably confirmed by increased share of people with higher education among the unemployed – from 9% (2008) to 15% (2018), and only in Rzeszów up to 26%.

Sectoral preconditions

Innovation in enterprises

On average about 16% of enterprises from Podkarpackie region declared having implemented innovations in the last 3 years. Over 90% of relevant expenditures were made by manufacturers, which corresponded to about 5.1% of the total of those expenditures nationwide in the industrial sector. A significant growth was observed in the share of funds used for R&D works, which constituted 39% of the total expenditures for innovative activities (in 2011 this was only 23%). Therefore the value of R&D works approached the amount of funds spent on purchase of innovative machinery and equipment – which in 2006-2017 amounted to about 50% of expenditures (about 40% of which were spent on imported machinery and equipment). Other expenditures for innovation were connected among other things with purchase of software, training personnel or marketing new and improved products. Those categories, however, were quite marginal in terms of their share, amounting to: 1.5%, 0.3% and 2.1%, respectively (with a decline tendency seen in the last case, which stood in opposition to the situation seen in e.g. the capital region).

Conducting innovative activity quite closely related to the size of enterprise. In Podkarpackie region 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 – in Podkarpackie Voivodship most willing to introduce innovation were foreign entities (almost 50% of them); this, however, could result from the fact that these companies were typically larger than entities with Polish ownership. At the same time it should be noted that the share of new or significantly improved products in the total value of sales dropped from about 20% in 2005-2007 to about 12% in 2017, which, however, was a general tendency observed in Poland. This could result from spreading of certain solutions, making them to no longer perceived as innovative, as well as from faster process of generating innovations.

Practically complete computerization of enterprises in Podkarpackie region (96%) is not accompanied by use of all the opportunities offered by the Internet. Only 72% of companies had their own website. Moreover only 12% accepted orders through the Internet and 30% used it in purchasing. Similarly as in the rest of the country, the cooperation with the science sector was quite poor. Cluster initiatives, on the other hand, in the last 3 years involved from 10% to 20% of small and medium-sized enterprises, which was a much better result than the national average (which was about 10%). This results from presence in Podkarpackie of strong clusters, with impact exceeding the regional borders: Aviation Valley, East Automotive Alliance, IT Company Cluster. But this also results from the requirements to obtain EU co-funding.

Patent activity of companies from Podkarpackie was, however, very limited. In 2018 there were 202 patent applications filed in Podkarpackie region, two-thirds of which were approved. This results in 6.3 patents per 100 thousand population. Even though the situation in this respect over the last 10 years improved significantly (2.3 patent in 2009), the activity was still lower than the national average (7.6 patent) and many times weaker as compared to the European average.

Salaries

Low salaries in Poland in comparison to Europe (ca EUR 1200 monthly per employee in 2018) have been, and still are, a key constituent of the competitiveness of Polish enterprises and a major factor attracting inward capital. However, over the past 2 years this situation has changed considerably due to a rapid salary increase (by 16% in 2016-2018) and pay differentiation across both occupations and regions. Salaries of professionals are typically more than 120% of the average salary, while salaries of workers employed in industrial processing are about 20% lower than the average. This gap is even better visible if we compare the sections of economic activity. While the salaries in the Information and Telecommunication section represented 175% of the average, in industrial processing (including professionals and managers) they were at the national average level. Reducing the pay pressure in Podkarpackie in the case of elementary occupation was facilitated by a relatively rate of registered unemployment compared to other regions, the potential to change the labour market structure due to the outflow of workers from inefficient agriculture and the inflow of migrant workers from Ukraine. However, the situation concerning professionals and specialists is different: Podkarpackie has to compete for such workers both with metropolitan areas in Poland and with other countries.

Social preconditions

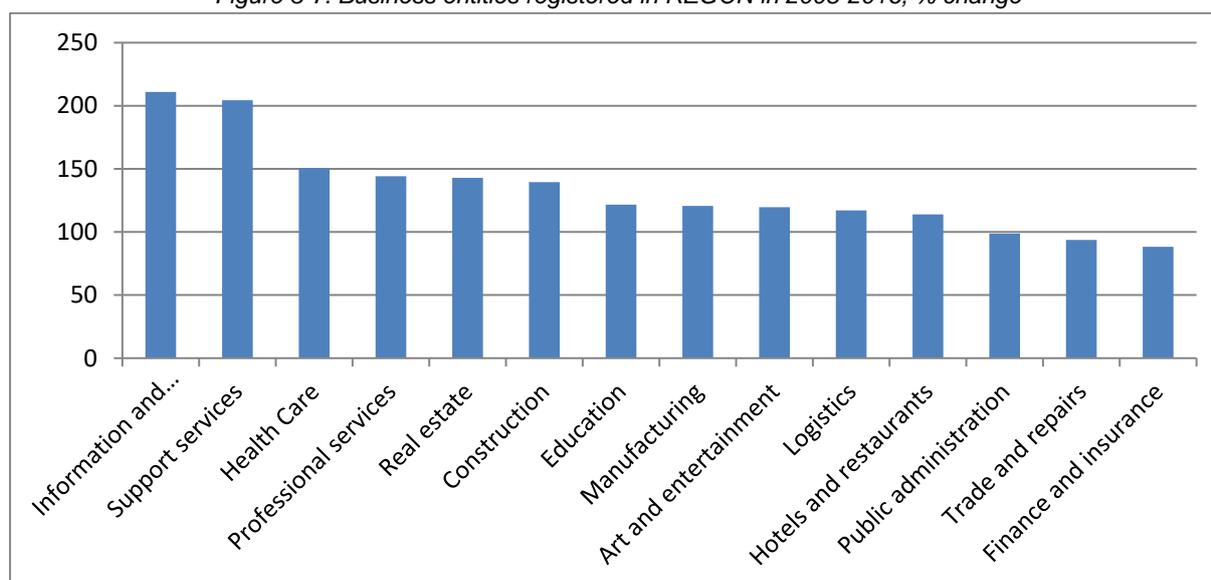
Education

In 2018 in Podkarpackie Voivodship at public higher education institutions had the total of 36.4 thousand students (4% of all students in Poland), in the following disciplines: a) engineering and technical 6.3 thousand (17.5% share, decline by 0.9 percentage points). b) ICT 1.5 thousand (4.2% share, increase by 0.4 percentage points), c) physics, mathematics and statistics 0.6 thousand (1.6% share, decline 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 Rzeszow. Summing up, the influx of graduates with skills potentially useful in technological transformation to the Podkarpackie labour market can be estimated at about 3 thousand per year, which corresponds to about 0.5% of the total employment outside agriculture.

Entrepreneurship

In Podkarpackie region there were 174 thousand registered businesses, of which over 95% had less than 10 employees. Their number in 2008-2016 increased by about 20%, while the average increase throughout Poland amounted to 16% (Figure 3-7). Just as in Poland at large, the fastest increase was visible in the IT/ICT sector and in support service activities, in which the number of businesses grew twofold. The number of businesses operating in healthcare, professional, real estate services and construction sectors has increased by half. A considerable 20% growth could also be observed in manufacturing activity, which was two times as high as the country's average. Overall, the share of this section in the aggregate number of enterprises totalled ca 9.5%, being surpassed only by two other Polish regions. This could suggest that the industrial clusters operating in the region might have a positive impact on the development of enterprise in this particular section.

Figure 3-7. Business entitles registered in REGON in 2008-2016, % change



Source: Compiled by the author based on CSO data.

Policy preconditions

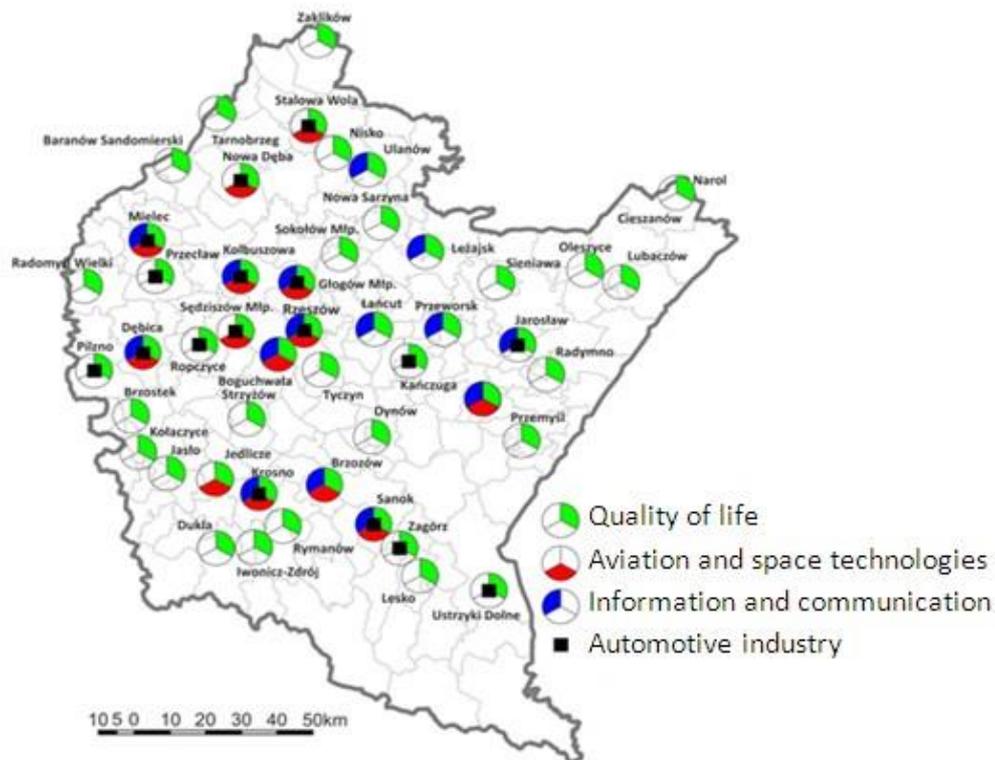
A policy that responds to the challenges of the 4.0 technological revolution in Poland is a matter of the recent years, with a major role being played by regulations at the national level. Industry 4.0 is one of the priority areas of the Strategy for Responsible Development Until 2020 (**SRD, 2017**) – a document that defines the future directions of Poland’s development until 2030. The Strategy recognises activities related to the development of Industry 4.0 as crucial for improving the competitive standing of Poland’s economy. The first area of intervention, that is Reindustrialisation, stipulates development of technical infrastructure and competences for Industry 4.0. The Strategy heralds the creation of the Polish Industry 4.0 Platform that will support industrial transformation towards digitisation of technological and management processes in enterprises. This process will notably include reconstruction and integration of infrastructure based on the forecasts concerning development of the market for the Internet of things, RES (renewable energy sources), fossil fuels, energy warehouses and electric cars post 2020. Activities related to Industry 4.0 envisaged in the Strategy are horizontal in character. The diagnostic part of the Strategy identifies changes on the labour market that include, among others, replacing human labour by high technologies and increased demand for workers with new qualifications and skills. Therefore, it anticipates a number of measures to support vocational education and training for the needs of Industry 4.0, as a precondition for making a leap into the future by the Polish economy. The Strategy proclaims implementation of a project entitled “*Modern human resources for Polish industry*”, which combines education and vocational placements at the employers’ establishments; active involvement of industry in preparing school curricula; development of practical training centres and vocational qualifying courses. The Strategy broadly discusses the determinants that may have an impact on whether the set objectives will be attained; among such factors, it lists digitisation in addition to human and social capital, transport, energy, environment and national security.

The key strategic document in Poland that in its entirety discusses issues of the technological revolution and applications of 4.0 technology is The Policy for Development of Artificial Intelligence in Poland for the Years 2019-2027 (**PDAI, 2019**). The document that provided the foundation for formulating the strategy was an action plan prepared in late 2018 by the Ministry for Digital Affairs, entitled Assumptions for AI Strategy in Poland (**AAIS, 2019**). The plan to promote a “data-based” economy in Poland was laid out in 3 perspectives: short-term (up to 2 years); mid-term (up to 6 years) and long-term (until 2030). In the short-term, it is recommended to undertake educational activities on the “learning by doing” basis; in the mid-term perspective, the document recommends first and foremost commencing activities that would enable the Polish economy to escape the equivalent of the “middle-income growth trap” in a data-based economy, and, in the long-term, public policy should focus on building a lasting, global domination of Polish enterprises in selected specialisations.

The aforementioned strategy entitled The Policy for Development of Artificial Intelligence in Poland for the Years 2019-2027 is an unofficial document, currently in the process of social consultations. Similarly to the national AI strategies of the EU Member States, this document was prepared in line with the recommendations laid down in the 2018 Communication from the European Commission, entitled Artificial Intelligence for Europe, whereas the deadlines for the formulation of these documents were provided in the European Commission’s Coordinated Plan on Artificial Intelligence. That material was prepared by an interdepartmental analytical and editing team, set up pursuant to the memorandum adopted on 26 February 2019 by the Minister for Digital Affairs, Minister of Entrepreneurship and Technology, Minister of Science and Higher Education and Minister of Investment and Economic Development. The key premise of the policy to develop Artificial Intelligence in Poland in 2019–2027 is to secure the best possible role for Poland in the global value chain, which is increasingly determined by technologies and applications of artificial intelligence. The Strategy identifies Poland’s potential for a dynamic shift from being a challenger to an AI leader, with the “+PL” brand that is recognised in international markets. Looking to the year 2025, the aim for Poland is to join a small group of 20-25% countries that develop AI. In practice, it means that the sector developing artificial intelligence must grow 25-fold. Such a strategy will help minimise the negative consequences for the labour market. As priority sectors where AI is expected to produce most benefits, the Strategy identifies industry, medicine, transport, logistics and energy sectors, and, secondly, state administration, commerce and marketing, construction and cybersecurity. The document defines the key activities for attaining this objective related to organisational, topical and financial infrastructure. These include, among others, the creation of the Future Industry Platform aimed to coordinate the cooperation of entities taking part in the process of digital transformation, such as the operation of digital innovation hubs, the learning factories and virtual research teams. The Strategy promises support to the Industry 4.0 processes: in institutional aspects, in the form of the Polish Computation Centre; in advisory aspects, in the form of the Observatory of International Policies on Artificial Intelligence and Digital Transformation; and in legislative aspects, in the form of the Virtual Chair for Ethics and Law at the ministry competent for IT matters.

The regional strategy for industry, formulated by the Marshal's Office in 2013 in the Regional Development Strategy, was updated and further developed in 2015 as part of the Regional Innovation Strategy (**RIS3 2016**). The main reason to do that was to adjust the regional policy to the new smart specialisations approach adopted by the European Commission. The smart specialisations catalogue for the region was further updated in 2016. The RIS3 had to be updated because of the need – identified as a result of an entrepreneurial discovery process – to expand the catalogue of the region's smart specialisations with the automotive industry. Currently, the document identifies four main sectors of major importance for the development of the Podkarpackie Voivodship, reflected in the region's smart specialisations. Development objectives for Podkarpackie consisted in becoming 1) a leading aviation, space and communication technologies innovation centre in Poland; 2) a region with a superior quality of life, particularly in terms of energy resources and sustainability initiatives in the energy sector; 3) a leading region in terms of generating and implementing innovative automotive technologies and manufacturing of top quality vehicles and auto parts with 4) widespread application and development of ICT . The updated Regional Innovation Strategy 2014-2020 for the Podkarpackie Voivodship did not specify the financing options or the expected amounts for specific operational initiatives. It only generally indicated programmes and priorities that could provide financing for the implementation of specific operations in the future. It was, however, clearly stated that the core funding for the initiatives envisaged by the operational plans would come from the Regional Operational Programme for the Podkarpackie Voivodship. The financial resources available under the national and trans-regional operational programmes were also taken into account, as well as the possibility of applying for financing from the Horizon 2020 Programme.

Figure 2.9 Location of smart specialisation enterprises in Podkarpackie



Source: Wais P., a presentation in the Ministry for Investment and Economic Development

In response to the uneven territorial distribution of entrepreneurial activity, also in all respects of smart specialisation (see Map 1), the regional authorities prepared two operational documents supplementing the Regional Development Strategy – Podkarpackie 2020. The first one is dedicated to the development of the Bieszczady Mountains, the second to the development of the municipalities located along the San River (**PSRB 2014; PSBS 2014**). Both strategies are to ensure effective use of own regional potential for the sake of economic growth and improvement of the quality of life. The strategies have no dedicated budget – instead, they are implemented as part of state and regional operational programmes; for instance, projects carried out by beneficiaries located in the strategic subregions get preferential points in the competitive procedures under the Regional Operational Programme. Recently the Programme for the Bieszczady Mountains has also been introduced on the state level.

Based on the analysis of the Regional Operational Programmes for 2007-2013 and 2014-2020 the major changes regarding industrial strategy can be summarised as follows:

- Increased focus on innovations in the enterprise sector, at the expense of e.g. purchase of basic equipment by small enterprises,
- Higher specificity and focus of the Programme's funds – reduced number of smart specialisations,
- Focus on equal educational opportunities for children and youth; modernisation and adjusting vocational education and training to the needs of the regional labour market,

- Increased significance of environment and energy issues, mostly that of improving energy efficiency and increasing the share of renewable energy sources in the energy balance.

The latest initiative related to the industrial policy of the Podkarpackie Voivodship has been creation of the Polish Cluster of Industry 4.0 in October 2017. The founding members of the cluster include the Rzeszów University of Technology and five enterprises located in the Podkarpackie Voivodship: Dopak, Splast, SVLR, GenPlast and RDC Materials. The cluster aims at supporting enterprises in the process of implementing Industry 4.0 solutions in terms of information, competencies and technologies; it also aims at promoting business-to-business and business-to-science networking. Among the cluster's initiatives was a conference held in February 2018, focused on innovative business software and particularly on prototyping⁸¹.

3.2.4 Actual transformations in the region

Economic transformation

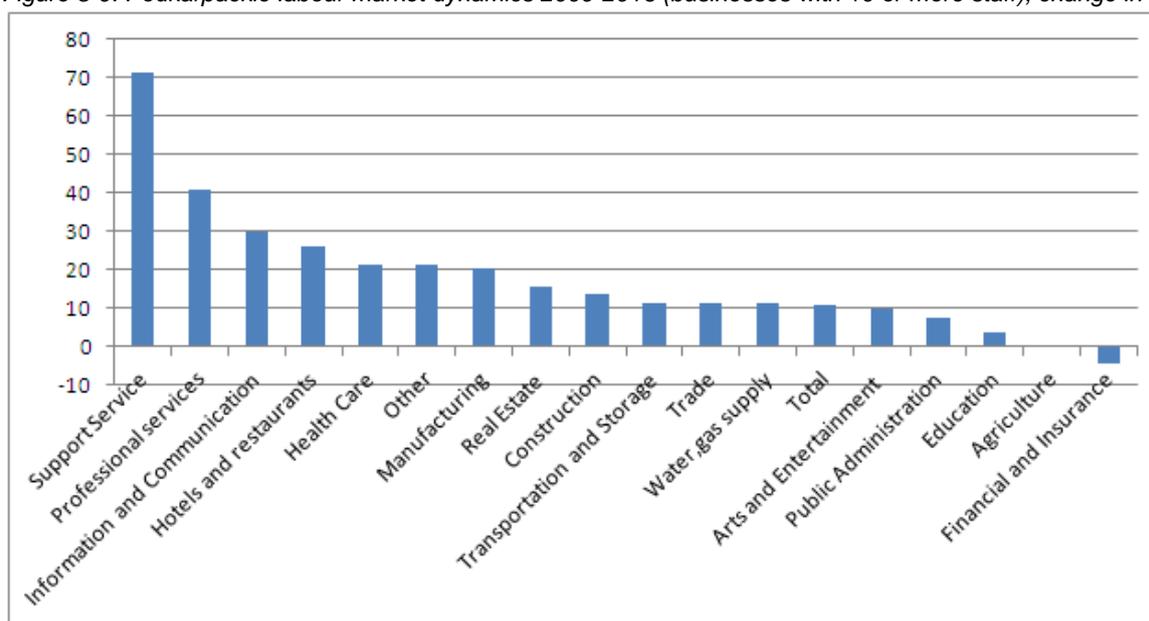
Labour market transformation

In absolute terms in 2008-2016 the highest number of new jobs (26 thousand) appeared in Podkarpackie industry, with increase in employment figures by 20% (Figure 3-9). Following a 2009 decline in the number of people employed in manufacturing due to the global economic crisis for three years employment in this sector remained at about 135 thousand. Since 2013, however, there was a rapid growth, on average amounting to 5 thousand people per year, and in the last two years exceeding 7 thousand persons.

Relatively faster employment growth than in 2008 took place, however, in business services such as: administrative and support services (also including some of the technology start-ups) (71%), professional services (40%) and information and communication (30%). Their development (total of 17 thousand new jobs) can at least partly be attributed to externalizing manufacturing sector services, even though some of this increase may be assumed to also result from increased demand from clients from other voivodships. Faster than average growth also took place in basic services, including: transportation and storage services, trade, as well as construction and real estate services. This could at least partly result from a good situation in the industrial sector.

⁸¹ Based on: <http://industry40.edu.pl/>; <http://gospodarkapodkarpacka.pl/news/view/22600/w-rzeszowie-powstal-klaster-industry-4-0>.

Figure 3-9. Podkarpackie labour market dynamics 2009-2016 (businesses with 10 or more staff), change in %



Source: Compiled by the author based on CSO data.

Internationalisation of enterprises

As mentioned above, the leading enterprises operating in the region's key industrial sectors, aviation and automotive industries, are heavily internationalised. Small and medium-sized companies in the region are dependent on orders from a larger partner; they would not have been able to join the global value chains alone: *a company in Krosno makes bolts that end up in some plane. They wouldn't get there by themselves, it all depends on "Sikorski" from Mielec, or "Pratt Whitney" from Rzeszów, who allow or even encourage them to do that (W1/PODK)*. The structure of aviation industry concentrates around big players and those, who themselves are contractors of a global corporation. Processes accompanying the adoption of the Industry 4.0 solutions are expected to make these linkages even stronger. The Aviation Valley companies focus entirely on the global market, and thus their business is largely dependent on externally imposed technological trends. They start the adaptation processes in advance – in terms of technology, organizational structure and staff. At the same the aviation industry has significant inertia when it comes to adoption of innovation and is more vulnerable to threats – economic, political and technological – coming from external markets: *the inertia of aviation industry processes is high; once a process is approved it does not change that easily (W8/PODK)*.

The development of information economy in Poland significantly facilitated the internationalisation of enterprises operating in the IT sector. This trend is also visible in the Podkarpackie region. At the same time the mechanisms of making changes are different due to different structure of the industry. The reason is different structure of that sector, dominated by the small and medium-sized companies focused in Podkarpackie IT cluster. *Most of us are small and medium-sized companies, quite similar to one another, their work area is quite similar, which makes communication and cooperation between us relatively easy (W1/PODK)*. These companies stated to reorient their activity on international markets

by offering services to international clients. The industry sees specialization processes, strengthened by personal contacts between the members of the cluster: *I took a deliberate decision to stop dealing with e-commerce issues and now I know a CEO of a company dealing with e-commerce. If it turns out that my client have built a hotel I have a hotels guy. If they need fibreoptics I know guys who do that, so I don't need to deal with that myself. Such cooperation is based on more friendly terms, which translates into higher quality of the cooperation (W1/PODK).*

Cluster activity

Cluster initiatives in Podkarpackie are very strong. Accordingly to statistics on innovative enterprises in the last 3 years the share of small and medium-sized enterprises involved in clusters raised from 10% to 20%, which was a much better result than the national average (about 10%). This results from presence in Podkarpackie of strong clusters, with impact exceeding the regional borders: Aviation Valley, East Automotive Alliance, IT Company Cluster, Renewable Energy Cluster. There are also some newer initiatives more directly related with technological transformation, namely 4.0 Industry Cluster and Cluster of Unmanned Systems⁸². The development of clusters results also from the requirements to obtain EU co-funding.

Interesting conclusions follow from analysis of ambiguous role the interviewees ascribed to the technologically leading aviation sector in terms of technological revolution. On the one hand they mentioned the significant role of change leaders, including Pratt&Whitney and the Aviation Valley Association. At the same time Marek Darecki, President of Aviation Valley and President and General Manager of Pratt & Whitney Rzeszow, is depicted as a local leader with vision not only for the aviation sector, but also for the regional development directions, able to influence vocational training in the region and improve the global perception of Podkarpackie (see 3.2). *“Success is made by leaders. Founding of the Aviation Valley Association by Marek Darecki and a group of aviation industry enthusiasts initiated rapid, almost snowball, growth of enterprises, very often family businesses, small and micro-companies, cooperating with the giants. The companies developed specialization in production of subtle details necessary in aviation (W7/PODK).* On the other hand interviewees notice various downsides of this situation, like internal competition within the aviation sector, technology changes depending on outside decisions taken in the home corporation of the parent company and limitation of freedom of development in this respect.

Operation of the clusters in Podkarpackie might be a good example to demonstrate that technological development must be followed, or rather accompanied, by organisational solutions that would also be shared by the cooperating companies: *strong leadership, but based on partnership, leads to creating a kind of organizational culture (W7/PODK).* Consequently, unification of companies in the production chain – making their operation highly standardized – is inevitable: *we now get back to the model of a*

https://cluster.unmannedsystems.eu/about_us/

steam engine driving the whole company. And now cooperation between various businesses will be so unified that they will effectively function as one company (W8/PODK).

Business environment for start-ups

In the recent years, several locations with a conducive climate for startup development have been established in Podkarpackie. In particular, these include the Technological Incubator and Academic Preincubator in the Aeropolis Podkarpackie Science and Technology Park in Jasionka near Rzeszów. *“There are many interesting things taking place also in those small businesses of ours, startups with teams of 5-8; here in the Incubator we also have firms working with AI” (W3/PODK).* These are both IT startups, for which such business incubators are set up in the first place, and businesses from the aviation sector. Podkarpackie has successfully launched the second round of a programme addressed to startups, entitled “Platforma Startowa Start in Podkarpackie”⁸³.

One example of the incubator’s operation is the emergence in the region of a new, robustly developing branch at the intersection of IT and aviation industry, i.e. unmanned aerial systems (UAS). It is anticipated that in 2030 the sector will generate 10% of overall income from the aviation industry in the EU and will offer thousands of jobs. In Podkarpackie, the UAS sector includes manufacturers (over 15), software developers, training companies and a research centre affiliated to the Unmanned Systems Cluster. Also, the Rzeszów University of Technology is an active player in the sector’s development. The Podkarpackie (Rzeszów) RDA represents the sector in the INTERREG project entitled “Aerial Uptake - removing barriers to the uptake of innovative unmanned aerial systems in the EU”, launched in September 2019 and aimed to map out potential applications of unmanned systems, e.g. in public safety, logistics, environmental protection and monitoring, agriculture and medicine⁸⁴.

A major challenge facing the institutions and programmes supporting startup development is how to encourage their cooperation with larger businesses. Cooperation with firms that are subsidiaries of international corporations is extremely demanding and requires many decisions and approvals to be made at a higher level, whereas cooperation with Polish firms often even does not get off the ground at all because startups are not regarded as equal partners. *“I won’t even mention those corporate bodies because these involve complex decision-making processes, which makes collaboration with them extremely difficult. And, [as regards others] the still persisting mindset is: what do I need cooperation with a startup for if I can employ those three boys myself instead” (W3/PODK).* Cooperation programmes should be construed in such a way as to minimise the risk of oligopolisation in the process of small business reskilling.

Social transformation

New jobs and role of skills

⁸³ <https://www.parp.gov.pl/component/grants/grants/platforma-startowa-start-in-podkarpackie>

⁸⁴ https://www.biznesistyl.pl/biznes/biznes-na-co-dzien/8937_.html

According to the authors of the report on the assumptions of the AI strategy in Poland (**Ministry of Digital Affairs 2018**) participation in processes of AI development and not only in the implementation of AI-based solutions is crucial for the situation on the labour market since, according to estimates, every 100 liquidated jobs (of consumers) will create about 130 new jobs for AI programmers. *“This has been discussed practically since the 19th century, that is the industrial revolution began and people believed that using machines and other devices in manufacturing will decimate the number of workers in factories. In reality, it proved very wrong. Now new occupations are being created and we can be relatively at ease, even if an occupation or trade will become outdated it might re-emerge in a wholly new form”* (**W7/PODK**). In the short term, however, the labour market may be adversely affected. Not all interviewees, were optimistic about the impact of the Industry 4.0 on the Podkarpackie labour market in a short term: *I’m afraid that there may be a big problem here. So that it isn’t too... so to say... too harsh”* (**W8/PODK**).

According to ILO forecasts, the global technological revolution and growth of artificial intelligence (**Ernst et al. 2018**) is expected to increase labour market polarisation, with some differences, however, dependent on the level of individual groups of countries. In highest-income countries there has been, and can still be observed, an increase in the number of highly qualified jobs, accompanied by a falling demand for medium-skilled workers and a stable number of workers with lowest qualifications. In parallel, in lowest-income countries, the greatest increase can be observed and is anticipated among low-skilled personnel, whereas in countries with low to medium level of income the number of jobs for highly qualified staff is expected to increase, but the number of jobs for medium and low-skilled workers is anticipated to fall rapidly. These predictions are confirmed by other forecasts for the USA and Western Europe (**MGI 2018**), which anticipate a considerable fall in demand for workers with physical and manual skills and basic cognitive skills by 2030, coupled by a lower increase in the category of workers with higher cognitive skills. Conversely, demand for workers with technological skills and those with social and emotional skills is anticipated to grow significantly. According to the authors, these changes are expected to balance out, not leading to any considerable increase or decrease in the demand for work expressed in hours. It is to be expected that this forecast may also be accurate for Poland.

In Podkarpackie region’s industry the situation should not differ from this general picture. This means that 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: *the demand for less qualified workforce in industry will decrease, while the demand for highly qualified employees will naturally rise. Indeed, there must be a lot of smart, intelligent and well educated people* (**W8/PODK**). However, the displacement of low-skill jobs might be above the average and the displacement of the high-skill job - below the average (see map 5.7 in the Main report).

Quite common is the perception on incoming industrial revolution in logistics and transportation sector in connected with increasing automation of those processes. A profession that will undergo automation in the first place will be, for example, that of a computerized numerical controlled machining tools operator: quite recently demand for CNC operators was high and a couple of years ago the profession

seemed to have big future. But 4.0 revolution will eliminate it entirely (W8/PODK). Those trends will have to be reflected in adjusting the educational offer: I'm telling the 4th year students of logistics: *you can be in this profession only for a while and then look for something else for yourselves (W4/PODK).*

The answers of interviewees are usually full of optimism connected with faith in technological progress and its ability to generate new professions: *"the world made such a great progress, because each subsequent level generates new needs, generates new jobs, generates new professions, generates new needs and opportunities" (W1/PODK).* It was pointed out that there exists potential for new jobs being created in services, in administration and in broadly understood security. *"Technological growth in all areas will require supply, provision of services by the administration, and will also require all those security systems. There will certainly be crime. Crime understood as data theft, national security (...). So these are sectors where employment will surely grow" (W7/PODK).* Examples of new occupations likely to emerge with the technological transformation which were listed by the respondents include e.g. UAS operators. Furthermore, the respondents expected that some occupations will be transformed depending on their specialisation, as for example in the case of IT professionals. Following the automation of manufacturing processes, the profession of IT specialist is becoming separate from that of the operator. *"There are fewer such IT guys, there's no need for them. They get a tool and become 'smart' in it, and the rest are people with some rudimentary skills only. This is a question of transition from a 'do-all' IT guy to a highly specialised one" (W4/PODK).*

Role of regional science and universities

The region's potential in science is not sufficient for developing 4.0 technologies on its basis. The report of National Information Processing Institute (OPI) and Digital Poland Foundation (DPF): *Map of Polish science in the field of AI* confirms that scientific sector of Podkarpackie has a minor role in processes of AI knowledge creation in Poland. Among 6.5 thousand of Polish researchers, who published scientific articles on AI in the years 2013-2018, only 155 were affiliated in Podkarpackie region. However the number of these researchers is the highest among other peripheral regions of Eastern Poland. Interestingly, apart from Rzeszow- the capital and the biggest academic centre in the region, smaller centres of Jaroslaw and Krosno are present on the Polish map of research related to AI. The most important universities, where at least 6 scholars representing AI research are affiliated are: non-public University of Information Technology and Management in Rzeszow (35 scholars), University of Rzeszow (51) and Technological University of Rzeszow (64). According to OPI report UITM has the biggest institutional potential to create the knowledge in the field of AI. Three AI centres are operating at that university in Applied Computer Science Faculty Department of Applied information Systems: the first specialised in new neural networks architecture with particular focus on memory, the second specialised in robot navigation applications and the third dealing with agent systems⁸⁵.

⁸⁵ Map of Polish Science in the field of AI, OPI, Digital Poland 2019.

The region has many promising cases of inclusion of enterprises in shaping educational offer of universities oriented towards development of Industry 4.0, as well as initiatives of enterprises with broad influence on vocational education, initiatives of regional clusters: Aviation Valley (12 Regional Centres for Innovation and Technology Transfer) and East Automotive Alliance (Podkarpacka Akademia Motoryzacji [Podkarpackie Automotive Academy] – innovative vocational training), dual studies on non-public University in Rzeszow and Rzeszow Technical University, Erasmus + SKY 4.0 project with the participation of Aviation Valley.

Universities in Rzeszów are open to cooperation with industry. One of the reasons identified by the interviewees is a growing challenge posed by origination of new technological trends in the industry, and not at universities. What happens is an interesting change of roles in this respect between the business sector and educational sector, typical for Triple or Quadruple helix systems. One of the interviewees expressed this in a following manner: *“when I was graduating I was valuable for industry and had no problems finding a job (...) I was expected to work at companies and everyone said they needed people knowledgeable in recent technologies, since you had then at the university. It was actually true, you would translate books, manuals, teach students, there were new devices, especially measurement devices. And the companies received those new things and us. And now we, the academics, catch up with the companies, meaning the high-tech is in those companies, and we just try to understand it somehow, describe and maybe do something with it – but all that is one step behind. And what needs to be done is for the university to be up-to-date, to participate in creation. So I think this is the best answer to the requirements of the 4.0 revolution.” (W4/PODK).*

Foreign immigration

As at the end of December 2019 (27.12.19), 428 thousand of foreigners had a valid residence permit, which is 2.5 times more than in 2015. Ukrainian citizens represented the biggest part of this group – 218.5 thousand, that is ca 51% of all foreigners. The same trend can be observed in relation to work permits: their number has increased 6 times since 2015. At the same time, 72% of work permits were issued for Ukrainian workers. The influx of immigrants is becoming an essential issue for the Polish labour market. Foreign workers supplement shortages in unqualified labour and contribute to the pool of specialists. The share of Ukrainians holding specialist positions is estimated at ¼ of the aggregate number of Ukrainians working in Poland.

However, in Podkarpackie the issue of foreign residents and employees is relatively less significant at the moment than in other Polish regions, especially in Warsaw where the number of foreigners is the highest. The number of residence permits issued in Podkarpackie totalled 8820. It is practically negligible in comparison to the whole immigration to Poland (2% of all permits issued in Poland) as well as in comparison to the number of inhabitants of the region (0.4%). The data on work permits confirm these findings. In 2018 the number of work permits issued in Podkarpackie was 5378, which accounted for 1.6% of all work permits issued in Poland. The number of legally employed Ukrainian specialists on the Podkarpackie labour market can be tentatively estimated at 900 employees.

Foreigners also increasingly chose Poland as a place to study. The number of foreign students in Polish higher education institutions has been on the increase in the recent years and exceeded 78.3 thousand, i.e. 6.3% of all students. The dominant group of students are those coming from Ukraine It consists of 39.2 thousand students (50.1%). Studying in Poland is less expensive and more prestigious than in Ukraine. The Polish diploma also offers more opportunities to find a good job in Poland after graduation.

The share of foreigners studying in Podkarpackie's HEIs is slightly lower than the Polish average. 2.7 thousand of foreign students started the 2018/2019 academic year in Podkarpackie, i.e. 5.8% of all students. The share of Ukrainians in the total number of foreign students in Podkarpackie exceeded 76.4%, which is much higher than on average in Poland. The most internationalised HEIs are: the University of Information Technology and Management in Rzeszow with 1.5 thousand of foreign students (57.9%), Eastern European State School in Przemyśl – 317 students (11.9%), University of Rzeszów – 217 (8.2%), Higher School of Law and Administration – 195 students (73%) and Technical University in Rzeszów – 162 students (6.1%). The number of graduates coming from abroad was 664 in 2018.

This topic was only occasionally mentioned by the respondents. However, the respondents gave several examples of successful businesses in the field of Industry 4.0 run by Ukrainian students, which indicates that Ukrainian students are active in business incubators. *“There is one startup in the incubator run by a young Ukrainian who is active here and who has already has completed a joint project with the European Space Agency” (W7/PODK).* They associate the development of 4.0 technologies in Podkarpackie with the creativity of students or graduates coming from out of the region.

Digitalisation of traditional services, platform economy and gig jobs

Some shared economy solutions are being implemented in the Podkarpackie region, albeit digitisation of traditional services based on platform economy solutions are not as advanced as in strongly metropolised areas such as e.g. Warsaw, an unquestionable leader in that regard. Moreover, many of these applications are only found in the region's capital. For instance, Uber services are not as yet offered in Rzeszów, and the Uber Eats app for e-catering services was made available for the city's residents as late as November 2019. Rzeszów is the 18th Polish city to offer such a service. In 2018, Blinker started its operation in Rzeszów, offering bicycles, e-mopeds and, as of 2019, also e-scooters.

New business solutions are also becoming increasingly popular in the market for office space lease. In the Podkarpackie region, however, traditional co-working, sharing-economy solutions are primarily visible. Best-known co-working space is offered e.g. by the Podkarpackie Business Incubator and 'Przestrzeń Kreatywna KWADRAT', a fundraising-based initiative established by the INUP foundation. There are also some local players such as pioneering ResCo-Work set up in 2017, as well as international business actors (Rise.pl) who offer network-based solutions. As a result, a gig-job market is developing, based on provision of temporary tasks in line with the current market situation.

3.2.5 Actual and/or expected impact

In the sector in the region

The 4.0 technological revolution in the production sector in Podkarpackie 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 (DPF 2019). This could flow from the fact that companies employing such solutions are gradually building their competitive advantage, and a growing economy boosts the development of the whole market. Some interviewees from the Podkarpackie Voivodship see Industry 4.0, among them automation, as bringing the benefit of satisfying labour shortages that become more and more scarce: *increasing workforce shortage, for industry in general, both in aviation and automotive industry, may force the use of new technologies to replace human work and push companies towards becoming more and more involved in those technologies (W2/PODK)*. The aviation industry is looking for new 4.0 technology solutions as it needs to meet the demand and expand its operations, which is made difficult by personnel shortages: *the first stage is automation, and then companies will use neural networks or even more advanced elements, as we drive towards replacing people. Companies from the Aviation Valley region are getting more contracts, but are not able to meet the demand due to workforce shortages (W4/PODK)*

For the regional companies in aviation and automotive industries, adjusting to the requirements of the company with the highest technological level in the cooperation network is necessary and crucial for remaining on the market. Interviewees compared this process to spreading of the ISO standards or other elements of standardization of production process. *For someone working for the former “Sikorski” there are technological requirements, series of standards and individual standards. The quality and parameters of the final result, the product, must be exactly as specified and not different, everything has to be compliant (W2/PODK)*. An important role in this process will have big companies with greater potential for adopting the latest technologies: *large companies will pull us up by our ears, because if we want to work with them we will be forced, as we are forced now to get certified, audited, to get approvals. If industrial, technological processes in large companies get defined for industry 4.0, the same will be expected from cooperating smaller companies (W8/PODK)*. Characteristic for Podkarpackie Voivodship is the fact that globalization of enterprises can contribute to quicker adoption of industry 4.0 solutions by them: *I can’t imagine high-tech production facilities not to come with high-tech technology. If, let’s say, a large foreign corporation is in the process of adopting the newest technology at home, then it must also introduce such solutions in satellite companies (W2/PODK)*. These processes are already present in the automotive sector in the region: *“The requirement of the specific industry is important. For instance, there is one firm which offers some plastic parts for automotive production and they are fully automated” (W4/PODK)*.

Particular industrial sectors in Podkarpackie region will have to face different challenges. For example in the automotive and aviation sector, where many regional companies operate as subcontractors, the

difficulties may involve an inferior role in the global value chain. Concern may result from the decisions taken in the head office, also in terms of adoption of new technological trends and in terms of division of production chain tasks. A weakness of companies in the Podkarpackie region is the lack of ability to create and sell a final product. *Currently we are a part of the global chain, manufacturing components for the big players; even engines, even complicated things, but we seem not able to generate certain things by ourselves (W2/PODK)*. According to regional stakeholders the main reason for that lies in discontinued university courses, lack of design offices and wasted potential in certain sectors, e.g. bus manufacturing. Strong international exposure resulting from cooperation with international corporations may pose challenge during unstable political situation in global markets and hit Podkarpackie stronger than other Polish peripheral regions: *We are corporately managed from the other side of the world. Today's trend is that we are here. But in a while it may turn out that we are to be switched off (W5/PODK)*.

The common challenge to be faced by the Podkarpackie industrial sector is shortage of staff that results not only from competing with other cities in Poland and abroad, but also from lower number of candidates accepted to some university courses – a process forced by the reform of Polish higher education: *The Rzeszow University of Technology is undergoing drastic cuts (W4/PODK)*. Changes in academic enrolment also pertain to the University of Rzeszów – the courses that attracted candidates and were necessary for the regional needs but with weak parameterization results are restricted: *we still have the traditional courses like physics, but we lost materials engineering, safety engineering, because of their weak parameterization grade. This employee evaluation rewards research, and not practical, results. And for a while, a couple of years, we wanted cohesion between what happens at the university and what is required by the economy, also the regional economy. But now those two go in opposite directions. Economy needs things that are certain, proven, tested, weathered in all kinds of conditions. This is what they can see and adopt (W6/PODK)*. Thus, due to the HEIs reform, the needs of the industrial sector in terms of staff are not expected to be fully met.

According to a report by the **Ministry of Digital Affairs (2018)**, there is a serious threat that those Polish businesses either will not implement new technologies or will delay their implementation, as a result of which they will lose their competitive advantage. This can affect both the advanced business services sector as well as traditional sectors such as trade, agriculture or industry. This can be especially pertinent in the case of the aviation and automotive sectors in Podkarpackie voivodship. In the situation of not sufficient adaptation to the needs of international companies Podkarpackie enterprises may be no longer be able to be involved in the global value chains and eventually lose their position as subcontractors.

In other sectors in the region

The IT industry starts to play the role of a hub for Podkarpackie industry for the purposes of technology 4.0 revolution. However, the mechanisms of industrial sector integration are baffling, because surprisingly, the main role in this process is played by SMEs. Accordingly to interviewees, the role of Asseco, the largest software manufacturer in Poland and Central and Eastern Europe, active in 50 foreign markets and employing over 24 thousand staff – is very limited. *Asseco, despite being here for*

years does not join any activities of the local industry **(W1/PODK)**. The company provides services to large clients, mostly institutional ones, which in the long run may hamper its creativity and cause its drive towards creating new solutions to be replaced with making improvements to the existing products that have already been adopted by large public sector partners. IT sector companies seem to have the tendency to create own solutions, especially small and medium-sized companies who create the most important solutions. *Asseco, which gets a lot of contracts due to its capacities, is afraid of a tiny company consisting in 5 people, because that's where the WOW factor, the creativity may be* **(W4/PODK)**.

Moreover, broader adoption of new technologies may contribute to Polish entities' stronger presence on foreign markets. Many IT SMEs from Podkarpackie region have no problems with reaching foreign clients and are competitive in the international environment. The advantages of Polish IT small and medium size companies are not only relevant education and price-competitive offer, but also closeness, both in terms of geography and culture, i.e. on US market. *IT outsourcing is a necessity, because in the US they don't have the resources. Quite a large city, with population of a couple hundred thousand, and the head of a large, old company is telling me that he has to find IT personnel and he'd rather find them in Poland – as he already tried working with the Hindu, but that' wasn't not possible, they couldn't see eye to eye. A different mindset, a different, totally different time zone, flight issues* **(W1/PODK)**.

Despite the growing potential of the IT sector in the Podkarpackie region and its internationalisation, the sector faces several challenges in the 4.0 technology revolution. Firstly, it may expect considerable entry barriers to a market controlled by global IT giants. Simultaneous research in the same subject area may inadvertently lead to loss of competitive position due to confrontation with the big actors. According to the interviewees the majority of serious technological works is endangered by competition from global companies with better resources and market position: *there are threats, obviously. The majority of serious technological works is endangered by competition from the giants, like the previously mentioned Alphabets. Competing against them is fun, but without chance* **(W1/PODK)**.

Another challenge of a more general character indicated by both the regional authorities and enterprises from Podkarpackie region is the lack of qualified employees. This is particularly painful for the IT industry in the region. *The competition in the IT services global market is incredibly high, we are not able to keep the best specialists* **(W2/PODK)**. Well-qualified IT employee is attracted not only by higher pay, but also by attractive perks and bonuses, including convenient work environment. *In Warsaw they have an app showing job offers nearby. IT is among very few professions in Warsaw who can be fussy: the office is too far away, three blocks away – oh no, that's too far. I would have to take metro, but I don't like the metro* **(W4/PODK)**.

Another sector whose development may be stimulated by the adoption of the 4.0 technologies is photovoltaic industry. This sector is represented in the regional 3S strategy within the fourth smart specialisation entitled “the quality of life”. However, accordingly to representatives of the Podkarpackie Renewable Energy Cluster, the development of the photovoltaic industry towards industry 4.0 in the region largely depends not on technological potential but on international legal background and national

political decisions. Development of the sector is hampered by lack of knowledge and competences at the level of local authorities (gminas) regarding energy management processes while the technology is already available. *The technology is not a problem (...), the key factor is the political sensitivity, depending on various lobbying interest groups (W6/PODK).*

It can be expected that the GDP of countries that develop AI will on average increase by 1.5 p.p. faster than that of other countries (**Accenture 2018**). 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 Industry 4.0 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 *“What poses a serious challenge for enterprises is to recognise the need to innovate – because many enterprises, more than 40 per cent, do not even see such a need because in their opinion these innovations will not affect the quality of the product that these firms will offer” (W2, PL/PODK)*. Such lack of interest is also explained by a growing economy *“now the economy is booming, so entrepreneurs are not thinking about what tomorrow will bring. They do not analyse what will happen if they drop out of the value chain.” (W3, PL/PODK)*. 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 perceived by the regional authorities 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 businesses. The examples of the Industry 4.0 impact on the traditional sectors quoted by the regional authorities, however, pertain mostly to Industry 3.0 solutions. It is expected for the traditional sectors to benefit from adoption of IT tools, for example in respect of creation and marketing of a systematic tourism product: *the digital revolution may take place in the tourism-oriented south of the region as well (...), there are small agrotourist farms there, which are dispersed and those technologies allows them to present a common product (W2/PODK)*. The impact of AI on the agricultural sector was somehow disregarded by the regional stakeholders, despite the relatively high scientific potential in this area. *“A lot is written about AI in agriculture, and this sector is somehow neglected by policy makers, and it was only scientists who claimed that this is something they could do research on, and in fact the output of scholars in this field is considerable” (W11/PL)*. The respondents noticed that the 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 for implementation of the particular solutions. *“Obviously, we are the leader in the niche domains which require low expenditure. Thus, for instance we cannot be a leader in agriculture, because, firstly, the Polish agriculture is not highly industrialised, it’s one of the most fragmented in Europe, there is no demand, and expenditure must be made if we are to construct robots. The easiest thing is to actually run no cost businesses such as marketing, targeted advertising, cloud processing, retail” (WP10/PL)*.

In the region

The interviewees generally share relatively optimistic opinion that Podkarpackie will handle the fourth technological revolution well. Among the factors facilitating successful adoption of 4.0 revolution in the region our interviewees mentioned both universal factors and more specific, regional factors. The first group of factors is connected with inevitable advent of the technological revolution and the necessity to join the innovation race at a higher technological level in order to establish or retain competitive advantage, at least in some industries: *today we can either join this trend and have all plug-ins, be connected to everything we can be connected to, and send the whole information as required, or we cease to exist in the market. Creating a good product alone is not enough. It has to coexist with the rest of its ecosystem. Companies understand that better and better (W1/PODK).* Among the regional factors, the industrial and engineering traditions of this peripheral region were underlined: *„Industry 4.0 trend, in my view, is a big opportunity precisely for peripheral regions that still have the engineering spirit, with big industry, with universities, with opportunities for internship in companies” (W1/PODK).* Almost all interviews clearly mentioned historical background of Podkarpackie region and the industrial legacy of COP. References were made to the role of COP as an important city-forming factor, which changed rural landscape of Podkarpackie, as well as the socio-professional structure of its economy. Moreover the legacy and historical background of vocational education were pointed out. Because industry needs in the interwar period forced development of education, including education for the aviation (Rzeszów) and rubber (Dębica) industry. *I once prepared a slide presenting technology centres now and industrial centres before the war. They correspond to one another. In short, if someone had the idea to build a tyre plant in a place like Dębica, then now a company called the Tire Company, owned by Goodyear Group, is continuing the tradition started before the war (W7/PODK).*

Only a few of respondents expressed worries about a decline in the regional labour market. Quite the opposite, 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. *We want to automate tasks that are dull, hard, harmful or highly prone to human error. Which means things that no-one wants to be doing. What does that means for people’s work in enterprises? Only benefits! (W1/PODK).* The interviewees also indicated appearance of new professions or the tasks of the existing professions being performed using the new 4.0 technology: *New professions appear and we can rest assured that even if a certain profession dies out, it may be reborn in a completely new form. For example, conversations with BorgWarner suggested lack of specialists able to repair a tool. (...) And 2 weeks earlier I had a meeting with startups who invented augmented reality solution to be used by repair and maintenance teams; what’s more, I managed to match them with a large enterprise interested in the solution (W7/PODK).*

Despite the mostly positive assessment of the situation of the Podkarpackie region in the short term, several challenges were also identified. The low ability of the regional economy to create and commercialise technologically advanced regional final products was an important one. The aviation

sector – but also the automotive industry – in Podkarpackie region, despite consisting in many exporters, is generally focused on adopting externally-created technologies. *Podkarpackie industry feeds on technological innovation of others, we are very derivative. There are instances of something actually being invented, patented, prototyped, and then made ready for the market, e.g. the use of quantum dots, or photovoltaic printing applications (W7/PODK).* Creativity definitely exists in various industries, but any “made in Podkarpackie” brand is problematic. Because Podkarpackie region means aviation, there is no doubt about that; after aviation there’s nothing, and then there are Bieszczady Mountains (W4/PODK) A challenge for the Podkarpackie industrial sector is its dependence on international corporations. The interviewees indicated the need to build own value chains based on strong leaders rooted in the region: *a lot of companies make details, but the final product is a problem. We must have local leaders, strong companies, able to build value chain; but these are to be companies connected with the region, that will draw from it and not float away (W2/PODK).* Consequently, besides the globally known aviation sector immense hopes are placed in the IT sector. The IT sector can generate final products in market niches they arrange for themselves: *the niches will always be there, there will always be the need to adapt, there will always be the need to use the right adjustment to meet some market need (W1/PODK).*

Moreover, when thinking about the impact of the 4.0 technology adoption in a peripheral region, more general difficulties resulting from development of innovations in such a regions need to be considered. In a region with low economic potential, there is a threat that enterprises may become dependent on easily available external funding for innovative projects. In view of the decreasing expenditure on Cohesion Policy in Poland (by one-fourth in the next programming period), further functioning of certain enterprises may be problematic, so as that of institutions supporting cooperation between science and business or commercialisation: *I guess we got used to such outside support, we expect it and the resulting boost from the adoption of such new solutions (W6/PODK).* The problem is not with funding activities only, but with adjusting industrial policy to the requirements and directions set by the EU.

Last but not least, the research revealed an uneven adoption of technological trends by sectors of the regional economy. In particular, the public sector and the region’s residents are not catching up with the changes already seen in the business sector, including industry. In fact, the business sector (at least partially) has joined the technological revolution, while other sectors are considering such changes for the future. This is evidenced by, among others, lack of regional studies in that respect and different definitions being applied to technological changes by entrepreneurs and the authorities. Such differences in approaching the new developmental paradigm are exacerbated by low IT competences in the population at large, lack of knowledge on the factors, mechanisms and effects of the technological revolution and by the fact that legislative changes lag behind technological changes, which carries ethical and safety risks. This situation may question a successful adoption and affect the positive impact of 4.0 revolution in the region. *“The law is absolutely incompatible with the modern//advanced solutions (...) The computerisation attempts are, I have no doubts saying that, incompetent. Government applications are so clumsy, so unfriendly, practically unusable” (W8/PODK).*

3.2.6 Operational policy recommendations

The following operational recommendations for national/regional policy based on the result of research including opinions of interviewees could be formulated

1 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. *“There is no access precisely to enterprises’ data, for example to do some application projects. [...] if there is no demand for these services, there is no awareness that data should be gathered in a specific manner” (W11, WAW/PL).* 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 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.

2 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. *“And they are already thinking how to strengthen enterprises on the one hand, but also, on the other, how to strengthen the society so as to make it ready for these new technologies. Obviously, they invoke ethics a lot, but this is, well, seen everywhere in Europe, but as for us, in our strategy it’s only words so far, and I have a feeling that there are few actual activities being done on the ground. And they, they have a completely different approach, the issues they tackle are more advanced, and so are the questions they are trying to answer.”*

3 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 Industry 4.0 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. *“Such concrete solutions for the world of academia are lacking. Such a leading institute should be given support. The idea that circulates here is a bit Canada-like, to support several different bodies. Myself, I’m rather for an idea such as the NCBR [The National Centre for Research and Development], to have one strong institute in Warsaw, at the NCBR, at the NCN [The National Science Centre], at the University of Warsaw, several other higher education institutions, and together build once such centre where we can hire Poles today working with Open AI, give them really comparable salaries. If we have a virtual institute, which will become dissolved in the same, often petrified structures, in various locations, then this potential will be wasted. It should be a billion zlotys, a sizeable amount to attract an interesting professor from abroad, to grow” (W10, WAW/PL).*

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. *“And there (UK) they have a completely different way of thinking, the problems they formulate and the questions they try to answer are more advanced. An interesting example for me was how the Alan Turing Institute handled the question of data. They are no longer considering how to obtain data, structure them and so on. They are already considering how to store data, which data to store and who should make decisions on what data should be stored and what erased, because we have too many data” (W11, WAW/PL).*

4 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: *“The public sector, and in particular companies with a major stake of the state, should pursue such procurement and experiment” (W10, WAW/PL)*, 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.

5 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 Communication (KIKE), Polish Chamber of Information Technology and Telecommunications (PIIT), Digital Poland Foundation and the Polish Promotional Logo Foundation “Teraz Polska”. In the future, the formulat could be expanded through the support of the public authorities, both nationally and regionally.

4 Slovakia

4.1.1 Bratislava Region

Regional baseline

Bratislava Region is the most developed region and metropolitan centre of the Slovak Republic, dominated by the city of Bratislava, which is the capital of Slovakia. Total number of inhabitants was 650,838 in 2018, slowly increasing over the years (Eurostat). The population density was 319,8 inhabitants per square km, three times over EU average, but much lower than other metropolitan regions of central Europe.

In terms of economic performance, Bratislava region is among the most developed regions of the EU, with GDP per capita in PPS EUR 54,000. This represents 185% of EU average. The Bratislava region grew relatively sharply between 2000 and 2011, moving from 109% of the EU average in 2000 to 181% in 2011. Since then, its share has stabilised at around 180-185% of the EU average. The Bratislava Region is the most economically efficient region in Slovakia, with its GDP per capita in 2014 reaching 243% of the SR average. Since 1995, in which the region was 215% of the SR average, its position has strengthened by 28%. From the point of view of the methodology of the quantitative part of the study, Bratislava within the EU is above-average specialized in the carrier manufacturing sectors, service technology sectors and service induced sectors.

Economic growth in recent years has been mainly the result of increasing labour productivity, which has grown faster than the SR average. The increase in labour productivity was highest in the sectors of industrial production, construction, financial and insurance services, real estate activities, professional scientific and technical activities and arts, entertainment and recreation. However, the proportion of the productive population developed negatively. Since 2007, it has declined from 75% to 71% in 2013 and to 69% in 2015, the lowest in Slovakia. However, the total number of employees in the Bratislava region has steadily increased, while the share of employment in manufacturing has also increased. This is very unusual for metropolitan regions. The development of these indicators is shown in Table 4-1. In 2018, the share of manufacturing in total employment reached 14.2%.

Table 4-1. Employment in Bratislava region

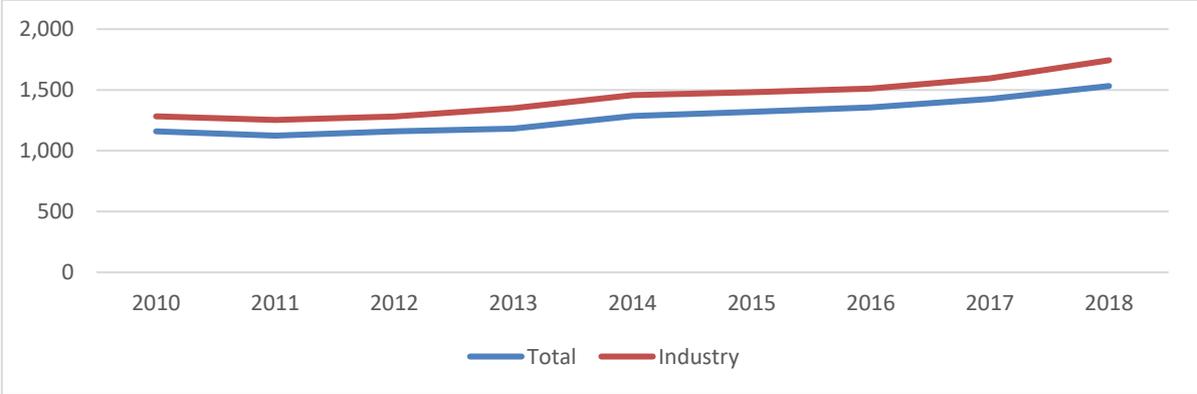
	2010	2011	2012	2013	2014	2015	2016	2017	2018
Total	275,070	277,168	293,840	30,300	32,165	341,698	368,748	375,063	38,931
Manufacturing	35,550	36,968	40,171	42,604	45,830	47,672	51,750	55,635	54,818
share of manufacturing	12.92	13.34	13.67	13.95	14.18	13.95	14.03	14.83	14.2

Source: *statistics.sk*

The unemployment level is quite low compare to rest of country and EU, reach 2.9% in 2019, lowering from 6.4% in 2013, which was the highest number over the last decade. The long term unemployment was 1.4% in 2019. The level of NEET in category of 15-24 years was 7.9% in 2017, compare to 10% of

EU average. The average wage in the region was EUR 1,522 but in manufacturing it was EUR 1,744. The development of average wages is shown in Figure 4-1.

Figure 4-1. The development of average wages in the Bratislava region



Source: Compiled by the author based on data from statistics.sk

The percentage of the population aged 25-64 who have successfully completed tertiary studies was 43.8%, higher than EU average 32.3% and Slovakia average 24.6%. The percentage have been continuously and quite sharply rising over the years from 29.2% ten year ago. Also, the percentage of the population aged 25-64 who have primary and lower secondary education (ISCED 0-2 level) was only 3.9%, compare 21.9% of EU average.

4.1.2 Adopted 4.0 technologies in the sector in the region

The Slovak Republic, including the Bratislava Region, does not show high level of 4.0 technologies deployment and is overall weak regarding the national and regional environment for the upcoming 4.0 technologies. Quantitative analysis within this project shows a very low rate of 4.0 inventions as well as a low rate of creation of highly qualified jobs in the region.

IMD’s Digital Competitiveness Index (IMD, 2018), which aims to assess the extent to which a country adopts and explores digital technologies leading to transformation in government practices, business models and society in general. In its 2018 ranking Slovak republic is 50th out of 63 countries, third worst out of the EU countries. For the subindex of regulatory framework the country plunges to 60th place overall.

Compagnucci et al. (2017) construct the I-Com Industry 4.0 Index for the EU countries. Slovakia ranks one of the worst in the EU. It achieved particularly good results in the automatic interconnection of systems with other companies (up to 23% of companies have such interconnections), ranked among TOP 5 EU countries. In-house interconnection was also significantly strengthened, in 2010 only 20% of the software connecting different functional areas of the company compare to 40% of the companies in 2015. Less than 20% of businesses used CPM systems.

The automotive industry is one of the leaders in the implementation of 4.0 technologies among different sectors and at the same time the Bratislava region is a leader in their implementation among other

regions. In Slovakia, this combination represents the most advanced implementation of 4.0 technologies.

The implementation of 4.0 technologies in the automotive industry is being implemented gradually, based mainly on the gradual automation of the sector, which significantly affects the deployment of 4.0 technologies. The automotive sector is the dominant industrial sector in Slovakia in terms of robotic deployment, as shown in Table 4-2.

Table 4-2. Number of autonomous industrial robots in use

Year	All manufacturing	Automotive	Percentage share of automotive
2005	189	138	73.01587
2006	234	154	65.81197
2007	337	227	67.35905
2008	536	287	53.54478
2009	763	477	62.51638
2010	1575	1240	78.73016
2011	1959	1575	80.39816
2012	2114	1666	78.80795
2013	3381	2872	84.94528
2014	3701	3092	83.54499
2015	4142	3393	81.91695
2016	5805	4891	84.25495
2017	6764	5699	84.25488

Source: World Association of Robotics

More than 80% of all automated systems are used in the automotive industry. However, we can also see that more massive deployment has occurred only in the last 8 years, and these processes are still lagging behind in other sectors in Slovakia and also in the Bratislava region. However, the high deployment of robots in carrier sectors in the Bratislava region, one of the highest in Central and Eastern Europe (see map 3.5 of the main final report), was not transformed into the deployment of robots in the induced sector or in technology sectors. In both cases, mainly because they contain a small share of FDI, which is located in the carrier sectors and rather forms a kind of dual economy in the region without significant spill-over to other sectors. 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). In particular, the final car producers themselves are the most dominant in the use of technology. For example, VW commented on the deployment of 4.0 technologies: "Approximately two thousand robots are installed in the production halls, and more are being added to the new bodyshop

and Porsche assembly hall. In addition, we also use augmented and virtual reality, big data, online production monitoring or smart gloves with a scanner.” (Gérer, 2018).

Significant investments in 4.0 technologies have hitherto been deployed towards in-house logistics such as artificial intelligence for autonomous vehicle driving. Nowadays, these technologies are moving towards external logistics management - links with subcontractors. Except automation, 4.0 technologies are intensively used in developing new models (or its parts in case of Bratislava region).

As far as automotive subcontractors are concerned, according to Pwc survey (2019), only 18% have not yet invested in 4.0 technologies. Primarily dominated by investments in robotics (over 50%), big data and digitisation of production processes (21%) and predictive maintenance (15%). According to an interview with the Automotive Industry Association, the sector is a major leader in deploying these technologies in the region.

Vast majority of 4.0 technologies are purchased from technology providers that are primarily large multinational corporations.

4.1.3 Preconditions for transformation

Regional preconditions

The specific regional conditions for the introduction of 4.0 technologies in the Bratislava region are well above the average compare to rest of the Slovak Republic, but in comparison with similar regions in Western or Central Europe, they are rather below average.

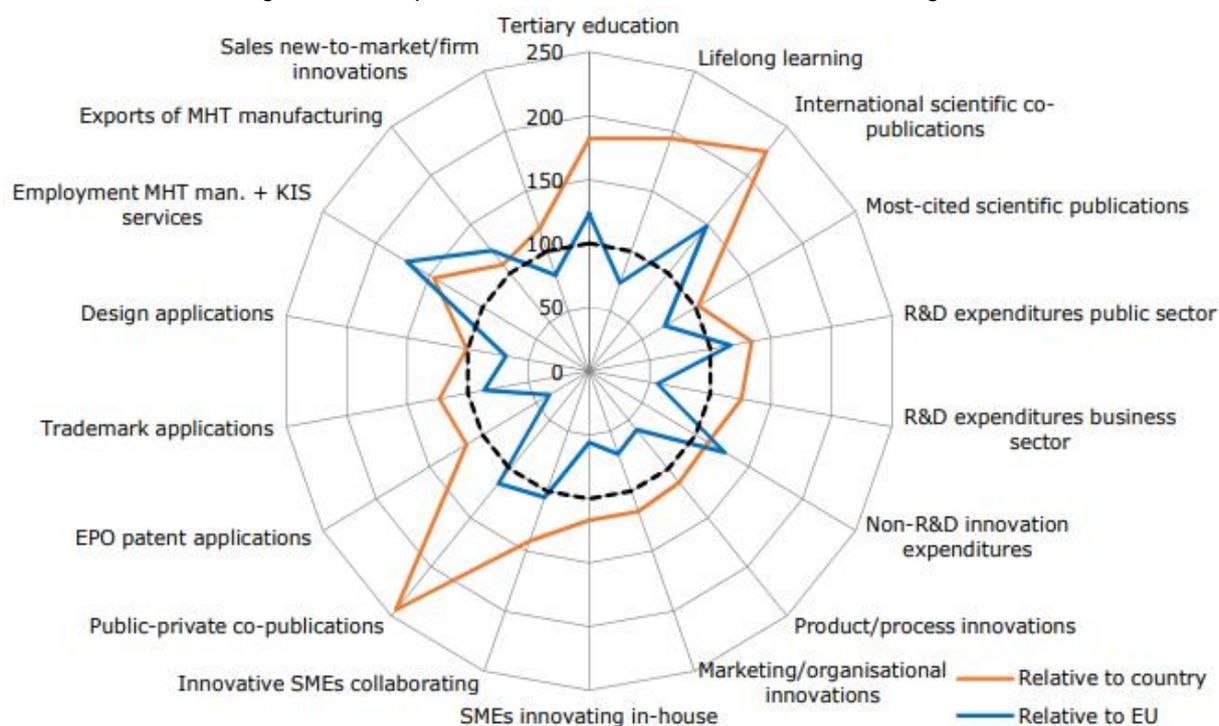
Key characteristics of innovation performance and preconditions for the creation of innovation and technological advancement of the region are shown in Figure 4-2. In most indicators, the Bratislava Region is around the EU average. Significantly above-average values are achieved in publishing outputs. On the contrary, it lags behind in the private sector's innovation activities, where indicators such as sales new to market innovations, R&D expenditures of business sector or EPO patent applications are well below the EU average. This low innovation performance of the private sector is further accentuated by the fact that the average GDP per capita in the Bratislava Region is well above the EU average.

In comparison with other regions of the Slovak Republic, it is above the national average in all the indicators. The Bratislava Region is the region with the most innovative capacities in Slovakia. Up to 47% of R&D employees work in the Bratislava region and the region's share of R&D funds is 58%. The volume of R&D finances in 2014 was 1.5% of GDP, which is significantly higher than the SR average. The structure is dominated by research supported from public and state resources (38%) and from foreign sources (37%). However, the strengths and weaknesses are similar to those of the EU comparison. The region is mainly dominated by scientific publication production. Compared to the EU, it is also very dominant in the share of third level education and lifelong learning.

This is also due to the fact that the region is the dominant centre of higher education in Slovakia. In total, approximately 37% of all university students study in the region and the two most important Slovak

universities - Comenius University and Slovak Technical University. Approximately one third of these students study technical and natural sciences.

Figure 4-2. Comparison of elements of RIS 2017 in Bratislava region



Source: Regional Innovation Scorecard 2017

On the other hand, the region performs quite weakly compare to EU in several indicators. The most markedly lagging behind in the EPO is patent applications, where it is less than 50% of the EU average. This may be partly due to the nature of the research that companies are focusing on - rather research on the processes in the production or applied innovations that are unique to that production and do not require patent protection (Šipikal and Buček, 2018). It is also the result of low private sector investment and the overall weak innovation activities of firms in the region, as can be seen from graph.

The ICT use is around EU average, as shown in Table 4-3. Above EU average is daily use of internet and E- banking use. In all cases, Bratislava region is leading region within Slovak republic regions.

Table 4-3. Main use of ICT

	EU Average	Bratislava region
Broadband (% of population)*	67.04	57
Daily use of internet (% of population)*	57.19	64
E-banking use (% of population)*	38.14	43
Online purchase in the last 3 months (% of population)*	35.27	31

Online purchase of holidays (% of population)*	23.36	16
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Source: Eurostat, *Year: 2011

From the point of view of the sector structure, the Bratislava Region is a region with the highest level of specialisation. The region is more specialised in services with higher knowledge requirements. The above-average employment concentration is in the knowledge intensive financial services (KIFS), high tech knowledge intensive services (HTKIS) and knowledge intensive market services (KIMS), and partly in less knowledge-intensive market services (LKIMS). Bratislava region is the center of creative and cultural industries. According to a study by SIEA (2014), up to 43% of companies based in Slovakia from cultural and creative industries are located in the Bratislava region. Total number of employee in technology and knowledge-intensive sectors was 343,000, representing 15% of total employment.

Entrepreneurial activity in the Bratislava region is significantly higher compared to the SR average. In 2015, the number of enterprises per 1,000 inhabitants was 103, which is significantly higher than the Slovak average. The highest intensity of business is in Bratislava, while in Bratislava I it was up to 380 enterprises per 1,000 inhabitants.

Research is more concentrated on the field of natural sciences, social sciences and humanities. The analysis of technological specialization from the point of view of patent activities shows that in the region there is more significant concentration of patent applications in the area of nanotechnologies, paper, chemistry, mining, separation and mixing and health and entertainment.

The main areas of international cooperation included information and communication technologies, security, nanotechnology, new materials and manufacturing technologies, agriculture, food and biotechnology, as well as projects in the social and human sciences, environment, health and energy. Commercialization of regional research is supported by the emerging institutional system (science park, incubator, technology transfer offices, special programmes). In addition, the county is the seat of the vast majority of national professional associations and several local cluster organizations. However, commercial collaboration in research is still relatively limited.

Table 4-4. Indicators of automation and patent activities

Indicators	EU	
	Average	Bratislava region
High tech patents – quartile (% of total patents)**	13%	4
4.0 technologies patents - quartile (% of total patents)**	1.3%	4
Jobs at high risk of automation – quartile (% of population)***	14%	4

Source: Eurostat **Year: 1997-2015; quartile=1 bottom 25%; quartile=4 top 25%. Please consider that patents figure by technological field in percentage terms can be influenced by the absolute low number of patents in the region. ***Year: 2011; quartile=1 lowest risk; quartile=4 highest risk

Sectoral preconditions

The automotive sector is one of the most important sectors in terms of innovation and 4.0 technologies in the world. The automotive sector is considered to be a “carrier” sector in terms of sector classification used in this project. Automotive products are among the most technologically sophisticated. The automotive industry is investing more than EUR 84 billion in R&D worldwide. The automotive industry alone accounts for up to 16% of total global R&D spending. It is up to 25% within the EU and Japan. (Slušná et al. 2015). A similar situation exists in Slovakia, which has become one of the manufacturing centers of this industry over the past 30 years, despite that 30 years ago the automotive sector in Slovakia, including Bratislava region, basically did not exist. Its history started in the early 1990s, when Volkswagen decided to establish a factory for automotive components production nearby Bratislava (Jakubiak et. al, 2008). It started as a joint venture company with a Slovak company “BAZ”. Especially throughout the 1990s, foreign investors typically began with a simple and/or low volume production and only later decided to assign local factories broader and/or more advanced functions within the MNC’s production network (Pavlínek, 2009). Since then, Volkswagen has become the country’s largest industrial producer and its leading exporter. Slovakia has become one of the leading car producers in Central Europe, mainly benefiting from the location of four world-class automotive companies: Volkswagen Slovakia in Bratislava; PSA Peugeot Citroën Slovakia in Trnava, Jaguar Land Rover in Nitra and Kia Motors Slovakia in Žilina. The automotive production in the region currently involves more than 200 companies, mostly based on FDI (Šipikal and Buček, 2018). The increasing concentration of automotive production in Central and Eastern Europe (CE) led to increasing external scale economies which improved the competitiveness of CE-based automotive producers (Pavlínek, 2009). More than 90% of the firms in this sector have foreign capital interest. FDI in the automotive sector played a crucial role in shaping the innovation profile upgrading of the sector within the region. (Šipikal, Buček, 2018).

Bratislava region is the dominant region in this industry in Slovakia. There is VW as the final car producer and 33% of TIER 1 suppliers are from the Bratislava region. At 15% TIER 2 it is 15% of suppliers and at TIER 3 it is 18% of suppliers (Slušná et al. 2015).

Central Europe, including Slovakia, was supposed to concentrate on the most cost-sensitive and labour-intensive segments of the automotive production chain and/or local market-oriented production; nevertheless, some of these countries have achieved higher growth rates and higher degrees of industrialisation than the core economies of Western Europe, along with experiencing significant industrial upgrading (Pavlínek, 2009). However, Slovakia has an unusually high share of capital and a low share of labour in creating value added. In 2009, it was 61.5% in automotive sector. The share of the highly qualified workforce in the creation of total added value in the industry was only 1.6% in 2009 (up to 35.4% for comparison in Germany). The share of highly qualified labor in the creation of added value in the industry was one of the lowest in the EU in Slovakia (Slušná 2015) (Table 4-5).

Table 4-5. TOP companies in Automotive sector in Slovakia

Company	Region	Position in whole country	Revenues 2018 (or 2017*)	Revenues 2010
Volkswagen	Bratislava	1.	10,380,075,000	3,764,534,091
Kia Motors	Central Slovakia	2.	5,184,666,000*	2,888,748,000
PCA Slovakia	West Slovakia	6.	2,694,699,000 *	1,656,734,000
Mobis Slovakia	Central Slovakia	13.	1,421,934,000*	703,817,000
SAS Automotive	Bratislava	20.	909,870,425	293,485,000
Faurecia Automotive	Bratislava	30.	578,052,000	n.a.
ZF Slovakia	West Slovakia	44.	478,142,000	63,840,400

Source: *Finstat.sk*

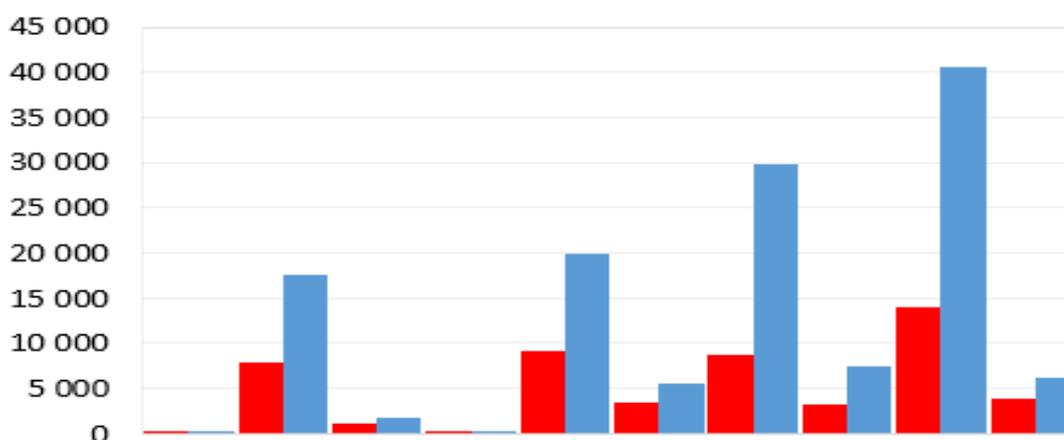
The Slovak Republic, including the Bratislava Region, does not show high level of 4.0 technologies deployment and also weak the national and regional environment preparedness for the upcoming 4.0 technologies. One of the few exceptions is the automotive sector. The automotive sector is one of the most important sectors in terms of innovation and 4.0 technologies in the world and in Slovakia too. It is also dominant industrial sector in Slovakia. The automotive industry is investing more than EUR 84 billion in R&D worldwide. The automotive industry alone accounts for up to 16% of total global R&D spending. It is up to 25% within the EU and Japan. (Slušná et al. 2015). A similar situation exists in Slovakia, which has become one of the manufacturing centers of this industry over the past 30 years, despite that 30 years ago the automotive sector in Slovakia, including Bratislava region, basically did not exist. The Slovak automotive industry has a key position in the Slovak economy, its share in GDP is around 5% (Slušná et al. 2015), in a broader perception of sectors linked to the car industry it can be around 13% (L'uptáček et al. 2013). The share of the automotive industry in total exports is up to 26% of total exports (Martišková, 2018). The whole sector is dominated by foreign multinationals. Slovakia has a very high share of foreign capital in value added, in industry it is about 60%, while in the automotive industry it is up to 93% (Pavlínek 2017). The dependence of the Slovak automotive industry is also shown by the low level of diversification of the target countries of export. More than 50% of total production goes to three European countries, 85% of production goes to only five European countries (Martišková, 2018). Logistics is one of the sectors tied to the automotive sector. The interconnection of these sectors provides an interesting insight into the leaks of the introduction of 4.0 technologies from the automotive industry.

The workforce is a key regional factor in the development or downturn of the sector in the region. The automotive and mechanical engineering sector accounts for 11.19% of total employment in the national economy of the Slovak Republic, making it one of the larger sectors. Nationwide, the share of men in the total number of people employed in the sector is approximately 71%. Despite the highest absolute number of employees in the automotive industry and engineering in the Bratislava region, the sector has the lowest relative share in regional employment, only 7.57%. However, it is strongest industry sector in region, representing around 25% of total manufacturing employment in the region. From the

regional point of view, the sector has the highest share in total employment in the Trnava Region, at 17.79% of the total number of employees in the Trnava Region⁸⁶.

In 2018, the highest share of persons employed in the automotive and mechanical engineering sectors was in the 40-44 age group. Compared to 2009, the share of employees in the 40-44 age group increased most significantly by 2018 and their number declined most in the 50-54 age group. The highest proportion of male employees in the 2018 age group was between 30 and 34 years, reaching 10% of the total number of employees in the sector this year.

Figure 4-3. Structure of employees in the automotive industry and engineering sector in 2018 by gender and level of education



Source: TREXIMA Bratislava, ISCP (MPSVR SR) 1-04, blue – men, red – women, columns from left to right – third level higher education, second level higher education, first level higher education, complete secondary education, complete universal secondary education, apprenticeship with graduation, secondary education without graduation, primary education

As for the preparation of the future workforce, the university graduates are prepared mainly by the Slovak Technical University, especially the Faculty of Mechanical Engineering and the Faculty of Electrical Engineering and Computer Science. The Faculty of Mechanical Engineering has its own professional education programme in the automotive industry with companies such as Volkswagen Slovakia, Schaeffler Skalica, Continental Zvolen, ZF Slovakia, Benteler Division Automotive, Boge Eastmetall Slovakia, Brose Prievidza and ZKW. Within it, students also practice directly in these companies during their studies and have a guaranteed position in them after graduation. In addition, students can study another 4.0 technology program, such as the automation and computerisation programme for machines and processes, or the automotive and mobile work machines programme. For the needs of the automotive industry, however, the number of students is insufficient. For example, only 760 students study at the Faculty of Mechanical Engineering. The reason is not in the capacity of faculty but it is rather the problem of less interest of students to study technical fields.

⁸⁶ www.sustavapovolani.sk

The Faculty of Mechanical Engineering also has research capacities for the automotive industry. For example, the Laboratory of Automatic Control and Mechatronics, the Laboratory of Automotive Mechatronics or the Laboratory of Control Systems work here.

Automotive Industry Association is actively implementing the SPICE project, which links practice requirements with schools. Companies within it have the possibility to assign their research needs to all cooperating schools.

Similarly, companies also cooperate with secondary schools. Even VW has set up its own high school, where it currently educates 400 pupils primarily for their needs. However, the dual education system, which makes it possible to study and practice in the company, comprises less than 100 pupils in the Bratislava region, of which less than 20 in the field of industry.

Overall, we can see negative developments in education. While 10-15 years ago, despite the low labour price, labour quality was one of the main elements of the successful development of the sector. Now, for the current needs of the automotive industry, this quality is perceived as insufficient. Only one tenth of companies in the industry are satisfied with the quality of university graduates. In the opinion of three fifths of respondents, they lack technical skills and experience that would correspond to their education. Almost half have noticed a lack of commitment and motivation to work, and a sixth of companies complain that graduates lack theoretical knowledge in the field (Pwc, 2019)

Social preconditions

Digital literacy and 4.0 technologies resonate marginally in society. According to a study (IVO, 2018) mapping the long-term adaptation of the Slovak population to modern information and communication technologies (ICT), it shows that a period of stagnation has occurred after years of increasing trend. In 2005, the proportion of people who easily adapted to ICT was only 45%. The rest consisted of people who were difficult to adapt or did not adapt at all (they did not learn to master ICT). The situation has gradually improved, and in 2015, up to 58% of the population over 17 years of age have adapted to ICT without major problems. However, this positive development has not been followed up over the past three years. In 2018 a total of 59% of respondents declared trouble-free adaptation - of which 21% declared that ICT adapts easily and another 38% rather easily. Conversely, the proportion of people claiming that ICTs adapt very hard or rather difficult from 18% in 2015 to 21% in 2018 has thus slightly increased. On the other hand, the share of those who refuse to learn and adapt to ICT has slightly decreased. Ten years ago, the "opponents" of ICT accounted for more than a third of the population. However, their share is continually declining, and at present, one-fifth of the population over 17 years of age is unable to master modern technology at all.

The perception of the risk of automation, where Slovakia is one of the most vulnerable countries in terms of job losses (OECD, 2018), is generally low. Overall, only 28% of respondents currently working or doing business are concerned that their robots will lose their jobs in the near future. only a third (36%) of the respondents say that in about 20 years a robot will be deployed in the job they perform.

Regarding the education system, secondary and higher education are quite strong in Bratislava region. In 2018 more than 32,000 students studied at universities, which represented more than 37% of all students in Slovakia (CVTI, 2019). There are two most important slovak universities - Comenius University and Slovak Technical University. The latter is the key partner of the automotive industry as well as the entire 4.0 technology transformation, especially its three faculties (Faculty of Electrical Engineering and Informatics - 1975 students, Faculty of Informatics and IT - 1191 students and Faculty of Mechanical Engineering - 727 students). At the same time there are 38 secondary vocational schools, with more than ten thousands students.

Policy preconditions

Most support activities are implemented at national level. So far, regional strategies have not addressed this issue at all, which is mainly due to the competencies of the region and cities in areas that can affect technology transfer for businesses.

Several strategies have been introduced at national level to address 4.0 technologies. However, these strategies have only been introduced in recent years, when the issue has become more relevant to the Slovak Republic. We present a timeline of their formation and institutional affiliation in Table 4-6.

Table 4-6. Timeline of key strategy documents

Year	Document	Responsible institution
2007	Operational Program Competitiveness and Economic Growth Operačný program Konkurencieschopnosť a hospodársky rast	Ministry of Economy of the Slovak Republic
	Operational Program Research and Development Operačný program Výskum a vývoj	Ministry of Education, Science, Research and Sport SR
	Operational Program Informatisation Operačný program Informatizácia spoločnosti	Government Office of the Slovak Republic
	Operational Program Education Operačný program Vzdelávanie	Ministry of Education, Science, Research and Sport SR
	Operational Program Employment and Social Inclusion Operačný program Zamestnanosť a sociálna inklúzia	Ministry of Labor, Social Affairs and Family SR
2012	Regional innovation strategy of Bratislava region Regionálna inováčná stratégia Bratislavského kraja	Bratislava Regional selfgovernment
2013	Research and innovation strategy for smart specialization Stratégia výskumu a inovácií pre inteligentnú špecializáciu	Ministry of Economy of the Slovak Republic and Ministry of Education, Science, Research and Sport SR
	Operational Program Research and Innovation Operačný program Výskum a inovácie	Ministry of Education, Science, Research and Sport SR
	Operational Program Effective Public Administration Operačný program Efektívna verejná správa	Ministry of Interior of the Slovak Republic
	Operačný program Ľudské zdroje	Ministry of Labor, Social Affairs and Family SR
2016	The concept of smart industry for Slovakia Konceptia inteligentného priemyslu pre Slovensko	Ministry of Economy of the Slovak Republic

	Action plan for smart industry for Slovakia Akčný plán inteligentného priemyslu SR	Ministry of Economy of the Slovak Republic
2017	Implementačný plán RIS3SK 2017 – 2018	Ministry of Economy of the Slovak Republic , Ministry of Education, Science, Research and Sport SR and Office of the Deputy Prime Minister for Investment and Informatisation
2019	Slovakia's Digital Transformation Strategy 2030 Stratégia digitálnej transformácie Slovenska 2030	Office of the Deputy Prime Minister for Investment and Informatisation

Source: Compiled by the author

Among the most important strategic documents related to the development and deployment of 4.0 technologies at the national level is the Smart Industry Concept for Slovakia (MH SR, 2016). The strategy summarizes the Slovak Republic's policy to support firms' competitiveness with the use of new technologies, materials, the creation of systematic connections among individual actors, but also other changes in the area of financing, research, education and public administration. The Implementation Document is the Action Plan of the Intelligent Industry of the Slovak Republic. It sets out 35 actions in 5 areas - Research, Development and Innovation; Cyber Security; Labour market and education; regulation; and Information and promotion planned to be implemented by 2020. The vast majority of the proposed measures in this period only have the nature of analytical studies and drafting. More specific measures are in the field of education and the labour market, where changes in mathematical, technical and information literacy are expected, or the graduates' practical skills are increased.

The area of digitalisation of society is covered by the Digital Transformation Strategy of the Slovak Republic until 2030, which is a broadly conceived strategy aimed at building a digital society. The Strategy is complemented by the Slovak Digital Transformation Action Plan 2019-2022. In this period, the following areas were identified: education, digital skills and employment, modern data and digital economy, and public administration capabilities to innovate and use data. The main areas of the investment should be data economy; innovative ecosystem; autonomous automobile and innovation in finance. The Office of the Deputy Prime Minister for Investment and Informatisation and Implementation is responsible for the implementation of the Action Plan to be coordinated by the Council of the Government of the Slovak Republic for the Digitization of Public Administration and the Digital Single Market. Specific financial resources are not allocated during this period, the use of existing funds from the ESIF for the period 2014 - 2020 in the OP Effective Public Administration, OP Research and Innovation, OP Human Resources is expected. Due to the short time since the strategy was approved, no further information is available yet.

Research and Innovation Strategy for smart Specialization of the Slovak Republic (RIS3SK) aims to support structural changes in the economy, in particular by supporting innovative activities of companies supporting excellent research. The strategy identifies areas of traditional sectoral specialization, highlights prospective areas and also sets out areas of specialization in terms of available scientific and research capacities. The Implementation Plan transformed into 5 domains of Smart Specialization

Means of Transport for the 21st Century; 21st Century Industry; Digital Slovakia and Creative Industry; Public health and health technology; Healthy food and environment. The SR Government Council for Science, Technology and Innovation (2013) was set up to be the main coordinating body for this area and a permanent RIS3 commission was established within the Council to oversee implementation. Key measures are related to increase financing, specially from private sector, Increase companies engagement in global value chains, institutional reform of research and development, increase quality of education and better matching with requirements of labour market.

The European Investment and Structural Funds were a key source of funding for all strategies. The most important operational programs in the period 2007 - 2013 were the Operational Program Competitiveness and Economic Growth and the Operational Program Research and Development. The Region could actively participate in the OP Research and Development, where it had its own measures with a total allocation of EUR 432 million which was also in excess of support for Objective 1 regions. . The region had its own OP Bratislava Region with a total allocation of EUR 87 million. However, only a very small part went to business support.

In the period 2014 - 2020, the Operational Programs supporting the areas related to the adoption of technologies 4.0 are OP Research and Innovation, OP Human Resources and OP Effective Public Administration. However, as a developed region, the Bratislava Region has only limited access to this funding.

Within the OP Research and Innovation, the region is affected by interventions under Priority Axis 2 Support for Research, Development and Innovation in Bratislava region with total allocation more than EUR 300 million including EUR 155 million national co financing. In particular, PA2 finances activities aimed at increasing the performance and excellence of research as well as promoting investment in R&D, including cooperation between public and commercial organizations. So far, support has not specifically targeted support for 4.0 technologies. Only in 2018 and 2019 the first calls for applications for the granting of support aimed at the support of smart innovations in the industry with an allocation of more than EUR 70 million went out. However, the call did not concern the Bratislava Region.

The OP Human Resources is defined by seven priority axes. Technology adoption 4.0 does not directly involve any measure, but several measures under Priority Axis 1 aim to improve education to reflect labour market needs. In secondary education, this is particularly the investment priority 1.2 Increasing the importance of the labour market in education and training systems, facilitating the transition from education to employment and improving vocational education and training systems and their quality, including through skills forecasting mechanisms, curriculum adjustments and development and development of workplace education systems, including dual and apprenticeship systems. In tertiary education, this is an investment priority 1.3 Improving the quality, efficiency and access to tertiary and equivalent education in order to increase the number of students and the level of education, especially for disadvantaged groups. In lifelong learning, this is an investment priority 1.4 Improving equal access to lifelong learning for all age groups in formal, non-formal and mainstream education, enhancing the

knowledge, skills and competences of the workforce and promoting flexible learning pathways through career guidance and validation of competences acquired.

The area of digitization and improvement of public administration services is supported by the OP Effective Public Administration. The main area is the priority axis 1 Enhanced institutional capacities and effective PA with an allocation of EUR 234 million (EU resources). It focuses on Enhanced Systems and Optimized Processes in Public sector.

At the regional level, the last document in this area was scaled back in 2012, when 4.0 technologies were not the centre of interest. Thus, the regional innovation strategy is not particularly dedicated to this segment. Among the related measures, it is more to support innovation in general (support for science parks, networking, support for the innovation fund), as well as support for dual education in schools. No other specific documents were created, mainly due to lack of competencies and consequently finances, of regional and local self-governments in this area.

A special possibility was support in the form of investment incentives, which companies could apply for individually. This aid was primarily in the form of tax reliefs (46% of the total amount of investment incentives provided), but could also be used to purchase investment property, promote job creation or support retraining. Until 2009, the share of the automotive industry had a dominant role in the incentives provided, and then started to decline. However, because of development limits for the Bratislava Region, this support was almost exclusively used by companies from other regions. Annex 1 shows the total amount of aid granted in the form of investment incentives.

4.1.4 Actual transformations in the region

Economic transformation

Main development and transformation of the automotive sector in the Bratislava region is summarized in Table 4-7. Table shows main stages, key preconditions and policy implication as results of interviews. The last stage become more apparent in the sector only last three years.

Table 4-7. Development of automotive sector in Bratislava region

Stage	Key activities	Key preconditions	Key policies realized	Key policies required
Early development	Inflow of foreign FDI	Cheap qualified workforce	Investment incentives	Investment incentives
Expansion of sector	Update of production lines (more sophisticated models, higher VA)	Cheap qualified workforce, strong network and critical mass of companies in the sector,	Investment incentives RD incentives	Investment incentives Improvement of workforce quality,
Automation of the sector	Increase level of automation	qualified workforce, qualified suppliers	Investment incentives RD incentives	Improvement of workforce quality,
4.0 technologies	Increase use of 4.0 technologies	qualified workforce, qualified	Investment incentives	Networking, Improvement of

		suppliers and KIBS		workforce quality,
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Source: Compiled by the author

Given that the sector is dominated by large multinational companies, the deployment of 4.0 technologies is decided mainly in the headquarters of these companies, so mainly outside the region itself, although always in consultation with local management. In most interviews, respondents also stated that their central offices are pushing the use of 4.0 technology significantly. Part of these companies also have their own long-term corporate strategies at the global level directly related to 4.0 technologies.

Technology deployment works in principle in two steps. The first step is to test or deploy the technology in a selected plant or plants. Ideas, what technologies or changes will be introduced can come either from the company headquarters or can be suggested by the local plant. As several interviews have pointed out, at this stage there is strong competition among plants within the MNC group, which often seeks to come up with an innovation that could be introduced and at the same time prove that they are the most suitable plant to implement this innovation. Instead of competition of regions, this is "competition of regional plants", where the regional government should aim to support these regional plants in introducing innovation, especially by providing skilled labor, innovation suppliers or the relevant scientific research base. Interviews confirmed that local management is trying to build a good position among the other plants of the MNC group. This is one of the few ways local subsuppliers or technology providers can get into global value chains. Interviews also confirmed that this strategy was one of the few to work with the involvement of Slovak suppliers of technology solutions. If an innovation is successfully piloted or tested, then the company headquarters is usually actively promoting it to other group plants, with the pilot plant and its suppliers usually actively working on it.

The most important factor in their deployment is the return on investment. In addition to technology itself and capital availability, return on investment is mainly influenced by labour costs. This is the most important regional factor influencing the deployment of 4.0 technologies, although this factor does not yet appear to be crucial for the decision-making process.

Hourly labour costs in manufacturing sectors in Slovakia are around one fourth of the German level. This could be assumed to result in a lower automation level in plants in these countries, but this is not exactly the case. Automotive factories in Slovakia are on average similar to western countries in degree of automation. Study done for CEE by Krzywdzinski (2016) has shown that automation is often driven by requirements regarding product quality and the stability of the production process as well as by a company's internal standardisation of its production systems Occupational safety, quality and stability of production or improvement of the environment (especially lowering waste production) were also mentioned as important reasons in the interviews.

Capital for investments is provided by the company headquarters, and most of them are mainly own funds of these companies or loans. None of the interviews identified the financing of the investment as a limiting factor for the introduction of 4.0 technologies, as long as the efficiency and return on investment were proven.

Several interviews have also confirmed that technology providers themselves play an important role in the initialisation phase of investment. They know in detail new innovations and opportunities that could help companies in the sector, and companies often lack the capacity to find new solutions. They have long-term relationships with companies in the sector, and in this case too, they are mainly foreign multinational companies. Thus, the entire communication often takes place abroad in company headquarters. A similar development as in Slovakia can be expected in this direction in several regions of Central and Eastern Europe, which have a significant share of the automotive industry, but especially in the form of FDI.

Supporting national or regional policy plays almost no role in the deciding on 4.0 technologies. Most companies were of the opinion that "If technologies cannot earn themselves, there is no point in deploying them". Some companies also see a problem in the timing of support, when deciding on support tends to be too long in relation to the processes that occur in companies. Most of the standard support policy is implemented through the Structural Funds, where the entire process from application to approval often takes more than a year. For example, the evaluation of the creative industry support scheme has been taking two years. Companies in the sector are increasingly interconnected by different systems, so one of the companies cannot wait to get support to implement the solutions. A big problem for companies is also the need to carry out public procurement. Companies usually have a clear technology supplier preference they would like. However, public procurement rules do not allow such direct contract.

State support was rather crucial for firms in the sector in establishing themselves in Slovakia, when many of them took the form of investment incentives, most often in the form of tax holidays. However, this process has also been gradually tightened and the provision of these incentives has been considerably reduced for the Bratislava Region. Only Volkswagen has used them from automotive companies in the Bratislava Region over the past 10 years.

Usually, changes occur when the production line is changed to a new type of model or its accessories. In most cases, the line needs to be rebuilt and the machines reprogrammed, which companies consider the best time to upgrade technology, including the implementation of 4.0 technology solutions. This introduction of innovation is now much more frequent than in the past. It is thanks to the introduction of 4.0 technologies that the time to launch new models has been greatly reduced. Before the introduction of a new model took 7 years, it is now often realised within 2.5 years. Thanks to virtual reality, companies can model the entire production line and test the most efficient deployment of machines without significant costs. At the same time, they can train employees for the new line much faster in these simulations, without the real need for it to actually be built.

On the other hand, if we look at the factors that hinder the more intensive deployment of 4.0 technologies, this is especially the problem of calculating the return on investment, which, as we have mentioned, is an essential criterion for decision making. For example, in predictive maintenance, it is difficult to calculate the money that will be saved. The same applies, for example, to the introduction of

a new information system or simulation of employee training. According to technology providers, companies sometimes expect returns very quickly. Providers of 4.0 technologies also consider management capabilities to adequately understand the importance and benefits of deploying these technologies as a partial barrier. A particular problem of this type, which has been highlighted in several interviews, is the “forced” introduction of these technologies by management with insufficient knowledge or experience. This is especially the case when the parent company headquarters decides on the established one, but the implementation is left primarily to local management.

As in the automotive industry, reshoring is a threat to international companies in other sectors linked to the automotive industry. Throughout the region, changes are less visible than in the automotive industry itself, which is the leader of these changes. Gradually, however, 4.0 technologies are also reducing jobs in other sectors, such as banking. The number of bank branches is decreasing and the structure is changing towards the need for a more skilled IT workforce. Much of the risk associated with 4.0 technologies is related to reshoring, but this is still a threat in the region rather than current developments, so we talk more about this in the societal and sectoral impacts.

Social transformation

The social changes resulting from the deployment of 4.0 technologies within the region are still very limited and there is no significant transformation of the region. This is mainly related to the slower deployment of these technologies outside the companies within global value chains. This is partly due to the stagnation of people in adapting to new technologies in Slovakia (Veľšic, 2018). Up to 24% of people in the Bratislava region are hardly or rather difficult to adapt to new technologies and 11% not adapt at all, with the second worst adaptive group after retired people being unskilled manual workers.

Likewise, the labor market and education systems are adapting only very slowly, and support policy has also started to address the changes in the business environment related to 4.0 technologies only in the last two years. Education policy also try to react and help with this adaptations, but some activities are visible only last few years. Namely, introduction of dual education system, national project for support of technical fields studying or introduction of more IT into education system.

One of the major hindrances to greater deployment of 4.0 technologies is the lack of IT workforce. The Ministry of Labor, Social Affairs and Family of the SR regularly publishes a list of professions that are insufficient for individual regions. Within the Bratislava region, this list is dominated by IT professions. According to Trexima (2018), higher education fields with the highest employment rate of graduates in the labor market in 2017 were software engineering, cybernetics and information systems. At the same time, they estimate that the region will need an additional 9 ths. Industrial workers and 6.3 thousand ICT workers. As mentioned in the interview, the lack of this type of workforce discourages greater deployment of 4.0 technologies in the region.

4.1.5 Actual and/or expected impact

In the sector in the region

All companies 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.

Customisation of production is also an important aspect for industry performance. The introduction of 4.0 technologies has led to higher customer satisfaction. Technologies have brought greater flexibility and speed of production, which are mostly key customer requirements.

The automotive industry profits significantly from 4.0 technologies, but the competitive advantage for the region in this case cannot be measured by this sector introducing 4.0 technologies at a much faster rate than other sectors, but at how fast it does in comparison with other competitors in the group or other regions. This then significantly affects the industrial performance of the sector within the region itself. Overall, Central Europe is slightly lagging behind Western Europe in the deployment of 4.0 technologies.

Part of this threat is the development of the automotive industry in the region. A regular survey of automotive suppliers in Slovakia conducted by Pwc (2019) mapping their views on future developments confirmed that most suppliers expect a positive development of sales, but not employment. This is starting to show the gradual introduction of 4.0 technologies, supported by expectations that wage costs will continue to rise (68% of respondents) and there is a shortage of skilled labour (58% of respondents). In the interviews conducted, companies also confirm their efforts to reduce the number of jobs in the future. The survey also said that in the future, companies plan activities in the area of digitisation of production (44%), reduction of vehicle weight and introduction of new quality materials (40%) and development of components for autonomous vehicles (20%).

In particular, the development within the Volkswagen plant itself, which is the dominant undertaking in the region and sector, is crucial for the region. Even here there are already some tendencies towards offshoring, the company announced for 2019 job cuts. The company wants to focus strongly on electromobility. The company also announced that the new models of electric vehicles, using a unified technical basis (or platform) MEB, are to be produced in German factories in Zwickau, Emden, Hannover and two other locations. Electric car production is about 30% less labor-intensive. The MEB platform is intended to bring economies of scale as it will become the basis for all models of Volkswagen cars. A few years ago, Volkswagen Slovakia also planned to invest in a new tool shop that was able to produce incredibly precise tools and components using the latest 3D printer. This investment was one of the few sophisticated and required an educated workforce. At the headquarters, it was decided that all innovative 3D printing solutions will be integrated into one unit to increase capacity and be located in Wolfsburg, Germany.

The continuous introduction of 4.0 technologies can lead to several key changes or scenarios that are summarized in Table 4-8. We have already talked about reshoring and changing the structure of jobs,

as these changes are already taking place to a lesser extent. In addition to deploying new IT solutions, one of the challenges will be their integration. As one of the companies said: “There are many software solutions we now use. Already he only has to control XPERT (is the current ERP - order management and delivery). QS1 - for SAP quality management system - OPIC. E- HUMAN. TEAM center - for change management. Shaere point. MESS. TIG - for real-time production.” However, this will again lead to a greater concentration of IT solutions by multinationals that will be able to meet a wider range of business needs.

In addition to deploying new IT solutions, one of the challenges will be their integration. As one of the companies said: “Many software solutions are a problem for the company. Employees need to know XPERT (current ERP - order and delivery management), QS1 - for quality management system, SAP - OPIC, E-HUMAN, TEAM center - for change management, Shaere point, MESS, TIG - for real-time production.”

This represents significant additional costs for the company. However, this will again lead to a greater concentration of IT solutions by multinationals that will be able to meet a wider range of business needs, so local support policy must try to support local IT companies to enter global value chains.

Table 4-8. Key future possible development in 4.0 technologies in automotive

Key developments	Expected impact on region	Policies to mitigate the effects
Reshore of companies	negative	Increase of quality of labour force Improve RD capacities in the sector
Reduction of jobs for lower qualified workforce	negative	Requalification support for other industries or higher value added jobs in automotive
Strong pressure on sub-suppliers	neutral	Programs for networking, involvement of SMEs in global value chains
Integration of IT systems	negative	Support local IT providers to enter global value chains Increase of quality of labour force

Source: Compiled by the author

As a decisive requirement for implementing policies, it aims to improve the quality of the workforce capable of working with 4.0 technologies. While in German plants, these jobs represent an average of 40–59% of all production jobs, the median in CEE plants is 0–19%. Jobs with high skill requirements and small minorities in CEE plants, while representing the majority in German plants - although only highly automated plants in both regions are considered (Naudé, 2019). This shows precisely the difference in competitiveness in the principle of similar plants and the reasons why German plants dominate the selection for pilot deployment of new technologies. Without improving the quality of the workforce, local plants will not be able to prosper in the region in competition with other plants of MNC from regions with more qualified workforce.

In other sectors in the region

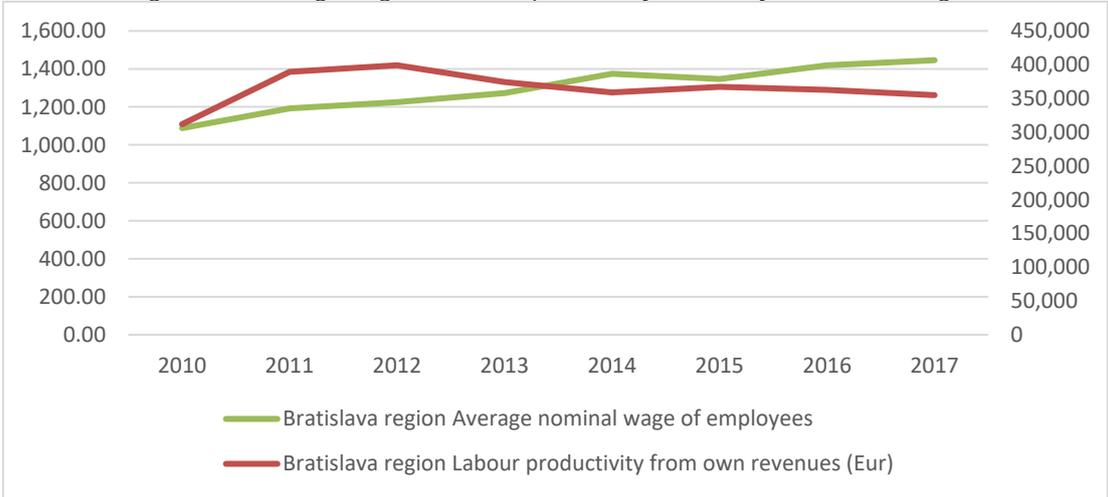
The most affected sectors by the changes in automotive industry are its suppliers. These are mainly companies in the textile, electrical, engineering and rubber industries. There is a similar process as in car factories, the gradual introduction of digitization and automation leads to slightly negative effects on employment and slightly positive turnover. As most of these suppliers are also multinational companies, the decision-making process is very similar to automotive. This process also affects support services companies. e.g. logistics. Basically, the process works as a kind of spill over from automotive with little time delay.

A special form of 4.0 technological changes is the interconnection of companies' IT systems with the end producers, which is increasingly intensive. This interconnection leads to unification of systems and even more intensive use of global IT companies capable of delivering such synchronized systems.

The same effect as in the automotive industry can be seen in the changes in the workforce of the related industries, in particular by increasing IT skills at all stages of production and reducing the need for a low-skilled workforce (Figure 4-4).

It is very interesting that the introduction of technologies has not yet led to an overall increase in labour productivity in the industrial sectors of the Bratislava region. There is no data on the share of the automotive industry in the Bratislava region, but within the Slovak Republic this industry is dominant, accounting for more than 46% of the total industrial production and similar number are expected for Bratislava region. The overall increase in labour productivity even has a downward trend, probably due to increase of labour costs.

Figure 4-4. Average wage and labour productivity in industry in Bratislava region



Source: own calculation based on Slovak statistical office data, left – average wage, right – productivity per employee, both in Eur

One of the major hindrances to greater deployment of 4.0 technologies is the already mentioned lack of IT workforce. This in turn leads to the positive effects being lower towards higher productivity or turnover, given that the plants are globally competitive and may therefore lose market shares over other plants in other countries that deploy 4.0 technologies more intensively.

The second very important aspect is the creation of very strong links between companies and their suppliers, which creates very significant barriers to entry for other potential suppliers. 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 applies in principle to any supplier. 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” effect. If some key elements of a given system move, the whole system has to move. This puts significant pressure on suppliers in other sectors and significantly strengthens their competitiveness. In the Bratislava region and its hinterland it related to transport, textile, electrical and rubber industries.

In the region

There are not many predictive studies on how 4.0 technologies will affect the development of individual regions. The main impact is expected on labour market. The risks of job losses due to automation in the Slovak Republic are among the highest in OECD countries. As shown in Figure 4-5, although the Bratislava Region is the least endangered region in Slovakia, the percentage of endangered cities is higher than the most endangered regions of most other OECD countries. The Figure 4-5 also shows that most metropolitan regions have much less risk of job losses.

Figure 4-5. Share of jobs at risk of automation in OECD regions



Source: Job creation and Local Economic development, OECD

The Bratislava region created jobs between 2006 and 2016, but the vast majority of them are at risk of automation, while again most OECD regions have created jobs that are not at risk (OECD, 2018).

The impact on the regional labour market itself can be seen in several dimensions. The first specific impact on the region and sector itself is the possible exit of firms from the region. Technology 4.0 will have significantly implications for the global distribution of manufacturing activities, the nature of manufacturing, and the contribution of manufacturing to employment and productivity growth (Naudé, 2017). One of the big threats to manufacturing in the central Europe, including Bratislava region, is that manufacturing activities could relocate as companies reconfigure their supply chains in light of new technologies associated with Technology 4.0 as well as rising labour costs (Ellram, 2013; Müller et al., 2017). E.g. Dachs et al. (2017) who finds from a sample of 2,120 manufacturing firms from the European Manufacturing Survey 2015 that there is a positive association between the adoption of 4.0 technologies and the likelihood of these firms to reshore activities. De Backer et al. (2016) concludes based on similar considerations that digitisation will discourage further offshoring to the CEEC and that the pressure is on reshoring of manufacturing back to Western Europe, especially in higher-tech sectors, due to the need for companies to be closer to where their main customer base is, and where research and development is being performed. This is even more supported by shortage of labour in manufacturing as a growing challenge. For instance, manufacturing firms in the Czech Republic, Hungary and Slovakia that reported labour shortages as a factor limiting production increased from an average of around 5% in 2010 to over 50% in 2017 (Naudé 2019). At the present stage of the sector's development, these departures have not yet taken place at large scale, although in a survey among subcontractors in 2019 for the first time, a larger number of companies said they expected a shift of activities from Slovakia rather than vice versa, a shift of activities to Slovakia. One of final car producer KIA (from region central Slovakia) already moved its complete IT infrastructure to Germany (Gérer, 2018). Still, vast majorities of companies in the survey expected to maintain or extend the activities in Slovakia (Pwc, 2019). Leaving tendencies have not been confirmed by companies within the interviews. However, a large number of companies are starting to actively feel a lack of skilled labour.

The second impact on the labour market is a change in the structure of jobs. The interviews have not yet shown the negative effects of emerging technologies on overall regional employment. In the past, the shortage of labour in the region was partly offset by imports of labour from other regions and countries. This also applied to the automotive industry, where the number of foreign workers began to grow. Thus, 4.0 technologies currently tend to replace this type of workforce and gradually eliminate foreign or temporary workforce. Interviews with technology vendors also confirm the tendency to change the structure of workplaces rather than to significantly reduce the number of workers. This is also contributed by an overall lack of a quality workforce. Most companies try to use internal resources and internal training and find a new position for existing employees. As an example of some companies' interviews: "We perceive great potential among the people in the company, we try to constantly select the best and send them for further education". "If employees can't handle the new technology, they have

to leave, but so far everyone has been able to adapt. We are greatly assisted by technology vendors, who themselves have a great interest in making technology work. This is done at the level of long-term contracts. When installing new technology under the supervision of a supplier, workers become valuable specialists.”

The workforce is particularly crucial in terms of the above-mentioned pilot introduction of new technologies. There it is necessary for the region to have a high proportion of university educated engineers and also to have a basic scientific basis in the area. When it comes to retraining people to already tested new technologies, companies can re-qualify the operator behind the belt in a relatively short period of time to be able to operate the new technologies. That is also why this part of jobs is not so much at risk at this moment. However, if local plants will be unable to become involved in the pilot deployment of new technologies, they will become increasingly vulnerable in terms of reshoring or even extinction.

There is one more important aspect to be mentioned regarding the impact on the workforce. As we have already indicated, the impact of the deployment of 4.0 technologies does not negatively affect the overall employment in the Bratislava region, although there is a slight decrease in the companies implementing these technologies themselves. This is particularly related to the good economic situation, where the overall unemployment rate is very low and the labor market is dominated by labor shortages. An important question is how the situation can change in the case of a worsening economy or a significantly more active deployment of 4.0 technologies. According to interviews and other published statements, it is here that the benefits of the metropolitan region should be felt and the region should be able to absorb the changes without significant problems, especially for two reasons. The first is a significant proportion of commuters from other regions (up to 33%), which will act as a buffer. This is reflected in the decreasing demand for these in the automotive industry. Possible negative consequences will thus primarily affect other backward regions outside Bratislava. The second is the relative lack of less skilled workers in the construction industry, crafts, but also skilled workers in the professions as a car mechanic, etc. Part of the workforce would thus fill these shortcomings. These are given in particular by extremely strict rules for the employment of foreigners, who often work in these positions. In Slovakia, foreign workers make up only 0.3% of the workforce (the EU average is 8.2%).

We can also see an interesting impact in the relationship between the services sector and industry. Within the quantitative results of the study, Bratislava represents the "Servitisation" transformation pattern, but with a very low rate of adoption and potential compared to other similar regions. Industry, which has a high rate of 4.0 transformation in the region, can play a major role here, draining an important part of the workforce needed for a higher rate of 4.0 transformation in the services sector. This is also confirmed by the overall cluster of Industry 4.0 regions around Bratislava (western and central Slovakia, southern Moravia or northern Hungary - see map 3.11 of the main report - taxonomy of regional transformation patterns), copying the interconnected FDI network in the automotive industry sector. Also, some of the technology services sectors are then more focused on working with industry.

4.1.6 Operational policy recommendations

When examining the case study of the automotive industry, several important moments have emerged towards a supportive policy for the deployment of 4.0 technologies or the elimination of the negative effects of the deployment for some risk groups. Based on this, we can formulate some recommendations that have contributed or could contribute (based on interviews) to the overall positive effects of 4.0 technologies.

1. Support of IT education

Supporting IT education at all levels appears to be a key aspect. Better IT skills are a prerequisite for maintaining jobs for low-skilled professions such as warehouseman, driver or operator. At this level, it mainly concerns the user skills of working with IT software. At the same time, they are also important at management level for the ability to understand the benefits and processes that 4.0 technologies bring. In several cases, the lack of management knowledge in a given area is a brake on the implementation of change. Limited understanding of processes significantly reduces management's willingness to invest in such technologies. Last but not least, it is important to increase the number of employees in the IT sector itself, which is important for the ability to create and implement new 4.0 technologies in the region.

2. Reshoring

Much more attention should be given to the reshoring risk, which is significant and could have major consequences for some regions. In the case of the Bratislava region, the threat is mainly the loss of introduction of new models in the automotive industry, which would gradually lead to a significant reduction in jobs. At present, there is no systematic support policy that actively supports the local MNC branches in their efforts to establish themselves more strongly within the concern itself and to acquire higher added value or pilot activities for 4.0 technologies. It is reshoring, unlike some other aspects of 4.0 technology, that puts less developed regions at significantly greater risk. The Bratislava region is one of the more developed regions with a relatively high-quality workforce. Nevertheless, even here this risk is very noticeable. In less developed regions, it is thus likely to pose an even more serious threat to development. In particular, the measures set out in points 3, 4 and 6 could be a reduction of this risk.

3. Integration into global value chains

The second important group, which should be the subject of support policy, are local IT companies with assumptions to participate in the global value chain. Integration of IT systems will require stronger "players" as partners for large enterprises also in the IT field. The involvement of local firms in the global value chain, or support for the creation of inflows of IT firms, will be important for maintaining local competitiveness. This measure can be successful especially in regions where there is already a basic base of such companies, e.g. regions with higher concentration of technology sectors that are able to produce 4.0 technology solutions. As also in the case of Bratislava, where technology sectors in services are concentrated above average of EU.

4. Greater emphasis on quality of labour force

The gradual introduction of 4.0 technologies also changes the mutual importance of the three key workforce attributes - price, quality and availability. The quantity is replaced by gradual automation and robotization, especially in industry. As shown in the main report, Slovakia is especially vulnerable to these processes. This puts the quality of the workforce at the forefront and support measures must reflect it. Appropriate measures that employers have mentioned or would suggest are, in particular: support for dual education and vocational training, a greater share of IT subjects at all levels of the school system from primary schools to universities, and greater support for the retraining of employees (not only the unemployed). The financial support for this retraining, where the public and private sectors would participate equally, is proving to be the most appropriate here.

5. Impact of policies between regions

The mutual impact of regional and national policies on different types of regions is also a factor that will need to be addressed. As shown in the Bratislava Region example, the most significant negative effects resulting from the deployment of 4.0 technologies are likely to be felt in the less developed neighbouring regions. This also supports the importance of policy coordination at national and national level.

6. Support for local SMEs in the creation and implementation of 4.0 technologies

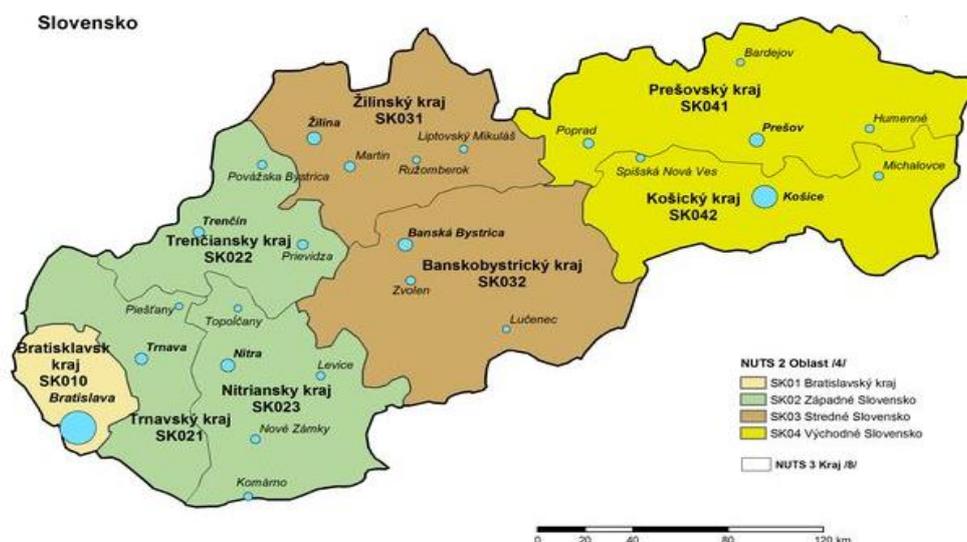
Small and medium-sized enterprises are disadvantaged by the introduction of some 4.0 technologies, as the introduction of these technologies usually has a much higher rate of economies of scale than traditional technologies. Therefore, their introduction is more advantageous for larger companies, which than, however, gain an even greater competitive advantage. In regions such as the Bratislava region, where most of large companies are foreign-owned with reshoring risk, this means even greater external dependence. Therefore, the support of local SMEs is also important, both in the area of implementation and creation of 4.0 technologies. This support may include financial schemes to encourage SMEs to enter new markets or to export.

4.2 Eastern Slovakia

4.2.1 Regional baseline

Eastern Slovakia is located in the east of Slovakia, bordering Ukraine in the east, Poland in the north and Hungary in the south. It consists of two administrative regions of Košice region and Prešov region (NUTS 3), which have their own regional government (Figure 4-6).

Figure 4-6. Regional administrative division of Slovakia



Source: Czech Statistical Office, available at <https://www.czso.cz/csu/czso/slovakia-nuts>, last accessed on 9/7/2019

The disadvantages of the peripheral location of the region are also compounded by shortcomings in the transport infrastructure and weaker transport links to the west of the country.

Eastern Slovakia (NUTS 2) is the second largest region in Slovakia in terms of population and area (Table 4-9). The Eastern Slovakia region has 1.6 million inhabitants and area of 15.7 thousand km². However, the population density is relatively low. It was 103.6 inhabitants per km² in 2017, which is below the national average (111.7) and the EU28 average (118.3). The region is predominantly rural, with an urbanization rate of 56.1%. The largest cities in the region are Košice (250 thousand inhabitants) and Prešov (90 thousand inhabitants). These cities are the seat of two self-governing regions. Other settlements are relatively fragmented with a predominance of small municipalities.

Table 4-9. Main characteristics of the region

	Population	Population density	Rate of urbanisation
Eastern Slovakia region	1.6 mil.	103.6 inh./km ²	56.1 %
Slovakia	5.4 mil.	111.7 inh./km ²	58.2 %
EU28	512 mil.	118.3 inh./km ²	74.1 %

Source: Compiled by the author with data from Eurostat

In 2017, the region was the most underdeveloped region in Slovakia with GDP per capita of EUR 16.3 thousand (Table 4-10). It reaches approximately 53% of the EU28 GDP per capita average (PPS), ranking it also among the EU's most underdeveloped regions. The rate of GDP growth in 2010–2017 was faster than in Slovakia and significantly exceeds the growth rate of the EU28 economy. The region suffers from a relatively high unemployment rate, which was 10.1% in 2018, well above the national and EU28 average.

Table 4-10. Main socio - economic indicators

	GDP per capita (PPS, 2017)	Average annual growth rate of GDP (2010 – 2017)	Unemployment rate (2018)	Share of employment in high tech (2018)
Eastern Slovakia region	€ 16.3 thous.	4.44%	10.1%	3.4
Slovakia	€ 22.9 thous.	3.52%	6.5%	4.3
EU28	€ 30.0 thous.	2.81%	6.9%	4.1

Source: Own elaboration. Data from Eurostat

The region has substantial intra-regional disparities. Economic activity is concentrated mainly in the two largest cities. The more peripheral parts of the region have significantly less employment opportunities and, as a result, have consistently high unemployment rates and suffer from population emigration.

4.2.2 Adopted 4.0 technologies in the sector in the region

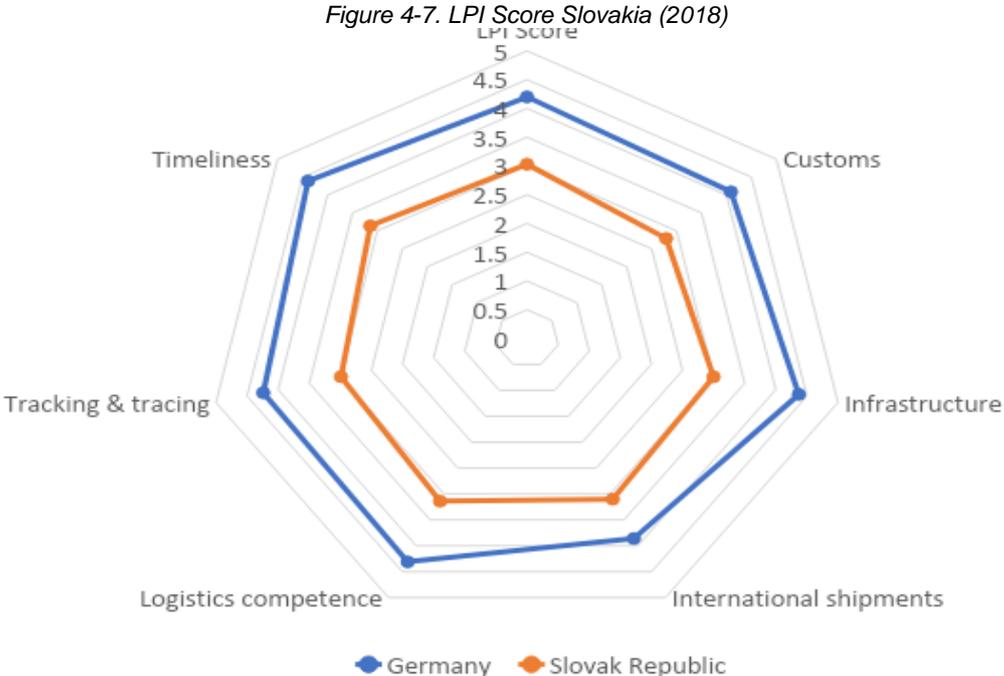
In general, adoption of 4.0 technologies in the region is rather in its infancy. This is the result of the lower technological level of the main sectors in the region because, as one of the respondents explained, "some firms do not even need new 4.0 technologies" as they operate in low tech industries. The IVO survey analysed the use of robots in Slovakia on a sample of 577 respondents. According to this survey, robots are part of the job for 11% of respondents in Slovakia, but this number is only from 5 (Prešov region) to 6 % (Košice region).

Considering the classification of industries in terms of technological transformation, the transport and logistics sector belongs to the so-called "induced" industries. These are the driving force behind economic transformation, as the digitisation of services and the automation of the production and distribution of services are taking place or will take place in near future.

The main technologies that influence the changes in logistics are those that influence the generation, processing and use of data (Winkelhaus and Gross, 2019). These are internet of things, cyber-physical systems, big data, cloud computing, mobile-based systems, social media-based systems and other technologies. Technologies are used in Enterprise Resource Planning (ERP), Warehouse Management Systems (WMS), Transportation Management Systems (TMS), Intelligent Transportation Systems (ITS) (Baretto et al., 2017). Main technologies aim to automate the gathering of information (cloud based solutions) and sharing information among different players in the value chain (connectivity, positioning). Software based technological solutions can be found in the traffic management systems, toll collection systems, predictive maintenance, artificial intelligence solutions, etc. Hardware solutions are in warehouse robotisation, electro mobility, warehousing supported by virtual reality and last mile delivery optimisation (mainly drones).

The World Bank (Worldbank, 2019) assesses the industry with the Logistics Performance Index (LPI), which assesses six dimensions - customs, infrastructure, international shipping, logistics competence, tracking and tracing, and timeliness (Figure 4-7). In 2018 Slovakia reached the level of LPI 3.03 from the maximum value of 5, which ranks 53th in the world. The leader is Germany with LPI value of 4.2.

Slovakia reaches lower values mainly in customs and in tracking of consignments. On the contrary, competences in logistics and timeliness have little bit higher scores.⁸⁷



Source: Compiled by the author with data from Worldbank (2019)

Logistics companies can be divided into categories according to the difficulty of the operations they perform for their clients. The lowest category is 2PL - second party logistics. This category includes companies that provide forwarding, transport and storage services. This form of outsourcing logistics is suitable mainly for small companies with a simple supply chain. A closer form of cooperation is 3PL - third-party logistics. This category includes companies that manage part or whole supply chain of the clients. Large companies, car manufacturers and foreign companies mainly use this form of cooperation. The logistics company manage transport of goods, organization of the flow of goods, planning and administration. In addition, these companies have technologies to optimize business processes of clients. In Slovakia, the vast majority of 3PL headquarters are located in the western part. This is due to the proximity of its clients and good transport accessibility. Most important 3PL companies in Slovakia are global companies such as DHL, Gefco, DB Schenker and Kuehne + Nagel. These companies established their branches also in other regions of Slovakia. In the region of Eastern Slovakia, mainly 2PL companies are located.

The pressure to use modern technology solutions results from several factors. The first factor is the technological requirements of the largest customers. These are mainly international manufacturing and trading companies in Slovakia or abroad. The growth of manufacturing industries in Slovakia was

⁸⁷ Data for the case study region are not available.

associated with an increase in demands on the efficiency of logistics. The increase in automation and digitization of final producers as well as suppliers in industrial production caused pressure to introduce new technologies also in logistics and transport companies. Companies usually use existing technology solutions (eg SAP, RAAL, TIMOCOM Augmented Logistics; TRANS, Dynafleet) to ensure the stability and efficiency of transport services and compatibility with customers. As one respondent stated, "*it is not worth developing your own solutions*". It is also due to limited research and development capacities in this technology in the region. The demand for new automated technologies in transport and logistics in Eastern Slovakia is lower compared to the Western Slovakia, mainly due to low labour costs. This is particularly evident in warehousing, where the potential for labour savings and productivity gains is highest.

The introduction of new logistics technologies is related to the need to increase transport efficiency and the need to meet customer requirements, while three main areas of change can be observed. In the area of business processes, efforts have been identified for compatibility with the data structure of key customers and transition to a compliant ERP system. International vehicle loading platforms (e.g. TIMOCOM, Shopvio) also play an important role. The use of platforms with artificial intelligence and machine learning allows quicker matching the demand and supply of transport, thus reducing empty traffic and idle time and results in the growth of orders. Companies in the region use existing international technological platforms, which establish their branches in Slovakia and customize their products for the Slovak market (e.g. Trans EU).

Another area is the introduction of fleet management and real-time traffic management technologies. An important factor in the introduction of these technologies is the requirement to control the driver's working time and mode of transport. The system provides instant access to vehicle control unit data, usually via GPS technology (location, fuel and driver consumption, vehicle temperature, flag length) via smartphone or tablet. These technologies are closely linked to the vehicle's control system, which is a major factor in purchasing technological solutions of original car manufacturers (e.g. Volvo's DYNAFLEET system). There is a trend for interconnection and cooperation of suppliers of these platforms with other suppliers of transport and logistics companies. Especially in the area of data sharing with the observe attempts to integrate data into a comprehensive solution for the carrier (e.g. data integration from Slovnaft refueling cards, electronic driver cards ČESMAD Slovakia, Tamex digital tachographs, Sygic navigation etc.). An important factor for adoption of new technologies is the safety of transport and driver protection (e.g. the driver does not start the vehicle unless the driver card is inserted into the control computer; the system controls the opening and closing the vehicle doors).

Another reason for the technological change in the sector is the legislative requirements for the use of electronic documents in international transport (electronic filing of transit documents and TIR carnets). This is related to the need to change electronic data processing formats and the use of Electronic transit system. This system is used by customs authorities and companies for the electronic interchange of data in predefined format. This requirement leads to the growth and establishment of specialized firms providing customs declaration services in international transport.

IoT technologies and data related to the identification of goods and the movement of goods are another example of 4.0 technologies deployed in the region. The most common type of labelling technologies of 2PL companies are barcodes and QR codes. Collection and processing of data is done by code readers, mobile terminals with WMS connection. We do not observe a system of intelligent containers of combined transport in the region. RFID technologies are also not currently used in the region. The Railway Company Cargo Slovakia operates several intelligent wagons with position sensors and other technologies. Thanks to IoT and Sigfox network the Cargo company can monitor the position of wagons or get information about wagons.

In warehousing, higher level of automation takes place in the western part of Slovakia. Companies use automated carts, automated transport systems and software solutions that enable to manage and optimize processes associated with warehouse operation, preparation and shipping of goods. Only warehouses with standardized goods are automated (the same packing sizes, the same or similar goods, the same packages, similar supplies, standardized pallets, etc.). The value of the warehouse operation is much more predictable for such goods. Automations of warehouses in the Eastern Slovakia region is much lower due to lower labour costs. Most warehouses use system of warehouse management, where the operators are navigated and the movement of goods is controlled by WMS (Warehous Management System) eg. Milsoft Software Technologies, Aimtec, Kodys.

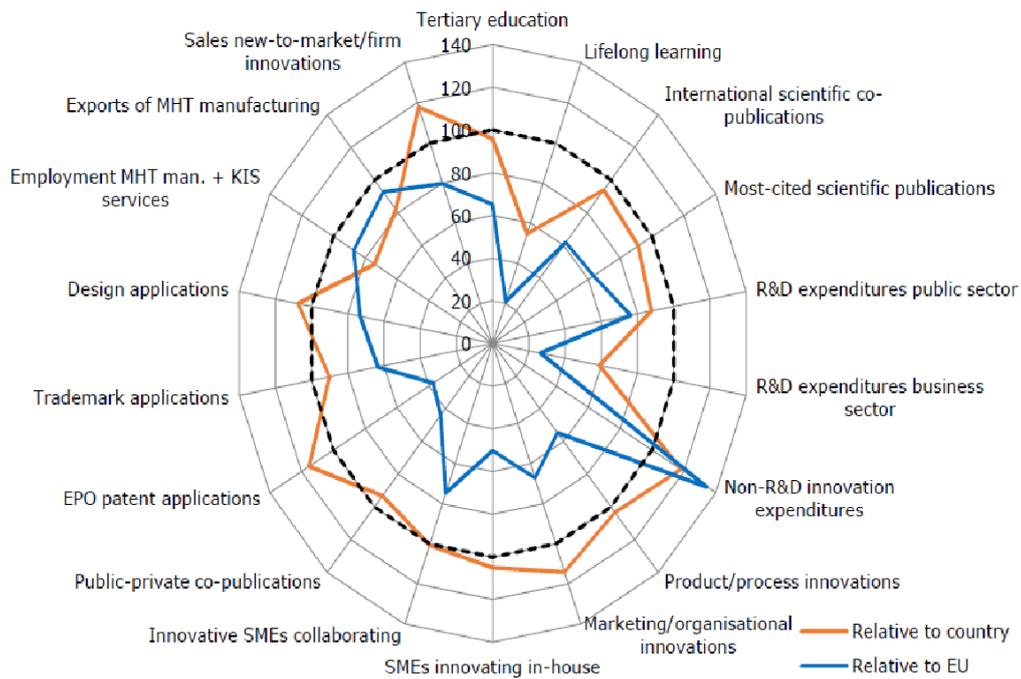
In the public transport domain, new technologies are used for tracking vehicles, providing information about transportation connections, on line payments and the use of IT solutions in public transportation at the client side as well as in the dispatching system. These technologies combine radio technology, on-board computers equipped with SIM-card, GPS modules and Wi-Fi in vehicles to manage public transportation. This combination enables real-time tracking of vehicles, communication with the driver, remote updating of transport schedules and routes and price lists directly from the dispatching centre and serving passengers with electronic cards. Passengers receive real time information about delays and closures of routes. The use of new technologies in public transportation in Košice was partly financially supported by the European Regional Development Fund within the Integrated Regional Operational Program.

4.2.3 Preconditions for transformation

Regional preconditions

According to the Regional Innovation Scoreboard 2018, Eastern Slovakia is a Moderate Innovator, but its innovative performance has been increasing over the past few years. The region's lower innovation level is significantly affected by the under-funding of R&D. Public spending on R&D in 2017 was 0.43% of GDP (Figure 4-8). This is approximately 88% compared to the Slovak average. Lagging behind the EU average is even more significant (77%). The situation is much worse in the area of R&D expenditures in the business sector. With 0.14% of GDP (2017) reaching 59% of the Slovak average and only 26% of the EU average. Low level of business investment in R&D is also associated with low outputs in research (publications) and innovations (patent applications, trademarks, design).

Figure 4.9. RIS 2019 Eastern Slovakia region – comparison of main indicators



Source: Regional Innovation Scoreboard

The relation link between the public and business research in weak. Joint publications between the public and commercial sectors account for about 44% of the EU average. Indicators of business innovation activity are slightly higher than the national average but are significantly lower than the EU average. The share of people with higher education was 27.5%, which is about 65% of the EU average. The problem is the extremely low proportion of the population participating in lifelong learning. With a level of 1.8% , it is only about 21% of the EU average.

The largest research institutions in the region are Technical University of Košice, University of P.J. Šafárik in Košice, University of Prešov and the institutes of the Slovak Academy of Sciences - Institute of Geotechnics, Institute of Materials Research, Institute of Geotechnics, Institute of Neurobiology, Institute of Parasitology, and the Astronomical Institute. There are also several private research institutes in the region, eg. (TSG VVÚ KOŠICE, a. S., Research Institute of Chemical Fibers). However, the research profile in the region is largely orientated towards traditional regional sectors, such as metallurgy, mining, chemical industry and agriculture.

An important institutional innovation in the governance of R&D in region was the establishment of three science parks and research centers in the region (Table 4-11). These were established during 2013 and 2017 with the support of ESIF. Of these, the Technicom Science Park in particular may become an important element in the regional innovation system in 4.0 technologies.

Table 4-11. Science parks and research centres in the region

Name	Partners	Focus
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University science park TECHNICOM	Technicom association (TU Košice, UPJŠ in Prešov, PU in Prešov)	ICT, electronics, automatization, robotics, artificial intelligence, mechanical engineering, construction engineering, environmental engineering
Research centre for progressive materials and technologies PROMATECH	Slovak Academy of Sciences – Institute of material research, Institute of experimental physics, Institute of geotechnics, Institute of material and engine mechanics, UPJŠ in Košice, TU in Košice	physics, material engineering, engineering, nanotechnologies, environmental engineering
Medical university park (MEDIPARK)	UPJŠ in Košice, TU in Košice, University of Veterinary Medicine and Pharmacy, Institute of Neurobiology SAV	biomedicine, biotechnologies, material research

Source: Compiled by the author based on Balog (2019)

Since its establishment, 7 joint research and development centres were established in Technicom. These centres are joint efforts of universities and private companies: FME TUKE - MinebeaMitsumi Football Humanoid Robotic Systems (TUKE and Minebea Slovakia), Innovation Center for Mobile Services and Communications (TUKE and SWAN KE), BIOINFORMATICS (TUKE and Clinical Trials Services), Innovation Center of Information and Communication Services for Science Support, research and technological transfer (TUKE and the Center of Scientific and Technical Information of the Slovak Republic), TUKE-SPINEA E-motion Center (TUKE and Spinea Prešov), Innovation Center for Research of Advanced and Special Methods and Procedures in Air Transport (TUKE and MSM Martin) Center of research and development of bioreactors (TUKE and SENYOR. And ENBICORE). At the same time, the TUKE Start-up Center and TUKE Incubator were established in the science park.

Several Horizon 2020 projects of local academic institutions supporting the development of 4.0 technologies in the region. *The Manufacturing Industry Digital Innovation Hubs* (TUKE) project aims to build a one stop shop for services and consultancy focused on higher digital technologies in industrial manufacturing. MIDIHs will leverage networks of local Competence Centres, each specialized in peculiar aspects of the CPPS / IIOT (Cyber Physical Production System / Industrial Internet of Things) technologies and able to attract, mentor and nurture local Manufacturing SMEs towards Industry 4.0 projects, experiments and business. The second project is *Industry 4.0 for SMEs - Smart Manufacturing and Logistics for SMEs in an X-to-order and Mass Customization Environment*. This project focuses on the creation of an international and interdisciplinary research network focused on identifying the needs and enablers for a smart and intelligent SME-Factory, creating customized concepts and design solutions for production and logistics systems in SMEs and developing suitable organization and business models. Scientific research in technology 4.0 is also supported by several national research projects funded by the Ministry of Education of the Slovak Republic.

In terms of sectoral structure, the region is specialized mainly in lower-tech industrial production and less knowledge-intensive services. In 2018, the share of employment in technology and knowledge intensive sectors was 3.4% of total employment, which is significantly lower than in Slovakia (4.3%) and

EU28 (4.1%). The dominant industries according the employment are metal production and processing, clothing and food production. The region is undergoing important sectoral changes and employment in these sectors is declining. There has been an increase in industries with a medium tech level (manufacturing components for the automotive industry) and in knowledge-intensive high-tech services (ICT). Employment growth in the higher-tech sector was also supported by the state investment incentives shown in the following Table 4-12.

Table 4-12. Companies with the largest investment incentives in the Eastern Slovakia region

Company	Sector	Year of investment	State investment aid
GETRAG FORD Transmissions Slovakia, s.r.o.	Automotive	2006	54,500,000
Magneti Marelli Slovakia, s.r.o. (2007)	Automotive	2007	13,937,429
Yazaki Wiring Technologies Slovakia s.r.o.	Automotive	2007	13,451,585
T-Systems Slovakia s.r.o. (2008)	ICT	2008	11,976,366
Honeywell Turbo s. r. o.	Automotive	2011	19,154,577
Magneti Marelli Slovakia, s.r.o. (2012)	Automotive	2012	27,500,000
Minebea Slovakia s.r.o.	Electronics	2017	19,250,000
SPINEA, s.r.o.	Robotics	2017	20,290,021
Mubea Automotive Slovakia s. r. o.	Automotive	2018	14,948,000
Railway Casted Components a. s.	Metalurgy	2013	9,939,754

Source: Ministry of Economy of the Slovak Republic.

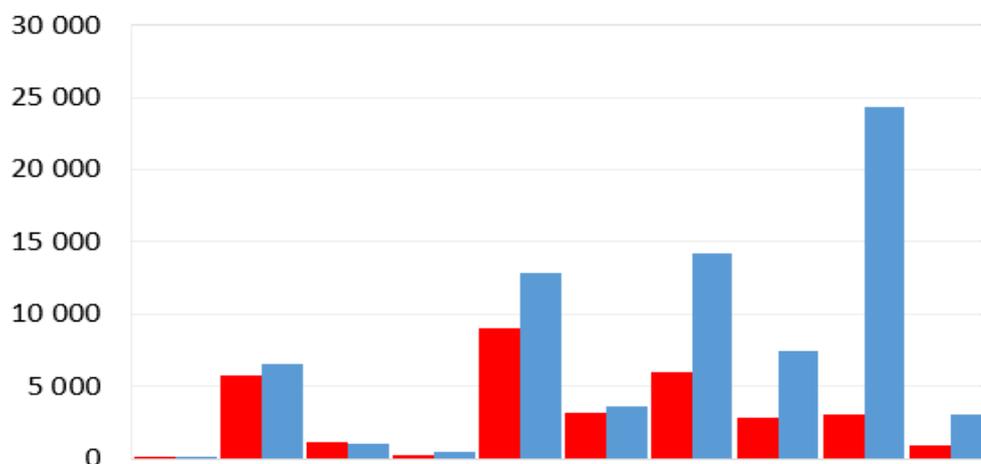
Technologically advanced companies located in the region established two regional industry clusters - Cluster Automation and Robotics (AT + R) and Cluster Košice IT Valley. The AT + R cluster was founded in Košice in March 2010 and associates 12 industrial companies, 2 universities, 2 self-governing regions, and 1 institute of the Slovak Academy of Sciences. The main initiators of the cluster are local innovative companies such as Spinea (Prešov), TSG VVÚ (Košice) and PROCONT (Prešov). Spinea focuses on manufacturing high-precision reducers for industrial robots. It was established in 1994 and currently has around 600 employees and sales of € 37 mil. The company owns a patent for the precision reducer TwinSpin and is the supplier of the largest manufacturers of industrial robots such as KUKA, ABB, Comau, RRRobotica. In 2013, Spinea established a subsidiary, Spinea technologies, which is an independent research, development and design entity in the field of mechatronics. The company ZTS VVÚ (Košice) is a supplier of engineering components and production units. Recently it also develops robotic systems, automation technologies, production units for nuclear power engineering, special vehicle constructions, special military technologies. The company has 104 employees and revenues of € 5.6 mil. PROCONT (Prešov) is a smaller company with up to 50 employees with revenues of € 4.8 mil. The company develop, design, manufacture and supply automated systems, electrical and manipulation technologies. Its customers are mostly companies in the Slovak Republic in the field of industrial production (automotive, woodworking, electrical, engineering), energy and construction. The main objective of the AT + R cluster is to support the innovative activities of members in the field of mechatronics, robotics, intelligent manufacturing systems and progressive materials. Key activities are development programs and projects, the transfer of new technologies and training programs in the areas

of business development, production and internationalization. The second important association is Klaster Košice IT Valley, which currently has 55 members. Klaster Košice IT Valley was founded in 2007 as a joint initiative of regional educational institutions, state administration and leading IT companies in the region such as T-Systems, Ness, Cisco, Microsoft, or Siemens Program and System Engineering. Today, the IT sector employs approximately 11,000 people in the region. The cluster is mainly involved in IT education, improving the quality of IT education programs, supporting all forms of cooperation and innovation, and preparing and implementing joint science and research projects. The development of IT sector in the Košice region was mainly driven by the establishment of branches of global IT companies which were attracted to the region by cheaper qualified workforce and sufficient number of graduates of local universities (Pástor, Šipikal, Rehák, 2013). Largest regional IT company is T Systems Slovakia. Company was founded in Slovakia in 2006. It provides outsourcing of information and communication solutions for the global corporate clientele of Deutsche Telekom AG. It is the second largest IT company in Slovakia with 3,850 employees (2016) and sales of € 151 mil. From the technological point of view, the branch in Košice is the leader in cloud solutions, dynamic computing, dynamic SAP solutions and SAP HANA solutions. The second largest IT company in the region is Lynx. Company has sales around € 22 million and approximately 100 employees. Lynx is a local company that was founded in Košice in 1991. It provides solutions for cyber security, but also design, construction and operation of information systems, networking, supply of complex security solutions and development of special applications. Since 2005, the global IT company Ness Digital Engineering has a branch in Ness KDC in Košice. Ness KDC is a development centre providing services to foreign clients in areas such as automotive, transport, financial sector, media and marketing, energy and big data. In 2018, the company had sales of € 19.8 million, and about 500 employees.

Sectoral preconditions

Transportation and logistics sector include firms which provide services in land and pipeline transportation, water transport, air transport, warehousing and ancillary transport activities, and postal and courier services. The water transport and air transport belongs to the group of knowledge-intensive services and the land transport and pipeline transport, warehousing, support activities for transport, postal and courier services are less knowledge intensive industries. In terms of educational structure, employees with secondary or lower education dominate the industry (Figure 4-9).

Figure 4-9. Structure of employees in the transportation and logistics by gender and level of education (2018)



Source: TRIXIMA Bratislava, ISCP (MPSVR SR) 1-04

Description: blue – men, red – women, columns from left to right – third level higher education, second level higher education, first level higher education, complete secondary education, complete general secondary education, apprenticeship with graduation, secondary education without graduation, apprenticeship, primary education

Share of the industry in total employment was 5.9% in 2018. Employment share is similar as the Slovak average (6.0%) and exceeds EU28 average (4.8%) (Table 4-13). In terms of employment, the largest companies in the branch based in the Eastern Slovakia region include companies providing local and regional public transport (Košice City Transport Company, Eurobus, Arriva, SAD Prešov, SAD Humenné), road management and maintenance (Správa ciest Košického samosprávneho kraja, Správa ciest Prešovského samosprávneho kraja) and freight transport (STD DONIVO, NOTHEGGER Slovakia) and related services (US Steel Obalservis).

Table 4-13. The largest employers in the transport and logistics sector in the Eastern Slovakia region

Firm	Specialisation	Employees
Dopravný podnik mesta Košice, akciová spoločnosť	Public mass transport	500-999
U. S. Steel Obalservis s.r.o.	Packaging	500-999
eurobus, a.s.	Road public transport	250-499
ARRIVA Michalovce, a.s.	Road public transport	250-499
NOTHEGGER Slovakia, s.r.o.	Freight transport by road	250-499
Správa ciest Košického samosprávneho kraja	Road management and maintenance	250-499
STD DONIVO a.s.	International truck transport, logistics	500-999
Správa a údržba ciest Prešovského samosprávneho kraja	Road management and maintenance	500-999
SAD Prešov, a.s.	Road public transport	250-499
SAD Humenné, a.s.	Road public transport	250-499

Source: Finstat

The largest revenues have companies that provide freight transport (Table 4-14). Transport companies provide mainly domestic and international freight transport and related services such as warehousing,

customs clearance, etc. (STD DONIVO a.s., ERFOLG s.r.o., DeutschMann Internationale Spedition s.r.o., Hudos, Vedos and the like). A specific feature of the region is the international transshipment of goods at the border of Slovakia and Ukraine (Čierna nad Tisou). Two railway gauge and two transport modes are meeting here which requires transshipment of goods. The largest company is BULK TRANSSHIPMENT SLOVAKIA, whose shareholders are BUDAMAR LOGISTIC, a.s. and Railway Company Cargo Slovakia.

Table 4-14. Companies with the highest revenues in the transport and logistics sector in the Eastern Slovakia region

Company	Specialisation	Sales
STD DONIVO a.s.	International truck transport, logistics	90,501,029 €
ERFOLG s.r.o.	International and domestic truck transport, warehousing, customs clearance	41,183,662 €
DeutschMann Internationale Spedition s.r.o.	International and domestic freight transport, express transport, logistics and warehousing	37,571,869 €
U. S. Steel Obalservis s.r.o.	Packaging of products	27,770,877 €
LC Sabinov a. s.	Logistics center, warehousing	25,049,051 €
AIR - TRANSPORT EUROPE, spol. s r.o.	Helicopter emergency medical service	18,727,306 €
HUDOS s.r.o.	International and domestic truck transport, warehousing	17,906,357 €
Dopravný podnik mesta Košice, akciová spoločnosť	Public mass transport	14,487,076 €
VEDOS, s. r. o.	International and domestic truck transport, storage, service and maintenance, production and sale of concrete	13,062,191 €
BULK TRANSSHIPMENT SLOVAKIA, a. s.	Freight rail transport, reloading of bulk and piece goods	12,731,436 €

Source: Finstat

Social preconditions

Several respondents criticized the lack of workers in the sector. Although the shortage of workers is not directly related to the deployment of technology, it points to more serious systemic shortcomings in the training of workers. In particular, the branch of secondary vocational education has been criticized in Slovakia for a long time because of its inability to adapt to the current needs of the labor market. Vocational secondary schools in the region are represented by a total of 134 schools, 61 of them in the Košice Region and 73 in the Prešov Region. A total of 42,818 pupils studied at vocational schools, of which 21,728 in the Prešov Region and 21,036 in the Košice Region. The structure of vocational education in the region is slowly changing by merging schools and restructuring curricula. The number of secondary vocational school pupils in the Eastern Slovakia region is decreasing. Number of students in 2017 was only 72% compared to 2008. This partial results from demographic decline in the regional population but also from the lack of interest of prospective students to study at vocational secondary schools.

At present, there are 6 universities located in the region. The largest institution is the Technical University of Kosice with 9,713 students followed by the University of Prešov (9,216 students) and P. J.

Šafárik University (7,480 students). Universities have predominantly only regional importance (Gurňák, Lauko, Križan, 2011) as the number of students from other regions is small. The number of secondary school graduates studying outside Eastern Slovakia is declining as well (Šebová 2018). The Faculty of Electrical Engineering and Computer Science, the Faculty of Production Technologies and the Faculty of Mechanical Engineering at the TU in Košice provide the most important curricula for the adoption and development of 4.0 technologies. These faculties offer study programs in electronics and computer science in manufacturing and transportation, development and management of intelligent manufacturing systems, and related topics such as cybersecurity, quality or environmental aspects.

The number of full-time university students was 26,950 in 2016, which is about 23% of the total number of students in Slovakia. The number of university students in Eastern Slovakia is constantly decreasing, but this is general demographic trend in Slovakia. Since 2008, the number of students declined by 13%, which is slightly less than the decrease in the number of students in Slovakia (16%). 4.0. Region faces an outmigration of university graduates. A case study of TU in Košice showed that only 35% remained to work in the region after graduation (Šebová, 2018). Low job opportunities and wage disadvantages are an important factor in the outmigration of human capital from the region.

Respondents did not comment directly on problems with the digitization of the economy and society in the region (Table 4-15). However, in international comparison, Slovakia is on the tail of digitization. According to the DESI index (European Commission 2019), in 2019 Slovakia ranks 21 out of 28 EU countries. The country is lagging behind in all five dimensions of internet connectivity, human capital (digital skills, IT graduates), use of Internet services, digital technology integration and digital public services. There has been a noticeable increase in recent years, particularly in the area of broadband coverage and the use of the Internet for purchasing and communication. Slovakia is improving in the open data indicator and improving the provision of digital public services to businesses. Regional data show that the Internet availability rate in the region is significantly lower than the EU28 average and slightly lower than the SR average. The share of households with home Internet access is 78% compared to 89% in the EU28 and 77% of households have broadband internet access compared to 86% in the EU28. Internet use and interaction with public authorities via the Internet is also lower than the national average as well as the EU28 average.

Table 4-15. Regional digital economy and society

	Households with access to the internet at home (2018)	Households with broadband access (2018)	Frequency of internet access: once a week (including every day) (2018)	Individuals who used the internet for interaction with public authorities (last 12 month) (2018)
Eastern Slovakia region	78	77	77	48
Slovakia	81	79	78	51
EU28	89	86	83	-

Source: Own elaboration. Data from Eurostat

Policy preconditions

The adoption of 4.0 technologies is supported by several strategic documents both at the national and regional level (Table 4-16). Competences related to innovation and R&D have traditionally been considered matters of the central government in Slovakia. Self-governing regions prepare separate strategic documents, but their implementation is problematic due to lack of financial funds and competencies. There are no separate operational programs managed by self-governing regions. Each region competes for the national support schemes launched by the central government. The following Table 4-16 gives an overview and institutional affiliation of the main strategic documents related to 4.0 technologies.

Table 4-16. Main Industry 4.0 Related Strategic Documents in Slovakia

Year	Document	Managing authority
2007	Operational Program Competitiveness and Economic Growth	Ministry of Economy of the Slovak Republic
	Operational Program Research and Development	Ministry of Education, Science and Sport of the Slovak Republic
	Operational Program Informatisation of Society	Office of the Government of the Slovak Republic
	Operational Program Education	Ministry of Education, Science and Sport of the Slovak Republic
	Operational Program Employment and Social Inclusion	Ministry of Labor, Social Affairs and Family of the SR
2013	Research and Innovation Strategy for Smart Specialization	Ministry of Economy of the Slovak Republic, Ministry of Education of the Science and Research of the Slovak Republic
	Operational Program Research and Innovation	Ministry of Education, Science and Sport of the Slovak Republic
	Operational Program Effective Public Administration	Ministry of the Interior of the Slovak Republic
	Operational Program Human Resources	Ministry of Labor and Social Affairs of the Slovak Republic
2015	Regional Innovation Strategy PSGR 2015–2020	Prešov Self-Governing Region
	Regional Innovation Strategy KSGR 2013 - 2020	Košice Self-Governing Region
2016	Intelligent Industry Concept for Slovakia	Ministry of Economy of the Slovak Republic
	Intelligent Industry Action Plan	Ministry of Economy of the Slovak Republic
	Human Resources Development Program in the Digital Economy in KSGR	Košice Self-Governing Region
2017	Implementation Plan RIS3SK 2017 - 2018	Implementation Plan RIS3SK 2017 - 2018 Ministry of Economy of the Slovak Republic and Ministry of Education of the Science and Research of the Slovak Republic Office of the Deputy Prime Minister for Investment and Informatics

2019	Digital Transformation Strategy of Slovakia 2030	Office of the Deputy Prime Minister for Investment and Informatics
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Source: Compiled by the author

The main strategic document related to the development and deployment of 4.0 technologies at the national level is the **Intelligent Industry Concept for Slovakia** introduced by the Ministry of Economy of the Slovak Republic in 2016. The strategy summarizes the policies for supporting competitiveness of companies using new technologies, materials, creating system interconnections of individual actors, but also other changes in the area of finance, research, education and public administration. The implementation document is the **Intelligent Industry Action Plan**. It sets out 35 actions in 5 areas - Research, Development and Innovation; Cybersecurity; Labour market and education; regulation; and Information and publicity, which is planned to be implemented by 2020. The vast majority of the measures proposed in this period are only analytical studies and drafting proposals. Measures that are more specific are in the area of education and the labour market, where changes in mathematical, technical and information literacy or enhancement of graduates' practical skills are expected. However, there is no report on the implementation of the action plan, so it is not possible to identify the financial resources spent or to identify those measures that have already been implemented.

The area of digitalisation of society is covered by the **Strategy of Digital Transformation of the Slovak Republic until 2030**, which is a broader conceived strategy aimed at building a digital society. The Strategy is complemented by the **Digital Transformation Action Plan** for the period 2019 - 2022. In this period, the following priority areas were set up: education, digital skills and employment, modern data and digital economy, and the capacity of public administration to innovate and use data. Investments in the data economy; innovative ecosystems; autonomous cars and financial innovation are expected to be supported in following years. Implementation of the Action Plan is in charge of the Office of the Deputy Prime Minister for Investment and Information Technology. The coordinating body is the Council of the Government of the Slovak Republic for the digitization of public administration and the Digital Single Market. No specific financial resources are allocated at this moment. It is expected to use existing ESIF for the period 2014-2020 within the OP Effective Public Administration, OP Research and Innovation, OP Human Resources. Due to the short time since the strategy was approved, no further information is available yet.

The **Research and Innovation Strategy for the Intelligent Specialization of the Slovak Republic (RIS3SK)** aims to support structural changes in the economy, in particular by supporting innovative activities of firms in support of excellent research. The strategy identifies areas of traditional sectoral specialization but also points to prospective areas of specialization in which country have available research capacities. In the implementation plan, 5 domains of the smart specialization are identified Transport Vehicles for the 21st Century; Industry for the 21st century; Digital Slovakia and Creative Industry; Population Health and Health Technology; and Healthy food and environment. The Government Council for Science, Technology and Innovation (2013) was established to be the main

coordinating body for this area and a permanent Commission for RIS3 was created within the Council to oversee implementation.

Most of the activities are financed or planned to be financed by ESIF. The most important operational programs **in the period 2007 - 2013** were the **OP Competitiveness and Economic Growth** and the **OP Research and Development**. Within the priority axis 1. Innovation and competitiveness growth (OP CaEG), 407 projects were supported with a total volume of € 165 mil. (EU + SR). In the OP R&D, most important priority axes were 1 Research and Development Infrastructure, 2 Support for Research and Development and 5 University Infrastructure. In total, 309 projects were supported, amounting to € 199 mil. In addition, several other OPs contributed to development of the context for the implementation of new technologies. These were Operational Program Informatisation of Society (PA1 Electronization of public administration and development of electronic services and PA3 Increasing access to broadband internet), Operational Program Education (Priority Axis 1 Education and Training System Reform and 2 Further Education as a Human Resources Development Tool). Employment and Social Inclusion Program (PA1 Supporting Employment Growth).

In the 2014 – 2020 programming period OP Research and Innovation, OP Human Resources and OP Effective Public Administration are the main programs for the support of deployment of 4.0 technologies. Most important priority axes in **OP Research and Innovation** are: Priority Axis 1 Support for Research, Development and Innovation and Priority Axis 3 Strengthening the competitiveness and growth of SMEs. The PA1 expect to support activities aimed at increasing the research excellence, business investments in R&D, including cooperation between public and commercial organizations. The PA3 supports entrepreneurship, new business models, internationalisation and expansion of existing capacities. Currently 327 projects are implemented in the Eastern Slovakia region with the support of the OP R&I (€ 119 mil. 1 is allocated in PA1 and € 199 mil. in PA3). Recently a call for proposals is announced to support smart innovation with an allocation of € 35 million. A similar call was already announced and closed in 2018 (allocation of € 30 million). The Priority Axis 1 in the **OP Human Resources** aims to support new educational reforms in secondary, tertiary education and life-long learning, which reflect the changing labour market needs. In total, € 549 mil. is allocated for less developed regions in Slovakia. So far, two calls were already announced - IP 1.3 Higher education for practice (€ 15 million) and in IP 1.4 DO NOT (DIS)QUALIFY yourself!. The digitization public administration is supported by the **OP Effective Public Administration**. Priority axis 1 *Enhanced institutional capacities and effective public administration* (€ 234 million) focuses on optimisation of processes, improving competences of human resources in public administration.

Košice and Prešov self-governing regions developed their regional innovation strategies in 2015. The ambition of the Regional Innovation Strategy of Košice region (2013-2020) is to create an innovation ecosystem that will enable successful commercial projects. The document identifies 6 key areas for regional R&D and innovation investment: the automotive industry; electronics; information and communication technologies and software; energetics and renewable energy; new and lightweight materials; medical technology and health care. Key strategic areas are excellent research and

development; research commercialisation and innovation; promotion of innovative entrepreneurship and promotion of quality human resources. The Action Plan 2015-2017 includes 13 activities out of a total of 65 RIS activities. The activities (Table 4-17) are mainly focused on building system links in the regional innovation system, promoting entrepreneurship and improving consistency between education and labour market.

Table 4-17. List of planned activities under the Regional innovation strategy in Košice region (2016 – 2017)

Area	Activities	Managing authority (partners)	Planned Budget (source)
Excellence in research and development			
Joint research teams	Support for involvement in major projects; conducting workshops; preparation of a memorandum of cooperation between the academy and companies, etc.	TUKE (UPJŠ, institutes of SAS, IT Valley, AT+R)	€ 10 000 (universities, research institutes, firms)
Commercialization of research and innovation			
Educational and mentoring programs	Creation of database of participants, definition of program content, preparation of projects	Technicom (Promatech, IT Valley, AT+R, SOPK)	€ 30 thous. (universities, research institutes, SBA/SIEA)
Pilot projects for technology transfer and research commercialization and spin off	Creating a research database with commercial potential; searching for resources, preparing projects, creating a regional grant system	Technicom (Promatech, Medipark)	€ 1,3 mil. (universities, research institutes, SBA/SIEA)
Supporting the preparation of joint research and innovation projects between the industrial and academic sectors	Creating project consortia, preparing project plans, submitting projects and, if successful, their implementation	TUKE (UPJŠ, Technicom, Promatech, Medipark, Institute of Neurobiology SAS, Institute of material research SAS, VRP, AT+R, IT Valley, CEIT BE)	€ 60 mil. – € 120 mil. (universities, research institutes, firms, grants)
Establishment of a regional shared prototype workshop for advanced manufacturing and technology	Addressing partners, creating a project proposal, preparing a project plan and, if successful, implementation	Technicom, AT+R (Promatech, TUKE, ústavy SAV)	€ 6 mil. – € 8 mil. (universities, research institutes, firms, grants, SBA/SIEA)
Promoting innovative entrepreneurship and promoting core and promising sectors			
Individual business consulting in the field of innovation management	Processing of educational program content, raising financial resources, addressing participants	Košice self-governing region (Technicom, IT Valley)	€ 60 thous. (own resources, universities, research institutes, firms, grants, SBA/SIEA)
Creating a cross-sectoral cooperation network	Addressing partners and creating a platform, organizing meetings, promoting collaboration by event organization and communication	Košice self-governing region	15 000 EUR (Podnikateľské zdroje Zdroje SBA/SIEA)
Quality human resources			

Student internships and jobs	student work exchange for some of the regional core industries, hackathon	Universities, vocational schools, SOPK (firms, clusters)	NA
Coaching of secondary and primary school teachers	analysis of similar existing activities, best practice, identification of teachers, identification of coaches, joint conference	Secondary schools, elementary schools (firms, universities)	The activity does not require direct financial resources
Cooperation of organisations in developing the education content	mapping of existing collaborations, overview of available experts and capacities of companies, proposal of platform and proposal of curriculum modification	Košice self-governing region (schools, universities, firms)	€ 20 thous.
Development of entrepreneurial competences of students	Overview of existing activities, promotion, preparation of program implementation	Košice self-governing region (secondary schools), towns (primary schools), universities (firms, incubators, startup centres (Eastcubator, JASR, KPMG a pod.))	€ 38 thous. (yearly)
Promotion of education in technical areas	mapping of existing activities, realization of specific events	Košice self-governing region (schools, firms, universities, research institutes)	€ 29 thous. (yearly)
Regional innovation ecosystem of European quality level			
Web RIS	content management system, online database of research facilities and expertise, calendar of events, newsletter, assignment	Košice self-governing region (firms, universities, research institutes)	€ 15 thous. by 2020

Source: Regional innovation strategy of Košice region

The vision of the **Regional Innovation Strategy of Prešov region** for 2014-2020 is to accelerate the economic growth of the lagging region and its transformation by technological investments, developing a knowledge-based economy, supporting structural changes in the economy and increasing innovation capacity. The innovation strategy does not contain any detailed description of the financial resources nor does it quantify the expected results (Table 4-18).

Table 4-18. Regional innovation strategy in Prešov region – objectives, measures, activities

Objectives	Measures	Activities
1. Development of innovative infrastructure	1.1. Development of innovative infrastructure to improve the conditions for increasing the innovation performance of enterprises	1.1.1. Support of cluster formation in Eastern Slovakia 1.1.2. Innovation Partner Center 1.1.3. Promoting international cooperation 1.1.4. Supporting the development of knowledge-based services and creative business
	1.2. Development of innovative R&D infrastructure of institutions	1.2.1. Establishment of technology centers

		1.2.2. Developing excellent research 1.2.3. Assistance in the protection and use of intellectual property
2. Development of human resources and innovative environment in the region	2.1. Supporting education in interaction with the needs of key industries at national and regional level	2.1.1. Training and upgrading skills in entrepreneurship 2.1.2. Supporting the education at secondary schools and universities and their connection with practice
	2.2 Promoting an innovation-friendly environment	2.2.1. Innovation Forum 2.2.2. Innovation awareness 2.2.3. Innovation advisory services
3. Development of financial infrastructure	3.1. Fund raising for promoting innovation	3.1.1. National innovation funding support programs 3.1.2. Supporting the emergence of complementary innovation financing instruments 3.1.3. Innovative vouchers 3.1.4. Working groups for attraction of investment in the region

Source: Regional innovation strategy of Prešov region

Financial support for small and medium-sized innovative enterprises is provided by institutions at national level. The main institution is the National Holding Fund, which manages three venture capital funds (Start-up Capital Fund, Regional Start-up Capital Fund and SISME Fund) and three independent venture capital firms (Slovak Development Fund, Slovak Growth Capital Fund, and Innovation and Technology Fund). These companies, together with other private equity and venture capital firms, have been associated in SLOVCA since 1995.

4.2.4 Actual transformations in the region

In the European comparison, according to the classification 4.0 of technological transformation, the region of Eastern Slovakia is classified as a low tech region, with a below-average intensity of patents in the field of 4.0 technologies and also a low degree of patent specialisation. It is the result of lagging behind and an overall low performance in the field of research and development at the national level, as all four Slovak regions share the same classification. The rate of technology adoption 4.0 in industry as measured by the rate of industrial robotisation is low in the case of 'technology' and induced manufacturing sectors and is average in the 'carrier' manufacturing sectors. The situation is different in the adoption of 4.0 technologies in services. The share of online sales in the 'technology' and 'carrier' service sectors is above average in European comparison and, in the case of the 'induced' service sector, is slightly below average. In all three cases, however, the region is a leader in Slovakia.

Economic transformation

The use of new technologies in transport and logistics in the region of Eastern Slovakia has resulted in the higher efficiency of internal business processes of regional firms. These are mainly processes in

transportation (ERP systems, Platforms on TMS), freight forwarding (combining supply and demand for transport), transport and storage (loading of vehicles and warehouses; faster transport of goods), fleet management and vehicle maintenance (efficient real-time care planning) or managing emergencies during transport (GPS vehicle control system; access to international carrier platform services - accompanying support services, autonomous emergency notification) etc. Technology 4.0 allows for greater transport safety, as it is possible to check the position of the goods at all times during transport. The driver's own work becomes safer, as the sensors provide driver assistance and can control the driving control in real time. An indirect effect is the reduction of the environmental impact of transport due to lower fuel consumption.

Automation is mainly in the storage activities. Automated are simple warehouses with standardized stock items where the warehouse operation is predictable. However, respondents say that automation is hampered by a relatively cheap workforce. The introduction of new technologies is largely a necessary condition for maintaining the market of the firm, especially for large customers. The emergence and more intensive use of Internet platforms of national and international transport and navigation systems have also made it possible to serve more distant foreign markets for transportation services. The use of new technologies also makes it possible to increase the competitiveness of companies in timeliness and error-free transport. These factors are more important to some customers than the cost of shipping.

In general, hiring and retaining the right skilled workforce is considered to be the largest barrier in the organization's transformation. However, the introduction of new technologies is still only at a lower level, and workers are usually expected only to master basic new technologies (e.g. navigation system). Maintenance and repair of technology is provided by external suppliers. The introduction of new technologies required retraining of workers such as truck drivers to use digital technologies or warehouse workers to work in SAP software. These short-term trainings are most often provided by the technology vendors themselves. Technological changes have not led to job cuts as the number of orders in the sector is increasing. The biggest changes are in warehousing, where there is a reduced need for warehouse workers due to automation. However, the automation process is significantly slower than in the west of the country.

Deployment of 4.0 technologies has not yet resulted in significant growth in new business opportunities in transportation in the region. It has to be mentioned that there are several examples of new regional transport and logistics companies or projects of existing companies whose business is based on new technologies. In particular, the shared economy is a good example of such projects. For example, the local IT company ANTIK, which is a provider of Internet and television services, has introduced the largest bikesharing system in Slovakia - Public bicycle. This service was extended to sharing electric scooters. The company also supported the development of electromobility by selling electric motorbikes, bicycles and scooters. The company is also moving into other segments of mobility. It deals with GPS monitoring services for households, businesses, but also self-government (city police) with intelligent parking solutions (parking sensors) and building charging stations. A similar initiative in this area is Share'Ngo, which offers urban electromobility services by sharing electric cars. The service was

launched by a local company 4 Sale, which offers 20 Chinese ZhiDou cars in the pilot phase. These are specially developed for urban mobility and are easy to share. The price of transport for two people is lower than public transport and clients also have free parking.

Respondents did not identify any major problems with technology deployment. However, the use of new technologies alone poses problems with long-term dependence on technology suppliers and their services. They also see a problem in the costs of new technologies. Concerns are also raised about the issue of protecting corporate data because of sharing sensitive information with technology vendors.

Social transformation

Deployment of 4.0 technologies requires adaptation of the workforce. The long-term Digital Literacy Project of the Slovak Institute of Public Affairs (Velšic, 2018) has been monitoring the use of digital technologies since 2005. The analysis shows that while in 2005 the proportion of people who easily adapt to digital technology was 43%, difficult to adapt 21% and 36% do not learn to use these technologies. This ratio has changed by 2018. Currently, 59% of respondents adapt easily, for 21% it is difficult to adapt and 20% do not learn how to use technology. People over 65, low educated; unskilled manual workers, the unemployed, people from the lowest-income households and the inhabitants of the smallest municipalities are learning to use new digital technologies to much lower extent. In the Prešov region, 54% easily adapts to new digital technologies, in the Košice region 53%, which is less than the national average. New technologies are not learned to use for 22% of respondents from Prešov region and 29% of respondents from Košice region.

The difficulty of adapting to new technologies in the region results from lower educational levels of the population, lower technological levels of companies in the region, as well as lower penetration rate of digital technologies in households. Several conceptual materials were elaborated in order to coordinate the transformation of the regional secondary vocational education. One part of the transformation is a restructuring of the school network (mergers and cancelation). Second part is a transformation of the curricula in order to adapt to changing labour market needs. Secondary schools have implemented several development projects, especially in the areas of informatisation, establishment of vocational training centres, promotion of vocational education in specific fields as well as investment projects for technical equipment and renovation of buildings. The main part of the development projects was financed from the Regional Operational Program, the Norwegian Financial Mechanism, subsidies from the Ministry of Education and the resources of self-governing regions. The establishment of vocational education and training centres was partly a result of the legislative anchoring of dual education in Slovakia. However, there is relatively low interest in these programs. Most attractive programs are mechanical engineering and metalworking production and electrical engineering. The demand for specialized transport and logistics workers has also led to the creation of a logistics study program at the Automotive High School in Košice, which is also focused on teaching new information technologies in the sector.

The updated version of the Strategy for the Development of Education in Secondary Schools in Košice Self-Governing Region also reflects the change in education needs with respect to 4.0 technologies. The region is growing in information and communication technologies is also reflected in the growth of the activities of schools in ICT education in cooperation with regional firms. The dominant initiative in this area is the IT Academy Project, which aims to innovate study programs and courses in cooperation with IT companies. According to one of respondents from regional selfgovernment "*there is a number of very good secondary schools in the region whose graduates are well prepared for technology 4.0, but these are rather isolated activities, lacking an integrated and strategic approach to the development of vocational education in the region*".

As we mentioned earlier, the use of new technologies in transportation changes consumer behavior. We also observe several examples of the interconnection of transport and information and communication services in the region. This is particularly the case for shared transport services and electromobility. There are several projects of local companies that use their competences in information and communication technologies to provide transport services in the region. New technologies are associated with the growth of the shared economy in the region. The increase in online purchases is driving demand for courier services and automated home transport solutions. Of course, new technologies are associated with concerns about information security and privacy. An open question will be the development of technologies for seniors, whose share will grow in the region.

4.2.5 Actual and/or expected impact

In terms of the typology of technological transformation of EU regions, the region of Eastern Slovakia belongs to the group of in which robotisation takes place in traditional industries. It is thus the only region of this type in Slovakia, as other regions are placed among the Industry 4.0 type. This type of region, in which robotisation takes place in traditional manufacturing sectors, is characterised by a higher degree of specialisation in induced industry sectors but only by limited adoption of 4.0 technologies. This is a typical feature of many other regions in Eastern Europe.

In terms of the effectiveness of the adoption of new technologies, the region of eastern Slovakia belongs to the group of low adoption potential regions. These are the regions that not only have a low rate of adoption of new technologies, but the overall economic impact of the technology adoption is also low. This type of region is found mainly in Eastern Europe. From the point of view of the social transformation of industrial production, displacement of manual as well as cognitive (routine and non routine) jobs that are encountered in Eastern Slovakia is again a typical feature of regions in Eastern Europe.

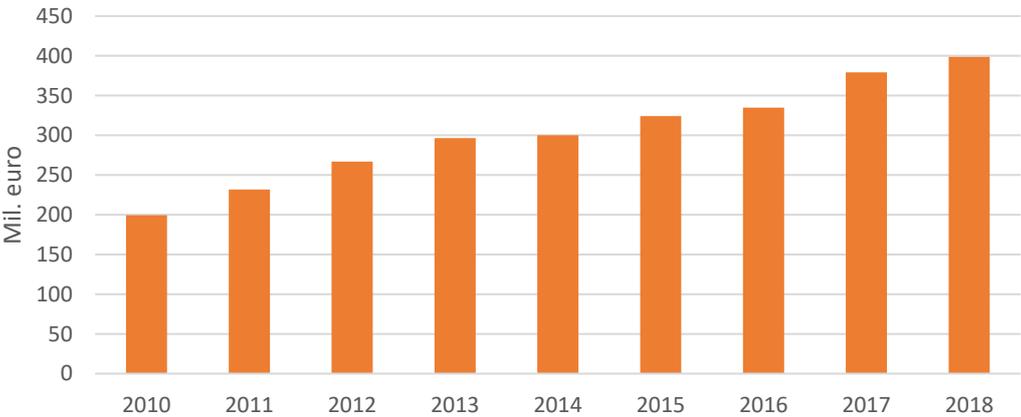
In the sector in the region

Regional data in this area do not exist and it is not possible to quantify the impact of the introduction of 4.0 technologies on economic indicators in the region. However, existing data on the national level suggest major trends. Overall, in the Slovak Republic, the transport and storage sector in the Slovak Republic is increasing in performance and sales. While in 2010 the revenues in the sector were approx. Euro 5,8 billion EUR, by 2018 revenues increased to Euro 9.6 billion. Road transport, including transport

via pipelines, accounted for the largest share, with revenues rising from Euro 3.1 billion to Euro 5.2 billion. Second largest segment is warehousing and support activities for transportation in which revenues increased from Euro 2.1 to 3.5 billion euros.

Financial micro-data from the region show that the twenty largest companies in the region of Eastern Slovakia (in terms of revenues in 2018) had cumulative revenues of approximately 200 mil. Eur (Figure 4-10). By 2018, their cumulative revenues had doubled to almost € 400 million. The average year-on-year increase in revenues was 9 percent.

Figure 4-10. Cumulative revenues of 20 largest companies (in terms of revenues in 2018) in the transportation and logistics in Eastern Slovakia



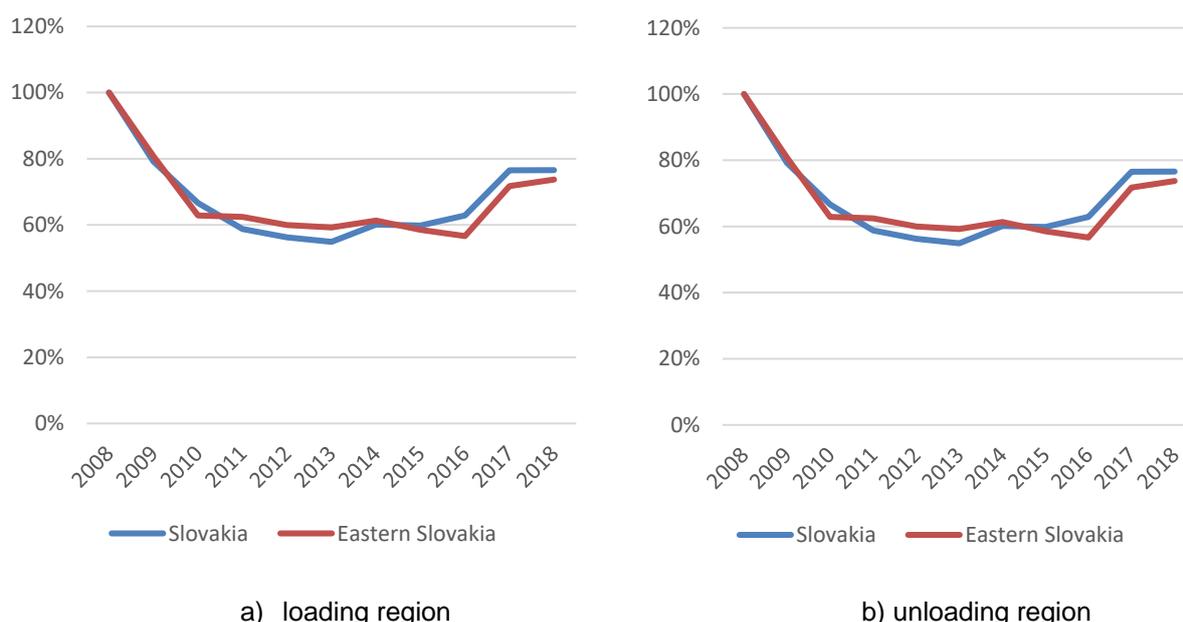
Source: Compiled by the author based on data from Finstat

At the same time, the number of employees in the Slovak Republic decreased by up to about 10 thousand workers and this decrease was almost exclusively in warehousing and support activities for transportation (Figure 4-11). The fall in employment may also be partly due to the increased use of sole traders in the sector. However, these figures suggest that labor productivity in the sector is significantly increasing, which may also be due to better use of technology.

Road transport performance is growing significantly. In Slovakia, the number of transported tons/kilometers increased from 27 million in 2010 to 36 million in 2018. Companies are much more engaged in international transportation. Penetration in the international market of transportation services was supported by the use of international logistics systems and legislative and technological standardization in the field of international transport.

National road freight transport also increased over the last two years following the economic crisis of 2008. The total weight of goods loaded and unloaded in the region in 2018 was 30 million tonnes This is still only about 74 percent of the volume from 2008. Overall, the growth in transport is slightly lower than the average in Slovakia.

Figure 4-11. National annual road freight transport by region of loading and unloading (2008 = 100%)



Data source: Eurostat

Employment in the sector faces the risk of automation. Martinák (2017) computed the risk of automation for different occupations in Slovakia using the data from PIAAC, Cedefop European skills and jobs survey, CEDEFOP and OECD. High risk of automation concerns 10.7% of jobs. In addition, 35.2% of job descriptions in individual occupation will be substantially changed. The risk of automation is substantially higher for drivers (23.8%) and support workers in transportation (31.6%). Job description is will be changed for 66.7% of drivers and 63.2% of support workers in transportation.

According to respondents, the lower use of 4.0 technologies is partly due to cheap labor. At present, however, companies are observing a lack of drivers. Given the boom in the industry, they consider the lack of labor to be a major barrier. Due to the lack of drivers, the flexibility of carriers and the capacity of vehicles are decreasing. According to DB Schenker (Trend 2017), one of the possible solutions is the development of autonomous vehicles resp. auto-guided truck convoys on which the parent company in Germany is working. The company expects this technology to become common in both passenger and freight transport within the next 5 to 10 years. Companies in Slovakia, however, do not expect such an early introduction, and speak more about the longer term of 10 to 15 years. Rather, regional firms see a solution to the labor shortage in the reform of the education system by supporting dual education or by increasing cooperation with secondary schools (Trend 2017).

Our interviews showed that new technologies in transport and logistics will not result in the decline in labour demand in the foreseeable future. As one of the respondents argues, the use of better information technology in transportation also allows the market of transportation services to grow. However, the structure of labour demand can be expected to change as the need for computational and analytical skills will increase and the integration of technology systems will also increase the need for skilled labor in the sector (Baretto et al., 2017). Based on a comparison age structure of employees in transportation

and logistics between 2009 and 2018, the sector is characterized by aging of employees (Trexima, 2018). Difficulties with 4.0 technology adoption may be a barrier to future growth for the industry.

According to the PwC Transport and Logistics Trends of 2019 (PwC 2019), CEOs expect technological changes (68% of respondents) and distribution channel changes (65%) to significantly affect transport and logistics business over the next five years. At the same time, up to 78% of them are concerned about the availability of digital skills in the industry. The main forces that change transport and logistics in the near future are digitization, changes in international trade, changes induced by software, changes in domestic trade (e-commerce and sharing economy) and changes induced by new machines. Digitization has been an important technological trend in recent years. This ranged from simplifying communication between the individual actors in the value chain up to its complete automation of information exchange. Opportunities for new business models based on more possibilities for personalisation concerning on line ordering, tracking and payment for services are now opening up. According to PwC survey (PwC 2019), respondents (54%) expect an increase in revenues mainly due to higher digitization (Figure 4-12). New technologies offer further possibilities to increase the efficiency of transport systems. Important software technologies include e.g. intelligent transport systems, robotic process automation, predictive maintenance, blockchain and artificial intelligence solutions. Further development of e-commerce is also expected. This requires investment in transport, warehousing and logistics and is associated with the development of courier services.

Figure 4-12. Five forces transforming the industry in Central and Eastern Europe



Source: PwC (2019). *Transport and Logistics Trends 2019*.

In the medium term (5+ years), the changes will be related to the development of new hardware solutions, which will include the use of robots in logistics processes in supply chain management, warehousing and transport infrastructure. Robotisation will include tasks such as quality control, sorting, in-warehouse transportation, picking, loading and unloading and delivery. Other important areas will be electromobility, the use of augmented and virtual reality e.g. in storage, building High Speed Rail infrastructure and last mile delivery optimizations (e.g. drones).

In other sectors in the region

Introduction of 4.0 technologies is not only changing the manufacturing sector - how firms make products, but also how they deliver them. The introduction of new technologies is mainly associated with positive economic changes. As companies usually do not have strong downstream relationships with other regional suppliers, the main effects are reflected in the company's customers. New technologies enable firms to connect with their clients in deeper relationship and enhanced efficiency. The development of technology is closely linked to the growth of the competitiveness of the main customers, which are trade and manufacturing firms in the region but also outside. The sector serves suppliers as well as final producers in the manufacturing sectors eg. in the automotive industry, electrical industry, steel industry, but also in construction, food, trade and others. Especially the sharp expansion of manufacturing in Slovakia required an increase in performance and efficiency in the field of transport and logistics. The development of the transport and logistics sector can potentially be linked to the developing information and communication technology sector in the region. The combined increase in the needs of workers with digital skills in both sectors can trigger higher demand for changes in the education system. At the same time, both sectors can benefit from cross-sector information spillovers through worker mobility.

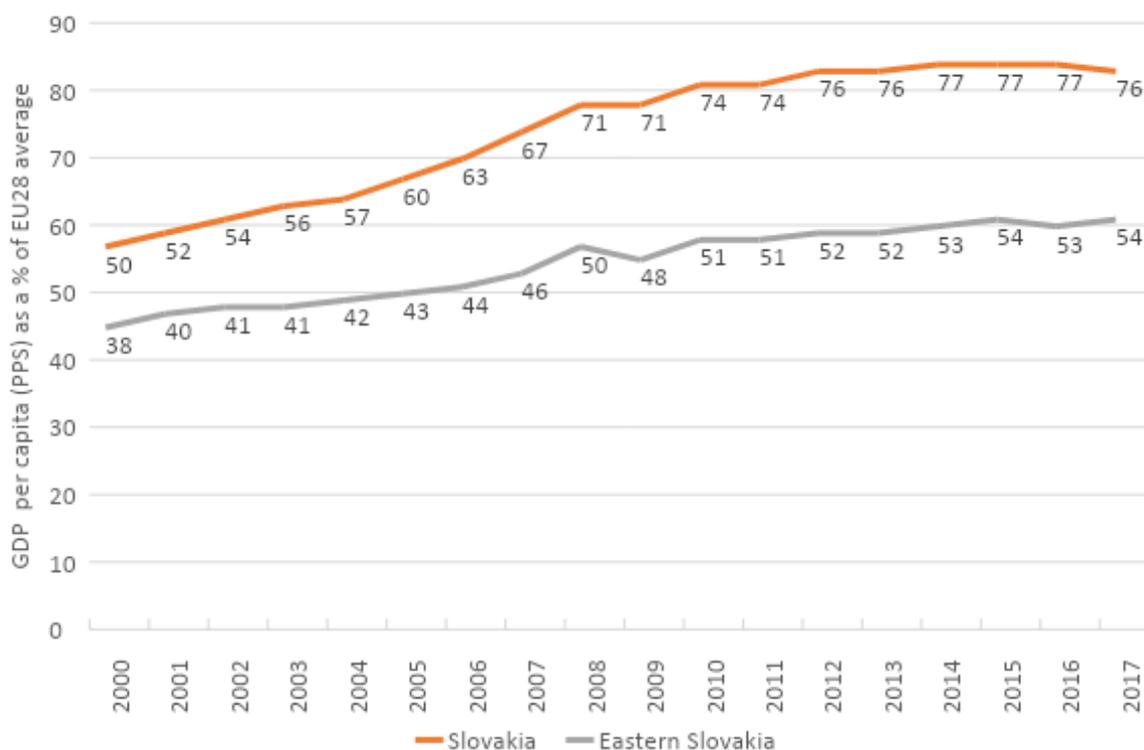
The deployment of new technologies was also closely related to the digitalisation of households and the development of e-commerce both in the country and in the region itself. The share of people who made purchases via the Internet in the Eastern Slovakia region increased from 32 percent in 2010 to 57 percent in 2018. The increase in e-commerce usage was associated with an increase in courier services as well as air transport.

The introduction of new technologies does not exert significant pressure on the risk of rising unemployment in the region, which is still relatively high at present. Respondents did not identify any induced impact on the risk of unemployment in other sectors in or outside the region. As already explained, the use of new technologies is more likely to have positive economic impacts on other sectors as it is related to the need of these industries to deliver more with higher accuracy and timeliness of deliveries.

In the region

In economic terms, the Eastern Slovakia region is slowly catching up with other EU regions during last 18 years. While GDP per capita in 2000 was only 38% of EU average, in 2017 it was 54% (Figure 4-13). Despite the economic growth during last years, the catching up process is slow. The gap between the regional GDP per capita and country GDP per capita (as a percentage of EU average) was 12 percentage points in 2000, it has grown to 23 percentage points until 2010 and was 22 percentage points in 2017.

Figure 4-13. GDP per capita (PPS) as a percentage of EU average during 2000 - 2017



Source: Compiled by the author with data from Eurostat

Technological transformation results in a growth of employment in high tech sectors (Table 4-19). Compared to 2008, the share of employment in high-tech sectors increased from 2.8% to 3.4%. While in 2008 the region lagged 1 percentage point behind the EU28 average, by 2018 the lag had fallen to 0.7 percentage points. In 2018, the share of employment in high tech sector was 3.4%, which is still lower than the EU28 average (4.1%) and the Slovak average (4.3%). The share of employment in high-tech manufacturing is approximately the same as the EU28. The share of knowledge-intensive high-technology services in total employment increased from 1.6 to 2.3%. Despite the substantial progress, employment in high-technology services remains well beyond the EU28 average.

Table 4-19. Employment in high tech sectors 2008 - 2018

GEO/TIME	High tech sectors		High tech manufacturing		Knowledge-intensive high-technology services	
	2008	2018	2008	2018	2008	2018
Eastern Slovakia region	2,8	3,4	1,2	1,1	1,6	2,3
Slovakia	3,6	4,3	1,8	1,5	1,8	2,8
European Union - 28 countries	3,8	4,1	1,1	1,1	2,6	3,0

Source: Compiled by the author with data from Eurostat

4.2.6 Operational policy recommendations

Functional upgrading in global value chains by adoption technologies 4.0 and innovative entrepreneurship The development of the transport and logistics industry is closely related with economic changes in industrial production and trade in the Slovak Republic in recent decades. Companies in these industries represent their main customers. The industry is growing steadily due to an increase in orders. Introduction of new technologies may help regional companies to improve their position in the value chain and move from 2PL to 3PL activities. However, especially in manufacturing there is a risk of reshoring, which would have a significant negative impact on the development in the transport and logistics. Regional transport companies have also established themselves in international truck transport, but they face competition from companies from other countries as well. Faster deployment eg. autonomous vehicles in Western European countries may result in a decline in demand for international lorry services and serving these markets by large Western European carriers. This is particularly a risk for larger local businesses that are part of global supply chains. From this perspective, support for the deployment of 4.0 technologies in local businesses is crucial. For local companies, one of the ways to support this can be to participate in pilot programs of large global logistic companies in the use of new technologies in transport and logistics such as blockchain. An great opportunity for the sector is also the GLIP project (project of Global Logistic Industrial Park). Project aim to establish a cargo transfer point for the future transportation on the Silk Road from Asia.

The introduction of new technologies is, on the one hand, the result of changing needs of companies (e.g. shortage of workers or rising labour costs) but also a reaction to the emergence of new market opportunities (e.g. internationalization of transport and logistics). The policy should focus mainly on promoting new opportunities related to the use of new 4.0 technologies in transport and logistics. It is possible to use measures such as provision of information services on technological and market trends or creating and promoting corporate showcases, which have strengthened their position in the global value chain by introducing 4.0 technologies. These types of measures are particularly important for regions with large foreign manufacturing companies in which the technological transformation is also taking place. Other possibilities are support of local companies for participation in pilot programmes of large global logistics companies, which are focused on the use of new technologies in transport and logistics (such as blockchain). In the global value chain of the transportation and logistics industry, there are various lead companies that include large transportation companies, express delivery or forwarding companies that complement local partner companies. According to the Digital Transformation Action Plan, Slovakia has the ambition to become a leader in testing autonomous vehicles and sophisticated transport solutions. The combination of a strong manufacturing sector and an evolving transport and logistics sector provides good preconditions for the success of such a development strategy.

The policy can also focus on supporting innovative businesses that develop new solutions in transport and logistics based on 4.0 technologies. Suitable tools are the organization of hackathons and competitions focused on e.g. and sharing economy in electromobility or last mile delivery. Also, the growth of open public data, especially in public transport, may also be associated with the pressure to

seek innovative solutions through the organization of the above events. Innovative entrepreneurship can also be supported by promoting pilot business showcases based on new technologies.

These types of strategies are especially suitable for regions whose transport and logistics industries compete on the basis of low labour costs, but companies already have experience with the internationalization of their business and at the same time there are manufacturing companies in the region that implement 4.0 technologies.

Public digital infrastructure and digital services

The region lags behind in the use of the Internet and access to broadband networks. This limits the use of e.g. e-commerce, the development of which is one of the drivers for the growth of courier services. Investing in IT infrastructure and promoting the use of digital technology by the population is an important aspect of future industry development. The public sector is also an important player in this area as it also implements new technological solutions. In the transport and logistics sector, these are mainly technological solutions in public transport (intelligent transport systems) but also, for example, in international freight transport (eg electronic customs clearance). Public policy could therefore focus on providing grants for cities or public institutions to increase the digitization of their services. An important part of this process is the generation of open data, which can also be used to create other local commercial services. Due to the fact that Slovakia is a relatively small country, it is suitable for testing new technologies with lower capital intensity. For example, the current deployment action plan envisages the preparation of a 5G smart town pilot project and pilot IoT solutions.

Investment in digital infrastructure is particularly suitable for lagging regions. The development of digital infrastructure is usually associated with a consequent increase in the use of digital services.

Education and skills

There is a relatively high competition in road freight transport and was largely based on lower costs compared to Western countries. However, there is growing competition from Eastern European countries (e.g. Romania, Serbia, Bulgaria), whose costs are even lower. Lack of workers in the sector is likely to result in wage increases, resulting in a loss of competitive advantage. However, the introduction of new technologies makes it possible to compete on the basis of higher quality and efficiency of services. Therefore, the policy should focus on supporting the education of workers in the form of short-term trainings as well as invest in the reconstruction of education at secondary vocational schools and universities. The first step in this area should be to identify future labour market needs in the transport and logistics sector. The policy should focus on analyzing future training needs in transport and logistics with a focus on digital skills. Innovations in transport and logistics are changing the way supply chains work, which will require workers who master technologies in the field of transport asset sharing platforms, big data, the internet of things, blockchain, etc. As these are more knowledge-intensive areas to a much greater extent, the involvement of local universities will be needed. Governments may, for example, finance the establishment of specialized centres which, in close cooperation with companies and technology suppliers, would develop training programmes, provide

short-term training for employees in the sector, organize student traineeship services and promote new occupations. The key is to involve the main stakeholders in the establishment and work of such a centre - local transport and logistics companies, technology suppliers, as well as industry associations and employees. There is a very dynamically developing cluster in the field of IT technologies in the region, so it is possible to use the existing capacities in this area. The industry is integrating individual activities (eg route planning, goods transport, payment), so educational activities should also cover these changes. Future jobs could also be designed to include new responsibilities in e.g. transport data analysis but also other related fields such as health, safety and environmental compliance. The growing volume of data in transport will require new analytical skills that need to be permanently built and improved in the existing education system. Technological changes in the industry as well as changes in the behavior of clients and final consumers will also require organizational changes in companies. These changes are management-intensive, so one of the focus areas for training activities is the change management for current or future managers. Thorough planning and coordination of individual activities is important for implementation, as experience in region shows that individual activities are usually weakly coordinated.

5 Spain

5.1 Catalonia

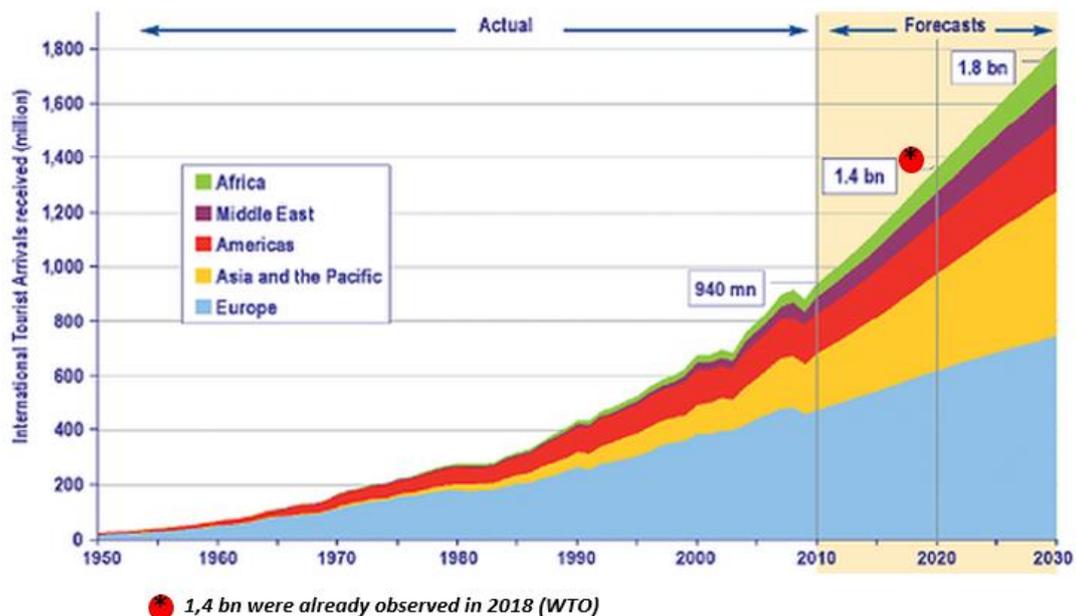
5.1.1 Regional baseline

This report focus on how 4.0 technologies are shaping the tourism industry in Catalonia. The following provides a broad introduction to the state of technology & tourism activity in Spain.

In the last decades, international tourism has been expanding constantly around the globe, including Spain (Figure 5-1). The number of international tourists in 1950 totalled 25 million worldwide, increasing to 1,4 billion in 2018. According to the World Tourism Organisation (WTO), this is expected to rise to 1.8 billion by 2030.

In 2018, 82,6 million international tourists visited Spain. The country has now replaced the US for second place in the world's favourite destinations (France is still the leader). However, although the number of tourists has stabilised, tourist expenditures still appear to be growing, highlighting the importance of the industry's strategy to attract higher quality tourism. Although the number of tourists that visited Spain in 2018 was similar to the total in 2017, the amount spent by those tourists increased by 2.8%, and daily expenditure rose by 6.4% (INE, 2019).

Figure 5-1. Global tourism evolution



Source: WTO (2018)

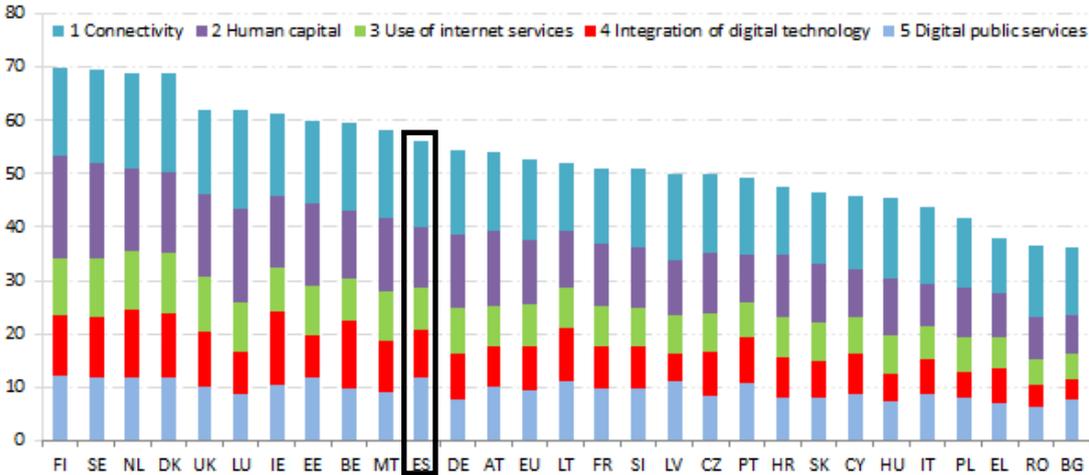
One of the key supports for Spain's economic growth during its recovery from the 2008-2014 financial crisis has been the tourism industry and particularly the strength of international tourism. Between 2016 and 2018, the average growth in tourism-related GDP was 4.8%. This is much higher than the 2.8% growth in the economy as a whole. In the same period, domestic tourism grew in line with the economy's overall GDP growth. This improved performance by tourism-related GDP is due entirely to the rise in international tourism (The Corner, 2019).

According to Social Security affiliations, the tourism sector generated a total of 50,093 new jobs in 2018, representing a 3/1% annual growth for the sector. This creation of employment has been accompanied by a 2/7% increase in salaries due to an agreement in the hospitality sector, confirming the industry's commitment to employment.

There is unanimity across the public and private sector on the value of a digital transformation of the tourism industry in Spain and its necessity to maintain international competitiveness.

Concerning technology development and implementation, Spain ranks 11th in DESI 2019 (Digital Economy and Society Index) (Figure 5-2). Spain's performance in the use of digital technologies by enterprises and in the delivery of online public services is above the EU average. In connectivity, progress is particularly strong in terms of subscriptions to fast broadband and NGA coverage is also high. Spain belongs to the cluster of medium performing countries (European Commission, 2019).

Figure 5-2. Digital Economy and Society Index



Source: DESI 2019 ranking

In relation to digital connectivity, Spain has a medium rank in fixed broadband uptake (19), while it scores low (22) in 4G coverage and ranks 11th in mobile broadband uptake. Regardless, Spain has improved in fast broadband subscriptions (54%). Over three quarters of Spain's population (around 75%) is online and 55% (2017) of the population has basic digital skills. ICT professionals make up a low percentage of total employment (2,5%). Though, the number of STEM graduates is significantly high, enabling companies to recruit the ICT specialists they need (Lazaro, 2017).

Spain ranks medium in the use of internet by citizens (12). Spanish Internet users engage in a variety of online activities. When transactions are involved, such as eBanking or eCommerce, they do so less than other European citizens (58%). Spanish companies are making progress in integrating digital technologies into their business processes, and a fifth of SMEs are actively selling online. These companies have demonstrated a strong adoption rate of cloud computing (15%). Spain performs solidly above the EU average in the delivery of online public services (89%), and performs well in Open Data (88%). The results of this data is mainly related to the degree of development, implementation, and

consolidation of policies, as well as strategies and initiatives about the emergence and transferral of 4.0 technologies in the context of Spain.

At the state level, the main actors in research and innovation are the Ministry of Science, Innovation and Universities, which is responsible for the design and management of research and innovation policy. The Council of Science, Technology and Innovation (CPCTI) is also an important actor and plays a coordination role in relation to regional governments and other stakeholders in the Spanish R&D system. Another related body is the Executive Committee for Science, Technology and Innovation policy (CDCTI) which is responsible for the planning, evaluation and coordination of the Spanish RDI instruments.

There are multiple strategies, plans and programmes for supporting digitalisation in Spain, including:

- Spanish Strategy for Science, Technology and Innovation 2013 -2020 (EESTI). It contains the rationale, objectives and indicators for the Spanish R&D and Innovation policy. The objectives are aligned with those set by the European Union within the “Horizon 2020” programme for the period 2014-2020, contributing to encourage the active participation of Spanish Science, Technology and Innovation System actors at European level.
- Spanish State Plan for Scientific and Technical Research and Innovation 2017 -2020 (PECTI). It is a tool for implementing the EESTI by setting the priorities, programmes, coordination mechanisms, costs and sources of funding to implement and consolidate scientific and technical research and innovation.
- Industria Conectada 4.0 Programme. It seeks to support projects that promote the digital transformation of industrial companies, thus complementing business efforts aimed at achieving their evolution to the digital economy, supporting the incorporation of knowledge, technologies and innovations for the digitization of processes and the creation of technologically advanced products and services.

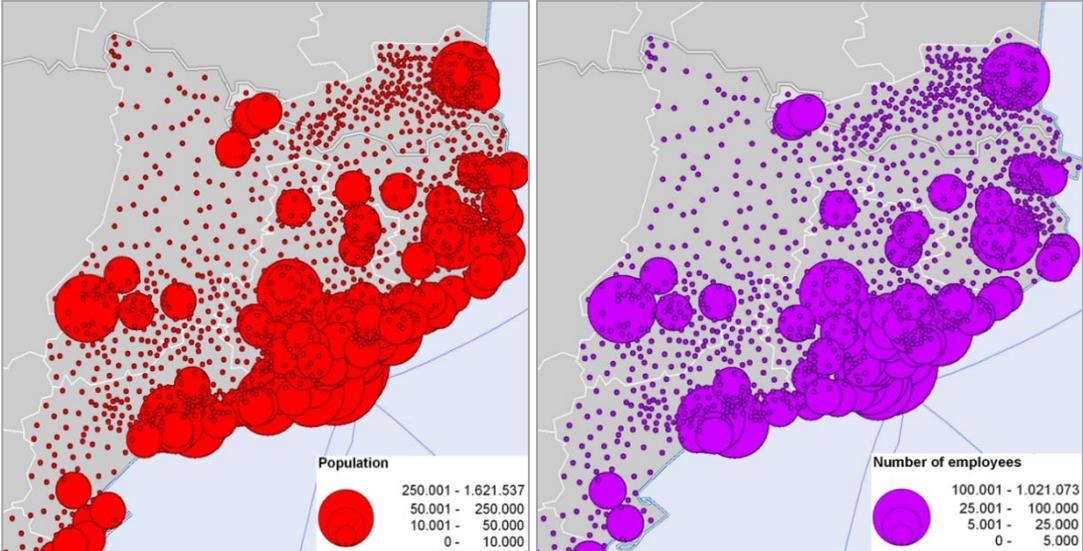
The specific context of Catalonia

Catalonia (ES51) covers an area of 32,108 km², and is comprised of 4 provinces (NUTS3): Barcelona, Girona, Lleida and Tarragona. It has 7,543,825 inhabitants (2018) and 947 municipalities, with the Barcelona Metropolitan Region (RMB) having a population of nearly five million – over 67% of the population of Catalonia contained in just 10% of its territory.

The Catalan economy has an important industrial tradition, concentrated in the largest cities, but has evolved over the years towards a service economy (Figure 5-3). The industrial network in Catalonia is essentially comprised of a broad network of small and medium-sized family firms in mature sectors, as well as a relevant number of large multinational firms. The industry represents 21% of the Catalan economy, while the service sector accounts for 73%. Considering other activities related to the industry, such as transport, energy, telecommunications and business services, this percentage reaches 50%. The construction sector constitutes about 5% and the agriculture sector accounts for roughly 1%. In

2018, the regional GDP of Catalonia was €242 billion, and GDP per capita was above the EU28 average at around €31.200.

Figure 5-3. Population distribution (left figure) and employment distribution across Catalonia (2013).



Source: ESPON TRACC

The industrial base and diverse service sector are considered a regional strength in terms of potential to adopt Industry 4.0. This is further strengthened by a growing ICT sector. This conjunction between industry and ICT is fundamental for the success of the adoption of technologies associated with Industry 4.0.

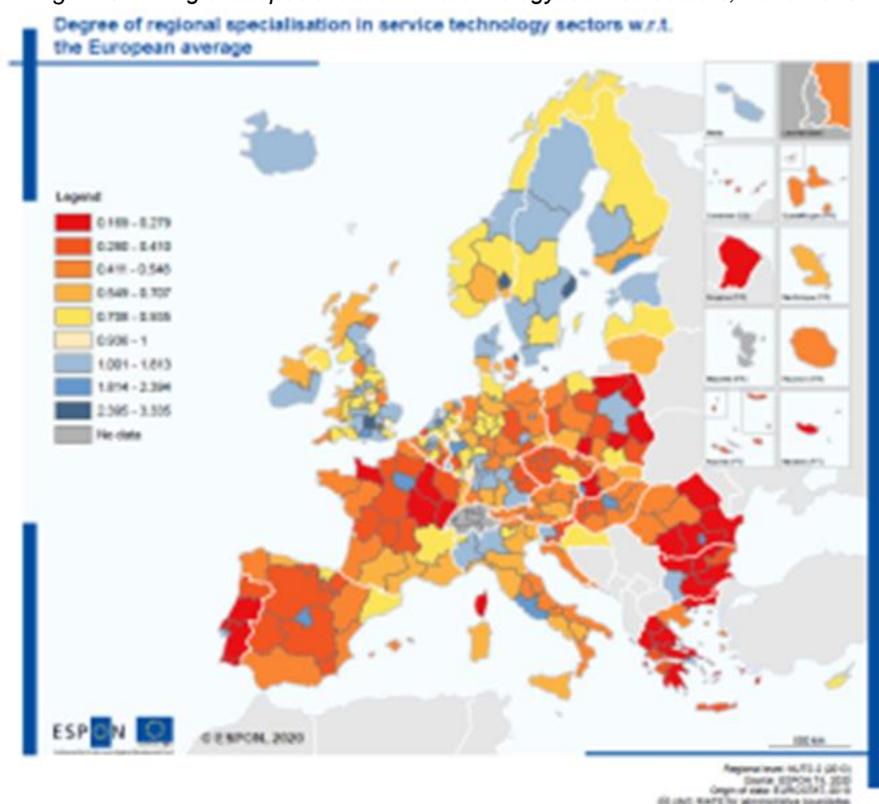
Catalonia has several strategies for the development of technologies 4.0, as is the case of the National Agreement for the Digital Society or the National Agreement for Industry. These strategies focus on the technological transformation of the Catalan industry through the incorporation of 4.0 technologies such as augmented and virtual reality, 3D printing, big data, artificial intelligence, 5G, the Internet of Things (IoT), blockchain, and robotics. Furthermore, the Catalan government has created a program, ProACCIÓ 4.0, with the goal of promoting the transformation of Catalan SMEs towards industry 4.0.

Catalonia has become one of main tourist destination with a mature and relatively diversified tourism sector in Europe, with more than 19 million tourists per year. The tourism sector accounts for 14% of employment (400,000 jobs) and around 12% of GDP (2018). Barcelona receives around 9 million annual tourists (2018). It is the sixth most visited city in Europe and is among the 20 most visited destinations in the world (2019). In the city of Barcelona, leisure tourism, shopping tourism, and business tourism, among others, are combined. According to projected growth estimates in the Strategic Tourism Plan of Catalonia, in 2030, Catalonia could receive between 28 and 36 million international tourists.

Tourism accommodation in Catalonia amounts to 5.856 establishments and 605,223 beds. Hotel accommodations received 79.7% of these travellers (19.1 million) and 69.4% of overnight stays (55.3 million). The remaining accommodation types (camping, apartments, others) housed the residual 20.3% of travellers (4.9 million) and 30.6% of overnight stays (24.4 million) (last data from 2016).

In Catalonia, there are 15,760 companies and 106,400 employees related to ICT (2018), of which 2,766 are concentrated in the city of Barcelona (CTecno, 2018). Among these companies, 97% are service-oriented. Catalonia holds a leading position within Spain (22%). In recent years, several centres based on ICT have been installed in Catalonia, especially, in the metropolitan area of Barcelona. These centres belong mainly to multinational companies that provide services on an international scale (Generalitat de Catalunya, 2019). In addition, Catalonia has some scientific infrastructures that are available to the technological and industrial community, being one of the Spanish regions with highest specialisation in ICT service sector.

Figure 5-4. Regional specialisation in 'technology' service sectors, 2008-2016.



Source: ESPON T⁴

Among the ICT sector in Catalonia, the city of Barcelona stands out. The City of Barcelona and its Metropolitan Area are being consolidated as a hub for attracting ICT companies and professionals. Barcelona has the largest number of start-ups in Spain and is ranked fifth among European cities, and holds ninth place as "the most attractive European city for digital entrepreneurs," according to the European Digital City Index 2016.

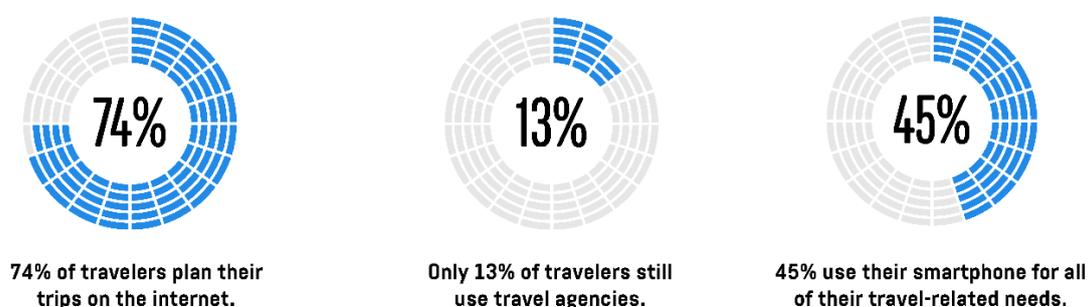
In relation to ICT companies dedicated to tourism, there are 371 companies which employ 9,000 persons and invoice more than 1,000 million euros per year (ACCIO, 2019). These are mainly medium and small companies (76%), focusing on travel technology, consulting, booking management and connectivity; the software for better management of accommodation, and the improvement of the user experience.

In 2018, Internet access in Catalan homes reached 88%, increasing the total broadband connection which was already installed in 87% of homes in Catalonia. In relation to the use of the Internet, 88% of people (between ages 16-64) routinely use the Internet, and 49% make electronic purchases.

5.1.2 Adopted 4.0 technologies in the sector in the region

The tourism sector (comprised of hospitality players, operators, traditional travel agencies, and online travel agencies) is a good example in which digitisation transforms the business model of the sector (Figure 5-5). The online information available to customers has destroyed the dominant position of travel agencies and brought dis-intermediation. The strong competition, technological advances and evolution of the user has created a push towards a new re-intermediation in which online players with a strong B2C reputation (online search engines, online agencies) are now the industry leaders.

Figure 5-5. Travel in the digital age



Source: "Tourism and Technology: How Tech is Revolutionizing Travel" (2018).

Tourism is strongly influenced by the progress of the technological revolution. The Internet has already changed the way that tourists search, explore, book and experience travel. The whole industry has to adopt new technology trends, rethink their strategies and reshape the way they provide services. Robots (maintenance, guest service, and room service), holograms with avatars (reception, staff), interactive displays, smartphones and gadgets are already becoming a reality in the hotel industry. Some parts of this technological future are expected to become an integrated part of the tourism sector; however, the level of technology in each hotel or tourist industry, in general, will depend largely on its strategy and positioning.

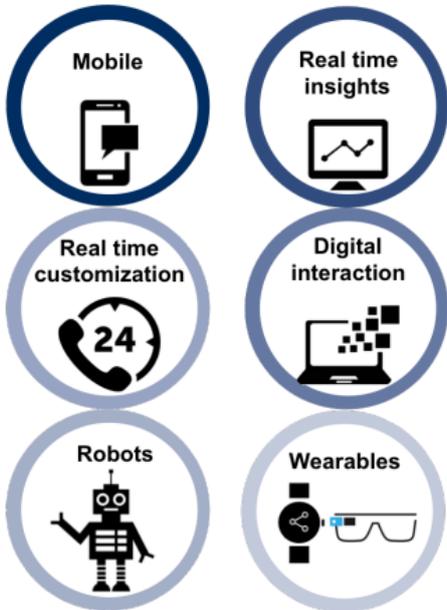
It should be noted that there are two major technological disruptions in the digital field which have marked the recent history of tourism.

The first is mobile technology. In 2007 Apple marked a milestone in mobile telephony by bringing out what would be the first mass-marketed smartphone. In 2005, Google had already launched GoogleMaps. The creation of a mobile terminal capable of integrating a map and serving as a communication interface with a network revolutionized the world of tourism. There was also a disappearance of European Roaming in 2017. Although the new European Data Protection Regulation has marked a turning point in the management of personal data, the traces left by tourists in the use of

their mobile devices generates a volume of information (social networks, economic transactions, searches ...) that allow tourism companies to analyse the behaviour of their clients at each destination. The use of intelligent systems allows tourist destinations to obtain and exploit, in real time, information, and convert it into data (González et al., 2018) useful for monitoring tourism activity.

The second major digital disruption comes from the side of the Service Platforms. These base their strength on the union of three basic elements: the Internet as an environment, the growth capacity of a P2P (person to person) model, and the confidence as a centre of success, in which the online reputation initiated in tourism by Tripadvisor has developed new tourism business models.

Figure 5-6. Key technology influences in tourism



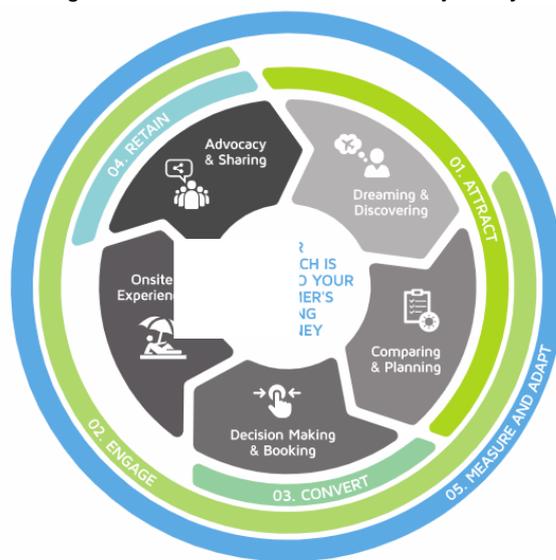
Source: Horwath HTL (2018).

According to experts, hyper-connectivity has been making rapid leaps in the direction of understanding the tourist experience. The technologies that have most impacted on the digital connectivity of tourists have been, in addition to the Internet, the appearance of smartphones, the emergence of the digital map (GoogleMap), the online reputation initiated by the Metasearch engines, the emergence of social networks, and, in the last decade, the disruption of digital platforms that have given access to microservices (Figure 5-6). The latter have revolutionised the intermediation ecosystem, as the OTA's did at the end of the 00's. The emergence of 5G technology promises a new turnaround for the sector, which when coupled with the end of Roaming in Europe, will allow tourists to accelerate data collection through voice and/or image services used by visitors.

Technology has changed the way of understanding tourists' trips, now generalised to the term "tourist experiences". Nowadays, with all the stimuli that a client receives, the customer journey has changed and, although these three steps still exist, the micro-moments have been extended and the client has

the ability to express themselves more and through different platforms (Figure 5-7). The first factor that has changed in the customer journey is the communication between the customer and the brand, caused mainly by the eruption of social networks, which are now the first point of contact between the customer and the brand. When a customer has already established this contact, the next step takes place: the purchase. This process has become much more complex with the evolution of technology in mobile applications, websites, in-store, in-store but online, and online but in-store.

Figure 5-7. Kind of tourism customer journey



Source: *Digital Tourism Marketing* (2019).

New digital tourists, in addition to personal experience, demand immediacy, and even more, services of recommendations for the future, based on their own tastes. At this point, Gatekeepers (Google, Amazon, Facebook), with daily contact to users, have a predominant role in tourist intermediation, effectively generating valuable information for the destination due to a society that is connected in real time.

Thus, companies and entrepreneurs in the tourism field handle large amounts of data, most of it being personal data. Because of this, the tourism sector is increasingly aware of the importance of the protection of personal data, as marked by laws. For example, with data protection in Spain, the LOPD (Organic Law on Data Protection) applies. The protection of tourists has become one of the main challenges of tourism sector, which has created new business opportunities. For example, the figure of the data protection delegate is emerging in tourism companies. These profiles are new in the tourism sector.

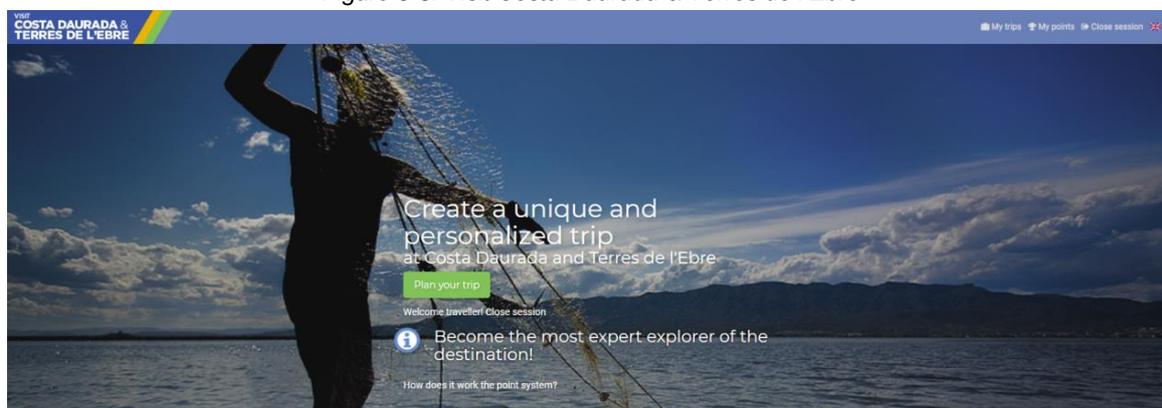
For some experts, the treatment of data is still difficult, since those who demand data do not have an orderly view of the offer, lack visibility on the set of public and private data available; and do not have enough people trained to analyse them.

Technology in the sector in Catalonia

The Catalan tourism sector is receptive to global trends in adoption 4.0 technologies: online booking, e-marketing, pricing, online reputation, data tracking and exploitation, market monitoring, Internet of Things, Artificial Intelligence (AI)...

Given the high presence of ICT companies and start-ups in Catalonia (and particularly in Barcelona), solutions based on Big Data is one of the fields more actively explored by tourism. Tech companies have developed specific products and services for the sector based on Big Data. There are currently 371 companies related to ICT and tourism, which employ 9.100 workers and invoice more than 1.000 million euros annually. Big Data is used for the prediction of consumer behaviour and the personalization of tourism services offered. Applications and other online platforms have been developed for improving the experiences of tourists in all phases of their travels. For example, the *Visit Costa Daurada & Terres de l'Ebre* platform provides services for tourists wishing to visit the destination (Figure 5-8). This platform supplies information about different activities and tourist points of interest based on the tourists' personal profile for a more personalised visit to the destination. This example project applied Big Data for the segmentation of messages and recommendations of itineraries, led by the Catalan Tourism and Science Technology Park, with financial support from the regional government (Diputació de Tarragona) and its Tourism Office.

Figure 5-8. Visit Costa Daurada & Terres de l'Ebre



Source: Visit Costa Daurada (2019)

There are other public and public-private institutions which are developing technological solutions to improve the management of tourism businesses and customer satisfaction as well. Eurecat Technological Centre, a provider of innovative technologies to Catalan companies, is developing apps to help local tourism businesses and SMEs in non-central destinations position themselves better within the digital process of transformation. The Observatory of the Department of Tourism Innovation of the Eurecat has designed the *Tourism Data System*, an application that helps manage and analyse the evolution of tourism activity (accommodation) and compare it with destinations around the globe, the type of accommodation, and other tourist brands selected. The *E-preus* app, which provides the marketing prices of tourist accommodations to the main online booking platforms and tour operators, is

another initiative related to Tourism & TIC. This application is designed to help associations of tourist establishments, and especially small and medium enterprises in the sector with price management.

Big Data is also helping to consolidate a tourism model based on “experiences”. Innovative tourism initiatives are valued positively, and a tourist's good feed-back will greatly impact the tourist destination. This must be considered in a world where online opinion is increasingly important in helping choose a destination of travel, participating in tourist activities, or booking accommodations. One of these initiatives, created in Barcelona, is the project “5G Interactive City”. This initiative allows visitors to explore the interior of monuments and shops in the city, view related content, or make virtual purchases thanks to glasses connected to the 5G network.

Catalonia is also the headquarters of innovative companies involved in the digitalisation of the tourism sector, such as eDreams. Born in Silicon Valley in 1999, the company chose to establish its head office in Barcelona one year later. eDreams is considered one of the largest online travel agencies, and has been a hotbed for future entrepreneurs and new projects based on 4.0 technologies. At least 50 startups, most of them launched in Barcelona, have been founded by people who had previously worked at eDreams. Other startups, including *Uvinum*, *DeporVillage*, *Beabloo* and *Metriplica*, were also established in Barcelona.

In a context where the digital revolution has changed the way tourists organize their travels, the Catalan Tourism Board (CTB) is developing new marketing strategies. In 2018, the Tourism Marketing Plan of Catalonia 2018-2022 was approved. This plan prioritizes the development of a new digital marketing strategy, focusing intensely on promotion through the web and social networks. The CTB has decided to implement a B2B/B2C CRM strategy, incorporating new customer recruitment plans by updating and adapting the *Catalunya.com* website to the “Customer Journey” strategy. In addition, to enhance the experiences of tourists, the CTB will carry out personalized contacts through CRM, segmenting those offers that fit better to their interests and motivations. The tourism board is also designing a program to measure the quality of the tourist experience, exploit the data created, and apply improvements based on the opinions of the customers.

In 2018, the CTB developed 200 digital marketing campaigns; 170 familiarization trips with tour operators, media personnel, and influencers; 70 presentations in international markets; attendance at 50 tourism fairs, etc.

Other institutions such as the Barcelona Tourism Observatory (BTO) work on collecting statistical information on tourism activity in Barcelona in order to understand the sector and improve its management.

In recent years, environmental and social issues are becoming more important. As a destination becomes more crowded, critical movements against tourism grow. Some initiatives offer support for the sustainable management of tourist destinations, as well as improving the environmental and social footprint of tourism. For example, the *Watertur Project* aims to implement innovative technology and intelligent systems to improve the management of the water cycles in hotel establishments. In

Barcelona, sensors have been installed to analyse the flow of tourists in real time, contributing to helping make better decisions in destination management, particularly in large buildings like Sagrada Família. This greatly improves the coexistence of mass tourism with local residents.

Other technologies developed have been Artificial Intelligence (AI) for improving customer support through solutions such as face recognition and voice commands, or Internet of Things (IoT) for creating a more dynamic traveller experience. Blockchain and cyber security are technologies that facilitate the management and storage of large volumes of data. In Catalonia these technologies have already been adopted. An example is the RFID (radio frequency identification) wristbands at the Sónar festival. There is also a cybersecurity office of Catalonia which has the function of planning, managing, and supervising the cybersecurity within the region.

5.1.3 Preconditions for transformation

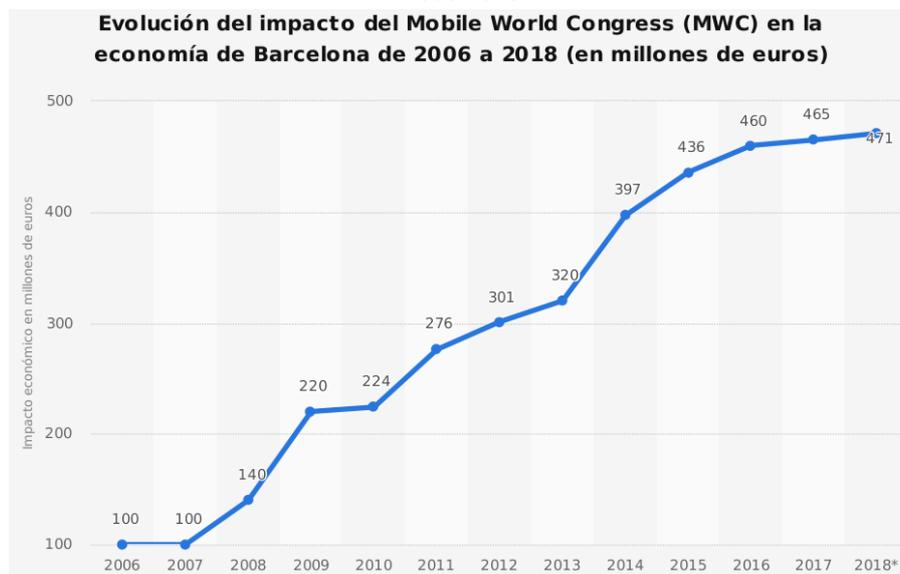
Regional precondition

According to interviewees, the main regional preconditions necessary for 4.0 technology adoption for in tourism in Catalonia are:

- **Existence of support global policies and strategies** – there are several policies, strategies and initiatives to support and promote among companies in the sector and among civil society by public administration. Of the Spanish region, Catalonia has the most policy initiatives to support the 4.0 technology transformation. There are also several strategies applied to tourism, including the Strategic Tourism Plan of Catalonia 2018-2022; Barcelona Strategic Tourism Plan 2020, and Girona Strategic Tourism Plan...
- **Financial support and funding for contributing innovation** – there are diverse financial channels for investing in innovation created from the public administration. The Department of Business and Knowledge, together with the ICF (Catalan Institute of Finance), provides Catalan companies with credit lines (150 million euros) to promote the financing of investments in accordance with the digitalization of the industry. There are other direct financial aids to help digitalize companies through Industry 4.0 coupons, with an annual budget of € 2 million. Cambra de Comerç de Barcelona also offers support lines for promotion innovation among businesses in Barcelona.
- **Supporting the technology sector.** Acció, the public agency for increasing competitiveness of Catalan companies, aims to boost the growth of technology sector, through the promotion of innovation, business internationalization and the attraction of new investments to the sector. It also advise companies on searching funds, offer training programmes and promote their adhesion to digital clusters. The results are: there are 22% of the total innovative companies in Spain are located in Barcelona, Catalonia concentrates the 23.3% of the Spanish total investments in R+D+i, and more than 37% of patent applications to the EPO are also produced in Catalonia (Accio, 2019).

- **Supporting entrepreneurship.** Accio offers specific services to facilitate the launch of new start-ups and services to find funding for growing. It also accompanies Catalan startups in their business consolidation process. In addition, it has a network of 40 Foreign Trade and Investment Offices around the world to facilitate its internationalization. There are more than 1.300 start-ups in Catalonia, several related to 4.0 technologies, also to mobile & software, and 13% of Catalan startups are Deep Tech. In these work 13,820 people.
- **Barcelona, positioning as a technological hub.** Barcelona is the second European city in the name of graduates in ICT (Cultural and Creatives Cities Monitor, 2017), in addition to being a pole of attraction for professionals. It is the first startup hub in southern Europe (EU-Startups, 2017), the fourth European city to invest in new startups (Atomico, 2017), and the fifth European city with more foreign investment in the technology sector (London & Partners and PitchBook) According to KPMG, it is among the eight urban areas in the world in attracting foreign investment projects in the 2012-2016 period, with more than 500 projects. It is also the third Smart City in the world, and the 5G hub in southern Europe.
- **Organization of international congresses with a strong technological component.** Barcelona is the first city in the world to organize international conferences and congresses: Mobile World Congress (MWC), IOT Solutions World Congress, Smart City Expo. Mobile World Congress (MWC) has positioned Barcelona as the world's mobile capital and as a international digital hub (Figure 5-9). The MWCapital foundation promotes and transfers technological development to education, industry, economy, science and, ultimately, to the city society. For example, through The Collider program, combining knowledge, innovation, talent and entrepreneurship to the implementation fo scientific advances to the Catalan society. In addition, the MWC generates a great activity for the hotel, restaurant and commercial sector of the city. According to 2019 data, the MWC had 109,000 visitors and left an economic impact of 490 million euros, plus 14,100 temporary jobs, and the presence of 170 government delegations and 8,000 CEOs and senior management positions of companies in the sector.

Figure 5-9. Evolution of the impact of the Mobile World Congress (MWC) on the Barcelona's economy (M€). 2006-2018



Source: *Expansión*. Statista 2018

Sectoral preconditions

According to interviewees the main sectoral preconditions necessary for 4.0 technologies adoption in tourism in Catalonia are:

- **Good international image of the “Barcelona brand”.** It is a city with icons and an imaginary built globally recognized. Barcelona is among the European cities with the most visitors and among the most attractive in the world. It is the first destination for congresses and professional meetings. The Barcelona brand also includes creativity and technology. In recent years, he has worked to attract talent and investment, and the reputation of the Barcelona brand goes beyond just tourism aspects. It is the third favorite city in Europe to start a start-up; It is the fourth most attractive city in the world to work abroad, and the ninth urban area in the world that receives foreign investment projects. In 2019, Barcelona launched “AlwaysBarcelona”, to strengthen the image of the city internationally.
- **Receptivity of the sector to adopt innovation** – the ICT sector is growing in the region, and it has also increased the percentage of industries to invest on R&D and the implementation of ICT. The sector is diversified, with high number of tourist accommodation. There are large hotel groups with technical and economic capacity to adopt 4.0 technologies in their internal management systems. In Barcelona there is technological multinational companies, most of them have huge influence on tourism.
- **Universities and research centres in the field of technology and tourism** – Catalonia has institutional support for developing solutions applied to tourism. There are clusters, research groups and institutions for developing new technologies by the sector and for increasing its competitiveness. Among these, EURECAT, the leading technological centre of Catalonia that

promotes innovation and competitiveness of destinations and tourism companies through tourism innovation services; focused on the promotion of the application of technologies, market intelligence and information systems in the field of tourism. The Innovation and Tourism Intelligence Laboratory was born from EURECAT.

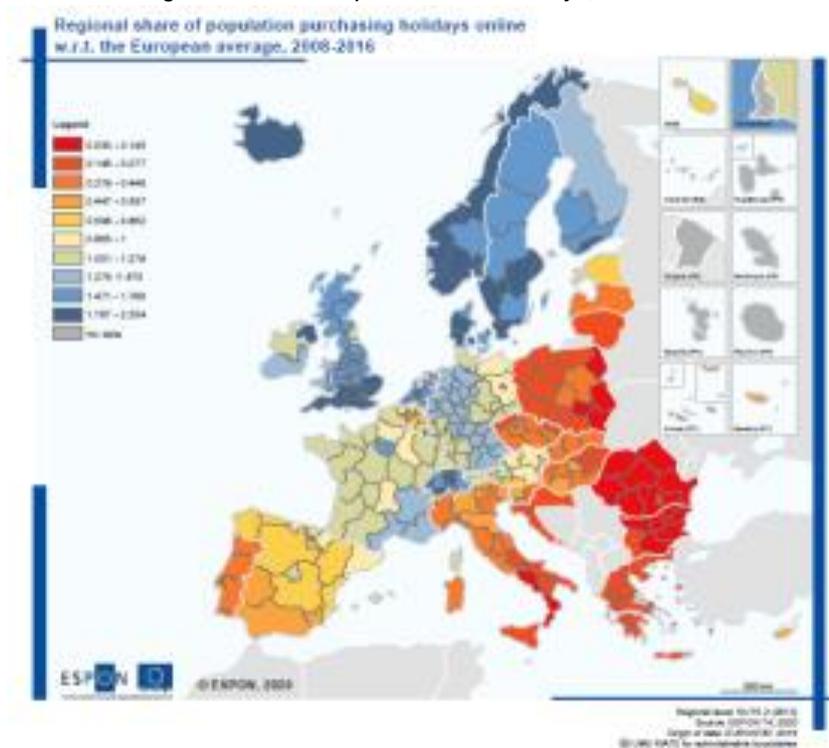
- **Public-private collaborations for improving tourism innovation** – there has been created a Tourism ICT cluster. This cluster is composed by private companies that combine technology and tourism, universities and technology centres, with the objective of working together on the improvement of innovation and technological competitiveness among Catalan tourism companies.
- **Tools and resources for facilitate tourism innovation among SMEs and business in secondary destinations** – companies in the sector have different tools at their disposal to boost their technological transformation. For example, Tourism in Catalonia has created a tool for companies in the sector to assess their ICT competitiveness. Aid for digitalization through a diagnosis of evaluation, recommendation and analysis in five dimensions: digital marketing, online marketing, ICT management tools, digitalization of experience and general analysis. Or they also have Tourism Open Knowledge, another tool that offers parameters and indicators for knowledge and decision-making in the tourism sector designed by the Science and Technology Park of Tourism and Leisure of Catalonia.

Social preconditions

According to interviewees the main social preconditions necessary for 4.0 technologies adoption in tourism in Catalonia are:

- **Culture of innovation** – Catalonia traditionally has been a region characterised by its high rates of entrepreneurship. In Barcelona, there are continuously born new business based on new technologies. Barcelona is one of the most attractive European cities for digital entrepreneurs. The culture of innovation is also associated to higher rates of the digitalisation of the society, which means a high percentage of online purchases of holidays by Catalans.

Figure 5-10. Online purchases of holidays, 2008-2016



Source: ESPON T⁴

- **Qualified workforce for adopting new technologies** – although now new generations are more proactive to study training programmes related to ICT through the dual occupational training programmes, there is insufficient workforce’ technological readiness. The workforce is still mainly composed by unskilled labour, especially in relation with ICT skills.
- **Transformation of education system** – it is introducing ICT in educative curriculums. The dual occupational training is considered an engine of change in the training of apprentices and the obtaining of qualified workforce, also, in relation to 4.0 technologies. It is increasing the number of entrepreneurial and proactive professors to develop technology initiatives among students.
- **Managing environmental carrying capacity.** Different tourism-related agencies in Catalonia and Barcelona are working to analyze and evaluate the load capacity of the sector. The aim is to make tourism a more environmentally, economically and socially sustainable activity. This is why we work to improve the adequacy of supply and demand, including aspects such as seasonality, to reduce excess capacity and the agglomerations of people. This is one of the main objectives set out in the Tourism Strategic Plan of Catalonia. In the city of Barcelona we will work to implement plans and measures for the management of visitors in the different districts of the city through the use of innovative technology. These questions were included in the Barcelona Statement in favor of a more responsible tourism.

- **Image of the sector among the local residents.** In the case of overcrowding, tourists end up using the same infrastructures and spaces as the locals. In addition, gentrification processes sometimes occur. This has caused population irritability or tourismism (negative population reactions due to mass tourism, noise, etc.). The application of technology in the tourism management of the destination helps to improve the image of the local resident about the sector. The Barcelona Tourism Strategic Plan works to improve the adaptability of tourism within the city.

Policy preconditions

Catalonia 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 political framework is necessary to move towards the achievement of those objectives proposed by the Public Administration to reach a more sustainable activity and socially more active tourism based on 4.0 technologies. In the current tourism strategies, there are different actions for promoting the digitalization of the sector and the technological innovation applied to the sector.

The following list presents strategies, policies and initiatives related to the promotion of digitalization, innovation and technology transfer:

- National Agreement for the Digital Society – Government of Catalonia (2017) – Policy protocol. The National Agreement for the Digital Society signed by the Government aims to respond to the challenges of the digital revolution, in five areas of action: a) Implementation of the SmartCAT strategy, integrating and coordinating local and supralocal initiatives and supporting companies to make Catalonia a smart country, b) Deployment and coordinated management of technological infrastructures and electronic communications that ensure equal opportunities for all territories, citizens and companies, c) Adoption of joint technological measures and tools in the field of cybersecurity and the protection of the rights of people and companies, d) Promotion of a new Digital Administration with the aim of making administration more agile, simple and effective, e) Development of Industry 4.0, understanding it's potential for market disruption, training human capital to respond to the demand for new profiles, and promoting the necessary infrastructures.
- SmartCat Strategy – Government of Catalonia (2014) – Strategy. SmartCAT is the Government of Catalonia strategy that, in line with the Europe 2020 strategy of the EU Commission, extends the concept of Smart City at a country level to carry out a program that integrates and coordinates local and supralocal initiatives, supports companies and deploys smart initiatives. It aims to make Catalonia a "Smart Country" of reference that takes advantage of the use of technology and digital information to innovate public services, boost economic growth and promote a more intelligent, sustainable and inclusive society.
- Research and innovation strategy for the intelligent specialization of Catalonia (RIS3CAT) –Government of Catalonia (2014) – Strategy. RIS3CAT promotes the vision of Catalonia as

an industrial-based country that has an open, competitive and sustainable economy and combines talent, creativity, a diversified business model, and a system of excellent research with the framework of a dynamic, enterprising and inclusive society. RIS3CAT focuses on seven sectors of specialization. This strategy is the response of Catalonia to the European Commission's demand that EU states and regions develop research and innovation strategies for intelligent specialization that fit their innovation potential.

- National Agreement for Industry – Government of Catalonia (2017) – Policy protocol. Promotion of sector 4.0 and the digitisation between Catalan industries and companies is among the strategic lines of the National Agreement for Industry in Catalonia. The work focuses on spreading the importance of the disruption that Industry 4.0 may cause in the market among companies, enable human capital to respond to the demand for new profiles, provide the advanced services, and promote the infrastructure necessary for the deployment of Industry 4.0, 17 actions are underway, grouped into four lines of work.
- Barcelona City Digital Plan - Barcelona City Council (2016) – Local Plan. The Plan raises measures based on technology and open source data to solve urban challenges, such as access to affordable housing, energy transition and participatory urban planning to move towards a sustainable and ecological city. It was developed with the participation of citizens, technological communities, creators, technology companies and researchers from the academic world.
- Report on Industry 4.0 in Barcelona. Prospects and proposals - Economic and Social Council of Barcelona (2018) – Local Plan. The report presents Barcelona as no stranger to the Fourth Industrial Revolution. In the international arena, Barcelona organizes fairs, conventions, and congresses where companies and institutions from all over the world share experiences, good practices, and knowledge in the fields ranging from smart cities to mobile telephony. These activities allow it to be a global meeting point for companies and institutions. The opportunities they offer go beyond economic benefits and are used to bring economic and social agents closer to universities, institutions and the world, where the changes are taking place.

In relation to plans, strategies and programs dedicated to promote the digitalization of tourism in Catalonia is the Strategic Tourism Plan of Catalonia. It establishes the bases to manage the tourist activity in the region, and one of its strategic lines, is the promotion of innovation and technology in the tourism. The tasks to be carried out are the promotion of the permanent use of new technologies among tourism companies and innovation through programs of technology transfer, ICT training, financial support and promotion collaborations between key actors with the objective of increasing the technological competitiveness of the sector. Barcelona has its own plan: Barcelona Strategic Plan 2020, which proposes the main actions to contribute a more sustainable tourism in the city.

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), the science parks and technicians, business incubators and other initiatives that bring new technologies to the citizenship (such as the Fab Labs). Some of the initiatives identified are below:

- **Office of Digital Innovation in Barcelona.** It is the office responsible for defining the technology and innovation policies of Barcelona, and rethinking the smart city, both in technological aspects and in order to meet the needs of citizens and the challenges of the city
- **Fab Lab Barcelona (Fabrication Laboratories).** FabLabs Barcelona are small-scale production and innovation centres, equipped with digital manufacturing tools and technologies for the production of objects, prototypes and electronics. Part of the Fab Labs worldwide network.
- **Digital manufacturing workshops.** They are a public service for the dissemination of technology and the science of digital manufacturing, promoted by the Barcelona City Council. The objective is to help people learn, work and collaborate to realize ideas that transform the environment and can contribute to social development.
- **22@ District in Barcelona.** The District 22@ is the Barcelona area where companies, universities, research, training and technology transfer centres have been established, with various promotion agents that facilitate the interaction and communication between them.
- **Poblenou Maker District.** It is a pilot initiative about digital social innovation with the objective to promote activities and projects that favour the interaction between local community through processes of reindustrialization of the urban network, using leading technologies for local production or for training workers.
- **Mobile World Congress – MWC Barcelona.** This is the benchmark exhibition for the mobile phone industry, and a congress of high-ranking companies from mobile operators, and owners of digital content.

5.1.4 Actual transformations in the region

Economic transformation

In general, and based on interviews conducted with experts from the sector in the region, tourism in Catalonia could be currently defined as technologically advanced, proactive and innovative. Catalonia has a strong ICT sector for the consolidation of a tourist model based on technology and innovation. The ICT sector is growing, and its business fabric increasing in number and turnover.

All interviewees agree that tourism is a strategic sector for the Catalan economy. It represents 12% of GDP and 13% of employment. In recent years, associated with tourism, different innovative projects have been developed based on technology, most of which are born from private leadership but have been driven by public-private partnerships.

According to literature, the development of ICT and its application in the sector have promoted **cultural and organizational changes** within tourism companies in Catalonia, which has meant a strategic reorientation of their activity. These changes in the sector have led to changes in the labor market, have increased the percentage that contributes to GDP and have created new opportunities for the sector. The use of ICT has allowed companies in the sector to innovate to differentiate the product or open up to **new marketing channels**. They have also led to collaborations between companies and with other institutions.

The use of ICTs as a strategic element in the company has been directly linked to the presence of highly trained workforce in 4.0 technologies. Greater intensity in ICT uses has made them more flexible and better adapted to market needs. But the degree of application of ICT resources varies depending on the size of the company. Small businesses have more difficulty incorporating and, above all, using ICTs in their daily operations. Most of them do not have enough resources to outsource services related to new technologies that then need to be taken over by the company's managers, of which only 30% have specific knowledge in new technologies. Large companies, on the other hand, have qualified staff to perform tasks with high ICT content, making more intensive use of them.

Among the different strategic transformations experienced by the sector, the following stand out: the consolidation of **new business models based on the P2P economy, new relationships with customers**, the development and implementation of cyber security systems or the use of Big Data to improve tourist promotion at destination. The analysis of the data at the origin of the potential tourist contributes in turn to improve tourism management at the destination.

Online search engines and online agencies are used by more than 50% of tourists arriving to Catalonia (available data from 2012). But it is no longer enough to be online, it is important to have good visibility (presence in blogs, social networks, good search engine positioning, appearance in services such as Google Maps, etc.). Rural tourism accommodation is specially hit by this; despite being the sector with most web pages, promoters still face large difficulties in ensuring high occupancy rates.

The monitoring of the tourist activity has special relevance precisely in saturated destinations such as the city of Barcelona. Monitoring (based on data obtained from tourists' purchases, GPS connections, online queries...) allows, for example, to address tourist flows to less congested tourism resources. It is a potentiality of the technology in the management of tourist destinations that Barcelona is beginning to apply. From these systems alternative tourist resources can be advised, and thus improve the tourist experience in the city. This could be done with the monitoring of queuing time in museums or other tourist monuments. Recently, in this line public-private projects have been launched, which use information about Internet connections of tourists to measure the tourist flows through out city's neighbourhoods.

Analysis of the data is used to:

- Monitor tourist mobility in the large destination like Barcelona.

- Monitor excursionists (tourist not sleeping in the city).
- Better govern tourism in the city.
- Monitor activity, to eventually apply levies and taxes.
- Better promotion of the destination.
- Management of online reputation.
- Management of accommodation and control of illegal ones.

Pilot project for analysing the flows of visitors around Sagrada Familia

A project that has applied the current technologies of IoT and Big Data to improve the knowledge of the tourist activity, to manage and optimize the flows of mobility in the areas of high tourist interest, such as the Sagrada Familia. The project consists of two phases: the first analyses the mobility patterns of tourists in Barcelona with the anonymized data of mobile phones, and the second phase of micromobility in the area of the Sagrada Familia with data from Wifi sensors, GSM sensors.

There were used the data from 5 million highly active Orange client devices for 3 months in 2014 and during July 2016, and basic socio-demographic data (age, gender, and zip code) to define tourist profiles and to track mobility in the city. The results identified three visitor profiles:

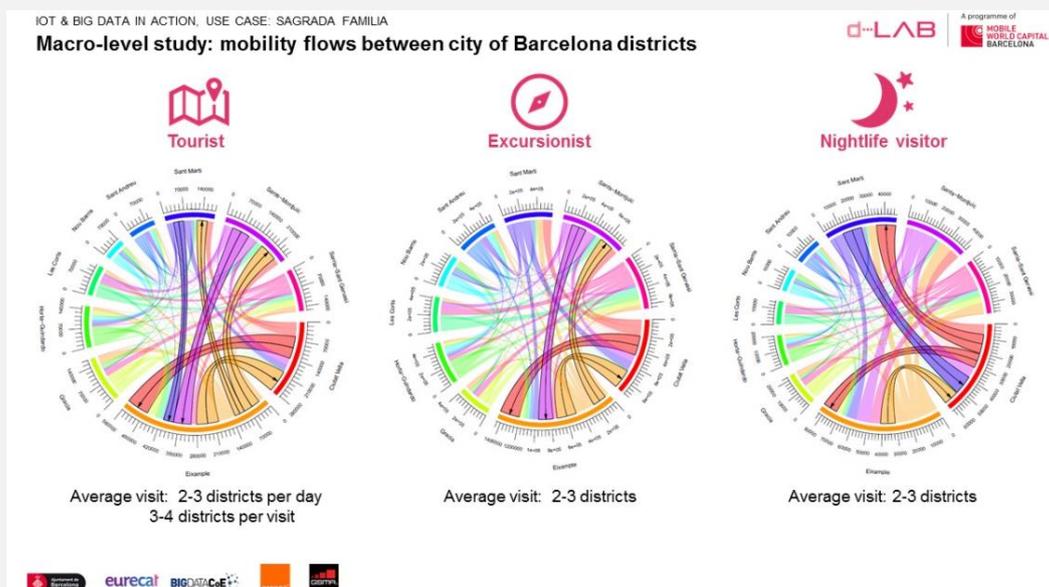
- Day-tripper: tours that start and end the same day. It has been shown that the average duration is 4.5 hours. The age profile is between 35 and 49 years.
- Tourist: visits that start and end on different days. The average duration is 1.5 days. During the weekend 33% increase. The age profile is 25-39 years.
- Night Visitor: These are visits that begin at around 6pm and end at 6am. The average duration is 5.3 hours. The age of the visitor is between 20 and 24 years.

The flows between districts have been analyzed, and the most visited are the Eixample Dreta (Passeig de Gràcia - modernist route) and the Sagrada Familia, the Gothic Quarter (Las Ramblas), Barceloneta, Sant Pere, Santa Caterina and La Ribera (the Cathedral), and Hostrafrancs (Sants train station).

The micromobility results of the second phase show the mobility patterns of tourists in the Sagrada Familia area, from where they move, and how they move around. The analysis shows that:

- 50% of visitors are in the Sagrada Familia area less than 40 minutes
- 80% of visitors are less than 100 minutes, which means that 20% access to Sagrada Familia
- the peak season is from 10am to 12pm, but on weekends the concentration is higher in the afternoons.

Figure 5-11. Study about mobility flows between city of Barcelona districts



Source: IOT & Big Data in action, use case: Sagrada Família (2017).

With the development of new ICT apps applied to tourism, there are created **new job opportunities** for the tourism sector. One of this job opportunities could be the analyses and monitoring of Big Data or the development of new online engines to commercialise tourism activities. The combination of ICT companies, and its commitment to develop ICT applications for tourism, is generating good relations between two sectors. Local administrations are taking advantage of it. The municipality of Santa Susana, for instance, has installed 23 smart signals equipped with *Beacons* technology that send notifications to tourists according to their location in relation to the resources they can find nearby, where to eat, what activities they can do or where they can stay (Figure 5-12). This kind of actions seek, among other objectives, the customization of tourism products, cause with the technology has changed the way of how is understood a trip. Now, tourists search “experiences”.

Figure 5.12. New tourist sign post that works with mobile phones in Santa Susanna



Source: *La Vanguardia*. Pedro Catena (2017).

Related to the search for new experiences, new destinations and resources, technology allows small destinations, or those that are not well known, can be better placed on the map. Airbnb and Igualada have established collaboration for promoting the city as a destination of sustainable tourism. This city, which traditionally has not stood out for its capacity for tourist attraction, intends with technology and new associations to be a new tourist reference in Catalonia. The multinational has installed in Igualada the first Healthy Destinations Lab of Airbnb', a project with international ambition that aims to explore the tourist attractions of the city as an economic opportunity and analysing different ways to increase the tourist attraction capacity of the city.

Social transformation

New tourism model adopted requires **new ICT skills** by the workforce. The workers in the sector are increasingly trained in the use of new technologies such as data management programs or mobile applications. However, there is still a considerable percentage of the workforce without ICT capabilities. That is why **educational programs related to tourism are under transformation** to adapt to the new demands of the tourism market. The experts pointed out the importance to the training in relation to the digitalization of tourism sector in the forthcoming years.

From the General Directorate of Tourism and the Catalan Tourism Agency, work is being carried out in the *#formacióturismecat* program, a homogeneous training offer to respond to the training needs of companies in the tourism sector. This new training plan is structured around innovation, digital transformation and digital marketing applied to tourism, offering three different training itineraries. The first is based on innovation in tourism product and service to respond to current remains in the creation of innovative products; the second based on digital transformation to facilitate the immersion of tourism initiatives in the current dynamic of digital transformation. And the latest training itinerary is about digital marketing and marketing for optimal use of new technologies as a marketing tool.

From the Universities, work has also been done to restructure the training plans so that they respond to the new digital challenges facing the sector. From the Faculty of Tourism and Hotel Management - Sant

Ignasi, for the Degree in Tourism and Hotel Management, the curriculum has been restructured, among other factors, to adapt the subjects and the content imparted to technological advances. Now, from the first year the students have ICT subjects in the curriculum (Internet content strategies to communicate products and online marketing strategy; data analysis in tourism and hospitality for the generation, treatment and dissemination of tourism data; distribution tourism and hotel electronics for the implementation of new technologies in the sector; or revenue management in the management of tools to set prices, manage online reservations and sales). From this University, it is committed to combining ICT skills with the most human aspects to generate greater added value to the available tourist offer.

Barcelona Activa, a public body that promotes innovation and economic growth in the city of Barcelona, also offers orientation, training, professional training and employment promotion programs in the field of tourism. Highlights courses dedicated to technology and applications aimed at tourism professionals in the *Cibernàrium* space.

With a well-trained workforce and the **promotion of public-private partnerships**, initiatives are born to improve the tourist experience of tourists at the destination.

New technologies are also useful to enhance the fit better the tourist activity into the city. Today the challenges are how to manage the tourism in the city, especially in those areas overcrowded, for instance in Barcelona (Sagrada Família, les Rambles, etc.). The differences between what is considered “tourist” and what has not been have blurred due to the new practices of visitors into the city. There are many types of tourism that are not so obvious or visible: business tourism, the visit of friends and family, attendant to musical festivals or sportive events, etc. The use of new technologies to monitor the flows and practices of tourist in Barcelona is being introduced as a new way to manage tourism in the city as it is reflected in the Barcelona Tourism Plan 2020.

5.1.5 Actual and/or expected impact

The tourism industry, today, faces a profound transformation that is mainly caused by those challenges resulted of the 4.0 technology emergence, the role of the new players of the sector (such as those born from the collaborative economy) and the changes in the requirements of the visitor. Given this scenario, the traditional tourist business structure has changed, and it will continue changing. The digital economy and technological advances represent a transformation of the tourism sector that could trigger new economic, social and territorial impacts in the region.

In the sector in the region

Tourism trends show how ICT will continue to contribute to its transformation. Catalonia is positioned to have a relevant role in the digitalization of the sector. Tourism in the region is immersed in a process of change. The new technologies have meant a reorganization in the management, evaluation and monitoring of tourism activity.

In turn, its digitalization is creating new business opportunities, has generated more applied knowledge about the sector, has promoted new relationships with customers, has opened new channels for the

commercialization of tourism products and has developed new tourism experiences that have contributed to improve the competitiveness of the tourist destination.

These changes have occurred in parallel to the changes in lifestyle and consumption that have occurred between generations.

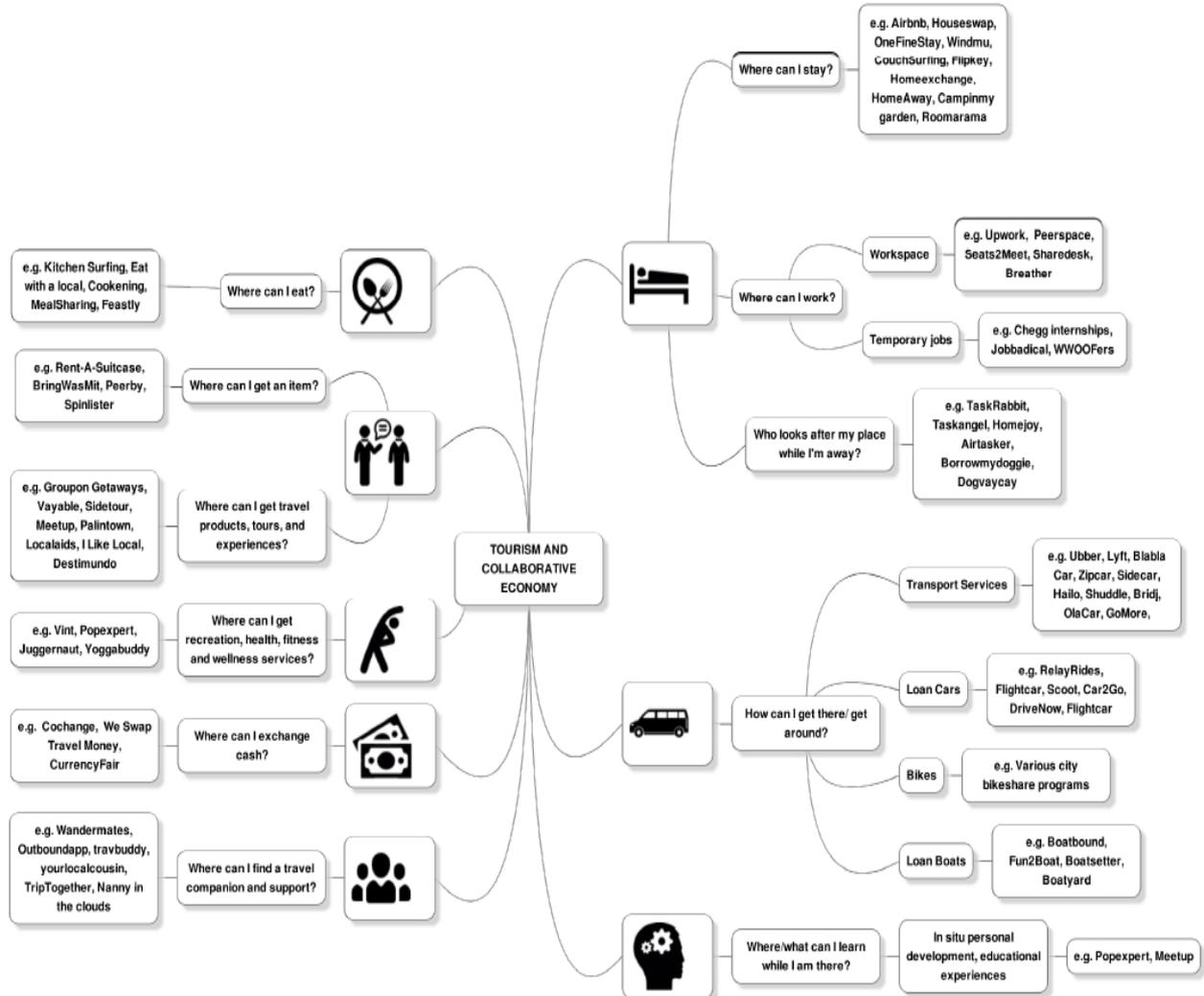
Although it is difficult to quantify several social and economic impact of 4.0 transformation on tourism, some impacts have been identified. With the progress of 4.0 technologies, these impacts will be reinforced.

Increased of value added, positive impact on turnover and better productivity and competitiveness. The technological advances are contributing to generate more economic activity into the region. Experts estimate that the adoption of 4.0 technologies by the accommodation sector would increase the competitiveness of the sector around 20%. Increased productivity is associated with the emergence of new ICT-based tools. These make it possible to redesign current tourism products to make them more competitive in the face of a growing market. The use of big data and online marketing also contribute to increasing the competitiveness of the sector. Price management is also a useful tool for predicting changes in demand and changing prices quickly to increase profitability.

New professionals' profiles demanded. The advances of 4.0 technologies applied to tourism new jobs are created, and some other could disappear (e.g. traditional travel agencies or local guides). New profiles demanded by the sector must have ICT skills. Thus, the new professional profiles that are currently required and with greater intensity in the future are: advanced ICT implementer, tourist destination planner, strategic sales manager, channel manager, social media manager or innovation manager. Other profiles will need to be redefined as marketers and marketing managers, public relations or brand managers in order to include the new communication and promotion channels offered by new technologies. In this sense, it would be low the unemployment risk. The sector will continue generating employment, but professional would be different.

New business models. *The digitalization of the sector has contributed to spread P2P economy (Figure 5-13).* In Catalonia, the number of accommodation, mobility or leisure services based on the collaborative economy has increased. Catalonia, and especially Barcelona, offers empty apartments, rooms and sofas, cars and bicycles, local friends, guides or restaurateurs through intermediary technology platforms. Globally, it is pointed out that the P2P accomadation model will increase annually (World Bank, 2018). In the Catalan case, these business modalities are also arising in secondary tourism destinations. Airbnb, leader in vacation rentals, has selected Igualada (city 60 km from Barcelona) as one of the mode destinations on its platform.

Figure 5-13. The collaborative economy and tourism



Source: Dredge & Gyimóthy (2015).

However, P2P accommodation is often unregistered and unregulated. The growth of P2P accommodation has badly matched with Catalan regulations for accommodation. Some regulations do not include the P2P sector at all; some are not applicable to the P2P sector; and others that do apply are not actively or effectively enforced. In Spain, laws and legislation for accommodation are determined by municipal regulation. That has generated some social conflicts in cities such as Barcelona, where many of the local Airbnb apartments are illegal. Therefore, Barcelona City Council requires hosts who rent out their property through a digital platform to register with local authorities. Accommodation that is not registered is considered unofficial and thereby illegal. In Catalonia, the number of tourists who stay in this type of accommodation has increased. Consequently, there are some areas that lose residents as a result of the rising of tourist apartments, and house pricing.

Distribution of benefits across the region. The progressive digitalization of the sector apparently allows the distribution of benefits, especially in the area of accommodation. Although there is a very large concentration of wealth in a few operators, many other actors have access to the tourism market, which they previously did not have access to. Digitization, and the emergence of platforms based on a P2P economy, have meant that a great number of small actors became part of the tourism market. In this way, the benefits of the tourist activity are distributed among many more beneficiaries. This has happened especially in Catalonia. And this redistribution not only occurs between actors, but also between territories. Although the most consolidated destinations still concentrate the large flows of tourists, nearby secondary destinations are positioned in the market.

Increased number of professionals with higher ICT skills. Adoption of 4.0 technologies would transform the workforce, generating new profiles related to the sector. There will be reduced of 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). The automation processes in the sector have not already occurred, but if it is taken into account the employment percentage of tourism, training in technology and tourism is an important issue to reduce possible negative impacts of automation processes.

Development of new training programs related to tourism. Tourism training is working to balance aspects of human abilities and technology skills: to extract the potential of artificial intelligence to increase the added value of human relationships. In this way, it will be necessary especially in workplaces with interface with the client. According to experts, it will become increasingly important "the hybridisation of competencies and, therefore, professionals and teams." The new professional profiles must be capable of performing an analysis of data in the commercial area (up-selling, cross-selling); data analysis for the customization of products; or behavioural insights along with marketing, etc. In Catalonia, the main university centres are working to adapt their programmes to the new demands of the sector, with the objective to fit better the tourism training into the future of the sector.

Importance of collecting real-time data about tourists. One of the benefits of digital platforms is their ability to collect data and glean insights on travellers in real time. Digital platforms can visualise, at an aggregate level, what travellers are searching for, what destinations they are considering, what kinds of accommodations and activities they are selecting, their levels of spending, devices used for bookings, whom they are travelling with, and so on. Some ICT Catalan companies are using Big Data and predictive analytics to increase the knowledge of travellers' behaviour for the sector. Big data is also being used to make tourist services more efficiently. Barcelona has analysed the consumption payments by credit card data to discuss the tourist spending or the analysis of tourist flows to some resources of the city, trying to design better routes for generating less impact on the daily life of residents. But, with the increased use of big data are new concerns over privacy, inaccuracy and misuse of such information.

The following table could synthetize the possible economic, social and institutional impacts of the implementation of 4.0 technologies in the sector. It reflects if the offer, demand, GVA, staff and infrastructure costs, the number of jobs may increase, maintain or decrease if 4.0 technologies are fully implemented in the region and according to the actor that do it.

Table 5-1. Economic, social and institutional impacts of 4.0 technologies in the sector

	Large operators on main destination	Small operators on main destination	Operators in secondary destinations	Service providers	Local tourist	Foreign tourist with "package tour"	Independent foreign tourist	Local administration	Regional administration	Europe
Offer increased	+	++	++	++				++	++	++
Demand increased	+	++	++	+	+	+	+++	++	++	++
GVA increased	++	+++	+	++	++	=	+++	+	++	+
Staff costs	=	+	++	+				++	++	+
Infrastructure costs	+	++	++	+				++	++	+
Qualified jobs	++	++	++	++				+	+	+
Non-qualified jobs	-	-	-	-				=	-	-

Source: MCRIT (2019)

5.1.6 In other sectors in the regions

The application of new technologies also has an impact in other sectors of the Catalan economy.

In relation to the labour market, one of the main features is the **greater presence of machines** (mainly robots, new operating systems and algorithms) in the production process. As new technologies become part of the productive process, it is likely that some tasks can be done with fewer workers or even some jobs may disappear. But it will become more important those professions in which there is a complementarity between the work of the machines and what the worker provides. A clear example is those professions (managers, data scientists, statisticians ...) in which new digital tools (machine learning techniques, big data or software capable of accurate predictions) can improve the quality of service offered by companies or make the production process more efficient. This fact is expected to be more important in Catalonia, given that the industrial sector (as in the case of the automotive industry) is more important in the Catalan economy. However, experts believe that there **will not be reduced the 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.

Technological advances also affect the way of companies operate and their size. New technologies allow the productive structure of companies to be increasingly spread over the world, with greater decentralization of production and of their headquarters. This tendency will continue to increase the off-shoring, and that businesses work less hierarchically and be more dynamic and flexible. This is especially noteworthy in the Catalan case, given the weight of the industrial sector (20%).

With regard to the business dimension, the technology leads to a dual structure. The digital advances will facilitate the **increase of the production and the access to new international markets**. But at the same time there will be more opportunities for small businesses specialized in specific products, thanks to technological advances which allow companies to produce goods at a much lower cost and to disseminate their products better (García, 2018).

5.1.7 European relevance

Tourism is a key economic sector for the European Union. According to Eurostat, “in 2016, one in ten enterprises in the European non-financial business economy belonged to the tourism industries, and it was employed over 13 million”. In 2018 the sector accounts for 10% of the EU's total GDP. In 2018, the continent welcomed 672 million tourists, half of the international arrivals in the world, with 51% of global tourism going to Europe (European Travel Commission, 2018). Increasing flows are seen from the United States, but especially from China, Asia and Latin America as new middle classes arise around the globe.

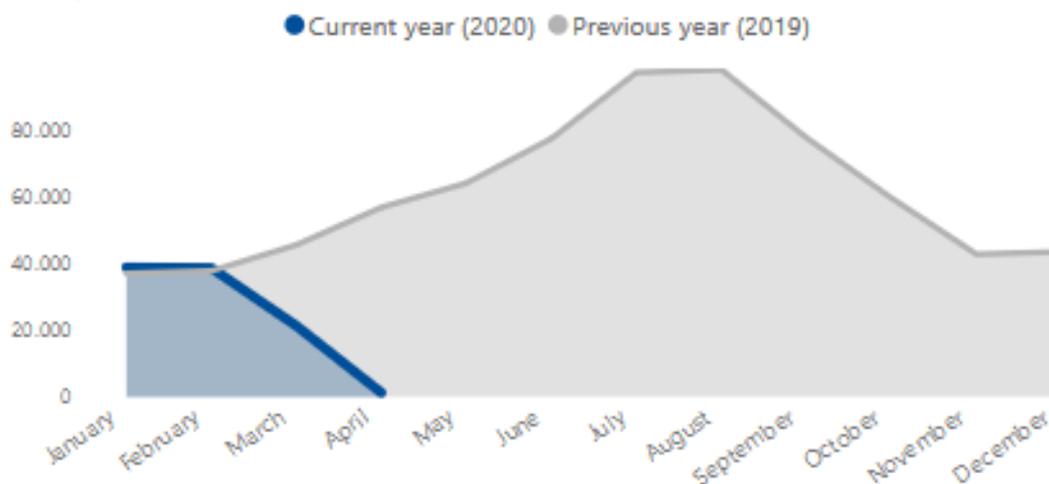
The European potential of technology 4.0 in tourism is therefore very large, as many regions in the continent rely in tourism for the health of their economies. Spain is the second European destination in Europe with some 83 million overnight stays yearly, but France leads with 90 million, and Germany has above 60 M visitors, UK, Austria or Greece all exceed 30 M visitors yearly. Tourism represents 12% of Spanish and Italian GDPs and 7% of French GDP (Eurostat).

But tourism is or can be also very relevant in other regions in transition with lower economic opportunities. It can contribute towards employment and economic growth in rural, peripheral or less-developed areas. The European Territorial Agenda has observed tourism as one of the legs in which a renewed urban-rural partnership can be built. The un-tapping of endogenous potentials and the pursuit of bottom-up economic development initiatives is relevant especially in rural areas, remote areas, sparsely populated areas. Infrastructure created for tourism purposes contributes to local development, while jobs that are created or maintained can help counteract industrial or rural decline. The role of technologies in those cases is crucial for maintaining tourist activity, and offering new economic opportunities and promoting the economic diversification of some territories.

Future perspectives after COVID-19

The COVID-19 crisis is affecting tourism in restricting long-distance mobility of people, and in making more complex tourism activities at destinations. The final impact is yet unknown, but its economical magnitude will certainly be very large. There are higher regional risks in southern and eastern Europe considering a higher dependence of international tourist arrivals and a sector integrated by large numbers of SMEs and microbusinesses.

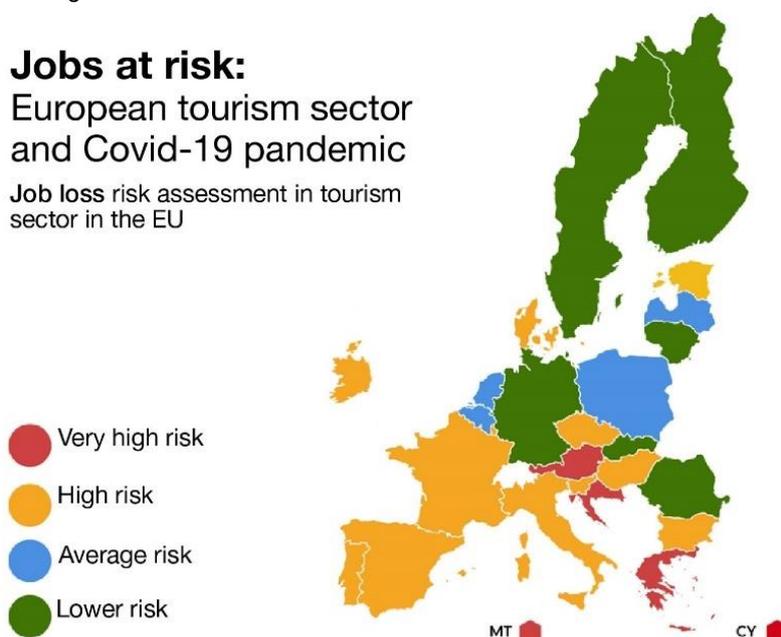
Figure 5-14. International tourist arrivals (thousands) in Europe in 2020, compared to 2019



Source. UNWTO 2020

Figure 5-15. Job loss risk assessment in tourism sector in the EU

Jobs at risk:
European tourism sector and Covid-19 pandemic
Job loss risk assessment in tourism sector in the EU



Source. CEDEFOP 2020

The pandemic episode may force to rethink a new start for tourism industry and according to experts these measures have to be based on 4.0 technologies. With the outbreak of COVID-19 the tourism

sector has to be experience a new transformation, through the acceleration of its digitalisation. Safety and health become more important, and it is here that new technologies are considered necessary to guarantee them (Smartravel, 2020).

- Solutions based on Artificial Intelligence, IoT platforms and blockchain technology will be spread fast. These solutions allow monitoring accesses to public spaces, tracking of tourism activities, or automated disinfection of museums or theatres, among others.
- In the case of airports, some experts foresee the implementation of infrared temperature controls to detect feverish states, the extension of facial recognition or that the authorities may have access to “digitized health passports” (Smartravel, 2020).
- Tourist accommodation will have to apply new digital tools for achieving the safety and hygiene standards required by the health authorities. In the hotel sector, applications such as automatic doors, the online check-in and check-out process, digital invoices, the use of mobile applications to purchase products or book other services, mobile room cards, etc. will become generalized.

The implementation of these tools linked to 4.0 technologies will require the improvement and increase of the digital training of employee of the tourism sector, to ensure that the new technological systems are properly applied. This in turn can generate new workplaces associated with avoiding crowds in touristic spaces, or for checking the disinfection protocols, or the technical installation of new technological systems in airports, hotels, museums, restaurants, etc.

5.1.8 Operational policy recommendations

Tourism activity is increasingly complex. In Catalonia, there are different types of tourism that make it difficult to homogenize tourism policies. This complexity is clearly visible in the city of Barcelona, where several types of tourism coexist in very specific spaces and concentrated in time.

Catalonia, like other Spanish Mediterranean regions, has successfully pursued diversification of a tourism model that is no longer based only on leisure but also on business, education and training, health and wellbeing, culture, temporary work. Resorts that formerly attracted mostly ‘sun-and-sea’ tourism have now diversified and modernised their tourism infrastructure and upgraded their clientele.

Tourism policy was mainly focused on the promotion and attraction larger number of visitors during the 90s and early 2000s overcrowding is beginning to be experienced by some destinations in 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 negative 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 its management (tourists who combine leisure and work, long-term tourists like Erasmus, or tourists who visit the city in one day). Different kinds

of tourism require different types of services and induce different types of economic, social and environmental impacts. Tourism activities have effects in many areas, spaces and resources that eventually were not presupposed as tourist only: mobility, security, environment, health, sports... that becomes a challenge for managing tourist activity. Tourists are dispersed in the city, and within the Airbnb model has contributed to this, how tourists living together with residents in the same buildings.

- **Technology allows to better understanding the microscopic scale of tourism in places of high affluence** (e.g. around the Sagrada Familia, the Picasso Museum, La Barceloneta ...) **or during mass events** (e.g. Mobile World Congress, music festivals, F1 racing...). It contributes to better management of carrying capacity and for mitigation social and environmental impacts over the territory through the implementation of environmental taxes, or mechanisms of value tourist transfer to the local residents.
- Monitor tourist activity must contribute to a better and more efficient management of tourism activity in the region. But **those operators that have the data does not manage tourism activity**, and often does not intend to share it either. The operators (for example, mobile operators) benefit from tourist activity but do not contribute to their management. In addition, there is also the challenge of ensuring privacy and anonymity of this data.
- **A good tourist image contributes to the global positioning, and to increase the attractiveness** of the region. In the case of Barcelona, for example, the brand and the tourist image are fundamental (unlike in other cities) in the creation of intangibles that allow to attract new economic activities and new temporary residents seduced by good quality life conditions. Tourism promotion and digital marketing strategies favour it.
- 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 destination. It is an example Barcelona and where innovative technological solutions have been developed to improve urban services, such as public transport, lighting, waste and water management, and social and health care. Efficient management of city services and resources can also have a positive effect on tourism management.
- **Public policies are strongly aimed at supporting SMEs business** for incorporating the new tourism strategies based on new technologies. Catalan Government has created different programmes with the goal of promoting transformation of Catalan SMEs towards 4.0 technologies.

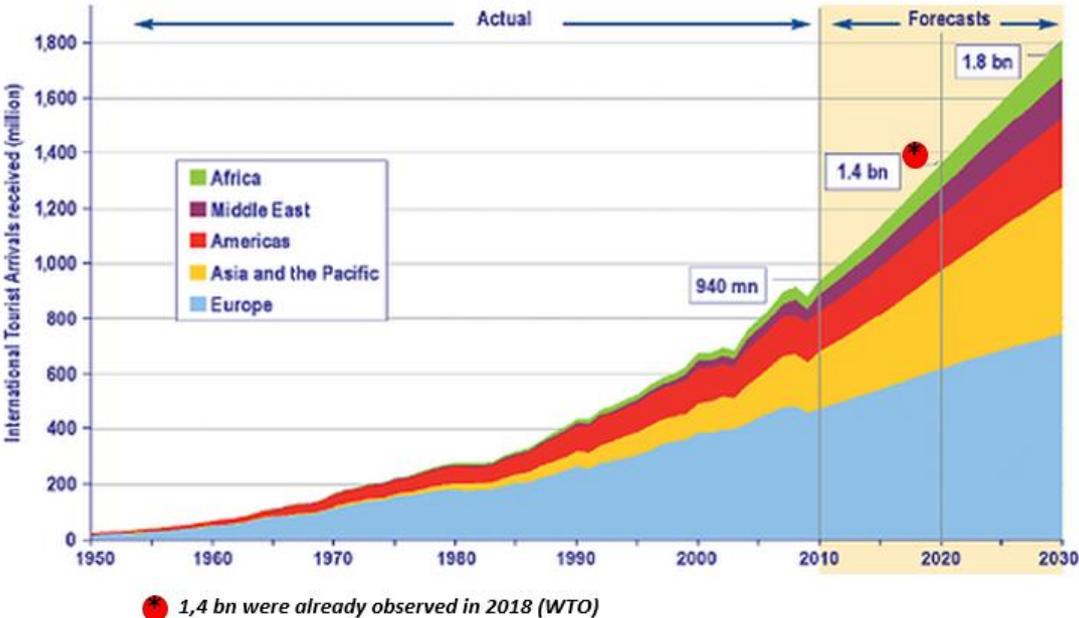
5.2 Canary Islands

5.2.1 Regional baseline

This report focus on how 4.0 technologies are shaping the tourism industry in the Canary Islands. To begin with, it is provided a broad look about the state of technology & tourism activity in Spain.

International tourism has expanded constantly in the last decades in the global sphere, also in Spain (Figure 5-16). The number of international tourists, in 1950 totally 25 million worldwide, reached 1.4 billion in 2018 and this is expected to rise to 1.8 billion by 2030 according to the World Tourism Organisation (WTO). In 2018, 82.6 million international tourists visited Spain. It has now overtaken the US as second in the ranking of the world’s favourite destinations (France is still the leader). However, although the number of tourists has stabilised, tourist expenditure still appears to be growing, highlighting the importance of the industry’s strategy to attract higher quality tourism. The number of tourists visiting Spain in 2018 may have been similar to the total in 2017 but the amount spent by those tourists increased by 2.8% and daily expenditure rose by 6.4% (INE, 2019).

Figure 5-16. Global tourism evolution



Source: WTO (2018)

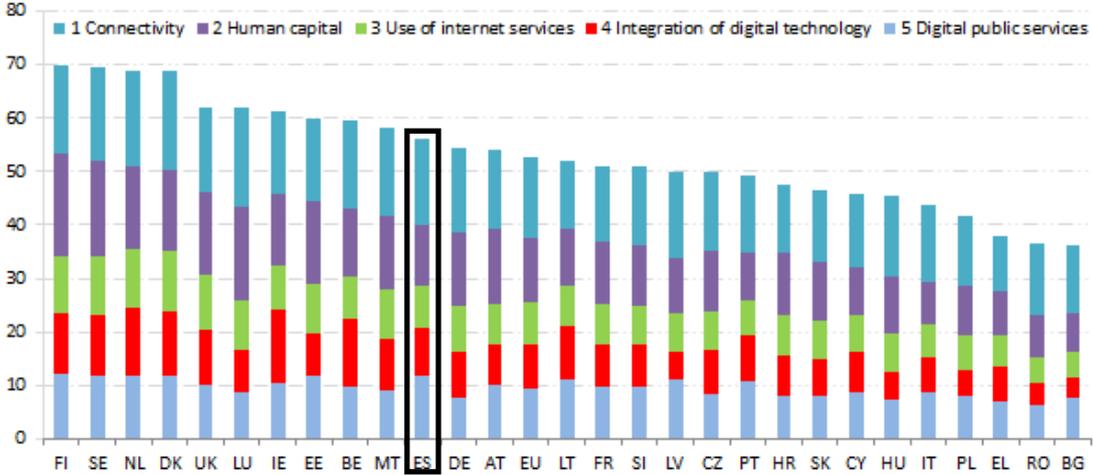
One of the key supports for Spain’s economic growth during the recovery from the 2008-2014 financial crisis has been the tourism industry and particularly the strength of international tourism. Between 2016 and 2018, the average growth in tourism-related GDP was 4.8% 6 year- on-year, much higher than the 2.8% growth in the economy as a whole. During the same period, domestic tourism grew in line with the economy’s overall GDP growth, so this better performance by tourism-related GDP is due entirely to the rise in international tourism (The Corner, 2019).

In 2018, the tourism sector generated a total of 50,093 new jobs, representing a 3.1% annual growth for this sector, according to Social Security affiliations. The creation of employment has been accompanied

by a 2.7% increase in salaries after reaching an agreement in the hospitality sector, confirming the industry's commitment to employment. There is unanimity across public and private sectors on the critical value of the digital transformation of the tourism industry.

Concerning technology development and implementation, Spain ranks 11th in DESI 2019 (Digital Economy and Society Index) (Figure 5-17). Spain's performance in the use of digital technologies by enterprises and in the delivery of online public services is above the EU average. In connectivity, progress is particularly strong in terms of subscriptions to fast broadband and NGA coverage is also high. Spain belongs to the cluster of medium performing countries (European Commission, 2019).

Figure 5-17. Digital Economy and Society Index



Source: DESI 2019 ranking

In relation to digital connectivity, Spain has a medium rank in fixed broadband take up (19), while it scores low (22) in 4G coverage and ranks 11th in mobile broadband take-up. Nevertheless, Spain has improved in fast broadband subscriptions (54%). Over three quarters of Spain (around 75%) are online and 55% (2017) of the population has basic digital skills. ICT professionals remain a low share of employment (2.5%), but the number of STEM graduates is significantly high enabling companies to recruit the ICT specialists they need (Lazaro, 2017).

Spain ranks medium in the use of internet by citizens (12). Spanish Internet users engage in a variety of online activities, but when transactions are involved, as in eBanking and eCommerce, they do so less than other European citizens (58%). Spanish companies are making progress in integrating digital technologies in their business processes and a fifth of SMEs are actively selling online. They show a good adoption rate of cloud computing (15%). Spain performs solidly above EU average in the delivery of online public services (89%) and performs well in Open Data (88%). The results of this data is mainly related to the degree of development, implementation and consolidation of policies, strategies and initiatives about emergence and transfer of 4.0 technologies in Spanish context.

At state level, actors in terms of research and innovation are the Ministry of Science, Innovation and Universities, which is responsible for the design and management of research and innovation policy.

The Council of Science, Technology and Innovation (CPCTI) is also an important actor and it plays a coordination role in relation to regional governments and other stakeholders in the Spanish R&D system. Another related body is the Executive Committee for Science, Technology and Innovation policy (CDCTI) that is responsible for the planning, evaluation and coordination of the Spanish RDI instruments.

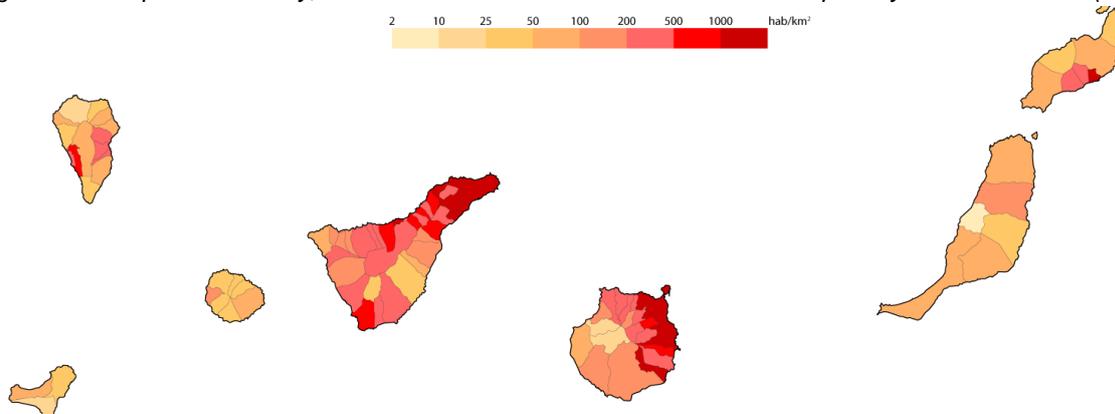
There are public strategies, plans and programmes supporting digitalisation in Spain:

- Spanish Strategy for Science, Technology and Innovation 2013 -2020 (EESTI). It contains the rationale, objectives and indicators for the Spanish R&D and Innovation policy. The objectives are aligned with those set by the European Union within the “Horizon 2020” programme for the period 2014-2020, contributing to encourage the active participation of Spanish Science, Technology and Innovation System actors at European level.
- Spanish State Plan for Scientific and Technical Research and Innovation 2017 -2020 (PECTI). It is a tool for implementing the EESTI by setting the priorities, programmes, coordination mechanisms, costs and sources of funding to implement and consolidate scientific and technical research and innovation.
- Industria Conectada 4.0 Programme. It seeks to support projects that promote the digital transformation of industrial companies, thus complementing business efforts aimed at achieving their evolution to the digital economy, supporting the incorporation of knowledge, technologies and innovations for the digitization of processes and the creation of technologically advanced products and services.

The specific context of the Canary Islands

The Canary Islands (ES70) is a Spanish archipelago, composed by Tenerife, Gran Canaria, Fuerteventura, Lanzarote, La Palma, La Gomera and El Hierro. The archipelago covers an area of 7,493 km² and has a population of 2,127,685 inhabitants (2018) (Figure 5-18). The density is of 284 inhabitants/km².

Figure 5-18. Population density, concentrated on Tenerife and Gran Canaria especially on coastal areas (2018).



Source: Creative Commons

As an Outermost Region, the Canarias economy has to overcome its remoteness from the continent (3 hours flight from Madrid), the small market size, the limited size of infrastructure, or the scarcity of qualified workers. These contribute to generate higher average production costs than in continental Spain and limits strategic options in terms of diversification. This would partly explain limited shares of the industry in the economy, and the strong orientation towards services. Services sector makes up 76% of GDP and represent 77.5% of employment (ISTAC, 2018). These ratios are higher than the Spanish average. Industry represented 7% of GDP in 2018, and was responsible for 4.5% of jobs. The GDP per capita is 20,425€, below both the Spanish average of € 25,100 and the EU28 average of € 31,200 (2018).

Unemployment is still higher than the average for Spain. In 2019, unemployment accounted for 21.2% of active population (13.9% on average in Spain) and more than two thirds of young people under 25 years are unemployed (40.8%, 32.8% on average in Spain). This is a problematic situation as so much talent and potential remains untapped, and this, in turn, reinforces the brain drain to mainland Europe.

Tourism is a large industry in the islands, being de main source of income and job creation. The tourist activity generated 35% of the GDP of the islands, 40% of employment, 11% of public spending, and collected 35% of regional taxes (2018). The Canary Islands is the first European region in terms of tourism, leading the ranking of European tourist regions according to the number of overnight stays. In 2018, about 15.5 million tourists visited the Archipelago. Main type of accommodation is in hotel (78%). There is a total offer of 553,634 beds: 53% in hotels, 31% in apartments, 17% in holiday homes.

The Canary Islands also plays an important role in the strategies of global tourism business groups, particularly those most linked to the holiday segment and the so-called sun and beach tourism. The islands have a climate, a landscape and some coasts that remain the main attraction for tourists. The tourism growth of the Canary Islands has traditionally been based on tour operators, who were in charge of the commercialization of tourist packages. Now with the emergence of new technologies, the sector is in a phase of deep transformation.

In terms of digitalization, the ICT sector reached 2,363 companies (2018), which represents about 2% of the total Canary companies (DIRCE, 2018). Most of these companies are specialised on tourism sector. These companies are mainly small and micro-sized. The employment figure in the ICT sector was around 16,000 people during the year 2018 (Government of the Canary Islands, 2019), a figure that represents 1.7% of those employed in Canarias. The Canary Islands generated 0.9% of the employment of the ICT sector in Spain in 2018, which places Canarias among the last Spanish regions in terms of job creation in the ICT sector.

Canarias companies with 10 or more employees have a different evolution in the adoption of ICT, but with general increase in the use of online resources. The use of ICT is similar to the national average, with categories in which it exceeds such as the use of social networks (53%), the sending of invoices for automatic processing (36%), or digital advertising (25%), and others in which it is below, such as the

use of the digital signature (74%), the use of cloud payment solutions (19%) and others such as big data (9%), robots (6%) and 3D printing (2%).

According to INE data, 20% of these companies make regular sales through electronic commerce (2017) and purchases through electronic commerce are close to 22%. Regarding the business field, at least 91% used the Internet to interact with the Administration.

In the Canary Islands, 87% of Canarias households had access to the Internet and broadband. Based on this data, it is estimated that 85% of the population routinely access the Internet and 27% make purchases through the network.

63% of the Canarias population has contacted or interacted with the Administrations or public services online throughout 2018, either to obtain information from official websites (53%), to download forms (40%) or to send forms (43%) (Martín et al., 2019).

5.2.2 Adopted 4.0 technologies in the sector in the region

The tourism sector (compendium of hospitality players, operators, traditional travel agencies, online travel agencies) is a good example in which digitisation transforms the business model of the sector (Figure 5-19). The online information available to customers broke the dominant position of the travel agencies and brought “re-intermediation”. The strong competition, the technological advances and the evolution of the user has pushed towards a new re-intermediation in which online players with a strong B2C reputation (online search engines, online agencies) are now the industry leaders.

Figure 5-19. Travel in the digital age



Source: “Tourism and Technology: How Tech is Revolutionizing Travel” (2018).

Tourism is strongly influenced by the progress of the technological revolution. The Internet has already changed the way tourists search, explore, book and experience travel. The whole industry has to adopt new technology trends, rethink their strategies and reshape the way they provide services. Robots (maintenance, guest service, and room service), holograms with avatars (reception, staff), interactive displays, smartphones and gadgets are already becoming a reality for example, for the hotel industry. Some parts of this technological future are expected to become an integrated part of the tourism sector; however, the level of technology in each hotel or tourist industry, in general, will depend largely on its strategy and positioning.

It should be noted the two major technological disruptions, in the digital field, which have marked and are marking the recent history of tourism.

The first is mobile technology. In 2007 Apple marks a milestone in mobile telephony by bringing out what would be the first mass market smartphone. In 2005, Google had already launched GoogleMaps. The combination of a mobile terminal, capable of integrating a map, and serving as a communication interface with the network revolutionized the world of tourism. To this it should be added the disappearance of European Roaming in 2017. Although the new European Data Protection Regulation has marked a before and after in the management of personal data, the traces left by tourists in the use of their mobile, the majority connected to Internet during their whole travel, generates a volume of information (social networks, economic transactions, searches ...) that allows tourism companies to analyse the behaviour of their clients at destination. The use of intelligent systems allows tourist destinations to obtain and exploit, in real time, information, to convert it into data (González et al., 2018), useful for monitoring tourism activity.

The second major digital disruption comes from the side of the Service Platforms. These base their strength on the union of three basic elements: the Internet as an environment, the growth capacity of a P2P model (person to person), and the confidence as a centre of success, in which the online reputation initiated in tourism by Tripadvisor has developed new tourism business models.

Figure 5-20. Key technology influences in tourism



Source: Horwath HTL (2018).

According to experts, hyper-connectivity has been making rapid leaps in the way of understanding the tourist experience. The technologies that have most impacted on the digital connectivity of tourists have been, in addition to the Internet, the appearance of smartphones, the emergence of the digital map (GoogleMap), the online reputation initiated by the Metasearch engines, the emergence of social

networks and, in the last decade, the disruption of digital platforms that have given access to microservices (Figure 5-20). The latter have revolutionised the intermediation ecosystem, as the OTA's already did at the end of the 00's. The emergence of 5G technology promises a new turnaround for the sector, which together with the end of Roaming in Europe, will allow tourists to accelerate data collection through voice and/or image services used by visitors.

Technology has changed the way of understanding the trip. Now it generalised the term “tourist experiences”. Nowadays, with all the stimuli that the client receives, the customer journey has changed and, although these three steps still exist, the micro-moments have been extended and the client has the ability to express themselves more and through different platforms. The first factor that has changed in the customer journey is the communication between the customer and the brand, changed especially by the eruption of social networks. They are now the first point of contact between the customer and the brand. When the customer has already established this contact, the next step takes place: the purchase. This process has now become much more complex with the evolution of technologies: from an app in the mobile phone, from the website, in the store, in the store but online, online but in store.

Figure 5-21. Kind of tourism customer journey



Source: *Digital Tourism Marketing (2019)*.

The new digital tourists, in addition to personal experience, demand immediacy, and even more, services of recommendations for the future, based on their own tastes. At this point, Gatekeepers (Google, Amazon, Facebook), with daily contact with users, have a predominant role in tourist intermediation, generating valuable information for the destination, this thanks to a society that is connected in real time.

Thus, companies and entrepreneurs in the tourism field, handle large amounts of data, most of them personal. That is why the sector is increasingly aware of the importance in the protection of personal data, as marked by the laws. In Spain, for data protection, the LOPD (Organic Law on Data Protection)

applies. The protection of them has become one of the main challenges of tourism sector, which has created new workplaces. For example, the figure of the data protection delegate is emerging in tourism companies. These profiles are new in the tourism sector.

For some experts, the treatment of the data is still difficult, since those who demand data do not have an orderly view of the offer, lack visibility on the set of public and private data available; and they do not have enough people trained to analyse them.

Technology in the sector in Canary Islands

In the case study region, tourism sector has adopted technological solutions in line with other advanced tourist regions in the World: online booking; e-marketing; pricing; online reputation; data tracking and exploitation; market monitoring; Internet of Things; Artificial Intelligence (AI)... So far, 4.0 technologies have often focused on online engines for searching and booking accommodation, using and processing big data obtained through the online queries made by tourists or managing the destination through reputation and marketing.

The Canary Islands have strongly opted for **e-marketing**. A strong foundation of the Canary Islands tourism strategy has been traditionally its marketing, which has increasingly become based on e-marketing solutions. Destination promotion is done online, but increasingly through "social networks", officially communication accounts but, also through bloggers, instagrammers... With this they seek to know their clients better to anticipate their wishes and provide them with an added value to their tourist experience. In relation to the use of **big data**, concrete actions of digital marketing have been carried out by segmenting the messages towards certain user profiles that fit the tourist offer of the islands to increase the percentage of direct sales. In this way, new travellers are attracted who, although a priori do not conceive of the Canary Islands as a preferred destination, discover aspects of the tourist offer that fits perfectly with their travel preferences.

The e-marking in Canary Islands is mainly developed by Promotur. It is a public institution for managing destination and the "Canary Islands" brand. This institution is specialized in the dissemination of the Canary Islands with microsegmented measures by regions and specific target groups. From Promotur, there have been developed 250 promotional actions in 14 different cities, it is in 50 digital platforms, and it has generated more than 2.500 microsegmented visual contents with infographics, illustrations and photographs. Communication contents are disseminated in 15 different languages. With the microsegmented promotional measures, the knowledge of the destination and its products has been improved, the regional image has been enhanced, the number of visits to the destination has increased, the connectivity has improved and there has been an increase in the average stay and tourist spending on destiny. Promotur has been awarded on more than one occasion for its continuous marketing and communication action, and innovation applied to the promotion of tourist destinations.

The main source of this data is the digital tourist himself, who constantly generates content through the new online channels: flight comparators, hotel reservation platforms, tourist rental portals ... Based on the analysis of these data, there is obtained the key information to develop a competitive and

personalized communication with currently and potential Canary Islands tourists. Canary Islands Government has a database of more than 350,000 *leads*.

Online booking systems have been developed and customer service is also done online. It has meant changes on sales channels. Tourism products, based on “customer experience” are visualized and distributed through ICT technologies (web platforms, mobile applications...), adapting better to the clients.

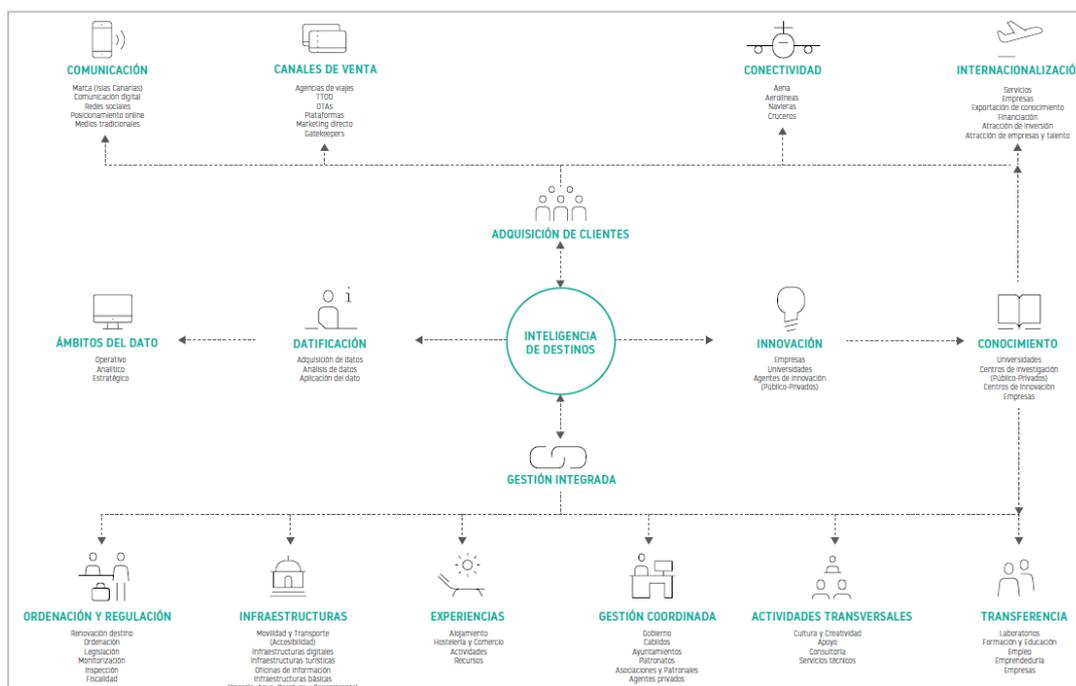
Innovation Tourist Institute and other research centres are working on the design of new technological applications for the development of management software and ICT projects, the renovation of the accommodation sector, and other alternative leisure activities (Figure 5-22).

Four territories of the Canary Islands have the *Smart Destination* badge (AENOR certificate): in Tenerife, Arona and Puerto de la Cruz, and El Hierro and Gran Canarias. These are innovative destinations, consolidated on a powerful technological infrastructure to guarantee their sustainable development and that facilitates the interaction and integration of the visitor with the environment, increasing the quality of their experience in the destination.

Tenerife and Gran Canarias have more than 50 companies in the tourism sector that are clearly committed to innovation. Some examples are: Atlantis Technology NT that has developed *CX Hospitality*, a technology that allows you to design, through various channels such as web pages, chat, personal telephone service and social networks, a tourist offer tailored to each client, or *FeelTourist* that is responsible to give integral solutions to the communication needs inside and outside the hotels.

However, most 4.0 technologies adopted in the region are provided by global service providers, for instance Tripadvisor, Booking, Expedia but also specialised tools like “beonprice” (Spanish firm implemented in Europe, USA, Mexico and Colombia), “review pro” (Spanish multinational firm) or “trust you”. Vast majority of ICT companies belong to multinational corporations, providing services on an international scale. Related to big data, gatekeepers as Google, Amazon or Facebook are the main producers of data used by the sector.

Figure 5-22. Framework of tourism digitalisation



Source: Plan de Canarias para el Turismo 2025.

5.2.3 Preconditions for transformation in Canary Islands

Regional precondition

According to interviewees the main regional preconditions necessary for 4.0 technologies adoption in tourism in Canary Islands are:

- **Existence of support policies and global strategies** – strategies and policies related to the promotion of digitalisation, innovation and technology transfer among industry and also among civil society. Concentration of a significant number of scientific and technological centers in the Canary Islands in different fields (e.g. the recently approved “Canary Islands Strategic Plan for Tourism (PECT 2025)” stresses up the value of technological transformation for ensuring sector competitiveness in the tourism global framework).
- **Financial support and funding for adopting 4.0 technologies** – instruments such as technological bonds and grants to promote the creation and expansion of technology-based companies focus on tourism activities. There are tax benefits to invest on the sector. Nevertheless, there is still low investment in regional R&D. Level of spending on R&D and innovation in the Canary Islands relative to other Spanish Autonomous Regions is relatively low.
- **Innovation support for developing solutions** – there are collaborations between public administration and private companies focus on tourism for adopting 4.0 technologies. In Gran Canaria, there is the ICT Demonstration Centre for Tourism Innovation, a platform where public sector and private companies share their knowledge about the implementation of technology on the sector. In Tenerife, there is Tourism Innovation Cluster, for contributing the creation,

implementation and consolidation of tourist initiatives based on 4.0 solutions. Also in the Canary Islands, the National Congress of Digital Tourism is organized in which the digitalization of the tourist, the offer of digital services, the technologies for a future traveller or cybersecurity in the sector.

- **Promoting the digital culture to a further extent** – from the *Instituto Tecnológico de Canarias, SA*, the Canary Islands Agency for Research, Innovation and Information Society of the Canary Islands Government and from Island Councils have been promoted the creation and consolidation of the fibre optic network, access to the Internet and the development of new digital skills by Canarias citizens.
- **Promoting individual development strategies by each island** – Canarias is composed by seven islands with particular characteristics each one, which means difficulties to develop a homogenized 4.0 technology strategy for all of them as a region. There are but individual development strategies by each island, especially for those are bigger in population and area. It can be highlighted Gran Canaria and El Hierro in development technological solutions to tourism.
- **Priority in the implementation of fibre optics** - collaborations between public and private entities are important to improve services and the implementation of fiber optics in the region. Both businessmen and the public administration are committed to having the necessary infrastructure for the implementation of fiber optics throughout the territory. For example, to establish the free Wi-Fi service on the beaches you need to have this consolidated infrastructure.

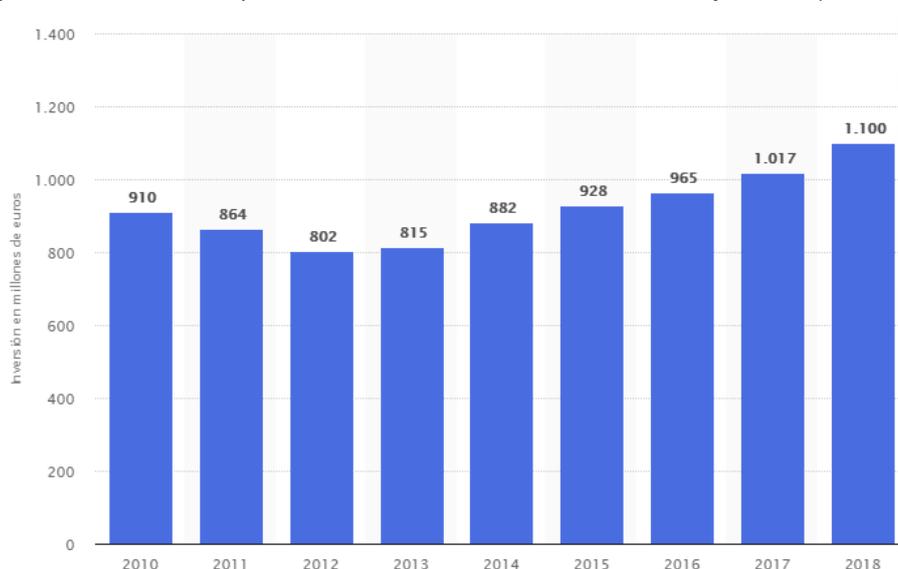
Sectoral preconditions

According to interviewees the main sectoral preconditions necessary for 4.0 technologies adoption in tourism in Canary Islands are:

- Generational changes in the industry – 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.
- Receptivity of the sector to adopt innovation – the size of the sector and its transversal structure favour the receptivity of 4.0 technologies adoption. There are large hotel groups with technical and economic capacity to adopt 4.0 technologies in their internal management systems. Tourism sector is running in Canary Islands, for the large part, by internationalized operators, which play a major role in channeling the accommodation prices.
- The importance of private sector investment – easy adoption of technological advances in the sector with the private sector intervention (Figure 5-23). The volume of private investments in the Canary Islands is situated around 1 billion €/year (2018). After the hardest years of financial

crisis in which the investment was around € 800 million, in 2017 and 2018 the figures for private investment in the islands exceeded one billion euros. These investments are mainly destined to improve and reform accommodation establishments, restaurants and leisure centres and to invest in transportation, purchase of rental vehicles, travel agencies, real estate activities related to the sector and cultural and recreational services.

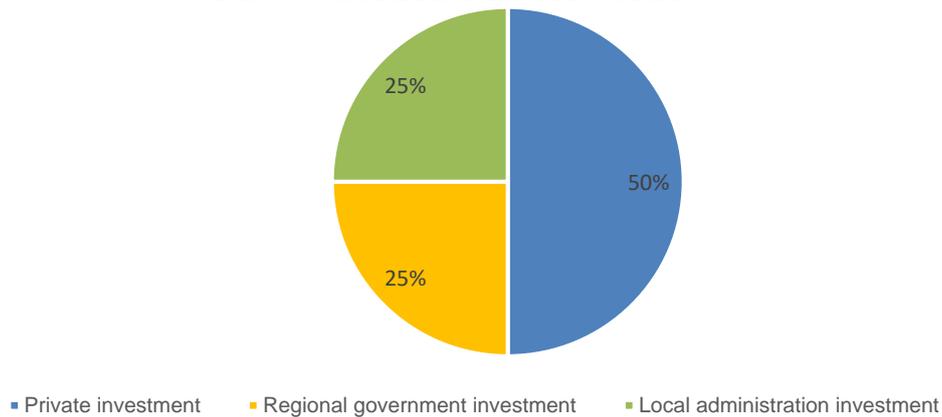
Figure 5-23. Evolution of private investment in the sector in the Canary Islands (2010-2018)



Source: Statista 2020.

- Public sector investment and initiative – The Canary Islands are committed to a tourism model that approaches customer knowledge through new technologies (Figure 5-24). Tourism goes through the necessary and obligatory digital transformation of the destination, both in its public and private infrastructures, to reach and implement new management models that increase the competitiveness of the sector. €510 million public expenditure of the Government of the Canary Islands went to tourism in 2018 for tourism training, promotion, management of tourist centers, planning, information systems and in tourist support services (security, health, culture). Local administrations are also highly involved in the development of innovative tourism strategies. In 2018, they spent €541 million to guarantee the adequate provision of services to tourists.

Figure 5.24 Investment in the Canary Islands (2019)



Source: *IMPACTUR Canarias 2018. Exceltur (2018)*

Social preconditions

According to interviewees the main social preconditions necessary for 4.0 technologies adoption in tourism in Canary Islands are:

- Culture of innovation – some stakeholders pointed out a lack of innovation culture in a part of Canarian society. Many operators and entrepreneurs do not still possess the necessary skills to exploit mobile applications or online marketing tools. Online information is crucial for developing new technological initiatives. This is not to say that there are not some active entrepreneurs on tourism initiatives related to technology and innovation systems, the consolidation of entrepreneurial projects is still relatively low, according to the indicators from ISTAC. But still, capacitation of the agents across the islands is a challenging long-time discussed.
- Sustainability awareness – new demands of tourists have more social and environmental approach – 67% of Millennials prefer to stay in accommodations that respect the environment and are more socially active. There are two projects in Tenerife that respond to these characteristics. One “Birmagen-Añaza Eco Axis”, through which the possibilities of creative management of resources for an environmental, economic and social improvement for the area and “Effi-e Play Green” are studied, an app communicates the tourist consumption of energy and water that it realizes in real time and the saving measures that it adopts.
- Language capacities – there are not a huge knowledge of languages, which would be considered one constraint of large and fast implementation of 4.0 technologies advances.
- Bet on innovative training programs – development of an innovative training program that responds to three basic demands of the tourism sector: language skills, skills in organizational and managerial activities, and skills in interpersonal and social relationships, through the development of digital skills. Work is also being done to improve the training of personnel who participate in the entire tourism value chain (from transport, to accommodation, through the intermediary, guide / informant, restaurant or leisure activities), in areas digital or in areas specifically linked to innovation.

Policy preconditions

Canary Islands 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 political framework is necessary to move towards the achievement of those objectives proposed by the Public Administration to reach a more sustainable activity and socially more active tourism based on 4.0 technologies. In the current tourism strategies, there are different actions for promoting the digitalization of the sector and the technological innovation applied to the sector, and the implementation of Smart Tourism Destinations.

Some of these strategies are developed and executed by each island. Those islands bigger have available individualized strategies for their own territory. The smaller ones do not have own strategies, and are run by regional programs.

The main strategies, plans and programs for the technological transformation of tourism are described below.

- Canary Islands Strategic Plan for Tourism – PECT (2025). This plan aims to define the new Canarian tourism model through the consensus instrument between all actors involved; mthe the sustainability of the territory; the social development; and technological advances. One of the strategies of this plan is based on the “datification” of the sector. It is focused on the acquisition, processing and management of data for the destination based on instruments such as the ISTAC (Canary Islands Institute of Statistics). The Plan promote four key programs: the digitalization of the sector and the administration, innovation, knowledge and technology transfer.
- Strategy “Intelligent Specialization Strategy Canary Islands 2014 - 2020 - Government of the Canary Islands (2013)”. This strategy assumes a broad concept of innovation, which goes beyond investment in research or in the manufacturing sector, and that promotes competitiveness through design and creative industries, social innovation and services, new business models and innovation based on experience. Priorities of this strategy highlight the achievement of smart leadership in the tourism sector with the objective of improving the competitiveness and productivity of the Canary tourist product.
- The Canary Islands Tourism Infrastructure Plan 2017-2023. This plan works to boost the process of adaptation of tourism infrastructure, the correct development of tourism products, and the promotion of innovation in destination management. The interventions are articulated with territorial planning and urban planning, in addition to meeting the peculiarities of each tourist space.
- Strategy “White Paper on Innovation in the Community of the Canary Islands (2007)”. The analysis of the state of innovation in the Canaries as of 2007 shows: a) the activity of innovation, as the whole of the Canarian business activity, is greater in the Services sector, b) the public

system of R&D of the Canaries is the fundamental provider of science and technology, c) there are several technology transfer organizations (OTRI, foundations, etc.) in the Canary Island, d) funds for the promotion of innovation are destined for 50% to public centres and intermediate entities, and the other 50% to direct aid to companies.

There are some islands that have developed their own tourism strategies and plans. Specifically, Tenerife and La Palma stand out. There are others instead that do not have a specific Plan for their own territory.

- Strategy “Tenerife 2030 - Cabildo de Tenerife (2017)”. This strategy has been structured around five programs: Tenerife Educa, Tenerife Innova, Tenerife Creativa, Tenerife Digital and Tenerife Sports. Among these programmes *Tenerife Innova*, allows development through different actions in which the training and training of people prevails in projects such as technology parks or the closing of the insular telecommunication ring, promoting research, innovation, technological development and entrepreneurship. *Tenerife Digital*, ensures that citizens have access to the digital world and electronically access the Administration, improvement of eGovernment, cloud services and island and smart cities.
- Plan “La Palma. Intelligent Territorial Strategic Plan 2014 – 2020”. The main objective of the Strategic Plan is to identify the lines of action and specific projects that, after starting up, allow the development of new activities and make the economic, industrial and social growth of the island possible. La Palma Government has already initiated some actions framed in the Antares Project, Strategy for Economic and Social Transformation based on Science and Technology, focusing on one of the strategic lines of the project, Smart Citi4es and Smart Islands, as potential economic and social development.
- Sustainable Tourism Strategy of La Gomera 2018-2022. Among the objectives of this strategy is the development of research and innovation projects related to sustainable tourism (sensor technology, big data, information analysis, intelligent decision making, etc.)

Furthermore, 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. They are:

- **Clúster 'Canary Islands Excelencia Tecnológica'**. It is an association of ICT companies dedicated to the promotion and dissemination of Information and Communication Technologies as a key factor of economic and social progress in Canary Islands.
- **Smart Islands Initiative**. The Canary Islands are also member of the “Smart Islands Initiative”, a bottom-up effort of European island authorities and communities. The aim is to convey the significant potential of islands to function as laboratories for technological, social, environmental and political innovation.

- **Red CIDE.** It is the Canary Islands Network of Innovation and Business Development Centres. The goal of this network is to bring innovation closer to the Canary Islands society, especially to the companies and institutions, as well as to increase the innovation activities in the region. The centres organise trainings and conferences on innovation, they provide information about the different grants and financial schemes to support innovation and, overall, they develop business support activities.
- **InsertaTIC.** It focuses its efforts on encouraging companies to take advantage of the potential of digital technologies. First, innovation diagnoses have been made to companies, thus detecting the main needs in digital skills by workers and professionals. Secondly, workshops have been carried out to promote digital transformation. Thirdly, through an online training platform, content and tools for digitalization training applied to operational and business processes are offered.
- **Canary Islands Future Lab.** It is a joint initiative between London School of Economics (LSE), Satocan/Archipiélago Next, Government of Gran Canaria through the Society of Economic Development of Gran Canaria, the Government of the Canary Islands, PLOCAN, DroneMasters and Future Lab Berlin, among other local and international partners. They actively collaborate on promoting the development of technologies which are adapted to the Smart Islands, digital solutions and sustainable innovation for the Blue Economy and support to social and business projects focusing on equitable economic growth, digitalization, globalization and sustainable tourism.
- **El Hierro en Red.** The initiative seeks to expand the energy autonomy of the island with renewable energies, provide it with ICT services, guarantee and improve ICT services, promote technological innovation applied to the tourism sector, value cultural heritage through the use of innovative digital platforms, promote entrepreneurship and economic development, through the improvement of technological infrastructures.
- **La Palma Smart Destination.** Bet on creating infrastructure, equipment and fundamental ICT services on which to develop the island, on which to make it accessible and inclusive, for all, citizens, tourists and businesses.
- **Tenerife Smart Island.** The objective of this forum is to promote innovation and digitization in the Island in order to create more efficient services and infrastructure.

5.2.4 Actual transformations in the region

Economic transformation

Tourism is considered the main sector of Canary Islands economy and the main source of income and job creation, characterised by not having seasonality. The sector generates more than 40% of employment (326,970 jobs) and its contribution to GDP exceeds 35%. The Canary companies that are dedicated to the hospitality industry are around 13%.

According to interviewees, **the sector is quite innovative, and proactive, with has institutional support and financing channels** for its development. Although there would still be improved. For example, the Association of Tourist Municipalities of the Canary Islands (AMTC) believes that the Canary Islands have not fully involved into the digital era, being one of the Autonomous Communities that least invests in innovation.

In spite of this, technology is generating **more economic activity and new job opportunities**, transforming sector labour market. The interviewees point out that some traditional jobs related to the sector could be disappeared (like travel agencies or local guides) due to irruption of online booking platforms, but there are being created new jobs related to analyses and monitoring tourism data, or manage online opinions in public and private tourism institutions or in the hotels. New companies will be created to support them on these purposes.

However, the implementation of new technologies in accommodation or restoration is still low. The expense on technological transformation is high, especially for small hoteliers, which has tighter investment budgets. This sector, as well as generally in Spain, is characterized by being 60-70% of small entrepreneurs. The remaining 30-40% is in the hands of large operators. At this point, **the sector is under generational changes**. The new owners are starting to invest to renovate their hotels, introducing new improvements, based on new technologies.

In this sense, the sector demands the improvement of ICT skills. The sector requires **new professionals' profiles with high technological skills**, and nowadays, some tourism companies have difficulties to incorporate workers to their innovation departments for the development of their digital transformation projects or to hire them externally, specifically the small companies. For these reasons, currently many of the hoteliers are being trained to use search engine marketing strategies, email marketing, social media campaigns, digital advertising, or also data processing.

Some experts point out that those technological advances applied to tourism have been possible with the intervention of private companies in the sector. The private sector contributes to continue advancing in the application of 4.0 technologies to the sector. At least this is detected in the Canary Islands. The role of collaborations between public-private entities is key, and more if it are considered the variety of factors that influence the development of tourism activity in the Canary Islands (both public and private). The region has the ICT Demonstration Centre for Tourism Innovation, located in Gran Canaria. The purpose of this centre is to provide local society and tourism businesses companies with the knowledge and adoption of ICTs.

So given its importance in economic terms, public administration has strived to boost the tourist promotion of the destination, and it has been strongly committed to do it through digital channels. Now, with the emergence of new technologies, the tourism strategy of the region is committed to **CRM programs and customer loyalty**. With an increasingly segmented, almost individual communication strategy, the personalization of the tourist experience in the destination, one of the main trends of current tourism, is pursued. Communication control has been taken in all phases that the user experiences

before, during and after the trip, which is being possible thanks to the work in social networks and online promotion. In the Canary Islands, more than 70% of tourists hire their vacations through online search engines or online agencies. In this sense, there are chatbots to improve customer service. Thus these are present in the official tourism promotion pages of the Canary Islands, or Tenerife. From Promotur they use chatbots to offer tourists help to find and book the flight or the hotel according to their needs and preferences.

Another aspect that is monitored from the public administration to increase tourism activity in the islands is the number of flights that operate between the Islands and the European continent. The public company *Promotur Turismo de Canarias* has recently announced new airline routes from the Flights Development Fund. This Fund has the objective to create new airline routes from emerging markets to Canary Islands, strengthening current ones and improving connectivity with the Peninsula Iberica. It is promoted as an incentive for those airlines that value the opening of new routes to the Canary Islands. The fund, authorized by EU competition regulations, has served to open a relevant number of new routes.

The market relationships are being affected by the adoption of 4.0 technologies by the sector with the increase of **search and book online platforms** (Booking, Expedia...) as the interviewees pointed out. The sector, through CRM programmes (Customer Relationship Manager), design personalized tourist experiences to its customers. The Canary Islands Government has been working intensively on customer knowledge and motivations for several years, with the aim of improving communication keys and personalization of messages. So bet on a differentiated, almost individual communication. The tourism promotion agency of the islands works with 350,000 leads, tourists who know by name and with whom they have direct contact to offer them the travel options that best suit their tastes.

Traditionally, the Canarias tourism model was based almost exclusively on tour operators. The tour operator was responsible for the marketing and image of the islands. The hotel was guaranteed the hiring of the whole year and only had to worry about the management of the stay of the tourists in their respective hotels. There was no knowledge of the clients' concerns during the planning of their trip or their subsequent opinion about their stay.

In synthesis, the actual economic transformations in the sector in the Canary Islands are:

- Increased economic activity. The implementation of 4.0 technologies is transforming sector labour market. Traditional jobs related to the sector could disappear (like travel agencies or local guides) due to irruption of online booking platforms.
- New job opportunities. There are being created new jobs related to analyses and monitoring tourism data (e.g. hotels are creating new departments to manage online opinions from online platforms).
- New market relationships. The irruption of search and book online platforms (like Booking or Expedia) of accommodation has changed the relationships between the sector and tourists.

Now the sector is also committed to CRM programs (customer relationship manager) and customer loyalty for the personalization of the tourist experience. There is no longer a direct relationship between the client and tourism service providers.

- New skills required. The sector requires professionals' profiles with high technological skills. New jobs created have to know how to manage data and analysed it.
- Updated tourism promotion. Canary Island has one of the most developed tourism promotion systems in Spain. Public administration has changed and still changing the way to promote Canaries destination, using now online platforms, social media and onle booking engines.

However, some changes expected have not taken place yet in the region. Companies from the sector would demand new training and lifelong programmes "on tourism and tech", but education system is reactive, and adoption is hard to undertake. On the other hand, new platforms allow for more actors to offer products, services and accommodation. Many of these new actors may not be "professionals" of the sector (e.g. particulars renting flats on Airbnb). There are risks of more difficulties in managing the overall offer quality, and this may impact on the image of the whole sector, especially in smaller islands.

Social transformation

Generational changes and technology are the axes in which the transformation of the tourism business model is turning. Tourism companies increasingly succumb to the demands of new customers, integrating new technological processes to reach them faster and more easily.

The digitalization of the tourism sector implies the need to combine technological innovations, such as artificial intelligence, with human processes. Only through this union of resources can actions be developed that contribute to expanding the scope of the Canary tourism offer. In this sense, the experts of *The Valley Canarias*, an innovation hub specialized in digital training, emphasize the importance of betting on digital training from the public and private sector, since having highly qualified professionals in technology is a guarantee of success in carrying out digital strategies to promote tourism in the region.

For these reasons, the sector training is working for design new programmes that combine ICT skills and human abilities. Despite the fact that it is a sector with many people with a medium-low level of education, it should not be forgotten that a part of the qualification is obtained through accumulated experience. It is a sector in which both situations of overqualification and subqualification can be observed. This is the case of the lack of language skills and digital skills. It is possible that the small size of many of the companies also forces many tasks to be carried out, not in many cases achieving adequate competitive specialization.

Therefore, from the Ministry of Education and Universities and Tourism, Culture and Sports of the Government of the Canary Islands they have developed an innovative training program that allows us to go one step beyond the current model of Dual FP. The students will be trained in Hotels School and in the companies of alternative form, being granted scholarships by the companies during the three

years of their formation. During this time it is pursued that they develop all the competencies required by the sector, including digital ones.

Nevertheless, some changes did not take place. In general, like in many regions in Spain and the World the workforce' technological readiness is still scarce. In the region, there would not be enough qualified workforce that is able to adopt new technologies in its daily work yet. It could also be linked to the lack of technological vocation by young people. It is still characterised by unskilled labour and professional profiles without ICT profiles without ICT skills. Technicians and personnel from the sector are not sufficiently trained to advance in the digitalization of companies and public administrations.

On the other hand, there are difficulties to retain talent in an archipelago, where some islands are very small and where labour opportunities are scarcer compared to the most populated islands (Tenerife and Gran Canaria) or compared to other regions of Europe. Those who have better capacities to deploy technology on their daily work move to other regions of Spain or Europe.

5.2.5 Actual and/or expected impact

The tourism industry, today, faces a profound transformation that is mainly caused by those challenges resulted of the 4.0 technology emergence, the role of the new players of the sector (such as those born from the collaborative economy) and the changes in the requirements of the visitor. Given this scenario, the traditional tourist business structure has changed, and it will continue changing. The digital economy and technological advances represent a transformation of the tourism sector that could trigger new economic, social and territorial impacts in the region.

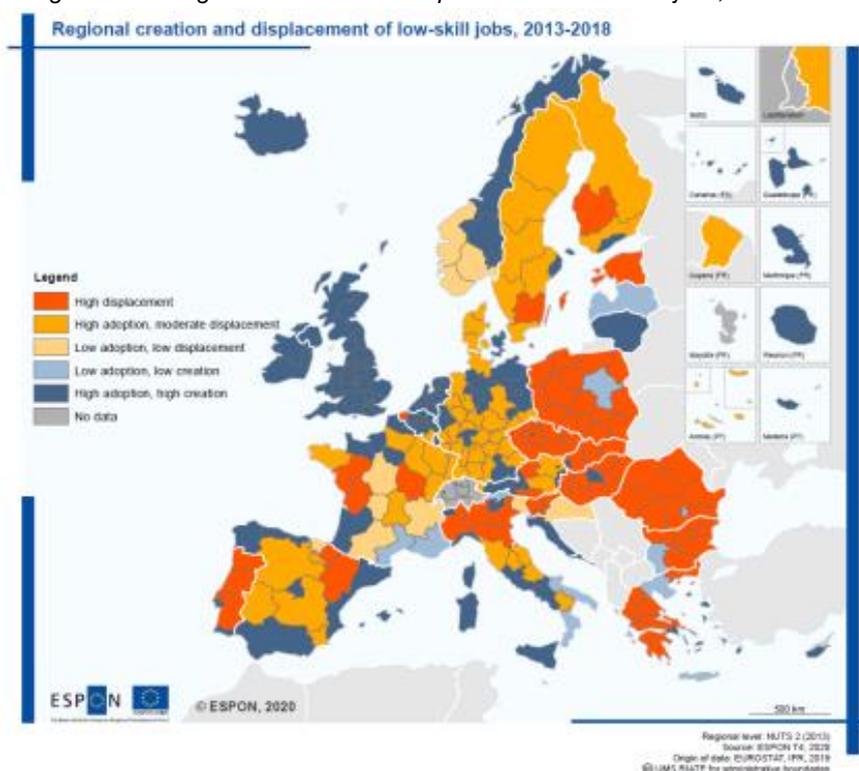
In the sector in the region

Even though, it is still difficult to quantify all social and economic impacts in the islands, experts interviewed share some of the futures impacts in the region due to the new models of tourism arisen by the 4.0 technologies implementation.

Increased of value added, positive impact on turnover and better productivity and competitiveness. The technological advances are contributing to generate more economic activity into the region. Experts estimate that the adoption of 4.0 technologies by the accommodation sector would increase the competitiveness of the sector around 20%. The exponential growth of international tourism, with the increase of millions of tourists from emerging markets, foresees an increase in Canarias tourism. This will be accompanied by the entry into the market of those digital natives who want to live the maximum possible experiences during their trips. They recommend, talk and share his experience through different digital devices and services. The implementation of technology in the search for quality badges is important in improving the positioning of the region vis-à-vis its main competitors and in improving their tourism competitiveness. With online marketing the volume of the activity increases and also its added value. The good position of the Canary Islands destination on digital channels and platforms, that is working the public administration, would increase the turnover and attracting new clients.

Increased of number of professionals with higher ICT skills. Adoption of 4.0 technologies would transform the workforce, generating new profiles related to the sector. There will be reduced of 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). The automation processes in the sector have not already occurred, but if it is taken into account the employment percentage of tourism, training in technology and tourism is an important issue to reduce possible negative impacts of automation processes. Although it seems that low-skill jobs could be adapted to the new scenarios and the displacement would be low following the tendency of last in years in the region.

Figure 5-25. Regional creation and displacement of low-skill jobs, 2013-2018



Source: ESPON T⁴

Development of new training programs related to tourism. Tourism training is working to balance aspects of human abilities and technology skills: to extract the potential of artificial intelligence to increase the added value of human relationships. In this way, it will be necessary especially in workplaces with interface with the client. According to experts, it will become increasingly important "the hybridisation of competencies and, therefore, professionals and teams." The new professional profiles must be capable of performing an analysis of data in the commercial area (up-selling, cross-selling); data analysis for the customization of products; or behavioural insights along with marketing and sales, etc.

Importance of collecting real-time data about visitors. One of the benefits of digital platforms for destinations is their ability to collect data and glean insights on travellers in real time. Digital platforms can see, at an aggregate level, what travellers are searching for, what destinations they are considering, what kinds of accommodations and activities they are selecting, their levels of spending, devices used for bookings, whom they are travelling with, and so on. In that sense, companies in the tourism sector are using big data and predictive analytics to increase knowledge of consumer behaviour and customise travel experiences accordingly. Indeed, the industry is already developing virtual assistants powered by artificial intelligence to help travellers' book trips more easily. Big data is also being used to make services more efficient and targeted by using such data to track purchasing behaviour and predict service demand. For instance, data generated through social media sites can impact the way decisions are made in the sector. However, with the increased use of big data come concerns over privacy, inaccuracy and misuse of such information.

But there are still obstacles. These would be low investment, especially by SMEs, which do not have sufficient technical and human resources for the adoption of new technologies, and the availability of data management experts. Another obstacle would be not having an adequate technological infrastructure.

Thus, those with the greatest guarantees in the short term of develop a Big Data strategy are travel agencies, tour operators or destination management institutions. The main challenge of the tourism industry in both regions is the collection and management of massive data by qualified professionals. The privacy of the data and the establishment of security policies that protect the client and limit the leakage of information, and at the same time guarantee transparency are another of the main challenges for the tourism sector related to big data.

Improvement of the quality of traveller's experience. The improvement of these experiences have been possible thanks to the analyses of opinions and evaluations when the clients book a trip. It let that the travel experiences can be totally personalised. Today's travellers crave personalisation; they feel that travel companies should tailor their information and overall trip experience based on personal preferences or past behaviours. Over the past years, digital data gathering practices have grown into machine-driven technologies, which allow targeting specific customers and gather information about them to personalise their travel. In the case of Canarias, through collating consumer behaviour insights, the public institution for tourism promotion can provide users with recommendations for hotels, destinations and even flight times that may suit their lifestyle. Furthermore, predictive analytics can be leveraged by administration to forecast the future of the sector in the region to increase engagement levels or make more informed decisions.

New ways to manage tourist destinations. The implementation of advanced technologies is contributing to more efficient and intelligent management of the destination. In the case of the Canary Islands, as a vulnerable destination due to its insular condition, the administration are working in favour tourism energy optimization, including transport. Thus, a pioneering energy experience of this type has

been designed on the island of El Hierro (Canary Islands), which tries to base its tourism innovation strategy on environmental quality.

The following table could synthesize the possible economic, social and institutional impacts of the implementation of 4.0 technologies on the sector. It reflects if the offer, demand, GVA, staff and infrastructure costs, the number of jobs may increase, maintain or decrease if 4.0 technologies are fully implemented in the region and according to the actor that do it.

Table 5-2. Economic, social and institutional impacts of 4.0 technologies in the sector

	Large operators on main destination	Small operators on main destination	Operators in secondary destinations	Service providers	Local tourist	Foreign tourist with "package tour"	Independent foreign tourist	Local administration	Regional administration	Europe
Offer increased	=	+	++	++				++	++	++
Demand increased	+	+	++	+	+	+	+++	++	++	++
GVA increased	++	+++	+	+++	++	=	+++	+	++	+
Staff costs	=	+	++	+				++	++	+
Infrastructure costs	=	+	+	+				++	++	+
Qualified jobs	+	++	++	++				+	+	+
Non-qualified jobs	-	-	-	-				=	-	-

Source: MCRIT (2019)

In other sectors in the regions

In other sectors in the region, it is expected low impact on their turnover. The technological transformation will be stronger on services sector, but especially on tourism activity, the main economic sector of the Canaries economy. The degree of 4.0 technologies adoption would impact less in industry sector due to the low share that industry has on the Canarias economy. In that sense, the automation of currently job positions would be less important in Canary Islands, given that the low weigh that the industrial sector has over the regional economy.

To overcome these differences between sectors, and homogenize the implementation of technologies throughout the whole of the economy of the region, the Canary Islands Government is working to promote the *Agenda for the Digital Transformation of the Canary Islands*. This agenda will include integrated actions of technological innovation, business innovation and training in digital skills.

Related to labour force the dynamics would be similar as it will be occurred on tourism. The level of employees with ICT education will increase in all sector of the region. There will be required ICT profiles,

which have to be able to combine social skills, such as knowing how to communicate, leadership, or teamwork those skills that technology has no capacity to develop yet. As it will occur on tourism, the employment will be transformed.

Future perspectives after COVID-19

The COVID-19 crisis is affecting tourism in restricting long-distance mobility of people, and in making more complex tourism activities at destinations. The final impact is yet unknown, but its economical magnitude will certainly be very large. There are higher regional risks in southern and eastern Europe considering a higher dependence of international tourist arrivals and a sector integrated by large numbers of SMEs and microbusinesses. In this case, the economy of Canary Islands is strongly dependent of tourism, where this sector generates more than 40% of employment and its contribution to GDP exceeds 35%, with the arrival of more than 15 million tourists annually (2018).

European tourist destinations must protect tourists against the virus and also the health of the local population, especially in archipelagos such as the Canary Islands, where economic and social dependence on the sector is so high, and where the tourists have to take a flight to travel to Canarias inevitably. How these challenges can be tackled is discussed more in depth in chapter 5.1.7 *Future perspectives after COVID-19*

5.2.6 Operational policy recommendations

The role that technology applied to tourism plays is extremely relevant in the Canary Islands. The digitalization of tourism has increased competitiveness in the global tourism market and, in the case of the Canary Islands, has favoured the tourist resurgence of some Mediterranean destinations, which are now absorbing an important part of the visitors that traditionally arrived to the. This tests the strength of the Canary sector and forces the actors involved to face new challenges related to the emergence of new technologies and their application to tourism. Those tourist actors that do not join the new digitalization processes in the sector may lose a significant percentage of their final turnover.

The increase in international competitiveness means developing a wider **promotion of the destination**. It means positioned better the destination "Canary Islands" among the main tourist destinations through the new digital tools. For this, the challenge is to develop new techniques based on big data to get to know tourists better, which allows for the necessary information to make an adequate diagnosis of the characteristics of the market. But in the attempt to improve the processes of the Canary tourism sector it is not enough to make an adequate diagnosis of the situation. The analysis of big data has to materialize in concrete actions of digital marketing by segmenting the messages towards certain profiles of users that fit with the tourist offer of the islands.

In order to achieve this, it is important to **promote training on ICT skills**. The digitalization of the tourism sector implies the need to combine technological innovations, such as artificial intelligence, with human processes. In this line the new training offers in tourism must be designed. Having highly qualified professionals in technology is a guarantee of success when carrying out digital strategies to promote tourism in the islands.

These actions acquire relevance by taking into account the situation of periphery that the Islands have in relation to the continent. The sector is highly sensitive to any negative circumstances related to changes in air traffic prices or changes in the conditions of international tour operators. The collapse of Thomas Cook has led to a reversal in the sector in the Islands by losing, among others, connectivity.

Among these factors, it is important to take into account the weight of tourism on the economy in terms of job creation and wealth for the region. Tourism activity generated 35% of the GDP and it achieved the 40% of employment. Failure to carry out the appropriate actions for the digitization of Canary tourism could lead to losses in the competitiveness of the sector, the gross added value of the activity over the region, and losses in the number of jobs of the sector.

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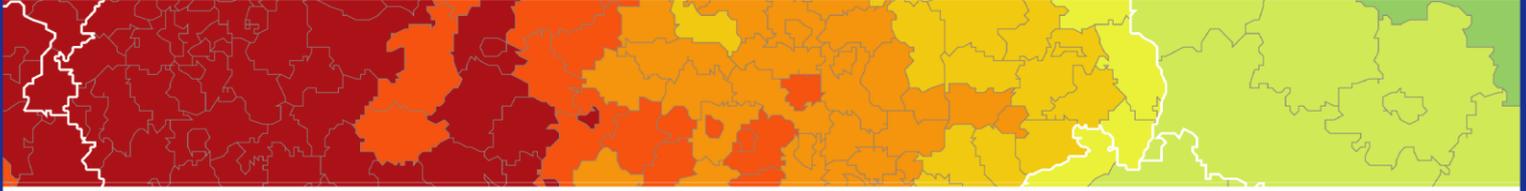
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